P E D O
PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION
Government of Khyber Pakhtunkhwa Peshawar
Energy & Power Department

No. 325/PEDO/PD Karora HPP
Dated the 31/10/ 2016

The Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower, G-5/1, Islamabad.

Subject: **DESIGN, PROCUREMENT AND CONSTRUCTION OF KARORA HYDROPOWER PROJECT**
CONTRACT NO. ICB/KR-01
Application for Grant of General License.

Dear Sir,

I, Ijaz Noor Shinwari Project Director Karora Hydropower Project, Pakhtunkhwa Energy Development Organization (PEDO) being the duly Authorized representative of PEDO by virtue of authority letter No. 2933/PEDO/CEO dated 31/10/2017, hereby apply to National Electric Power Regulatory Authority for the grant of a General License to PEDO for 11.80 MW Karora Hydropower Project, pursuant to the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

I certify that the documents-in-support attached with this application are prepared and submitted in conformity with the provisions of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999 and undertake to abide by the terms and provisions of the above said regulation. I further undertake and confirm that the information provided in the attached documents-in-support is true and correct to the best of my knowledge and belief.

A BANK DRAFT in the sum of Rupees ..... being the non-refundable license application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure), 1999 is also attached.

(Ijaz Noor Shinwari)
Project Director
Karora Hydropower Project.

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

Government of Khyber Pakhtunkhwa

No. 2933 /PEDO/CEO
Dated 31 / 10/ 2017

To

The Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower
G-5/2, Islamabad.

Subject: **Authority Letter**

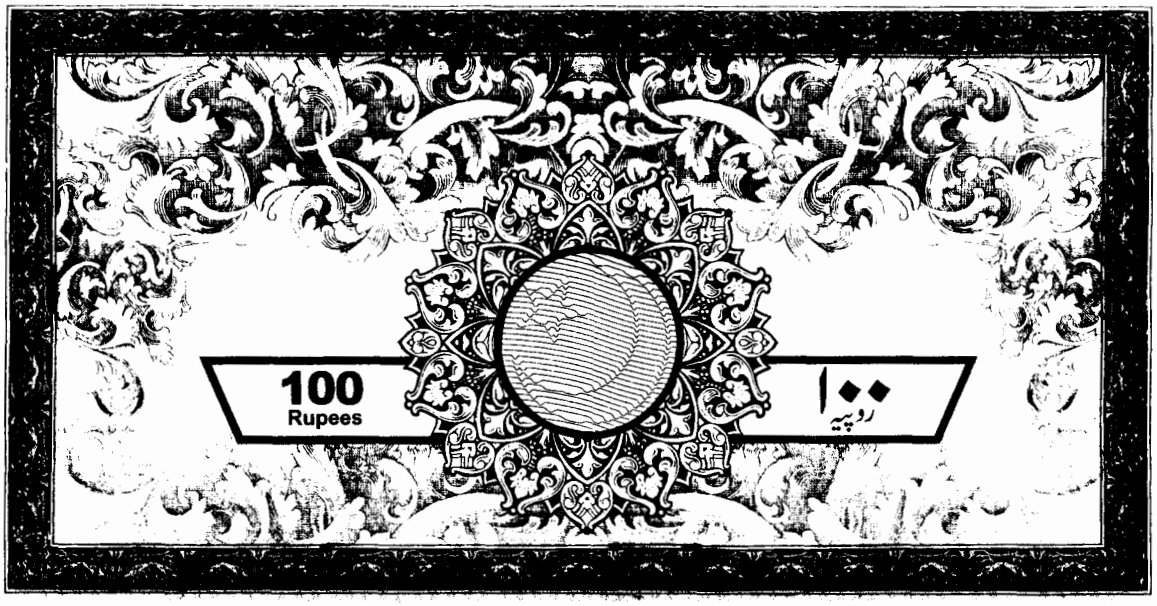
Mr. Ijaz Noor Shinwari S/o Hazrat Noor Shinwari Bearing CNIC No 14301-0228995-9 is hereby appointed as authorized representative of Pakhtunkhwa Energy Development Organization (PEDO), for the purpose of filing an application for determination of tariff for Karora Hydropower Project(11.8 MW) and to submit before NEPRA, an application for grant of Generation License for the said Project. He is also authorized to attend any meeting(s) and discussions related to the determination of tariff and grant of generation license and to provide any information & documents needed in this regard.

For and on behalf of

Pakhtunkhwa Energy Development Organization
(PEDO)

(Muhammad Naeem Khan)

Chief Executive Officer



BEFORE THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY

Affidavit

I, Ijaz Noor Shinwari Project Director Karora Hydropower Project, being duly authorized representative/ attorney of Khyber Pakhtunkhwa Energy Development Organization (PEDO), hereby solemnly affirm and declare that the contents of the accompanying General License application dated 9 / 11 / 2017 including all supporting documents are true and correct to the best of my knowledge and belief that nothing has been concealed.

I also affirm that all further documentation and information to be provided by me in connection with the accompanying petition shall be true to the best of my knowledge and behalf.

ATTESTED

09-11-2017

Deponent

14301-0228995-9

PROJECT DIRECTOR
Karora HPP
PEDO, Peshawar.

Check List for Examination of
New Generation Facility (Hydel) - License Application

Name of Company: Pakhtunkhwa Energy Development Organization (PEDO) Karora Hydropower Project
Capacity: 11.8 MW
Prepared/Updated on: September 25, 2017

Regulation	Information/Documents Required	Compliance		Remarks
		Yes	No.	
3(1)	Authorization from Board Resolution / Power of Attorney	Yes		Letter contents sent to PEDO
3(3)	Application fee (including Indexation)	Yes		Draft enclosed
3(4)	Three copies of Application	Yes		Attached
3(5)(a)(i)	Certificate of incorporation		No	PEDO is a public sector organization constituted under SHYDO Act 1993 and is Exempt under Section 24 of NEPRA Act and thus not required
3(5)(a)(ii)	Memorandum and articles of association	Yes		PEDO is a public sector organization constituted under SHYDO Act 1993.Notification for renaming to be provided by PEDO.
3(5)(a)(iii)	Annual Return statements or in lieu thereof		No	PEDO is a public sector organization constituted under SHYDO Act 1993 and therefore, not required to submit annual Return Statement
3(5)(b)	Profile of experience of the applicant its management, staff and its members in power sector.	Yes		Introduction of PEDO and its completed and ongoing projects attached.
3(5)(c)	CVs of applicant's Senior Management and Technical professionals	Yes		Provided
3(5)(d)(i)	Cash balance & bank certificates		No	PEDO is a public sector organization constituted under SHYDO Act 1993 and therefore, it is not required
3(5)(d)(ii)	Expression of interest to provide credit or financing along with sources and details thereof		No	1) 80% HDF(Hydel Development Fund, KPK KPK Provincial Government) 2) 20% ADP (Annual Development Program, KPK Provincial Government) Above funding sources are internal, therefore, EOI is not required.
3(5)(d)(iii)	Latest financial statements		No	PEDO is a public sector organization constituted under SHYDO Act 1993 and therefore, not required to submit annual Return Statement
3(5)(d)(iv)	Employment records of Engineers & Technical Staff	Yes		Provided

3(5)(d)(v)	Profile of Sub-contractors	Yes		N/A
3(5)(d)(vi)	Verified references w.r.t. experience of the Applicant and its sub-Contractors	Yes		EPC awarded under PEC rules after ICB and complete verification of contractors. Arranged by MC
3(5)(e)	Encumbrances on assets	Yes		N/A
3(5)(f)	Technical and financial proposal for Operation, maintenance, planning and development of the generation facility.	Yes		EPC executed and work on the project is in progress under the EPC signed with GRC JV.
3(5)(g)(a)	Type of Technology	Hydel		Provided
3(5)(h)	Feasibility Report	Yes		Provided
3(5)(i)	Prospectus	Yes		Provided

Cont'd.... P 2

Schedule II				
1.	Location (location maps, site maps) land	District Shangla		Provided
2.	Plant: run of river, storage, weir	Run of River		Provided
3.	Head: Minimum, maximum			Net Head-142m
4.	Technology: Francis, Pelton, etc. Size, number of units.	Francis		Francis,2x6.36 MW
5.	Tunnel (if proposed): length, diameter	Yes		L-2976m Dia-2.65m
6.	ESSA (Environmental and Social Soundness Assessment)	Yes		Provided
7.	Detailed feasibility report	Yes		Provided
8.	Resettlement issues	No		Settled
9.	Consents			EIA and land acquisition already approved. Customs and other duties at concessionary rates will be applicable as per GOP/GoKPK Policy.
10.	Infrastructure development			Included in EPC
11.	Interconnection with National Grid Co. distance and name of nearest grid, voltage level (single line diagram)	Yes		Approved Interconnection Study Report and Consent Letter from NTDC is attached. The interconnection scheme for the Power dispersal from Karora Hydro Power Plant would be through 10 Km Double Circuit 132 KV transmission line running on Twin Bundle Rail Conductor from Karora power plant to Besham Qila connecting Karora power plant with National grid as per NTDC recommendations.
12.	Project cost, information regarding sources and amounts of equity and debt.	Yes		3,263.278 Million

13.	Project schedule, expected life			Construction period:35 months, Project life 30 years
14.	Peaking/base load operation			No peaking
15.	Plant characteristics: generation voltage, power factor, frequency, automatic generation control, ramping rate, control metering and instrumentation			Generating Voltage -11 KV Frequency --50 Hz Power Factor - Leading 0.9 & Lagging 0.85 Automatic Generation Control –Yes (through AVR) Ramping Rate -10 minutes Alternative Fuel -No Auxiliary Consumption -0.3 MW (2% of installed capacity) Time required to Synchronise -5 minutes(if running on load)
16.	System studies load flow, short circuit, stability			Studies completed and approved by NTDC.
17.	Training and development			Details provided in the EPC Contract

Article – 1

Definitions

(1) **In this Licence**:

a. "Act" means the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 (XL of 1997);

b. "Authority" means the National Electric Power Regulatory Authority constituted under Section 3 of the Act.

c. "Licensee" means Paktunkhwa Energy Development Organization (PEDO) Jaboori Hydropower Project

d. "Rules" mean the National Electric Power Regulatory Authority Licensing (Generation) Rules, 2000.

(2) Words and expressions used but not defined herein bear the meaning given thereto in the Act or in the Rules.

Article – 2

Application of Rules

This Licence is issued subject to the provisions of the Rules, as amended from time to time.

Article – 3

Generation Facilities

(1) The location, size, technology, interconnection arrangements technical limits, technical functional specifications and other details specific to the generation facilities of the licensee are set out in Schedule - I to this Licence.

(2) The net capacity of the generation facilities is set out in Schedule - II hereto.

(3) The Licensee shall provide the final arrangement, technical and financial specifications and other details specific to generation facilities before commissioning of the generation facilities.

Article – 4

Term

(1) The Licence is granted for a term of ***thirty (30) years*** after the commercial operation date.

(2) Unless revoked earlier, the licensee may, ***ninety (90) days*** prior to the expiry of the term of the licence, apply for renewal of the Licence under the Licensing (Application and Modification Procedure) Regulation, 1999.

Article – 5

Licence Fee

The Licensee shall pay to the Authority the Licence fee in the amount and manner and at the time specified in the National Electric Power Regulatory Authority (Fee) Rules, 2002.

Article – 6

Tariff

The Licensee shall charge from its consumers only such tariff which has been approved by the Authority.

Article – 7

Competitive Trading Arrangement

(1) The Licensee shall participate in such measures as may be directed by the Authority from time to time for development of the Competitive Trading Arrangement. The Licensee shall in good faith work towards implementation and operation of the aforesaid Competitive Trading Arrangement in the manner and time period specified by the Authority:

Provided that, any such participation shall be subject to any contract entered into between the Licensee and another party with the approval of the Authority.

(2) Any variation and modification in the above mentioned contracts for allowing the parties thereto to participate wholly or partially in the

Competitive Trading Arrangement shall be subject to mutual agreement of the parties thereto and such terms and conditions as may be approved by the Authority.

Article – 8

Maintenance of Records

For the purpose of sub-rule (1) of Rule 19 of the Rules, copies of records and data shall be retained in standard and electronic form and all such records and data shall, subject to just claims of confidentiality, be accessible by the authorized officials of the Authority.

Article – 9

Compliance with Performance Standards

The Licensee shall conform to the relevant NEPRA rules on Performance Standards as may be prescribed by the Authority from time to time.

Article – 10

Compliance with Environmental Standards

The Licensee shall conform to the environmental standards as may be prescribed by the relevant competent authority from time to time.

Article – 11

Provision of information

(1) The obligation of the licensee to provide information to the Authority shall be in accordance with Section 44 of the Act.

(2) The licensee shall be subject to such penalties as may be specified in the relevant rules made by the Authority for failure to furnish such information as may be required from time to time by the Authority and which is or ought to be or have been in the control or possession of the licensee.

Schedule - 1

It contains the following information / drawings / sketches relating to the Power Plant Equipment and related System which are attached here with:

Plant Details

- General Information
- Plant Configuration
- Fuel Details
- Emission Values
- Installed Capacity
- Derated Capacity
- Expected Life
- Operation Record
- Cooling System
- Plant Characteristics
- Other details specific to the generation facility of the licensee such as:
    - Technical Limits of the Plant
    - Site Plan of Ranolia Power Plant
    - General Layout of entire Ranolia Power Plant
    - Interconnection Arrangements with National Grid

Plant Details

1. General Information

- Name of Applicant: Paktunkhwa Energy Development Organization (PEDO) Karora Hydropower Project

- Address of the registered office : PEDO House,38-B2,Phase-5
- Plant Location : Jabori, District Mansehra , Province of Khyber Pakhtunkhwa

- Type of Facility : Run of River Hydropower Project

Plant Configuration

- High Head Hydropower turbines(Francis Turbines)
- Capacity of the Power Plant : 11.8MW
- Type of Technology : High Head Hydropower p
- Number of Units / Capacity - : Two units / 5.9 MW each
- Power Plant Make and Model : Francis turbine and Horizontal Generators

- Commissioning Date:30 November,2019

Fuel Details

- Type of Fuel : Hydropower Project
- Fuel (Imported / Indigenous) NA
- Fuel Supplier NA

- **Emission values**

- SOx ---------- NA
- NOx ---------- NA
- CO ---------- NA
- PM10 ---------- NA

- Installed Capacity – 11.80 MW

2. Derated Capacity : No Derating as compared to ISO

3. Expected Life of the Facility ---------- 30 years

7. Operation Record ----------New Plant to be commissioned by November, 2019.

4. Plant Characteristics

- Generating Voltage ---------- 11 KV
- Frequency ---------- 50 Hz
- Power Factor ---------- Leading 0.9 & Lagging 0.85
- Automatic Generation Control ---------- Yes(Through AVR)
- Ramping Rate ---------- 10 minutes
- Alternative Fuel ----------No
- Auxiliary Consumption ----------0.3 MW (2% of installed capacity)

Time required to Synchronise ---------- 15 minutes

SCHEDULE – II

The Net Capacity of the Licensee's Generation Facility

- Gross Installed Capacity of the Plant (ISO) ---------- 11.80 MW
- Derated Capacity of the Plant ---------- 11.80 MW
- Auxiliary Consumption of the Plant ---------- 0.3MW
- Net Capacity of the Plant ---------- 11.5 MW
- Construction Period ---------- 35 months
- Expected date of Commercial Operation of the Plant – **30 November 2019**
- Note: These are indicative figures provided by the Licensee.

The Net Capacity of the Plant available for dispatch to Power Purchaser will be determined through procedures contained in the EPC Agreements or Grid Code

Interconnection Arrangement with National Grid for Power Dispersal of the Plant

The interconnection scheme for the Power dispersal from Karora Hydro Power Plant would be through 10 Km Double Circuit 132 KV transmission line running on Twin Bundle Rail Conductor from Karora power plant to Besham Qila connecting Karora power plant with National grid as per NTDC recommendations.

PROSPECTUS

General

Pakistan is rich in hydropower potential but, unfortunately, Pakistan's investment in hydelpower generation has remained caught up in confusion and paradoxes for more than a decade, while no significant progress has been achieved. On the other hand, the Government is trying to facilitate private investors to promote hydel generation. Pakistan is endowed with a hydel potential of approximately 40,000 MW, most of which lies in the Khyber Pakhtunkhwa, Gilgit - Baltistan, Azad Jammu and Kashmir and to a lesser degree in Punjab. Electric power is a stimulator for the socio-economic uplift of the country, yet only half of the country's population has access to it. After the creation of Pakistan, the country faced numerous problems including dearth of electrical power. Since then efforts has been made to exploit the hydropower potential of the country, however, abundant hydel potential remains untapped, which needs to be harnessed.

In this respect, Sarhad Hydel Development Organization (SHYDO) and Deutsche Gesellschaft fur Technique Zusammenarbeit (GTZ), A German Government Agency for Technical Co-operation, in 1992 carried out extensive studies in Pakistan for the identification of potential sites for the generation of hydropower. During this exercise, SHYDO-GTZ, inter alia identified 18 MW Koto hydropower project on Panjkora River near Temergara, District Lower Dir, 8 MW Jabori hydropower project on Siran River near village Jabori, District Mansehra and 7.5 MW Karora hydropower project on Khan Khwar near village Karora, District Shangla.

The Asian Development Bank (ADB) provided a loan for financing the consultancy services to carry out Feasibility Studies of above-mentioned three hydropower projects. M/S Associated Consulting Engineers - ACE (Pvt.) Ltd has been appointed as Consultants by SHYDO to prepare Feasibility Studies for Koto, Jabori and Karora. The Contract Agreement for the study was signed between SHYDO and M/S Associated Consulting Engineers (ACE) in July 2008, with a time period of 18 months to complete the proposed Feasibility Studies.

After the completion of feasibility study, tender documents were prepared by the consultants and competitive bids were invited for the implementation of the project on EPC basis. After the evaluation of bids , GRC Joint Venture were appointed as EPC Contractor and the work on the project started forthwith. Project is at advanced stage of construction and the Commercial Operations Date (COD) is expected in November, 2019.

The Project

Brief Description of the Project

Karora Hydropower Project will use the water resources of the Khan Khwar River for power generation. It will comprise four main components, viz., Weir, Intake Structure, Power Tunnel, Power channel, Sand trap and Powerhouse. The Weir will be located near Kuz Kana Village on the Khan Khwar River. The Power House and outlet portal of the Power Tunnel will be located at Settlement Mareen, Village Ranial about 9 km downstream of the Weir structure.

River bed elevation is 1005 masl and weir crust elevation is 1020.6 masl, as a result dam height is 8 m. The maximum operating reservoir elevation is 1011 masl. Reservoir capacity (at Elev. 1013) is 22,521 m^3. Tunnel length is 2,960 m long and power channel length is 430 m. The design hydropower capacity is 9.3 MW. Two bridges were required, one at weir site and other at power house site, plus access roads were established for excess to project construction sites.

Project Objectives

The project objective is to generate 9.3 MW of electricity on a least cost basis to meet the increased energy demand. The main objectives of the Karora Hydropower Project are to assist the government of Pakistan (GoP) in its efforts to:

1) Develop domestic energy resources and reduce load-shedding in a cost-effective and environmentally sustainable manner, thereby supporting the country's long-term energy development objectives.

2) Reinforce and complement the reform program for the power sector.

3) Strengthen the Water and Power Development Authority's (WAPDA) and Sarhad Hydel Development Organization (SHYDO) capability to address environmental and resettlement issues related to hydropower projects and

4) Further rationalize the use of non- renewable resources.

Environment, Resettlement and Mitigation Measures for Adverse Effects

The proposed Karora HPP is a run-of-river scheme, about 300m upstream of Kuz Kana village on Khan Khwar River. The proposed Weir site is located near Kuz Kana Village on the Khan Khwar River. The power house is located near village Ranial.

Karora Hydropower Project is located in tectonically and seismically critical zones of convergence between Indo-Pakistani and Eurasian continental plates. More than ninety percent of severe earthquakes of Pakistan and adjoining countries are located within this Orogenic belt.

The lands in the project areas are mainly proprietary and used for cultivation. Before flood it was estimated that the project will use 64.321 kanals of private land, out of which 68.4% of cultivated, 9.3 % forest/grazing, 21.8 % uncultivated/waste and 0.5 % of residential land that is likely to be consumed by the Project. By and large this is the proprietary land. Only 1 house is falling in project area and needs relocation.

After flood, the project is estimated to consume equivalent sum of land as before flood but land use status have been changed from agricultural to waste land. Statistic tells that out of 64.32 kanals, 40 % is agricultural land, forest/grazing land is 3.11% and 34.2% is waste land consumed after flood, which was 44%, 9.33% and 21.8% respectively before flood.

Before flood, about 139 shade trees and 65 fruit trees (204 trees) lie in project area and have to be cut. General Flora of the project area includes Drawa, Deodar, Pine, Poplar, Chir, Bakain, Pear, Persimmon and Walnut.

After flood, numbers of trees have been reduced from 204 to 155 (112shades trees and 43 fruit trees) because flood washed away numeral of plantation.

Maize and wheat are staple food of locals. Wheat and maize production is about 200 kg and 160 kg/kanal respectively as derived from census survey analysis.

No air quality monitoring data is available for the project area. However, no major sources of air pollution, viz., industries, exist in the project area except for road traffic in the valleys of Khan Khwar River and other nullahs. Due to presence of ample plantation, the quality of air is good. Quality of air along roads is impaired to some extent.

The main surface water resource of the Project area is the Khan Khwar River besides spring water. In general water of the nullah/river and springs are safe for consumption but the potable water would require appropriate treatment, before use for drinking by non-local construction crew.

The socio-economic environment of the project area is a mixture of rich and poor with a low percentage of middle income groups. People are relying for their earning from small agricultural land holdings and/or providing services on daily wages.

Before flood, number of micro hydel generators and water mills exist in between reservoir to power house area; they will face water shortage during low flow season. So, they will be provided with adequate river water to run their micro hydel generators/ water mills.

Now in post – flood condition there is no such diversion or usage exists. But in near future, it will quite possible that local people will rebuild their disrupted structures. So, they will be provided with adequate river water to run their micro hydel generators/ water mills.

It is recommended that the proprietary land should be compensated in cash in accordance with the market rates currently prevailing in the area. The villages of the nearby project will be facilitated with proper drainage and sewerage systems. The project area will be rehabilitated after the completion of project.

Before flood, the total environmental cost comes to about Rs. 14.806 million, when land acquisition is limited to the reservoir retention level of El 1013 m.

After flood, with change in land use status and reduced number of trees total environmental and resettlement cost comes about Rs.13.567 million. But figure 14.776 (say 14.8) million rupees are recommended because land use status can been changed when project being executed.

Arrangement would be made for release of some water from the weir for downstream reach because it might be possible that all micro hydel generators and water mills will be restored.

It is concluded that the project activities at some components will have adverse effects of low-to-medium level at local environment while the overall environmental impact rating is low-adverse, as before flood.

There would be trained staff at the project site for environmental management and monitoring. SHYDO as the Implementing Agency will develop its internal capacity to implement and monitor the measures in the environmental management and monitoring plan by hiring two consultants one as supervisory consultant (Environmental and Resettlement Specialist) another part – time consultant for external monitoring.

EXECUTING AND FINANCING AGENCIES

Executing Agency (EA) for implementation of the Project is Pakhtunkhwa Energy Development Organization (PEDO) of KP Province headed by Chief Executive Officer, PEDO. The Authorized Representative of EA is the Project Director, Jabori Hydropower Project (PEDO), assisted by the MC.

The project is being financed by the Government of Khyber Pakhtunkhwa from its own resources. 80% of project cost

is being funded by HDF (Hydel Development Fund, KPK KPK Provincial Government). And 20% ADP (Annual Development Program, KPK Provincial Government).

PROJECT IMPLEMENTATION ARRANGEMENTS

Executing Agency :		Pakhtunkhwa Energy Development Organization (PEDO)
Consultants	:	A Consortium of:
		PAKISTAN ENGINEERING SERVICES (PVT.) LTD. &
		DEVELOPMENT & MANAGEMENT CONSULTANTS
		in association with:
		Nippon Koei Co. Ltd., Japan

SALIENT FEATURES

Following are the key parameters of the Project.

Location	Karora (District Shangla), Khyber Pakhtunkhwa, Pakistan
UTM Co-ordinates	43 S, Easting = 3177700.00 m Northing = 1191566.00 m
River	Khan Khwar
Type	Run-of-River
Purpose of Project	Supply electricity to National Grid

Hydrology

Catchment Area	235 km^2
Normal Reservoir Level	1013.00 masl
Design discharge for Power	9.75 m^3/s
Selected design flood for Weir	1000 years frequency
Flood Discharge (Q_{100})	826 m^3/s
Flood Discharge (Q_{1000})	1196 m^3/sec

Diversion Weir / Dam

Type	Ogee Type
Crest level	1019.50 masl
Crest of flow section	1013.00 masl
Length of Weir	58.0 m
Design Flood	1000 years frequency
Flood discharge	1196 m^3/s

Surcharge due to design Flood	5.09 m
Total Height of Weir	13.5 m above river bed
Stilling Basin	USBR Type I
Size of Basin	47.8 x 19.0 m
Intake gate size	Vertical lift gate 3.35 x 2.23 m
Embedded Channel design	25% extra over discharge (8.00 m^3/s)
Size of embedded Channel	3.2 x 2.1 m
Water level in embedded channel	El: 1012.58 masl

Connecting Channel (BOX Section)

Design discharge	11.70 m^3/s
Invert Level	El: 1010.90 masl
Water level at start	El: 1012.70 masl
Bed Width	3.2 m
Flow depth	1.8 m
Side slope	Vertical
Bed slope	1.0 in 500 m
Free board	0.3 m
Flow velocity in channel	2.37 m / sec
Total Length	400 m

Sand Trap (Two Chambers)

Limit particle size	0.2 mm
Average velocity in chamber	0.2 m/ s
Length of chamber	75.0 m
Length of U/S transition	8.0 m
Length of D/S transition	10.5 m
Freed board	0.6 m
Size of chamber at start	B = 5.5 m, D = 8.1 m
Size of chamber at end	B = 5.5 m, D = 10.25 m
Inlet gates	Two lift gate with hoisting (2.1m x 2.4m)
Outlet gates	Two lift gate with hoisting (2.3m x4.2)
Flushing arrangement	Two rectangular gates (0.8m x 0.8m)
Flushing discharge	2.34 m^3/s i.e., 25% of design discharge
Spillway Section	Overflow type
Crest level of spill section	EL: 1013.0 masl
Length of spill section	12.0 m
Surcharge due to design flood	5.09 m
Head losses in Sand trap	0.002 m

Headrace Channel (Rectangular Section)

Design discharge	9.75 m3 / s
Invert Level	EI: 1004.50 masl
Water level at start	EI: 1012.106 masl
Size of Channel	3.2 x 2.1 m
Bed slope	1.0 in 1000 m
Free board	0.3 m
Flow velocity in channel	1.45 m / sec
Total Length	100 m

Aqueduct

Design discharge	9.75 m3 /s
Dimensions of turf	3.2 x 2.1 (B x D)
Free board	0.30 m
Bed Slope	1.0 in 1000 m

Intake Portal

Invert elevation at start	EL: 1004.50 masl
Invert elevation at Tunnel inlet	EL: 1004.50 masl
Water level at intake	EL: 1012.106 masl
Freeboard	0.60 m
Min: submerged provided	3.25 m
Spillway section	Ogee, Overflow sharp crested at EL: 1013.0 masl
Length of spillway section	28.45 m
Surcharge due to design discharge	0.34 m

Power Tunnel

Type	Inverted U-Shape
Height and Width	2.50 m and 2.30 m
Invert elevation of tunnel at U/S	EL: 1004.525 masl
U/S Water level at design discharge	EL: 1010.90 masl
Flow area	5.536 m^2
Bed slope	1.0 in 240 m
Average flow velocity	1.77 m / s
Equivalent diameter of Tunnel	2.65 m
Length of Tunnel	2976 m
Bed level at Surge tank	EL: 991.690 masl
Total loss in Tunnel	3.33 m

Surge Tank

Type	Simple Surge tank
Maximum surge level	EL: 1022.7 masl
Minimum surge level	EL: 996.9 masl
Diameter of surge tank	5.5 m

Height of surge tank	33.0 m

Penstock

Material	Alloy Steel (ASTM A516 Gr.70)
Invert level	EL: 992.5 masl
Total length	362 m
Diameter (Main / Branch)	1.8/1.275 m
Thickness	12 ~16 mm
Manifold Thickness	22 mm
Average velocity	3.83 m/s
Gross Head	151 m
Head losses	3.9 m
Invert level at Powerhouse	EL: 859.7 masl

Power Facilities

Powerhouse	Surface Powerhouse
Size of Powerhouse	38 x 14 m
Turbine type	Horizontal Francis
Units	Two
Turbine Design Discharge	4.875 m^3 / s
Turbine Capacity	6.36 MW
Generator Capacity	6.14 MW
Gross Head	151 m
Net Head	142.00 m
Net Head losses	9 m
Installed Capacity	11.8 MW
Average annual energy	71.39 GWh
Plant Factor	69.06 %

Tailrace Channel

Type	Rectangular Concrete channel
Dimensions	3.0 x 2.5 m
Average velocity	1.74 m / s
Length of Channel	20.0 m
Freeboard	0.30 m

Switchyard

Size of Switchyard area	56m x 42.5 m

Transmission Line

Transmission Line	10 Km Double Circuit 132 KV transmission line running on Twin Bundle Rail Conductor from Karora power plant to Besham Qila connecting

	Karora power plant with National grid as per NTDC recommendations
Employer's Colony	
Overall Area	7651 m^2 (including roads and parks)
Access Roads	
Permanent Access to Power house & Switchyard	L= 350m(Approx.), Total Width=5.0m, Roadway Width= 3.70m
Temporary Access to Tunnel Outlet & Surge Tank	L= 1425m (Approx.), Total Width=5m Roadway Width= 3.70m
Access Bridge to Power house & Switchyard	L= 81m, Total Width=5m, Clear Width=3.7m, Spans=3x27m, Piles= 20
No	25m long and 760mm diameter.

PEDO PROFILE

KHYBER PAKHTUNKHWA HYDEL DEVELOPMENT ORGANIZATION

1. Introduction

Khyber Pakhtunkhwa Province of Pakistan is blessed with huge hydropowerpotential.This potential remained focus of interest to private investors and international funding agencies. Most of the hydel projects of Pakistan including Tarbela and Warsak hydropower stations are located in KP.

Pakhtunkhwa Energy Development Organization (PEDO), since its inception in 1986, has been instrumental in identifying and exploiting hydel potential in Khyber Pakhtunkhwa. The organization is under the administrative control of Energy and Power Department of Provincial Government and is governed by the Board of Directors. PEDO has so far identified a number of promising hydel potential sites of more than 6000 MW capacity, which can be developed in a systematic manner either through Public sector or Private sector.

i. Objectives of the Organization

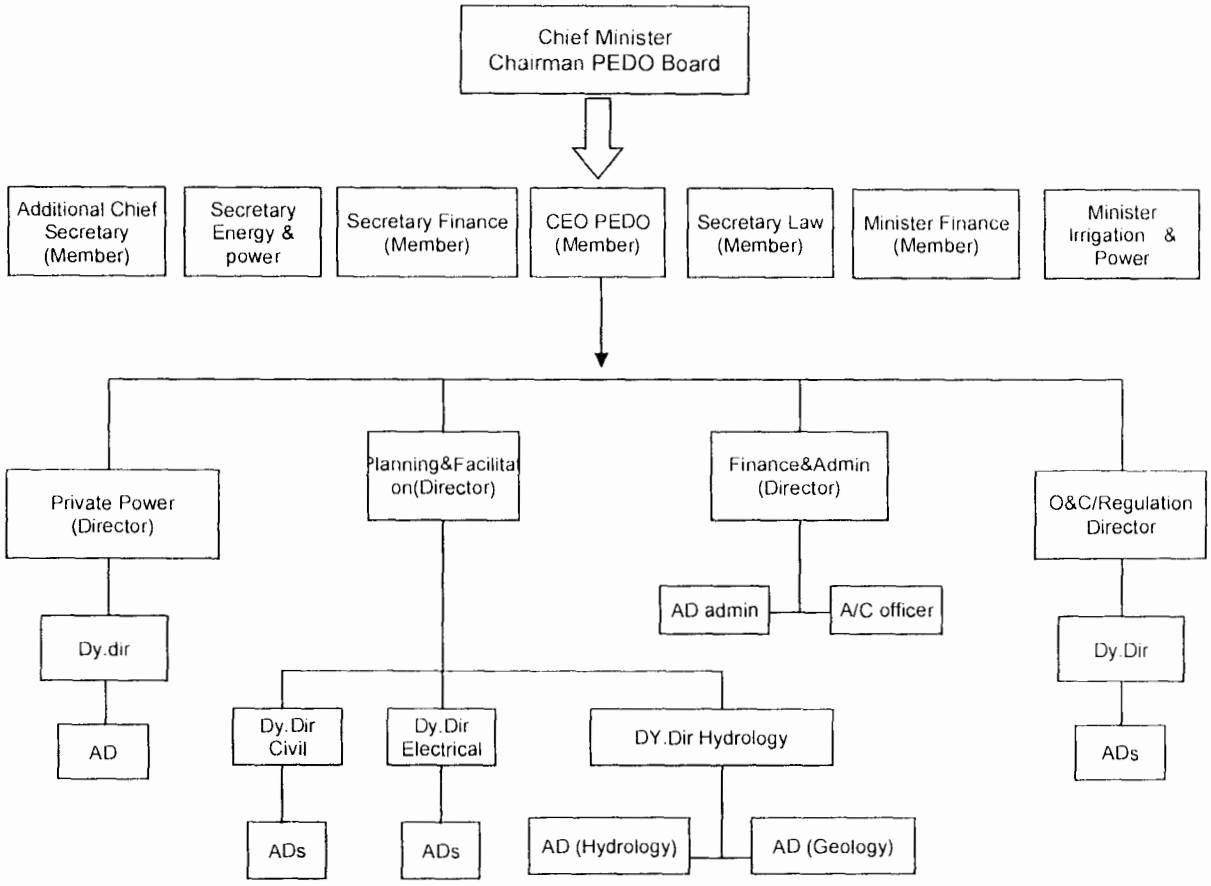
- Prepare comprehensive plan for development of the power and energy resources of the province.
- Frame schemes related to Generation, Transmission and Distribution of power, construction, maintenance and operation of powerhouses.
- Advisory body for the Government of KP in power sector matters regarding hydropower development.
- Conducting feasibility studies, surveys ofhydel potential sites etc.
- Implementation of Provincial Hyde-l Power Policy to promote private sector investment in generation, transmission and distribution of power.

ii. Role of PEDO

The Provincial Government has entrusted a dynamic role to PEDO, which mainly oriented towards private sponsors participation in power sector projects besides developing projects in public sector. PEDO has established a dedicated Directorate to provide one window facility to private sponsors.

iii. PEDO Organization

An eight member Board of Directors under the chairmanship of the Chief Minister of Khyber Pakhtunkhwa governs affairs of PEDO. The members include Minister Energy &Power, Minister Finance, Additional Chief Secretary, Secretary Irrigation &Power, Secretary Finance, Secretary Law and Chief Executive Officer PEDO. The head office of the Organization is at Peshawar.



2. Achievements by PEDO

PEDO, with the assistance of GTZ (German Agency for Technical Cooperation), has compiled a Master Plan for rural electrification in the Northern mountainous areas of KP with particular emphasis on those areas which were not connected to the National Grid System. The Master Plan entails a total potential of more than 6000 MW that has been identified for public and private sector development. The hydropower potential sites are mainly located in the Northern districts of K.P i.e. Chitral, Dir, Swat, Indus Kohistan and Mansehra.

i. Small Hydel Potential Sites

The Master Plan envisages small scale potential sites having total capacity of about 240 MW, comprising 53 hydel potential sites. These sites are suitable for regional supply to isolated communities in the mountainous areas of KP. The district wise breakup of sites is as follows:

Sr. No.	Region	Nos. of Sites	Power Potential (MW)
1	Upper Chitral	12	80
2	Lower Chitral	10	68
3	Kohistan	4	6

Sr. No.	Region	Nos. of Sites	Power Potential (MW)
4	Swat	5	5
5	Mansehra \Vest	2	19
6	Kaghan Valley	3	13
7	Dir	17	50
TOTAL:		53	241

ii. Medium /Large Hydropower Systems

During field investigations, some very attractive sites of medium and large hydropower potential were also identified by PEDO.

Sr. No.	Name of Project I Location	Capacity (MW)	Remarks
1.	Kandiah System, Kohistan a. Karang Scheme, 454 MW b. Kaigah Scheme, 548 MW	1002	Private sector is developing these sites under Federal Power Policy
2.	Swat System, Swat a. Upper Scheme AI, 101 MW b. Middle SchemeBl,410 MW c. Lower Scheme Cl, 148 MW	659	-do-
3.	Spat-Gah, Kohistan a. Upper Scheme 200 MW b. Middle Scheme 550 MW c. Lower Scheme 500 MW	1250	WAPDA has undertaken the feasibility study through KfW, Germany
4.	ChorNala System, Kohistan a. Scheme C-II, 700MW b. Scheme C-L 650 M\V c. Scheme K-II, 150MW	1500	-do-
5.	Kunhar River System, Mansehra a. Naran, 215 MW b. SukiKinar, 840 NW	865	Private sector is developing these sites under Federal Power Policy

iii. Feasibility Studies Completed

Out of the identified sites, PEDO has completed feasibility studies of the following potential sites. These schemes are in various stages of implementation.

Sr. No.	Proj ect / Location	Capacity (MW)	Remarks
1.	Daral Khwar HPP, Swat	36	Under imp implementation through ADB Loan
2.	Ranolia HPP, Kohistan	17	-do-

Sr. No.	Proj ect / Location	Capacity (MW)	Remarks
3.	PehurHPP, Swabi	18	Under construction by PEDO
4.	SummarGahHPP, Kohistan	28	Suitable for private sector
5.	Batal Khwar HPP, Swat	8	Suitable for private sector
6.	MatiltanHPP, Swat	84	Under public sector tendering stage
7.	Khan Khwar HPP, Besham	72	Picked up by WAPDA for implementation
8.	Duber Khwar HPP, Kohistan	130	
9.	Allai Khwar HPP, Batagrarn	120	

3. Hydropower Projects Completed

PEDO, after successful completion of following four small and medium size hydel projects with its own resources is planning to launch number of small, medium and large hydropower projects in view urgency for combating energy crises in the country.

Projects Completed by PEDO

Sr. No.	Name of Scheme	Location	Capacity in MW
i	Malakand-III HPP	Malakand	81
ii	PehurHPP	Swabi	18
iii	ShishiHPP	Chitral	1.8
iv	ReshunHPP	Chitral	4.2
		Total Installed Capacity	**105**

These projects are not only contributing towards the reduction in load shedding but also generating annual revenue of Rs. 2 to 3billion for the province.

Besides the above completed Hydropower Projects, PEDO is implementing following projects with the assistance of Asian Development Bank (ADB) for the development of Hydropower Potential in Khyber Pakhtunkhwa Province which will be completed within three years;

Projects under construction:

Sr.No	Name of Scheme	Location	Capacity in MW
i	Daral Khwar HPP	Swat	36.6
ii	RanoliaHPP	Kohistan	17.0
Iii	MachaiHPP	Mardan	2.60
		Total Capacity	**56.20**

Under the same loan, PEDO is conducting feasibility studies of additional/ following three projects with the total capacity of 48 MW. Construction works on these projects will start during the financial year 2012-13 and will be completed in the next five years.

Projects ~~ready for~~under construction

Sr.No	Name of Scheme	Location	Capacity in MW
i	Koto HPP	Dir Lower	40.8
ii	Karora New HPP	Shangla	10
Iii	Jabori HPP	Mansehra	10.2
		Total Capacity	**48**

The Honorable Chief Minister has issued special directives for the implantation ofhydel projects to address the acute energy crises in the country. In this regard, PEDO prepared all ACTION PLAN which has been approved by the ProvincialGovernment of Khyber Pakhtunkhwa, under which PEDO will construct the following eight (8) Hydel Projects having an installed capacity of 593 MW.

Construction Projects

Sr.No	Name of Scheme	Location	Capacity in MW
1	MatiltanHPP	Swat	84
2	Koto HPP	Dir	31
3	KaroraHPP	Shangla	10
4	Jabori HPP	Mansehra	10.2
5	LawiHPP	Chitral	69
		Total Capacity	**204.2**

In addition to construction projects PEDO has also completed feasibility study of the following 13 Hydel Power Projects with potential of 1322 MW under the same ACTION PLAN. The PC-IIs for feasibility studies of thirteen projects has been approved by POWP, the selection of consultant is in process and the feasibility study will be completed during the next two to three years. The construction of these projects will be achieved during the period 2011-2021.

Projects under Feasibility Studies

Sr.No	Name of Scheme	Location	Capacity in MW
1	Gahrit-SwirLashtHPP	Chitral	377
2	Jamshail-Toren More HPP	Chitral	260
3	Toren More – Kari HPP	Chitral	350
4	LaspurMarigramHPP	Chitral	230
5	ArkariGolHPP	Chitral	99
6	Istaru-BuniHPP	Chitral	72
7	Mujigram Shogo HPP	Chitral	64.26
8	BarikotPatrakHPP	Dir	47
9	PatrakShringalHPP	Dir	22
10	ShigoKachHPP	Dir	102
11	Ghor Band HPP	Shangla	20.6
12	NandiharIIPP	Batagram	12.3
13	Naram Dam HPP	Mansehra	188
14	BalakotHPP	Mansehra	300
15	Shushai-ZhendoliHPP	Chitral	144
16	Shogo Sin HPP	Chitral	132
17	BatakundiHPP	Mansehra	99
Total Installed Capacity			**2519.16**

In order to facilitate the private sector, PEDO has also been conducting Pre-Feasibility study of 10 raw sites in various districts of Khyber Pakhtunkhwa province having capacity and these sites have been offered to private sector for development.

INTERCONNECTION STUDY AND APPROVAL

NATIONAL TRANSMISSION & DESPATCH CO. LTD (NTDC)

General Manager Power System Planning, NTDC

No. GMPP/CEMP/TRP-300/ 4832-36 Dated: 21-08-2017

Chief Technical Officer CPPA(G) Ltd.
Ground Floor, ENERCON Building,
G-5/2 Islamabad.
Fax #: 051-9216949

11789 29-08-2017

Sub: Approval of Grid Interconnection Study of 11.8 MW Karora Hydro Power Plant (HPP) near District Shangla

Ref: (i) CPPA-G letter no. CPPAGL/DGMT-II/MT-IV/Karora SHPP/21584-87 dated 02-05-2017.
(ii) GMPP letter no. GMPP/CEMP/TRP-300/3132-34 dated 01-06-2017.

This office received the final grid interconnection study report of the subject HPP vide above referred letter (i). After review of the report, it was found that some corrections in the studies were needed which were communicated to M/s PPI on 01-06-2017 vide above referred letter (ii). Afterwards, M/s PPI submitted the revised final grid interconnection study report after the required corrections on 10-08-2017. Therefore, the grid interconnection study report of 11.8 MW Karora HPP is approved by NTDC as per the assumptions and study results presented in the report.

It is also important to intimate that the subject report has been approved only for power evacuation/interconnectivity aspects of the subject HPP. The other matters should be discussed with CPPA-G and relevant departments of NTDC/PESCO.

It is added that during EPA, if there is any major change in the parameters of the subject power project as used in the interconnection study, then the relevant studies will have to be revised.

21/08/2017

for General Manager Power System Planning

CC:

- General Manager (Services Division) NTDC, 522 WAPDA House, Lahore.
- Chief Commercial Officer (PESCO), Sakhi Chashma, Shami Road, Peshawar.
- Project Director, Karora Hydropower Project, DRU Building opposite PTCL Building, Main Bazar Besham, District Shangla.
- M/s PPI, 64-F/1 Wapda Town, Lahore. S/F
- *Master File (MP)*

Report No. PPI-175.3-Draft/16

INTERCONNECTION STUDY

For

11.8 MW Karora Hydropower Plant

Near Shangla District, KPK

Draft Report
(May 2016)

POWER PLANNERS INTERNATIONAL LTD.

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Executive Summary

- The study objective, approach and methodology have been described and the plant's data received from the client M/S TRIED is validated.
- The PESCO system data as available with PPI for other studies have been used.
- The interconnection study of Karora HPP to evacuate its maximum power of 11.8 MW is envisaged and studied in detail.
- The nearest substation of PESCO is Khan Khwar 132 kV and it is located at approximately 20 km from the site of Karora-HPP. The following scheme of interconnection of Hydro Power Plant with Khan Khwar to evacuate its maximum power of 11.8 MW is envisaged and studied in detail:
    - A direct 132 kV single circuit of 20 km length using Lynx conductor to be laid from 132 kV Bus Bar of Karora-HPP till Khan Khwar 132 kV substation.

The proposed scheme will require the following equipment at switchyard of Karora HPP:

- One breaker/line bay need to be added for the single circuit from Karora HPP to Khan Khwar.

- Detailed load flow studies have been carried out for the peak load conditions of September 2019 for the all the proposed schemes under normal and N-1 contingency conditions to meet the reliability criteria. 132kV Single circuit T/L has been proposed from Karora HPP to Khan Khwar 132kV Grid Station in the contract agreement by M/S TRIED and the TOR will be defined during the Power Purchase Agreement with CPPA.
- Steady state analysis by load flow reveals that proposed schemes are adequate to evacuate the maximum power of 11.8 MW of the plant under normal and contingency conditions shown in Appendix - C.
- The short circuit analysis has been carried out to calculate maximum fault levels at Karora HPP at 132 kV and other substations in its vicinity. We find that the fault currents for the proposed scheme are much less than the rated short circuit capacities of switchgear installed at these substations. It was found that there are no violations of exceeding the rating of the equipment due to contribution of fault current from Karora HPP.

- The short circuit level at Karora HPP 132 kV bus bar is 5.32 kA and 4.26 kA for 3-phase and 1-phase faults respectively for maximum fault current calculations for September 2019. Therefore the rating of switchgear for this switching station may be an industry standard of 25 kA (short time 3 sec) to accommodate future expansions of generation and transmission in this area.
- The dynamic stability analysis of proposed schemes of interconnection has been carried out. The stability check for the worst case of three phase fault right on the 132 kV bus bar of Khan Khwar HPP substation followed by the final trip of 132 kV circuits emanating from this substation, has been performed for fault clearing of 9 cycles (180 ms). The system is found strong enough to stay stable and recovered with fast damping. The proposed schemes successfully passed the dynamic stability checks for near and far faults. Moreover, the critical clearing time was found out to be **0.21 sec.**
- The proposed schemes of interconnection have no technical constraints or problems under steady state load flow, short circuit currents and dynamic/transient conditions; and are therefore recommended to be adopted.

Report Contents

8. Conclusions

Appendices

Appendix –A: Generation and Transmission Expansion Plan

Appendix –B: Sketches

Appendix –C: Plotted Results of Load Flow for Chapter – 5

Appendix –D: Results of Short Circuit Calculations for Chapter – 6

Appendix –E: Plotted Results of Stability Analysis for Chapter – 7

Appendix –F: Critical Clearing Time Calculation (Tcc) for Chapter - 7

Appendix –G: Dynamic Data for Karora HPP

1. Introduction

1.1 Background

The proposed project is a Hydropower Plant located at approximately 20 km from the Khan Khawar 132 kV Grid Station, KPK located in the concession of PESCO. The location of Karora-HPP is shown in Appendix-B. The net output planned to be generated from the site is about 11.8 MW of electrical power. The project is expected to start commercial operation by the year 2019. The electricity generated from this project would be supplied to the grid system of PESCO through the 132 kV Khan Khawar grid of PESCO available in the vicinity of this project.

1.2 Objectives

The overall objective of the Study is to evolve an interconnection scheme between Karora HPP and PESCO network, for stable and reliable evacuation of 11.8 MW of electrical power generated from this plant, fulfilling N-1 reliability criteria. The specific objectives are:

1. To develop schemes of interconnections of which right of way (ROW) and space at the terminal substations would be available.
2. To determine the performance of interconnection scheme during steady state conditions of system, normal and N-1 contingency, through load-flow analysis.
3. To check if the contribution of fault current from this new plant increases the fault levels at the adjoining substations to be within the rating of equipment of these substations, and also determine the short circuit ratings of the proposed equipment of the substation at Karora HPP.
4. To check if the interconnection withstands dynamic stability criteria of post fault recovery with good damping after 3-phase faults on the system.

1.3 Planning Criteria

The planning criteria required to be fulfilled by the proposed interconnection is as follows:

Steady State:

Voltage	± 5 %, Normal Operating Condition
	± 10 %, Contingency Conditions
Frequency	50 Hz, Continuous, ± 1% variation steady state
	49.2 - 50.5 Hz, Short Time
Power Factor	0.85 Lagging; 0.9 Leading

Dynamic/Transient:

The system should revert back to normal condition after dying out of transients without losing synchronism with good damping.

- For 132 kV and above, the total normal fault clearing time from the instant of initiation of fault current to the complete interruption of current, including the relay time and breaker interruption time to isolate the faulted element, is equal to 100 ms (5 cycles).
- For 11 kV the total normal fault clearing time from the instant of initiation of fault current to the complete interruption of current, including the relay time and breaker interruption time to isolate the faulted element, is equal to 180 ms (9 cycles).

2. Assumptions of Data

The detailed electrical parameters of the generators at Karora would be designed at the EPC stage. However for the purposes of this study, following assumptions have been made:

2.1 Karora HPP data

Generator data:

Number of Generating Units	= 2
Lump sum maximum generating capacity	=11.8 MW
Power factor	= 0.85 lagging, 0.9 leading
Generating Voltage	= 132 kV
Inertia Constant H (turbine + generator)	= 1.918 (MWs/MVA)

2.2 Network data

The surrounding networks available for interconnection to Karora Hydro Power Plant are as shown in Sketches 1 and 2 in Appendix-B.

3. Study Approach and Methodology

3.1 Understanding of the Problem

Karora HPP 11.8MW is going to be a hydropower project located at 20 km from the Khan Khawar Grid embedded in the distribution network of PESCO.

The nearest grid available is Khan Khawar 132 kV. This source of local power generation to be embedded in local distribution network at Khan Khawar shall provide great relief to the source substations in the vicinity and also help in terms of improving line losses and voltage profile.

The nearest facilities available for interconnection of Karora HPP is Khan Khawar 132 kV used for interconnection by Karora HPP. The adequacy of this system would be investigated in this study for absorbing and transmitting this power fulfilling the reliability criteria.

3.2 Approach to the problem

The consultant has applied the following approaches to the problem:

- A base case network model has been prepared for the year 2019, which is the commissioning year of Karora HPP, comprising all 500kV, 220kV and 132 kV system, envisaging the load forecast, the generation additions and transmission expansions for that year particularly in PESCO.
- Month of September 2019 has been selected for the study because it is high water season and we can judge the maximum impact of the plant on the network in these conditions
- Interconnection schemes without any physical constraints, like right of way or availability of space in the terminal substations, have been identified.
- Performed technical system studies for peak load conditions to confirm technical feasibility of the interconnection schemes. The schemes have been subjected to standard analysis like load flow and short circuit, and transient stability study to check the strength of the machines and the proposed interconnection scheme under disturbed conditions.
- Determine the relevant equipment for the proposed technically feasible schemes.

- Recommend the technically most feasible scheme of interconnection from the options considered.

4. Development of Schemes of Interconnection

4.1 The Existing and Ongoing Network

It was found that the nearest existing PESCO interconnection facilities at the time of commissioning of Karora Hydro Power Project would be:

- Khan Khwar 132 kV Substation

The existing 132 kV network available around these 132 kV grid station is shown in Sketch-1 in Appendix-B.

Given the physical proximity of Karora HPP to Khan Khwar 132 kV and the fact that the other facilities are at a considerable distance from the plant, the most feasible interconnection of the Karora Hydro Power Plant will be with Khan Khwar 132 kV substation.

4.2 The Scheme of Interconnection of Karora HPP

Keeping in view of the above mentioned network available in the vicinity of the site of the Karora HPP, the option for the interconnection of Karora HPP would be a direct 132 kV single circuit of 20 km length using Lynx conductor to be laid from 132 kV Bus Bar of Karora-HPP till Khan Khwar 132 kV substation. The scheme is proposed by M/S TRIED. The proposed scheme will require the following equipment:

- One breaker/line bay need to be added with single circuit from Karora HPP to Khan Khwar 132 kV grid station.

5. Detailed Load Flow Studies

5.1 Base Case 2019, Without Karora HPP

A base case has been developed for the peak load of September 2019, which is in the high water season and will allow us to judge the maximum impact of Karora on the PESCO network during high water conditions on the NTDC/PESCO network, using the network data supplied/authorized by NTDC.

The results of load flow for this base case are plotted in Exhibit 0.0 of Appendix-C. The system plotted in this Exhibit comprises of 132 kV network feeding Khan Khawar, and its surrounding substations.

The load flow results for the normal case show that the power flows on all the circuits are within their normal rating. We find that there are no capacity constraints in terms of power flow or voltage ratings in the surrounding network available in the vicinity of Karora HPP for its connectivity under normal conditions.

The following N-1 contingency tests were run:

Exhibit-0.1	Khankhwr to Allai-Khawar 132 kV Single Circuit Out
Exhibit-0.2	Dbr-Khwr to Khankhwr 132 kV Single Circuit Out
Exhibit-0.3	Dbr-Khwr to Allai-Khawar 132 kV Single Circuit Out
Exhibit-0.4	Kyal-khawar to Dbr-Khwr 132 kV Single Circuit Out
Exhibit-0.5	Allai 220 to Mansehra 220 kV Single Circuit Out
Exhibit-0.6	Manshra-N to Abbottabad 132 kV Single Circuit Out

The load flow results also show that there are no capacity constraints in the area surrounding and the voltage rating of the bus bars remain within their limits.

5.2 Load Flow with Karora HPP for September 2019

This proposed scheme of interconnection of Karora HPP involves laying a direct 132 kV single circuit of 20 km length using Lynx conductor from 132 kV Bus Bar of Karora-PP till Khan Khawar 132 kV substation. This interconnection scheme has been modeled in the load flow studies. The month September has been selected because it is a high water season and we want to see the impact of the project when loadings on the lines would be maximum.

The results of load flow with Karora HPP interconnected as per proposed scheme are shown in Exhibit 1.0 in Appendix-C. The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % off the nominal.

We find no capacity constraints on adjoining circuits under normal conditions i.e. without any outages of circuits. In the normal case, the 132 kV single circuit from Karora-HPP to Khan Khawar carry 11.8 MW of power on the circuit. N-1 contingency analysis has been carried and the plotted results are attached in Appendix – C as follows;

Exhibit-1.1	Khankhwr to Allai-Khawar 132 kV Single Circuit Out
Exhibit-1.2	Dbr-Khwr to Khankhwr 132 kV Single Circuit Out
Exhibit-1.3	Dbr-Khwr to Allai-Khawar 132 kV Single Circuit Out
Exhibit-1.4	Kyal-khawar to Dbr-Khwr 132 kV Single Circuit Out
Exhibit-1.5	Allai 220 to Mansehra 220 kV Single Circuit Out
Exhibit-1.6	Manshra-N to Abbottabad 132 kV Single Circuit Out

N-1 contingency criteria has been fulfilled in all the above contingency cases and are shown in Appendix - C.

For all other 132 kV outages the power flows on all circuits remain within their limits and the bus bar voltages are well within the rated limits. Hence there are no additional constraints introduced in this scheme due to the interconnection of Karora HPP.

5.3 Conclusion of Load Flow Analysis

From the analysis discussed above, we conclude that both the proposed interconnection schemes of Karora HPP with PESCO are adequate to evacuate the power of Karora HPP under normal as well as contingency conditions of the neighboring 132kV T/L as shown in Appendix – C except for the N-1 contingency between Karora HPP and Khan Khwr 132 kV due to the single circuit as proposed by M/S TRIED.

6. Short Circuit Analysis

6.1 Methodology and Assumptions

The methodology of IEC 909 has been applied in all short circuit analyses in this report for which provision is available in the PSS/E software used for these studies. The maximum fault currents have been calculated with the following assumptions under IEC 909:

- Set tap ratios to unity
- Set line charging to zero
- Set shunts to zero in positive sequence
- Desired voltage magnitude at bus bars set equal to 1.10 P.U. i.e. 10 % higher than nominal, which is the maximum permissible voltage under contingency condition.

For evaluation of maximum short circuit levels we have assumed contribution in the fault currents from all the installed generation capacity of hydel, thermal and nuclear plants in the system in the year 2019 i.e. all the generating units have been assumed on-bar in fault calculation's simulations.

The assumptions about the generator and the transformers data are the same as mentioned in Ch.2 of this report.

6.2 Fault Current Calculations

6.2.1 September 2019 without Karora HPP

In order to assess the short circuit strength of the network of 132 kV without Karora HPP for the grid of NTDC in the vicinity of the site of the plant, fault currents have been calculated for balanced three-phase and unbalanced single-phase short circuit conditions. These levels will not only give us the idea of the fault levels of Khan Khawar grid station and other grid stations in the vicinity without Karora HPP but also would help us know as to how much the contribution of fault current later on from Karora HPP may add to the existing levels.

The short circuit levels have been represented graphically on the bus bars of 132 kV which are shown in the Exhibit 2.0 attached in Appendix-D.

The fault currents in the Exhibit are given in polar coordinates i.e. the magnitude and the angle of the current. The total fault current is shown below the bus bar.

The tabular output of the short circuit calculations is also attached in Appendix-D for bus bars of our interest i.e. the substations connecting in the 132 kV circuits lying close to Karora HPP. The total maximum fault currents for 3-phase and 1-phase short circuit at these substations are summarized in Table 6.1.

Table 6.1
Maximum Short Circuit Levels without Karora HPP

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Khankhwr 132kV	**10.47**	**10.05**
Dbr-Khwr 132kV	**10.30**	**11.02**
Kyalkhwr 132kV	**10.10**	**10.37**
Alai-khwr 132kV	**10.89**	**10.76**
Allai220 220kV	**8.66**	**8.22**
Mansehra 220kV	**12.42**	**10.63**
Mansehra-New 132kV	**14.26**	**14.73**

6.2.2 September 2019 with Karora HPP

Fault currents have been calculated for the electrical interconnection of proposed scheme. Fault types applied are three phase and single-phase at the 132 kV bus bar of Karora HPP itself and other bus bars of the 132 kV substations in the electrical vicinity of Karora HPP. The graphic results are shown in Exhibit 2.1.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV bus bars of the network in the electrical vicinity of Karora HPP are placed in Appendix-D. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.2

Table 6.2
Maximum Short Circuit Levels With Karora HPP

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Karora 132kV	**5.32**	**4.26**
Khankhwr 132kV	**10.66**	**10.35**
Dbr-Khwr 132kV	**10.46**	**11.16**

Kyalkhwr 132kV	**10.25**	**10.49**
Alai-khwr 132kV	**11.08**	**10.94**
Allai220 220kV	**8.73**	**8.29**
Mansehra 220kV	**12.47**	**10.66**
Mansehra-New 132kV	**14.28**	**14.74**

Comparison of Tables 6.1 and 6.2 show slight increase in short circuit levels for three-phase and single – phase faults due to connection of Karora HPP in its vicinity; and some rise on the 132 kV substation of Khan Khawar, and other substations in plants vicinity. We find that even after some increase, these fault levels are much below the rated short circuit values of the equipment installed on these substations. The short circuit level at Karora HPP 132 kV bus bar is 5.32 kA and 4.26 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at the 132 kV substation of Karora HPP. It would provide large margin for any future increase in short circuit levels due to future generation additions and network reinforcements in this area.

6.3 Conclusion of Short Circuit Analysis

The short circuit analysis results show that for the proposed schemes of interconnection of Karora HPP, we don't find any problem of violations of short circuit ratings of the already installed equipment on the 132 kV equipment of substations in the vicinity of Karora HPP due to fault current contributions from this power house under three-phase faults as well as single phase faults.

The short circuit level at Karora HPP 132 kV bus bar is 5.32 kA and 4.26 kA for 3-phase and 1-phase faults respectively for maximum fault calculations. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at 132 kV substation of Karora HPP taking care of any future generation additions in its electrical vicinity.

interconnection of the plant and trip circuit or transformer as the case may be. The fault clearing time of 132 kV breakers has been assumed 9 cycles as stuck-breaker case (severe fault conditions).

7.2 Dynamic Stability Simulations' Results

Karora HPP has been modeled by laying a direct 132 kV single circuit of 20 km length using Lynx conductor to be laid from 132 kV Bus Bar of Karora HPP to Khan Khwar 132 kV substation.. All the simulations have been run using H = 1.918 MWs/MVA as per original assumption mentioned in Ch.2.

7.2.1 Three-Phase Fault at 132 kV Khan Khwr : Trip of 132 kV circuit between Khan Khwar and Dubair-Khwr

We applied three-phase fault on Khan Khwr 132 kV bus bar, cleared fault in 5 cycles (100 ms) followed by trip of 132 kV circuit between Khan Khwar and Dubair-Khwr 132kV. We monitored different quantities for one second pre-fault and nineteen seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows;

Fig. 1.1 Bus Voltages

The bus voltages of 132 kV bus bar of Karora HPP, Dbr-Khwar, Khan Khwar, Kyal-Khwar, Allai-Khwar and 220 kV bus bar of Allai are plotted. The results show recovery of the voltages after clearing of fault.

Fig. 1.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 1.3 MW/MVAR Output of Generators of Karora HPP

The pre-fault output of generator at Karora HPP was 11.8 MW and it gets back to the same output quickly after fast damping of the oscillations in its output. However MVAR output acquires equilibrium at a new value.

Fig. 1.4 Speed and mechanical power of Generators at Karora HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 1.5 MW/MVAR Flow on Khan Khwar to Allai Khwr 132kV circuit

Followed by clearing of fault, the trip of the 132 kV circuit from Khan Khwar to Dubair-Khwr 132 kV circuit caused the entire output of 11.8 MW to flow through the intact circuit of 132 kV between Khan Khwar to Alai Khwr. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 1.6 Rotor Angles

The rotor angles of the generators of Karora HPP, Dbr-Khwar, Kyal-Khwar, Khan Khwar and Allai-220 are plotted relative to machine at Allai-220. The results show that the rotor angle of Karora HPP gets back after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.2 Three-Phase Fault at 132 kV Khan Khwar : Trip of 132 kV circuit between Khan Khwar and Dubair-Khwar

We applied three-phase fault on Khan Khwar 132 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of 132 kV circuit between Khan Khwar and Dubair-Khwar 132kV. We monitored different quantities for one second pre-fault and nineteen seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows;

Fig. 2.1 Bus Voltages

The bus voltages of 132 kV bus bar of Karora HPP, Dbr-Khwar, Khan Khwar, Kyal-Khwar, Allai-Khwar and 220kV bus bar of Allai are plotted. The results show recovery of the voltages after clearing of fault.

Fig. 2.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 2.3 MW/MVAR Output of Generators of Karora HPP

The pre-fault output of generator at Karora HPP was 11.8 MW and it gets back to the same output quickly after fast damping of the oscillations in its output. However MVAR output acquires equilibrium at a new value.

Fig. 2.4 Speed and mechanical power of Generators at Karora HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 2.5 MW/MVAR Flow on Khan Khwar to Allai Khwar 132kV circuit

Followed by clearing of fault, the trip of the 132 kV circuit from Khan Khwar to Dubair-Khwar 132 kV, we plotted the flows of MW and MVAR on 132kV circuit from Khan Khwar to Allai Khwar circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 2.6 Rotor Angles

The rotor angles of the generators of Karora HPP, Dbr-Khwar, Kyal-Khwar, Khan Khwar and Allai-220 are plotted relative to machine at Allai-220. The results show that the rotor angle of Karora HPP gets back after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.3 Critical Clearing Time Calculation (Tcc)

Critical Clearing Time is calculated in order to determine the characteristics of the protection equipment used in the station. For this purpose, faults for different durations were applied to check for how long the system can bear a fault without losing its stability.

The system was stable up till 10.5 cycles of fault duration. When 11 cycle fault was applied, system lost its stability and didn't recover back. These plots are attached in Appendix – F. Hence the critical clearing time was found out to be:

$$\mathbf{Tcc = 10.5/50}$$

$$\mathbf{= 0.21\ sec}$$

7.4 Conclusion of Dynamic Stability Analysis

The results of dynamic stability show that the system is very strong and stable for the proposed schemes for the severest possible faults of 132 kV systems near Karora HPP. Therefore there is no problem of dynamic stability for interconnection of Karora HPP; it fulfills all the criteria of dynamic stability.

8. Conclusions

- The study objective, approach and methodology have been described and the plant's data received from the client M/S TRIED is validated.
- The PESCO system data as available with PPI for other studies have been used.
- The interconnection study of Karora HPP to evacuate its maximum power of 11.8 MW is envisaged and studied in detail.
- The nearest substation of PESCO is Khan Khwar 132 kV and it is located at approximately 20 km from the site of Karora-HPP. The following scheme of interconnection of Hydro Power Plant with Khan Khwar to evacuate its maximum power of 11.8 MW is envisaged and studied in detail:
    - A direct 132 kV single circuit of 20 km length using Lynx conductor to be laid from 132 kV Bus Bar of Karora-HPP till Khan Khwar 132 kV substation.

The proposed scheme will require the following equipment at switchyard of Karora HPP:

- One breaker/line bay needs to be added for the single circuit from Karora HPP to Khan Khwar.

- Detailed load flow studies have been carried out for the peak load conditions of September 2019 for the all the proposed schemes under normal and N-1 contingency conditions to meet the reliability criteria. 132kV Single circuit T/L has been proposed from Karora HPP to Khan Khwar 132kV Grid Station in the contract agreement by M/S TRIED and the TOR will be defined during the Power Purchase Agreement with CPPA.
- Steady state analysis by load flow reveals that proposed schemes are adequate to evacuate the maximum power of 11.8 MW of the plant under normal and contingency conditions shown in Appendix - C.
- The short circuit analysis has been carried out to calculate maximum fault levels at Karora HPP at 132 kV and other substations in its vicinity. We find that the fault currents for the proposed scheme are much less than the rated short circuit capacities of switchgear installed at these substations. It was found that there are

no violations of exceeding the rating of the equipment due to contribution of fault current from Karora HPP.

- The short circuit level at Karora HPP 132 kV bus bar is 5.32 kA and 4.26 kA for 3-phase and 1-phase faults respectively for maximum fault current calculations for September 2019. Therefore the rating of switchgear for this switching station may be an industry standard of 25 kA (short time 3 sec) to accommodate future expansions of generation and transmission in this area.
- The dynamic stability analysis of proposed schemes of interconnection has been carried out. The stability check for the worst case of three phase fault right on the 132 kV bus bar of Khan Khwar HPP substation followed by the final trip of 132 kV circuits emanating from this substation, has been performed for fault clearing of 9 cycles (180 ms). The system is found strong enough to stay stable and recovered with fast damping. The proposed schemes successfully passed the dynamic stability checks for near and far faults.
- The proposed schemes of interconnection have no technical constraints or problems under steady state load flow, short circuit currents and dynamic/transient conditions; and are therefore recommended to be adopted.

ENVIRONMENTAL APPROVAL

Environmental Protection Agency
Forestry, Environment & Wildlife Department
Govt. of Knyber Pakhtunkhwa

No.EPA/IEE/Dam/Karora/2017/582

Dated 26/12/2017

To

The Project Director,
Karora HPP,
Pakhtunkhwa Energy Development Organization,
Govt of Khyber Pakhtunkhwa

Subject: **REQUEST FOR ORIGINAL APPROVAL OF IEE/EIA REPORTS OF 11.80MW KARORA HYDRO POWER PLANT (HPP) NEAR DISTRICT SHANGLA.**

I am directed to refer to your letter No. 17/PEDO/PDKaroraHPP dated 20-12-2017 on the above cited subject and to enclose herewith attested photocopy of Environmental Approval issued vide tracking/file No. EPA/IEE/KaroraHPP/Kuzkana/436 dated 22-04-2013, please.

Assistant Director (EIA-II)

3rd Floor, Old Courts Building, Khyber Road, Peshawar Cantt.
Tel: 92(91) 9210263-9210148, Fax: 92 (91) 9210280

SCHEDULE-V
Decision on IEE

1. **Name, address of proponent:** Mr. Wajid Nawaz Khan,
Project Director,
Karora HPP 9.3 MW
Room No. 305, WAPDA House, Peshawar
Tel # 091-9212034
Fax No. 091-9211988

2. **Description of project.** Karora Hydro Power Project is proposed to be built on Khan Khwar River about 30 meter upstream of Kuzkana Village, District Shangla. The weir site is located near Kuzkana Village while power house is located near Village Ranial. The proposed weir site and power house site can be accessed through Lahore to Mansehra to Besham to Kuzkana to weir site or Peshawar to Mansehra to Besham to Kuzakana to weir site. The project would take about 35 month for its completion.

3. **Location of project.** The project is located in District Shangla.

4. **Date of filing of EIA.** 28/12/2011
(Ref: EPA Diary No.46)

5. After careful review, the Environmental Protection Agency, Govt. of Khyber Pakhtunkhwa has decided to accord approval of the Initial Environmental Examination for 9.3 MW Karora Hydro Power Project, District Shangla, in line with the guidelines issued by Pak. EPA and IEE/EIA Regulations, 2000, subject to the following terms & conditions:-

a) The proponent will adopt all precautionary and mitigation measures identified in IEE Report as well as any un-anticipated impacts during the construction and operation phase of project.

b) Safety of the social & cultural life of the local community must be ensured.

c) Number of affected houses, trees, agricultural land/crops and their compensation plan must be provided to this Agency before starting the physical work.

d) The plantation plan along with number, species and area must be provided to this Agency before start cutting of 402 number of trees in the project area

e) The existing metallic road shall be maintained properly for the public in the area.

f) The proponent must ensure to avoid dumping of debris into down slope. A prior area should be identified for disposal of debris.

g) The proponent must ensure the adequate water supply to 11 numbers of hydel generators and 10 numbers of water mills.

Assistant Director
Environmental Protection Agency
Peshawar

h) Non-technical jobs must be provided to local community.

i) The proponent must provide copy of agreement made with micro hydel generators/water mills to this agency before starting physical activities on the site.

j) The water pipe must be installed at least 70 meters upstream from the houses of syed Aqil Zaman and brothers.

k) The proponent shall provide the copy of this approval and IEE report to the contractor for information and compliance.

l) This approval is only issuing for the construction of hydro power project and not for any other kind of activities/industry/factory.

m) The proponent should ensure the strict and efficient health and safety measures for the protection of workers e.g. helmets, signboards and shoes etc.

6. The proponent shall be liable for correctness and validity of the information supplied by the environmental consultant.
7. The proponent shall be liable for compliance of Sections 13,14,17 and 18 of IEE/EIA Regulations, 2000, regarding approval, confirmation of compliance, entry, inspections and monitoring.
8. This approval is accorded only for the installation/ construction phase of the project. The proponent will obtain approval for operation of the hydro power project in accordance with the Section 13 (2) (b) and Section 18 of the IEE/EIA Regulations, 2000.
9. Any change in the approved project shall be communicated to EPA, Khyber Pakhtunkhwa and shall be commenced after obtaining the approval.
10. This approval shall be treated as null and void if all or any of the conditions mentioned above is/are not complied with.
11. This approval does not absolve the proponent of the duty to obtain any other approval or clearance that may be required under any law in force.
12. There is no legal case pending in the courts against the project.
13. In exercise of the power under Section 12 of the Pakistan Environmental Protection Act, 1997, the undersigned is pleased to approve the IEE Report for construction phase of the project with above mentioned terms and conditions.

Dated: Peshawar 22-4-13
Tracking/File.No. EPA/IEE/Karora HPP/Kuzkana/ 536

22.4.13

DIRECTOR GENERAL
EPA, Khyber Pakhtunkhwa.
3rd Floor, SDU Building,
Khyber Road Peshawar Cantt.

Assistant Director
Environmental Protection Agency

CHAPTER – 10

ENVIRONMENTAL AND SOCIAL ASSESSMENT

(IEE & SIA)

10.1 General

Hydropower is a primary domestic and renewable source of energy. Pakistan is endowed with a hydel potential of approximately 40,000 MW, most of which lies in the Khyber Pakhtunkhwa, Gilgit Baltistan, Azad Jammu & Kashmir and some parts of Punjab. In spite of this, Pakistan's energy market investment in hydel power generation has, unfortunately, been caught up in confusion and paradoxes for many decades and no significant progress has been achieved so far. The Government is also trying to facilitate private investors to promote hydel power generation in the country but the efforts have so far not succeeded. Electric power is a major stimulator for the socio-economic uplift of the country. However, only half of the country's population has access to electricity. After the creation of Pakistan, the country faced numerous problems including dearth of electrical power.

Fortunately, abundant hydel potential remains untapped which needs to be harnessed. The total installed capacity of the hydropower stations in the country is about 6,595 MW, out of which 3,767 MW is in Khyber Pakhtunkhwa, 1,698 MW in Punjab, and 1,036 MW in AJK and 93 MW in the Gilgit Baltistan, which represents merely 15 % of the total identified potential.

10.2 Need for the Environmental Study

The law makes it mandatory to carry out Initial Environmental Examination (IEE) or detailed Environmental Impact Assessment (EIA) of the development projects depending upon the nature and magnitude of the impacts. Pakistan Environmental Protection Agency (Pakistan-EPA) regulatory guidelines (Pakistan Environmental Assessment Procedure; 1997; Policy and Procedures for filling, review and approval of environmental assessment (pp15 & 17)), exempt a hydropower and dam project from being put to EIA only when:

- The dams and reservoir have a water storage volume less than 50 million m^3 or the surface area is less than 8 km^2.
- Hydropower generation capacity is less than 50 MW.

The Karora Hydropower Project is generally a run-of-the river project wherein the reservoir storage capacity and areal spread is for less than the limits identified above and even power generation capacity is less than 50 MW. Moreover, the project does not induce significant environmental and social disruption. On these grounds the project does not qualify for Environmental Impact Assessment (EIA), rather an Initial Environmental Examination (IEE) will suffice. As the Project falls in the jurisdiction of Pak-EPA, for that matter Environmental Protection Agency of Khyber Pakhtunkhwa and Asian Development Bank, therefore, it desirable that regulatory requirements for environmental protection and social safeguards of both Government of Pakistan and Asian Development are adhered to.

All ADB projects are assigned one of four categories (A, B, C, or FI) for environmental assessment. The category is assigned based on the project's potential for environmental impact. The proposed Project is classified by the Asian Development Bank (ADB) as categories B – a project which has some adverse environmental impacts, but of lesser degree and/or significance than those for category – A projects.

This chapter has been prepared keeping in view the regulatory requirements of both Pak-EPA and ADB.

10.3 Approach Adopted for the Study

Initial Environmental Examination study is required to cover several parameters relating to physical, biological and human setting of the project area. Both primary and secondary sources were explored to gather information regarding various environmental and social parameters of the project. As a first step a reconnaissance visit to the project area was made to familiarize with the environmental and social setting and to carry out a screening process to identify the probable areas of impacts. On the basis of this, a plan was prepared to carry out environmental and social survey and to conduct scoping sessions for public consultation. Consultation was also carried out with officials of various department, knowledgeable people, public representatives and local NGOs. In addition to this primary source, information was also extracted from the published literature and data from secondary source.

10.4 Scope of the IEE Study

The scope of IEE study includes:

- Assessment of the existing status of environment and socio-economic aspects.
- Identification of potential impacts on various environmental components due to activities envisaged during construction and operational phases of the proposed hydro-electric project and proposed mitigations actions.
- Prediction of significant impacts on major environmental components.
- Delineation of Environmental Management & Monitoring Plan (EMM_tP) outlining measures to minimize adverse impacts of the proposed project.
- Prepare abbreviated resettlement plan for compensating the affected persons (AP's

10.5 Environmental Baseline Condition

The environmental baseline conditions have been established on the basis of information gathered from the field through structured interviews, formal and informal scoping sessions, and group discussions with the communities of various settlements located along the river and in the vicinity of sites selected for construction of project components. In addition, information was also gathered from officials of various departments including departments of Forestry, Wildlife, Agriculture and Revenue. The information available from the limited secondary source has also been used for drawing inferences.

10.5.1 Delineation of the Project Area

From environmental viewpoint the project area is defined as the areas of project influence. Some of these areas are directly impacted while others may be influenced indirectly. For this project the areas of most concerns are as follows:

- Areas falling in the vicinity of the structures viz. Weir, Power/Box Channel, Power House and upstream and downstream portals of the Power Tunnel.
- Areas to be used for establishing construction camps and colony.
- Areas likely to be submerged by water impoundment.
- Areas likely to be used for dumping of spoil material from excavation of tunnel and the sites where weir and power house are going to be located.
- Areas to be used for developing haul tracks.
- Quarry areas.
- About 9 km stretch of the river reach from Weir up to the Power House that is going to be deprived from the river flows during low-flow season for its practical diversion into the Power Tunnel for power generation.
- Areas located on high-benches through which the Power Tunnel is going to be excavated. These areas are not going to be directly affected, but it is likely that the settlements on these benches may be disrupted due to vibrations from blasting and drilling of the Power Tunnel.
- Majority of residential area is not going to be directly impacted by the project; however, the area is likely to have indirect effects of mixed type. Primarily, the induction of heavy machinery and vehicles when transporting construction material from quarries falling on other side of the town will cause traffic congestions and hazards, while on the other hand the induction of outside workforce will be beneficial in boosting the local business.

10.5.2 Land Resources

10.5.2.1 Geology, Morphology and soil

The project area is a part of land formations developed at the foothills of Himalayan Range through tectonic events subsequent to those that caused building of Himalaya. The rock formations include extremely folded beds of various types of sandstones, clay-stones and silt stones. Both the banks of Khan Khwar at weir site are almost fully covered with thick alluvial material having terrace cultivation, cluster of trees at places and self - grown grass and plants etc. The power channel will run along the left bank (Khan Khwar) hill slopes which are generally covered with vegetation, comprising cultivated terraces, self - grown grass and plants and trees. The geological conditions observed for the construction of an open channel did not seem favorable and thus a cut-and-cover concrete conduct had had to

be selected. The geologic conditions at forebay, penstock and power house are almost similar and favorable.

Mostly the mountains are covered with primary soils, except along the river and nullahs where the beds are almost devoid of soil material either for steep slopes or for the scouring action of the river/ nullah flows. The texture of the primary soils varies from moderately fine to moderately coarse depending upon the rock type from which these have developed. The soils of the raised terraces in floodplains are generally devoid of the stony material whereas the soils of lower terraces generally contained varied quantities of pebbles, cobbles and boulders.

10.5.2.2 Seismic Hazards

The project area lies in an earthquake prone area with high degree of seismicity. A number of active local and regional faults pass around the project area. It lies very close to the Main Boundary Thrust (MBT) which is at a distance of about 15 km towards east. Karora Hydropower Project is located in the Kohistan Island Arc (KIA) which is seismically active zone of convergence between Indo-Pakistan and Eurasia continental plates

10.5.3 Water Resources

10.5.3.1 Surface Water

Khan Khwar and most of its tributaries originates from mountains ranging in elevation from 2000 m to 3000 m above mean sea level. Consequently the mountains remain covered with snow caps for parts of the year that contributes the river discharges. However, the major contribution in the annual flows comes from the monsoon rains that are spread from July to September. A minimum discharge observed in the Month of January 2003, is 1.86 m^3/s and maximum value 18.52 m^3/s in the month of April 1991 from weir site. These values depict that mean monthly flows vary between 3.45 m^3/s (9.25 MCM) in December to 11.26 m^3/s (29.19 MCM) in April.

A minimum of 2.03 m^3/s observed in the month of January 2003 and maximum value is 20.2m^3/s in the month of April 1991, at power house area. These values depict that mean monthly flows vary between 3.77 m^3/s (10.09 MCM) in December to 12.29 m^3/s (31.85 MCM) in April.

10.5.3.2 (a) Water Use in Project Area (Before Flood)

There are eight hydel power stations and six water mills falling in the river stretch between the Weir and the Powerhouse. All of these hydel generators possess capacity of 11 kW and average intake discharge is 0.12 cumec.

In all, six water mills are in operation in the project area. On average one mill require 0.08 cumec of water for operation. Detail of all micro hydel generators and water mills with respect to their location, owner name and discharge is given in the Table-10.1.

10.5.3.2 (b) Water Use in Project Area (After Flood)

Flood 2010 washed away all irrigation schemes, water mills and micro hydel generators in project area. Now there is no such diversion exist between weir to powerhouse site.

10.5.3.3 Groundwater

Basically, the project area and the Shangla District in that matter, is devoid of any true ground water aquifer. This is because of the rocky formation of the area and steep slopes of the mountains. However, springs are widely spread in the area. Local people normally use spring waters for consumptive purposes.

10.5.3.4 Water Quality

The water from nullah/river and springs are safe for consumption because there is no industries exist in project area which discharge their effluent in Khan Khwar River. Besides this, water would require appropriate treatment, before it is used for drinking purpose by non-local construction crew.

10.5.4 Biological Resources

10.5.4.1 Protected Areas in Khyber Pakhtunkhwa

Khyber Pakhtunkhwa as a whole is believed to possess nearly 17 percent of high hill coniferous forest cover. Extent of various protected areas, spread across the province, is given in the Table-10.2.

None of the protected areas indicated above, are within close vicinity of Karora Hydropower Project.

10.5.4.2 Rare or Endangered Species

There is no rare or endanger species is the vicinity of Karora Hydropower Project.

10.5.5 Flora

The district is rich in natural vegetation. Besides the scattered vegetation in almost entire area, the hills are covered with forests of broad leaf and pine trees in accordance with the altitude. Fruit trees are generally found in the courtyards of the farming communities. Most common trees are Deodar, Pine, Poplar, Drawa, Daroon, Kikar, Beri, Kahu and Bakain. Trees of Apricot, Pear, Peaches, Persimmon, Walnut, Orange and Apple exist in area. Main flora in the District is shown in Table-10.3.

10.5.6 Main Flora in Project Area (Before Flood & After Flood)

Before flood, number of trees is spread over the project area. In plain areas or terraces shade trees, shrubs and some grasses are present. Among shade trees Kikar, Deodar, Pine, Bakain, Poplar and Beri are common. While among fruit trees Orange, Walnut, Persimmon, Banana and Apple trees are to be found.

After flood frequency of occurrence of flora has been changed, because flood washed away the number of trees in the project area. Among shade trees Kikar and Darawa are completely disappeared while rest of the other shows just decline in their percentage of occurrence in the project area. Detail of flora in pre and post flood conditions are shown in Table-10.4.

10.5.7 Fauna

Most of the fauna in the project area are local. During winter, however, a few migratory bird species visit the project area on route to further south. Owing to winter severity and moderately pleasant and short summers, no significant reptiles have been reported from the project area. Reptilian and amphibian fauna of the area is not well documented. However, local people have reported some snakes. Rock lizards are common in the region. The project area is devoid of any habitat for the migratory species. Some species however use local water resources as resting and feeding ground. Table-10.5 (a) and Table-10.5 (b) enlists the wildlife occurring in the mountains of the District and fauna in project area respectively.

10.5.8 Aquatic Life

Fish diversity in the Khan Khwar River is limited. No definite data is available about the aquatic life and fisheries in the project area. There is no commercial fishery observed in the area. However, some fishing is carried out for household use and recreational purpose.

Aquatic ecology and fisheries was discussed with the official of wild life department and it was declared that the project area has no natural habitat which impacted with the project implementation.

10.5.9 Avifauna

Bird life is scanty. The birds such as crow, kite and common sparrow, King Fisher, Little brown dove can be seen. The bird population is thin in project area. Some common birds are King Fisher and Little brown dove.

10.5.10 Climate

10.5.10.1 General

District Shangla is at an elevation of 1800 to 3100 meters masl and as such the winter season remains extremely cold in the upper half of the district while in the lower half it remains moderate. Snow-fall generally starts by the end of November on the high peaks of the mountains and descends downwards as the temperature falls further. Snow fall also occurs in late February and continues sometimes up to the middle of the March after which the weather becomes pleasant and usually remains mild during the remaining period of the year. The area situated in Sub-Tehsil Besham and Martung remains very hot in the summer season. Detailed data of temperature and precipitation is not available directly for district Shangla.

10.5.10.2 Temperature

The data shows that the average monthly mean maximum temperature varies from 11.2° C in January to 32.5 ° C in June, whereas monthly mean minimum temperature ranges between (minus) -0.9° C in December to 19.3 ° C in July.

10.5.10.3 Precipitation

The average annual precipitation in the area is 1,415.9 mm. However, there is a great seasonal variation. The maximum rainfall occurs during the months of February and March when the average precipitation is 172 mm and 242 mm, respectively. Minimum rainfall is experienced in November with the average of 50.7 mm

Data of mean temperature and rainfall recorded at Dir station for the period 1961-90 is shown in Table-10.6.

10.5.11 Ambient Air Quality

No air quality monitoring data is available for the project area. However, no major sources of air pollution, viz., no industries, exist in the project area except road traffic in the valleys of Khan Khwar River and other nullahs. This may be deteriorating the quality of air to some extent. However, due to along presence of liberal plantation and green areas, on the mountains off side the roads, the air quality is expected to be generally good.

10.5.12 Ambient Noise Levels

The project area is located in the valleys surrounded by steep slopes having vegetation. There are some houses located near the sites of project component. Though the roads are available in the project area but the intensity of traffic is very low and the level of noise is assumed to be low. Generally, the ambient noise level in the project area is less than the permissible limits of 85 dB A as fixed by NEQS, 2000 and also as compared to the WHO noise guidelines that prescribe a limit of 55 dB A with respect to receptors in outdoor areas.

10.5.13 Human Resources/ Socio-Economic Set-up

10.5.13.1 Political and Administrative Set-up

Shangla District covers an area of about 1,586 square kilometers and is administratively divided into five Tehsils namely, Alpuri, Besham, Chakisar, Puran and Martung. Politically, the district is governed by District Coordination officer (DCO) supported by Deputy District Officer (Revenue), The DCO is responsible for law & order and is custodian of state property. On the revenue side, each sub-division has a separate revenue setup consisting of Deputy District Officer (Revenue), officers, kanungo and patwaries.

10.5.13.2 Demography of the Project Area

Kuz Kana village (weir site) is located in Union Council Kuz Kana in Alpuri Tehsil of Shangla District. The population of Kuz Kana UC is 10,368. Kuz Kana with a population of 7,276 is the biggest village population wise amongst the two villages falling in the UC Kuz Kana.

51.7% of total village population belongs to male gender. Above 18 year population is 47.1% while 37.8% falls in the category of 21 year old and above. Out of women of marriageable age 80.6% are married.

Ranial village (power house site) is located in Union Council Ranial in Alpuri Tehsil of Shangla District. The population of Ranial UC is 11,731. Ranial with a population of 2,868 is the 2nd biggest village population wise amongst the three villages falling in the UC Ranial. 52.4% of total village population belongs to male gender. Above 18 year population is 48.4% while 40.3% falls in the category of 21 year old and above. Out of women of marriageable age 82.4% are married.

Literacy rate of above 10 year plus population of Kuz Kana village is 12.1% and that of Ranial is 5.4%. The Project Area settlements of Kuz Kana and Ranial are deprived of education and health facilities. The people have to go far places for schooling and health facilities.

Project area is home to a diverse group of people including different tribes and clans as shown in Table-10.7.The Table shows, Shalmani Pathan are 48.3%, Sunar are 3.4%, Syed are 20.7%, Yousaf zai are 6.9% and Mian are 20.7%.

70% Pacca, 3% semi Pacca and 27% Kacha housing structure exist in Kuz Kana (weir site). While at Ranial (power house site) 83% Pacca, 10% semi Pacca and 7% Kacha housing structure exist. 5.6% houses of Kuz Kana village and 4.8% houses of Ranial village has potable water facility and only 0.2% of houses in Kuz Kana and 0.6% percent of houses in Ranial has electricity facility.

10.5.13.3 Socioeconomic Conditions of the Project Area

Most of the people are following labour as occupation. Agriculture and business (shop or water mill) are other occupations. Generalized view of occupation in project area is given in Table-10.8.

Data was collected on the assets possessed by the households (HH) which reflect that 100% of households posses Radio. Cell phone is available with 13.8 of the households and vehicle is present within 20.7% households. Average % of assets with their average per unit price can be seen in Table-10.9.

Results of social survey show that 0.33% households own a shop/business, Water mill is owned by 0.3 % of HH and mature fruit and shade trees are possessed by more than half of the households. These results along with average number of assets available within a household and average per unit price are given in the Table-10.10.

Socioeconomic data reflects that livestock holding per household is not very high. On the average, each household possess 0.83 Cow, 0.33 Buffalo and 6.23 Poultry/Chickens. (See Table-10.11)

The findings of the analysis of field survey on the provision of social amenities//infrastructure for the households reveals that drinking water and washing / bathing points, mosques, graveyards, electricity and primary and secondary schools for

boys/girls, are those amenities which are available to either all or to a large proportion of households (see Table-10.12). Comparatively to these above services, dispensary, land telephone connections and disposal of solid and liquid waste, are available to lesser percentages. Availability of social amenities and the degree of efficiency according to residents is depicted in Table-10.12.

10.5.13.4 Land Ownership Status in Project Area

The lands in the project area are mainly proprietary and used for cultivation and settlements. The river and nullah beds along with side, slopes are also proprietary land .As such, the project components, viz., Weir, Intake structure including intake portal of the Power Tunnel and Power Channel will be located on the proprietary land. The land required for construction camps and colony will be acquired from the land available along the river bank near village Ranial and Kuz Kana. Mostly people are resident owner having formal legal status. On the other hand, the reservoir will cover proprietary land and shamlat as well. It is also observed that the landholdings are small.

10.5.13.5 Land Use in Project Area

Of the total landholdings in the project area 50.79 % is available for cultivation, 23.62 % is forest land and 25.59% is waste land or lie in the form of uncultivable waste land. Different land types in the project area are shown in Table-10.13.

Wheat and Maize is cultivated on 100% and 80% of available agricultural land in project area, respectively. Wheat is cultivated for the individual families self needs and average cultivated land per family is about 2 – 15 Kanals. Rice is not a common crop in project area. Detail of crop cultivated in project area with respect to their production in kgs/kanal and per kilogram price, is given in Table-10.14.

The Project is going to affect lands of about 18 families from villages Kuz Kana (12 No.) and from village Ranial (6 No.). Out of these, only one family will be losing their land as well as their structure while the rest of 17 families will lose cultivated or other land types.

10.5.13.6 Food Sufficiency and Security

Most of the respondents do not experience any shortage of food in any part of the year. However, according to less than one third of respondent households, food deficiency does occur in winter months.

10.5.13.7 Gender Situation in Project Area

Within the prevailing social culture, preference of a son over a daughter is predominant mainly for reasons of securing lineage and right to property. Women are infrequently consulted; usually men have the deciding power and even make purchases for the females. Rural women mostly remain inside the home. Young girls are born to be submissive and have to obey the rules laid down by the males.

The situation of women in the project area has been analyzed through Gender Survey conducted in the project villages. An overall situation of women in the project area based on the findings of this survey is summarized below.

Food Consumption: Women's share in the daily consumption of food was assessed in comparison with men. According to the opinion of 65 % of respondents, women's share in daily food consumption is somewhat less as compared to men. Protein in the form of meat, eggs, milk and beans are frequently consumed by women, i.e. there is no gender difference in the quality of food.

Housing: On the average each household share 3.11 rooms in which 1.5 rooms are used exclusively by women. Bathroom and toilet facilities within the house are available for women in most of the houses.

Decision Making: Decisions of marriage of children, sale purchase of property and purchase of household consumption items, largely rests with the men with a meager role of occasional consultation with women.

Responsibilities: Women's pressing responsibilities are maintenance of house followed by food arrangement for household, child rearing and treatment of ailing members both men and women.

Awareness of Project: The awareness of the project amongst women is quite low as only 6% women respondents had knowledge that a hydropower project is coming in their area. They however expect that project will be beneficial for the area and shall resolve their some of the economic and social problems. They are anticipating that project will bring schools and educational facilities and hospitals in the area and hoped that the problems of women shall also be addressed and resolved by the project.

10.6 Public Consultation

The Environmental Protection Act makes the participation of the local communities mandatory in the planning and design of a development project. Scoping session is a process that ensures participation of the communities, knowledgeable people of the project area and other stakeholders of the project. The objectives of this process were to:

1. Share information with stakeholders on proposed project and expected impact on the physical, biological, and socio-economic environment of the project area.

2. Understand stakeholders' concerns relating to environmental hazards and social disruption and recording their suggestions in respect of mitigation actions and facilitations.

3. Understand the concerns of the female members of the affected population.

4. Address specific issues relating to:

- Disruption of settlements, graveyard, earning of people who get benefits from the river, etc. The latter category include about 8 micro hydel generator and 6 water mills between

weir to power house site, they use river water for generate electricity and grind their grins.

- Depletion of river bed for part of the year in the stretch between Weir and Power House when the flows will be diverted through the Power Tunnel.
- Social concerns of the population settled on the high benches near both the portals of the Power Tunnel and Power House that is not directly disrupted by the Project.

10.6.1 Memorandum of Understanding (MOU) with local people

A meeting was held, in August 2009, with the local Jirga of Kuz Kana village (Karora area) for resolving the issues raised by locals, who were quite strict about their demands and issues. However, with the help of local district Government representatives, the matter was amicably resolved and a MOU was signed between locals and clients for record and future use. Salient features of MOU are listed below.

10.6.2 Grievances/Objections and Demands

1. The name "Karora hydropower project" of the dam is objectionable because most of land affected by the construction of the project belongs to Kuz Kana village. Therefore, the project name should be Kuz Kana Hydropower Project.
2. Due to construction of the dam, there are 22 micro hydel generators and 18 water mills are going to be disrupted. Proper compensation package should be given to the affectees/ owners of these Power houses and water mills.
3. Appropriate compensation package should be designed before acquisition of land and settlements falling in the project area.
4. Proper disposal of spoil/ excavated material is the responsibility of the project proponent because it will affect the agricultural land.
5. Affected Land should be protected through protection wall.
6. Houses, Orchards, Link road, Bridge and Agricultural land will be affected due to construction of project.
7. Provision of an irrigation channel from the power channel to irrigate land below the power channel.
8. Provision of compensation water for the operation of generators and water mills shall be kept in the project.
9. Salinity and water logging will affect the land due to construction of dam.
10. Jobs are announced for the affectees and union council Kuz Kana.
11. All labour should be hired from union council Kuz Kana.

10.6.3 Resolution of Grievances and Demands

1. Name of Karora Hydropower Project will be changed to Kuz Kana-Ranial Hydropower Project because pre-feasibility study is carried out in the name of Karora Hydropower Project and since land of Kuz Kana and Ranial is affected by the project hence both names i.e Karora - Kuz Kana-Ranial are suggested.

2. No micro hydel generator and water mill is going to be disrupted by the project as is observed during reconnaissance survey of the project area.

3. Compensation for the built up property will be assessed according to the current market price prevailing in the area plus 15% Compulsory Acquisition Surcharge and will be given to the affectees. The agricultural and other land will be compensated as per detailed land acquisition procedure given in Abbreviated Resettlement Plan.

4. Excavated/ spoil material from excavation of different structures will be dumped on waste land, along the river bed and nullah with appropriate precautionary measures as described in Table-10.25.

5. Proper protection to avoid the damages to the land and property will be done wherever required.

6. Total land required for the project as described in Table-10.21 (a) & (b), shows that there is no orchard, link road and bridge will be affected by the project while the agricultural land is only 40 kanals and only 1 house with an area 0.321 kanal is disrupted.

7. Appropriate arrangement for irrigation supplies will be provided.

8. Water requirement for the operation of 8 micro hydel generators and 6 water mills falling in the river stretch between Weir to Powerhouse will be fulfilled as per detail given in Table-10.1.

9. Geological investigations reveals that the soil of the area is acidic in nature, hence chances of water logging and salinity is negligible but if this happens then proper measures will be adopted to mitigate this.

10&11 Employment to local people/ affectees will be given according to their skill abilities and qualification.

10.6.4 Main concern of the stakeholders

Main concerns raised by the stakeholders are provided following paragraphs:

10.6.4.1 Construction Phase

- Contractor should not use the local resources without permission of the community.
- Contactor should employ the local people, as they know the local norms and customs.

- Affected people should provide the job opportunities during construction phase on preference basis.
- Contractor labour should be careful about local customs.
- Mobility of local women should not be hindered due to construction activities particularly at time of their usage of open field latrine facilities.
- Construction activities should not hinder the daily activities of the locals.
- Contractor should keep their machinery within the project area.
- Contactor should make proper arrangements to control the noise and air pollution.
- Contractor should not dispose off their camps waste in the community area and it should be properly disposed off.
- Contactor should not cut the tree nearby the project area for their consumption for food cooking in camps. He should arrange alternative sources like gas cylinders, etc for cooking purposes.

10.6.4.2 Operation Phase

- Project should provide the job opportunities to the local community on regular basis.
- Local community would be face water scarcity due to diverting the water to power tunnel there should be an arrangement for release some compensation water for community uses.
- Project should provide gas, telephone, and water supply facilities to the local community.
- Arrangements should be made to control the noise and air pollution.
- A process of community consultation should be continued even at operation stage of the Project.

10.6.5 Addressal of Stakeholders' Concerns

Following measures will be adopted to address the stakeholders' concerns.

10.6.5.1 Construction Phase

- Preference will be given to the local people for employment during construction activates.
- Contractor will make arrangements for utilization of resources with the consultation of community.
- Contractor will ensure the availability of gas cylinders for cooking in camps.

- Wastes of the construction camp will be disposed of properly.
- Camp site will be at least 500 m away from nearby settlements.
- Contractor will comply all the local norms and customs.
- Waste of construction camps will not be disposed of into the community area.
- Proper working timings will be adopted to minimize the hindrance to the local community mobility particularly woman.

10.6.5.2 Operation Phase

- Local population will be provided the job opportunities particular to PAPs.
- Efforts will be made to provide the utility services in the nearby localities which are under influence of the Project.
- Release of water from weir made compulsory as per social or aquatic ecological requirements.
- Proper measures to control the noise and air pollution will be adopted by the Project.
- Community consultation process will be continued even at operation stage.

10.6.6 Perception of Respondents about the Project

There is no change about the perception of project of the project affected community because the impact of flood was negligible at project area. Flood effects study area very much as a result local community shows great interest in construction of project. Representatives of households were asked about their understanding regarding: positive and negative impacts of the project, upon employment opportunities, mobility of the villagers, income generation activities, living standard, availability of electricity, agricultural activities, deforestation and about drinking water. A large number of respondents considered that the project will have positive impact and expressed their views that the project will provide good opportunities in all the fields.

Peoples have same concerns, demands and grievances as in post – food conditions there is no change in mind set of community except they feel that flood might be control with dam. Now the most pressing need of the community is bridges which were damaged with flood 2010.

Table-10.15 gives the brief account of the scoping sessions while list of person contacted during visit is enlist in Table-10.16.

10.7 Potential Impacts of the Project

10.7.1 Area of Influence

Before proceeding to the environmental analysis of the project, it is imperative to delineate the areas of project influence. In general, the project affected areas have been considered at two levels, viz. primary and secondary. The primary level affected areas are those that are directly

impacted by the project. These include areas where major construction activities are going to take place for construction of project structures, establishment of construction camps and colonies, borrow, quarrying and spoil disposal areas, construction of access and haul tracks, etc. In case of dam and hydropower projects the downstream flows are also reduced due to retention and diversion of water. Therefore, the downstream reach up to a certain limit, most likely till another tributary discharges its flow into the concerned Nullah, is also considered as primary affected area.

Besides the directly impacted areas referred to above, the construction-related and subsequently traffic-borne noise and air pollution may influence areas at large distances away from the primary affected areas. The project construction as well as operational activities may have a variety of direct and indirect effects on the physical, biological and human resources of the project area and its environment. Even the direct impacts may be of primary or secondary nature. Strictly speaking, the primary impacts are directly related to the circumstances where land is to be acquired; people are affected in so far as their physical displacement or relocation is involved. Likewise, removal of vegetative cover for construction may also be considered as a primary impact.

On the other hand, secondary impacts entail the direct impacts on physical, biological and human resources arising from the pollution caused by noise, vibrations, toxic emissions, spills, dust, or consumption of natural resources, etc.

Depending upon the direct and indirect impacts, the area of influence would be of two types, i.e., one taken in consideration of land acquisition and resettlement and the other on the basis of environmental aspects.These are referred to as area of influence – A (where project components exist i.e. weir, power house, power channel etc.) and area of influence – B.

While it is easy to delimit area of influence – A fixing of the area of influence – B limit is a difficult subject. This is because the secondary effects are dependent on many factors relating to the environmental settings, type of resources and the project-related parameters. The situation becomes even more complicated when the indirect impacts are also taken into consideration. For example, game reserve areas or habitats located even at a relatively large distance from the construction areas may come under stress due to the increase in number of visitors resulting from the improved access condition. Even noise levels may be disturbing to the wildlife. Similarly, it may enhance the benefits of archaeological/recreation sites due to increase in the number of visitors.

10.7.2 Project Impact Matrix

Table-10.17(a), exhibits impacts of the project in the form of a matrix in pre – flood conditions while Table-10.17 (b) shows the situation in post – flood conditions. This illustrates the impacts of various components of the project during construction as well as operation phases on various physical, biological and social environmental parameters qualitatively. The evaluation ranking of effects on various environmental parameters has been depicted with symbols denoted as "O" for insignificant or none, "L" for low, "M" for medium and "H" for high while type of effect is designated as "A" for adverse and "B" for beneficial. Likewise, "NA" denotes for not applicable and "ND" for not determined.

In general, the impact assessment has been made specific to the areas likely to be affected directly by the project components. However, since the project may disrupt natural habitats that are located at quite far off distances and elevations from the construction site, therefore, this aspect has also been considered and an environmental parameter has been included in the matrix indicated as "Wildlife (Scaring/Facilitating)". It has been assessed that the construction activities of the project will not disrupt the natural habitats however the noise generated by the construction machinery may result in adverse effects on the wildlife but of very low level or insignificant. On the other hand creation of an impoundment during the operation of the project will be beneficial for the wildlife though by providing a feeding and drinking ground. Fortunately, no habitations are located in the vicinity of the project affected areas.

The impacts in respect of health and safety hazards will be low adverse for the local communities, one of the main impacts will be noise and air, since the construction area is very near and the valley is very narrow. Settlements near the access road will be more affected due to noise and dust. The risks in respect of these parameters will be there for the crew working at the site. In consideration of these factors, and assuming that the contractors will take every precaution for protecting the workforce from the construction hazards through providing safety equipment and imparting training to the workforce, the level of impact from these parameters has been kept at "Low" adverse.

The preceding paragraphs provide a generalized overview of the Project Impact Matrix, while detailed account on the effects of the Project on various environmental and social parameters, particularly with reference to potential effects of the Project, is describes in the subsequent sections.

Flood 2010, does not impact all project areas but some components have to be elaborate. The project areas where flood 2010 effects have also been discussed with special reference of pre and post flood conditions in following section.

A – ENVIRONMENTAL IMPACTS AND MITIGATIONS (with Pre & post Flood Conditions)

10.7.3 Land Resources

This section explains how the proposed project could potentially affect the land resources through change in land use, soil erosion and contamination, and describes mitigation measures to manage these impacts.

10.7.3.1 Impacts on Land Use and Resources

a) Land Productivity and Use

- It is obvious that acquisition of land for weir, access road or establishing contractor's facilities will change the local land use pattern. The change in land use for the former activity will be permanent while that for latter ones it will be temporary.

- It is envisaged that use of borrow material will be very limited because the majority of the material will be formed at excavation at the weir site. However, it will cause the loss of

some of the fertile plough layer and a drop in the elevation thus resulting in the decrease of land productivity.

- Potential conflicts may emerge with landowners regarding the restoration of temporarily acquired areas for establishing contractor's facilities, particularly borrow and spoil disposal areas.

- Borrow pits and other landscape depressions if left open, may prove hazardous to human beings, livestock and wildlife. Moreover rain water pounding in open pits can be a potential health hazard both for human beings and livestock due to mosquito breeding and the pollution caused by stagnation of the water.

c) Soil Erosion and Land Sliding

- Soil erosion may occur due to back water effect of reservoir water. This will impacted the agricultural terraces of local community.

- Soil erosion may occur in the workshop areas as a result of improper runoff drawn from the equipment washing-yards and improper management of construction activities in hilly areas particularly in the vicinity of natural streams. Soil erosion may also occur at quarry areas, if unmanaged blasting is carried out.

- The reduction in vegetative cover will reduce the binding capacity of the soil and susceptibility to erosion by the force of rainfall, resulting in increased soil erosion and removal of plant nutrients. The loss of vegetative cover can increase propensity for landslides.

- Uncontrolled dumping of waste or excavated material on the valley side slopes will over load and overstress the top of the slope and upon saturation these loose dumps will slide down into the river.

- Excavation at the toe of the hill for widening of the road will destabilize the colluviums resting on the upper part of the slopes thus will promote the landslides. This particularly implies in the case of cutting of access road construction. Thus if hillside or valley side slopes are left unprotected these will be subject to a natural weathering and become increasingly prone to soil erosion and land sliding.

d) Soil Contamination

- Land may be contaminated by the spillage of chemicals like fuels, solvents, oils, paints and other construction chemicals and concrete. This normally happens when these materials are transported in open or loosely capped containers or by careless handling.

- The possible contamination of soil by oils and chemicals at campsites, workshop areas, and equipment washing-yards may limit the future use of land.

- It is anticipated that a large quantity of excavated material will need to be disposed off. If this waste material is not properly disposed off, it will contaminate the soil and water resources, especially during the monsoon season.

10.7.3.2 Mitigation Measures

The mitigation measures, which will be carried out in construction as well as operation stages for land resources are as under:

b) Land Productivity and Use

- Project facilities, viz., construction camp and workshop will be located at a minimum distance of 500 m from wildlife habitats and settlements, etc. This limit will be 1000 m in the case of asphalt batching plant. If there are constraints to meet with these conditions due to hilly terrain, the contractor will consult the Engineer–in-charge for resolving the matter.

- Prior to the commencement of construction activities, the contractor will submit a layout and location plan of the facilities to the Engineer-in-charge, Local Government and Khyber Pakhtunkhwa-EPA, for its scrutiny and approval.

- As far as possible, waste land i.e. areas not under agricultural, residential or forestation use will be used for borrow material and setting up project facilities.

- Where the use of agricultural land is unavoidable for borrow of earth material, the top 30 cm of the plough layer will be stripped and stockpiled for redressing the land after the required borrow material has been removed. In case deep ditching is carried out, the top 1 m layer of the ditching will stripped and stockpiled. The ditch will initially be filled with scrap material from construction then leveled with the stockpiled topsoil to make it match the rest of the area. It shall be ensured that the scrap does not contain any material that would contaminate soil or water resources.

c) Soil Erosion and Land Sliding

Good engineering practices will help control soil erosion both at construction sites and in peripheral areas, particularly in borrow and dumping areas and a long haul tracks. Soil erosion and landslide remedial measures will be based on geotechnical, geomorphic and hydrological conditions of the project area and these will vary from site to site. However, the following measures will be adopted as per site conditions:

- It is presumed that the free boat effect of reservoir will impact the agricultural terrace on the left side of the weir any how protection dike is proposed as per local community demand.

- Depending upon the valley side slopes, retaining walls will be provide for ensuring the integrity of the road embankments against erosion, slippage under gravity, particularly when under-stratum is scoured by the river, or due to saturation from the rain water and plastic flow of the material down the slope and erosion.

- For mild valley side slope vegetative cover will be provided to check the erosion.

- The plantation for slope protection will constitute fast growing indigenous trees with deep root system for anchoring the soil material and under growth of bushes and creeping grasses having capability of developing mesh of shallow fibrous roots to protect the slope against pitting from rain water.

- Proper monitoring of the soil erosion and landslide prone areas will be carried out during operation phase and soil conservation measures (if needed) will be carried out like provision of physical structures e.g. retaining walls, etc.

d) Soil Contamination

The following practices will be adopted to minimize the risk of soil contamination:

- The contractor will be required to train its workforce in the storage and handling of materials like furnace oil, diesel, petrol and chemicals, etc., that can potentially cause soil contamination. The contractor will be required to prepare a training manual and module for all the construction related activities along with the schedule of training program and submit to the supervising consultants for approval.

- Soil contamination by asphalt and other obnoxious material will be minimized by placing all containers in caissons or dumped into pits lined with impervious liners to contamination of soil/groundwater from leachate.

- Solid waste generated during construction and at campsites will be properly treated and safely disposed of only in demarcated waste disposal sites.

10.7.4 Water Resources

This section explains how the proposed project may affect the water resources use, contamination of water bodies and groundwater, siltation of natural streams and alterations in drainage pattern; the section also describes mitigation measures to manage these impacts. All this will discussed in the light of pre and post flood conditions.

10.7.4.1 Impact on Water Resources

The surrounding land's drainage system and water resources will be affected by construction activities as follows:

a) Depletion of the River Flows

Depletion of the river flows when the water is diverted through Power Tunnel will affect the population of villages as well as aquatic ecosystem falling in the river stretch between the Weir and the Powerhouse.

Pre – Flood Conditions:

People use river water for irrigation purpose through cemented or non- cemented water channels detail of water channel is given in Table-10.1. That table shows that total overall discharge is 0.76 m^3/s. In addition of this ecological flow will also be needed to maintain downstream ecosystem.

Post – Flood Conditions:

Due to flood 2010, all irrigations channels in project area, which has been discussed in earlier were washed away. As result dependences of people on river water has been reduced.

b) Use of Local Water Supplies

- Local water supplies will need to be tapped to meet campsite and construction requirements, thereby competing with local use.
- Local water supplies mainly through the springs and may be affected due to implementation of project both in quantity as well as quality.

c) Contamination of Surface and Ground Water Resources

- Surface and subsurface water resources in the selected project area may be contaminated by fuel and chemical spills, or by dumping of waste material and effluents generated by the kitchens and toilets at construction campsites.
- Natural streams and hill torrents will be contaminated with chemicals, oil, lubricants, detergents, etc. through runoff from the construction area, construction camp, workshops and equipment washing-yards.
- Soil erosion may occur at quarry areas, and it may contaminate the surface water resources if unmanaged blasting is carried out.
- If waste material is not properly disposed of, seepage of polluted water during monsoon season will pollute surface as well as groundwater quality.

10.7.4.2 Mitigation Measures

Measures to be adopted to mitigate the adverse impact on water resources and surface drainage patterns are discussed below:

Mitigation Measure:

a) Depletion of the River Flows

Pre – Flood Condition:

- The proponent will make arrangement during for release of water from the Weir to meet the demand of downstream reach of the river. Proponent will ensure the release of water discharge during construction and operation phase of the project.
- In the absence of a specific guideline or recommendations in Pakistan for the amount of water (residual water) to be retained in a watercourse when water is diverted for hydropower purposes, there is three different method considered to evaluate ecological flow:

1. USA (Montana) Method

Percentages of mean flow are specified that provide different quality habitat for fish e.g. 10% for poor quality (survival), 30% for moderate habitat and 60% for excellent habitat. This method is known as Tennant or Montana method. The Khan Khwar River reach downstream LS Dam site has low biological productivity. Fishery is not being practiced in the reach. Therefore for

survival of natural ecological habitat in this river reach 10% of mean flow may be specified as per this method.

2. Swiss Standards

The Swiss mountain topography and hydrology is similar to the mountain streams of northern Pakistan. The minimum residual water flow to be left in a river is determined by a formula. For water bodies with a 500 litres/s discharge for Q^{347} (there Q^{347} means the discharge appearing in the river for more than 347 days of the year, i.e. more than 95% of the time) a residual flow of 280 litres/s must be retained in the water body. For each further discharge of 100 litres/s, above, 500 litres/s an additional 31 litres/s must be left in the water body.

3. CEMAGREF Model:

For the determination of ecological flow, a formula representing a function of the available mean monthly discharges and the mean annual discharges, was used as presented below,

$Q_e = \{(0.0651 \times Q_m + 2) / 100\} \times Q_a$

Where Q_e = Mean monthly ecological flow (m^3/s)

Q_m= Mean monthly flow (m^3/s)

Q_a = Mean annual flow (m^3/s)

The formula was also used for feasibility study for Madian HPP and feasibility study of the Gabral-Kalam HPP and was developed by CEMAGREF which is an Agricultural and Environmental Engineering Research Organization of (Antony) France. The model is also recommended by the International Association of Small Hydropower.

The last one method (CEMAGREF Model) is used to calculate the mean monthly ecological flows and results are given in the Table-10.18. This depicted mean monthly ecological flows from 1975 to 2008.

Discharge of 0.918 m^3/s (discharge of 0.158m^3/s for ecological flow + 0.760m^3/s water usage by community) is the recommended mean monthly ecological or residual flow which covers river water usage for the community as well. The project has adopted this figure for energy calculation.

Post – Flood Condition:

Flood 2010 washed the water channel which had been using for irrigation purposes so there is enough quantity of residual flow will be discharge. On the other hand if people built back their water channels then in that situation 0.918 m^3/s is enough for their utilization as well as for ecological or residual flow.

b) Use of Local Water Supplies

- The contractor will explore the alternative water resource so that the existing community water resources are not impacted. No existing spring water under the use of community will be exploited by the Contractor for campsite as well as construction purposes.

- Availability of water for campsite facilities and construction purposes will be ensured by the Contractor prior to start of construction activities. As per Local Government Act, the contractor will seek approval from the local government for exploitation of the water resources.

- The Contractor will be required to liaise closely with local communities to ensure that any potential conflicts related to common resource utilization for project purposes are resolved quickly.

- The contractor will prepare guidelines for the workers for minimizing the wastage of water during construction activities and at campsites.

c) Contamination of Surface and Ground Water Resources

- Camps will be located at least 500 m away from the nearest local settlement to prevent the contamination of community-owned water resources like springs, hill torrents, etc.

- Construction camps will be established in areas with adequate natural drainage channels in order to facilitate flow of the treated effluents.

- Wastewater effluent from contractors' workshops and equipment washing-yards will be passed through gravel/sand beds to remove oil/grease contaminants before discharging it into natural streams. Similarly, the wastewater effluent from the campsite will be treated before disposal into a stream. According to local laws, the BOD_5 concentration in sewage must be brought down to less than 80 mg/l before being discharged into a natural stream with a capacity to dilute the effluent further by 10 times.

- Borrow pits and natural depressions with pre-laid impervious liners will be used to dispose of obnoxious material, and then covered with soil. This will check potential groundwater contamination. Such measures will also be provided at river side disposal of waste material in addition to retaining walls or gabions. Available stone (boulders) from excavated rocks will be used for retaining walls as well as for gabions. It will reduce the quantity of dumping material.

10.7.5 Ambient Air Quality

This section discusses the impact of the construction and operation on the ambient air quality and noise levels along the Project area. It also describes the mitigation measures to manage these impacts.

10.7.5.1 Impact on air Quality

a) Dust Smoke and other Pollutants from Plants & Equipments

The emission or dust from the batching plant or construction machinery and batching plant can be very harmful for the site worker and the local population. The emission/dust could cause skin and respiratory disease e.g. skin rashes, lungs problem etc. Roads and traffic will be affected due to the heavy vehicles movement in the area carrying plants and material.

Contractor could select the suitable location provided the following control measures are in place.

b) Smoke from Burning of Waste Material or Burning Firewood

A number of big and small fires in the labour camp can produce smoke and smog which can cut off visibility, reduce traffic ability and cause suffocation along with causing diseases of respiratory tract.

c) Impact on Air Quality of Earth Work Activities

Excavating activities will generate dust and pollute the surrounding area. The emission from the plants use in earth work activities will also degrade the air quality of the site. Exhaust of noxious gases from movement of heavy machinery will further pollute air which will adversely affect health and vigor of plants.

10.7.5.2 Mitigation Measures

a) Dust Smoke and other Pollutants from Plants & Equipments

- Air quality should be monitored on regular basis near the plant.
- The plant should be located at least 500m away from any living area.
- Regular spraying of water should be undertaken to minimize the dust pollution.
- All vehicles, machinery, equipment and generators used during construction activities will be kept in good working condition to minimize the exhaust emissions.
- Proper PPE should be issued to the site worker and make sure the worker wears the PPE properly during working on site.

If batching plant is close to the living area. This site can only be use for batching plant if the following conditions are followed:

- The plant has to be Zero Emission Plant. This will include using washed aggregate and enclosed cyclone with automatic injection system of material in to the mixing chamber.
- The access roads for the delivery Lorries pass through the living area. These roads/paths should be sprayed with water on regular basis to minimize dust pollution.

b) Smoke from Burning of Waste Material or Burning Firewood

- It is contractor's contractual obligation to use and provide clean and smoke free fuel in the labour camp.
- Cutting and burning trees or shrubs for fuel shall be prohibited.
- Gas Cylinders should be used in the labour camp for cooking purposes.

c) Impact on Air Quality of Earth Work Activities

- Regular spraying of water should be undertaken to minimize the dust pollution.

- All vehicles, machinery, equipment and generators used during construction activities will be kept in good working condition to minimize the exhaust emissions.
- The Contractor will regularly spray water on the site traffic routes to minimize the dust pollution.
- Enforce the maximum speed limit to 20km/h for vehicles using embankments and access road.

10.7.6 Noise

10.7.6.1 Impact of Noise pollution

a) Noise Pollution from Construction Activities

Construction activities particularly blasting site near the powerhouse area could generate noise and disturb the natural habitat.

10.7.6.2 Mitigation Measures:

a) Noise Pollution from Construction Activities

- Use of vehicles and machinery of good condition and well tuned engine that will reduce noise hazards according to permissible limits as fixed by Pak EPA for noise is 85 dB (A) while the WHO noise guidelines prescribed a limit of 55 dB (A), these limits will be considered in operation phase of the project. The WHO guideline values for community noise in specific environment is as shown in Table-10.19 and Table-10.20 provides an indication of relative sound dB (A) levels compared to various activities for reference.
- Monitor noise level on regular basis and maintain the level within the NEQS level.
- Monitor noise level on hourly bases at the start of the work activities for at-least first 2 days of work. The monitoring interval could increase to daily after two days.
- All working activities should be restricted within the allowed during the day time particularly for blasting.

10.7.7 Biological Environment

The impact on flora and fauna and corresponding mitigation measures are described in the following paragraphs:

10.7.7.1 Impacts on Flora and Fauna

a) Flora

Pre – Flood Conditions:

Proposed project will impact about 204 trees (about 139 shade & 65 fruit trees) and during construction activities the Contractor's workers may damage the vegetation and trees (for use as fire-wood to fulfill the camps requirements).

Post – Flood Conditions:

Now after the flood project will impact about 155 trees (About 112 shade trees & 43 fruit trees) and during construction activities the Contractor's workers may damage the vegetation and trees (for use as fire-wood to fulfill the camps requirements).

The cutting of trees will cause degradation of local environment as under.

- It will enhance soil erosion. Without the branches and leaves, to break its fall, heavy storms can quickly wash away the soil from even a gentle slope. Cutting down of trees/shrubs also takes away the roots that would otherwise help in binding the soil.

- During the entire construction period dust laden polluted air will form a dust film on leaves thus blocking sunshine and stomata consequently hindering photosynthesis processes causing detrimental effect on the plant health.

b) Fauna

i) Mammals and Reptiles

- During the construction phase, there will be adverse impacts on the mammals and reptiles of the area, due to construction activities involving excavation, blasting, access roads, movement of labour, carriage of goods and machinery to various sites along the Project area. Mammals, such as jungle cat, jackal, fox, etc. will avoid these areas. Same will be the case with reptiles. Some reptiles may be killed during the earthworks operations. Movements of the mammals and reptiles will be restricted during the construction phase.

- Uncontrolled blasting may damage the existing wildlife of the project area. Food and refuse at the Contractor's camps may attract wildlife that might in turn be hunted by the workers.

- Due to establishment of labour camps, food storage, setting up of kitchens production of sewage and waste water 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.

ii) Birds-Avian Fauna

Birds will try to find shelter and food somewhere else and will tend to move away from the project area due to the activities mentioned above for fear of being hunted/ trapped. Unmanaged blasting activities may harm birds.

iii) Aquatic Fauna

There is no definite record about fish is available, as there is no official from the Fishery Department posted in project area. There is no commercial fishery in the area. Even traditional fishermen do not exist. However, some fishing activities are carried out for household use and recreational purpose.

10.7.7.2 Mitigation Measures

a) Flora

Before Flood:

It is estimated that against cutting of about 204 trees SHYDO will make a provision of compensatory plantation at the ratio of 1:3. As such, the total compensatory plantation comes to about 612 trees more ever to minimize the impacts on flora;

After Flood:

It is estimated that against cutting of about 155 trees SHYDO will make a provision of compensation plantation at the ration of 1:3. As such, the total compensatory plantation comes to about 465 trees more ever to minimize the impacts on flora.

Following measures will be adopted construction and operation stages.

- Campsites, workshop and batching plants will be established on waste/barren land rather than on agriculturally productive land. However, if such type of land is not available, it will 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 Contractor's staff and labour will be strictly directed not to damage any vegetation such as trees or bushes. They will use the paths and roads for movement and will not be allowed to trespass through farmlands or forested areas.
- Contractor will provide gas cylinders at the camps for cooking purposes and cutting of trees/bushes for fuel will not be allowed.
- Cutting of mother trees, if any, will be avoided, as far as possible, so that the negative effect to the process of natural regeneration of the species is minimized.
- A tree plantation program will be formulated by the SHYDO with the help of local Forest Department of Khyber Pakhtunkhwa and about 630 trees will be planted. The SHYDO will enter into an agreement with the Forest Department to implement the program under deposit work. As the land along the slopes generally belong to the communities/individual owners, the Forest Department will involve the communities carrying out plantation on the lands. The Department may also involve the communities on participatory basis to construct dry stone masonry check dams to break the length of the slope thus abating the erosion problems.
- Open fires should be banned in the area to avoid hazards of fire in the area, especially in the Chir zone.

(b) Fauna

i) Mammals and Reptiles

- Hunting, poaching and harassing of wild animals will be strictly prohibited and Contractor will be required to warn its labour accordingly.
- Blasting and other noise generating activities will not be carried out during the night.
- Camps will be located at least 500 m away from the nearest wild life area and their source of food as well as water.
- The camps will be properly fenced and gated to check the entry of wild animals in search of eatable goods. Similarly, wastes of the camps will be properly disposed of to prevent it being eating by wild animals, as it may be hazardous to them.

ii) Birds

- Special measures will be adopted to minimize impacts on the wild birds, such as avoiding noise generating activities during the critical periods of breeding.
- Staff working on the project should be given clear orders, not to shoot, snare or trap any bird.
- If possible nests of bird, on trees need to be uprooted, be shifted to other nearby trees.

iii) Aquatic Fauna

- The weir intake structure will be designed and constructed to allow the minimum mean monthly 0.918 m^3/s (month wise detail is given in Table-10.18) of water flow to always be maintained in the Khan Khwar River for the maintenance of riparian as well as aquatic ecosystem of downstream.

B – SOCIAL IMPACTS, MITIGATIONS AND RESETTLEMENT (with Pre & post Flood Conditions)

This section describes the impacts of the proposed project on local communities, construction worker, indigenous and vulnerable people as well as on structures and sites of cultural and religious significances.

10.7.8.1 Social Impacts

a) Permanent Land Acquisition

Pre – Flood Condition

- Before flood, it was estimated that the project will involve acquisition of about 64.321 kanals of land which includes, 44.321 kanals of agricultural land, 6 kanals of forest or grazing land and 14 kanals of waste land. By and large this is the proprietary land. Breakdown of land required for the project is given in Table-10.21 (a) same is depicted in Figures-10.1 & 10.2.

After Flood:

After the flood It is estimated that the project will involve acquisition of about 64.321 kanals of land which includes, 40.321 kanals of agricultural land, 2 kanals of forest or grazing land and 22 kanals of waste land. By and large this is the proprietary land. Breakdown of land required for the project is given in Table-10.21 (b) same is depicted in Figures-10.3 & 10.4.

Temporary Acquisition of Land

The contractors will require temporary acquisition of land for:

- Establishment of aggregate quarries, Contractor's camp and other facilities. It is estimated that about 16 kanals of agricultural land is required for established these structures.

a) Impacts on Local Communities/Workforce

The Project areas surrounding communities will be affected during the construction phase as follows:

- During the construction phase the general mobility of the local residents and their zalivestock in and around the project area is likely to be hindered. Likewise access to the natural resource may be affected. This particularly applies to the women folk and children.
- Construction activities, particularly excavation and movement of haul truck and machinery may disrupt the existing tracks leading from the valley access road to settlements. This will limit the accessibility of the local population to the valley access road.
- Usage of Community's 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 hazards during the construction activities.
- The presence of outside construction workers inevitably causes some degree of social disruption and even active disputes with the local community as a result of social/cultural differences. This particularly relates to the disruption of the privacy of women folk working in the fields or even the yards of their houses, should the house lying at lower elevation than the working sites. Likewise the risk of theft of the community assets by the Contractor workers and vice versa may occur.
- During construction activities, traffic flow will be disturbed. The Besham – Alpuri road being used for access between weir to power house for the movement of construction material, there will be limited scope for providing diversion tracks for the mobility of local and through traffic. This aspect needs to be carefully handled in accordance with site specific conditions.
- The Contractor will prefer to work during the night hours. The night time working will be having intrinsic problems relating to safety and noise hazards for the communities and the workers.
- After flood number of bridges has damaged. Before flood, there were two bridges exist in the project area one at weir site for vehicular movement and the other at power house site for pedestrian (foot bridge). Flood washed away these two bridges as well. Now with the

execution of project the project area will get new concert bridges at both sites (weir or power house site).

b) Loss of Income

Before Flood

- Due to implementation of the Project, about 64.321 kanals of agricultural land will be acquired. For which proper compensation as per current market price will be paid the affected people as per entitlements.

After Flood

- Flood turns 4 kanals of agricultural land into the waste land. As a result for the implementation of the project about 40.321 kanals of agricultural land will be acquired. For which proper compensation as per current market price will be paid the affected people as per entitlements.

c) Gender Issues

- The rural women normally are actively participate in other outdoor socio-economic activities such as livestock rearing, bringing of potable water, etc which may also be affected by the project activities.
- The induction of outside labor may create social and gender issues due to the unawareness of local customs and norms. It will also cause hindrance to the mobility of local women for working in the field, herding livestock, picking fuel wood, etc.

d) Indigenous and Vulnerable Households

- During the social field survey of the project, no indigenous or vulnerable household group of people was identified. So no impact on these people is envisaged due to the implementation of the project.

e) Safety Hazards

- Occurrence of accidents/incidents during the construction activities, particularly from blasting and excavation activities is a common phenomenon. Safety of general public residing at the top of the hill where blasting/excavation is to be carried will particularly be at stake. The local people, particularly the children and women, may get injuries or even fatalities.
- Contractor staff while working at steep hilly slopes may slip and get injuries.

f) Relocation of Private Houses & Public Infrastructure

- The project will disrupt one residential unit located at the route of power channel. Total area covered for this house is about 6 Marla (1,748 ft^2). Detail of disrupted house is given in Table-10.22 and location in Figure-10.1.

g) Religious, Cultural and Historical Sites

- No historical or archeological site has been observed along the Project area.

10.7.8.2 Mitigation Measures

a) Land Acquisition

Permanent Land Acquisition

The land required for the reservoir and other structures will be acquired in accordance with the provisions of the Land Acquisition Act, 1894.

Temporary Land Acquisition

Land required for establishing contractor's facilities including borrowing earth material and dumping excess spoil will be leased directly from private landowners by the contractor. The provisions of the Land Acquisition Act, 1894 will not be invoked under temporary land acquisition, as the acquisition of the land will be on short term basis, and will be covered by short-term lease agreements between the landowners and contractors. Rental terms will have to be negotiated to the satisfaction of the landowners concerned. Given that there is no compulsory land acquisition, conflicts between the contractors and landowners are unlikely. The staff of the SHYDO and Supervisory Consultants will monitor the process of restoration and ensure, through the terms of the construction contracts, that landowners are compensated according to the terms of the lease agreements, and the restoration actions agreed upon by the contractors are duly carried out. The photo-documentation of the existing land prior to temporarily acquisition will be available, which will be beneficial to resolve the restoration conflicts between the landowner and contractor. Similarly, prior to the start of work, Contractor will carry out base line survey for selecting the campsites, dumping sites; public and community/ private owned utilities, in conformity with the requirements specified in IEE studies and obtain approval from the Supervisory Consultants.

a) Local Communities/Workforce

Potential social conflict will be contained by implementing the measures listed below:

- The contractor will ensure that the mobility of the local communities, particularly women and children, and their livestock is not hindered by the construction activities. The contractor will provide crossing points at the project structure specially power channel area at appropriate places to facilitate the people for going across the road for their daily works and having free access to the natural resources.

- Generally the contractor will avoid using the village tracks for hauling the construction material. However, if it is unavoidable, the existing ones will be widened, overlaid with shingle or surface treated to accommodate local as well as contractors traffic.

- The contractor will ensure that blasting is not carried out in the near vicinity of the settlements and village tracks that are very frequently used. Here only excavators will be used.

- Blasting will be carried out during the fixed hours (preferably during the mid-day). The timing will be made known to all the people within 500 m from the blasting site in all directions. People, except those who actually light the fuse shall be evacuated from the area of 200 m from the blasting site in all directions at least 15 minutes before blasting.

- In areas where potable water is scarce and where the people use spring water, the contractor will make alternative arrangement in accordance with water requirement for Contractor's camp and construction activities.

- Camps will be located at least 500 m away from the nearest local settlement to avoid the contamination of community-owned water resources.

- Approval from the local administration will be obtained before using the local water resources by the Contactor.

- The Contractor will be required to maintain close liaison with the local communities to ensure that any potential conflicts related to common resource utilization for the project purposes are resolved quickly.

- Effective construction controls by the Contractor to avoid inconvenience to the locals due to noise, smoke and fugitive dust. The contractor will frequently sprinkle water at the work areas and haul tracks to avoid generation of fugitive dust. The frequency of sprinkling will be determined by the weather condition. During long spell of hot and dry weather the sprinkling will be done after 2 or 3 hour intervals.

- Haul-trucks carrying concrete, aggregate, sand and earth fill materials will be kept covered with tarpaulin to help contain construction materials being transported between the sites.

- Good relations with the local communities will be promoted by encouraging Contractors to provide opportunities for skilled and unskilled employment to the locals, as well as on-the-job training in construction for young people. Contractor will restrict his permanent staff to mix with the locals to avoid any social problems.

- Local vendors will be provided with regular business by purchasing campsite goods and services from them.

- The Contractor will warn the workers not to involve in any theft activities and if anyone would involve in such type of activities, he will have to pay heavy penalty and would be handed over to police. Similarly, at the time of employing, Contractor has to take care that the workers should be of good repute. The Contractor camp will be properly fenced and main gate will be locked at night with a security guard to check the theft issues from community side.

- Contractor will take care of the local community and sensitivity towards the local customs and traditions, particularly in the context of privacy of women folk.

In case of night time working the Contractor will adopt the following measures:

- It is desirable that the night-time working may be avoided at places where settlements are very close to the construction sites.
- If the above is unavoidable, the use of heavy machinery generating noise should be avoided only the manual works or light machinery may be deployed.
- No blasting will be carried out during the night time.
- The Contractor will provide adequate light at the site and display florescent sign boards at appropriate places for warning to the communities and drivers.
- Take safety precautions for the workers and the local communities.
- The Contractor will keep first aid boxes at the site and make availability of vehicle for transporting the injured people to the hospital. This arrangement will also be made even during the day time working.
- The Contractor will share the plan and schedule of night time working with the Supervision Consultants for approval.

(b) Loss of Income

- Compensation will be provided as per eligibility and entitlement matrix for PAP's (Project Affected Peoples) who lose their land. The land will be acquired in accordance with the Land Acquisition Act using the current market prices.
- Moreover, PAP's will be given priority on jobs placement.

(c) Gender Issues

- The Contractor will have to select the specific timings for the construction activities particularly near the settlements, so as to cause least disturbance to the local population particularly women considering their peak movement hours.
- Contractor will take due care of the local community and sensitivity towards local customs and traditions will be encouraged.
- Contractor will warn the staff strictly not to involve in any un-ethical activities and to obey the local norms and cultural restrictions particularly with reference to women.
- During construction activities, if privacy of the nearby households is affected, the Contractor will inform the house owner to make some parda arrangements. Similarly, Contractor will have to take care as much as possible that the construction activities should not affect the privacy particularly with reference to women.

(d) Indigenous and Vulnerable Households

- As referred earlier, no indigenous or vulnerable household group of people was identified in or along the project area, so the ADB Policy will not be triggered.

(e) Safety Hazards

- Complying with the safety precautions for construction workers as per International Labour Organization (ILO) Convention No. 62, as far as applicable to the project contract.
- Training of workers in construction safety procedures, environmental awareness, equipping all construction workers with safety gadgets including safety boots, helmets, gloves, and protective masks, and monitoring their proper and sustained usage.
- Contractor will ensure the provision of medicines, first aid kits, vehicle, etc. at the campsite and working place.
- Warning to local communities prior to blasting and to enhance blasting safety the contractor will use protective devices, including wire containment, displaying warning signs along the work site, blowing sirens, etc.
- Prior to blasting thorough inspection will be conducted.
- Safety lookouts will be built to prevent people and vehicles from passing at the time of blasting.
- Cordon off the work areas where necessary.
- The storage of all solid waste shall be practiced so as to prevent the attraction, harborage or breeding of insects or rodents, and to eliminate conditions harmful to public health or which create safety hazards, odors, unsightliness, or public nuisances.

f) Relocation of Private/Public Infrastructure

- Houses will be compensated on replacement cost basis that is given in Table-10.22 and proposed location is shown in Figure-10.1.

g) Religious, Cultural and Historical Sites

- As referred earlier, no relocation of religious structures is involved, so no mitigation is required except that contractor will follow the prayer timing particularly at prayer of Juma and the workforce will observe the sanctity of religious properties.
- There are no archaeological sites located within the project area and no impacts on archaeological sites are envisaged. However, the Contractor will be required to instruct the construction crews and site supervisors in archaeological site recognition, conservation procedures, and temporary site protection.

10.7.9 Risks of Dam Failure

There are two natural forces that may be catastrophic for the hydraulic structures of the project. These include heavy floods and seismic activity. In spite of the fact that provision has been made for both the design of the weir, mathematical model studies are required for confirmation of the design parameters. These may be carried out during the detailed design stage of the Project. According to guidelines of the US Army Corps of Engineer, the project

falls in intermediate category of dams with respect to the height of the weir as well as the storage capacity (Reference Table-10.23). The storage capacity of the Karora HPP is about 22,521 m^3 and the weir height is about 5 m. Therefore, it falls in small Category. According to US Army Corps of Engineer, the Hazard category of the weir would be "Low" since there is no population within the reach of the flood that would be at risk under dam failure. Additionally, there is no economic structure of any value that is likely to get damaged as a result of weir failure flood. Therefore, the weir needs to be designed as a low hazard and intermediate size classification. From Table-10.24, it follows that the structure has to be safe against flood ranging from 100 year frequency to 50% of Probable Maximum Flood (PMF).

10.8 General

In this context, following options have been considered.

10.8.1 No Action

Pakistan is facing critical shortfall of electric energy since long, particularly during the last few years. It has been estimated that during the last five years the annual power demand has been increasing by 4.8% that is likely to increase by 8 to 10% by the end of this decade. Existing installed generation capacity of the country is 17,772 MW. Out of these 17,772 Megawatts, the Water and Power Development Authority (WAPDA) of Pakistan owns 9,884 MW, another 5417 are owned by private, Independent Power Producers (IPPs), the Karachi Electric Supply Corporation (KESC) capacitates 1,756 MWs while the rest is the installed capacity of nuclear and other cogenerating industries. Thermal plants using oil, natural gas, and coal account for about 68% of this capacity, with hydroelectricity making up 29.4% and nuclear plants 2.6%. Hydroelectric generation which is about 30% of the National total generation is generally constrained somewhat due to the multipurpose nature of most of the facilities. Irrigation demands normally control the seasonal operation of reservoirs and the resulting distribution of energy production. Currently WAPDA is facing a shortfall of about 5,000 MW during peak hours, which may increase up to 5,529 MW by year 2010. This demands enhancement of installed capacity by 2000 MW per year.

With this scenario, Pakistan is forced to exploit every source of power generation including hydro, oil, gas, coal, nuclear, wind, solar etc. Even realizing constraints in the public sector investment and to take up the task on fast track, the Government of Pakistan framed a policy in 1994 to attract private investors for power generation by using thermal resources. This policy was revised in 2002 to include hydropower in private sector, which previously fell under the jurisdiction of WAPDA but now SHYDO is also following the same policy to increase hydroelectric generation in KP involving private sector to build and operate power house.

As a result of Power Policy of 1994, a number of thermal power projects have been installed in the country. These include Uch Power Plant (550 MW), Hubco Power Plant (1300 MW), and Liberty Power Plant (235 MW) besides privatization of WAPDA' Kot Addu Power Plant (1500 MW). Besides, during this period three power generation projects, namely Ghazi-Barotha Hydropower Project (1450 MW), Chashma Hydropower Project (184 MW) and Chashma Nuclear Power Plant (325 MW) were implemented in public sector. Similarly, despite lately enhancement in the power generation capacity, there is still a wide gap between power generation and peak hour demand of power supply.

To cater for this gap of power supply and also to meet the future power demand, Pakistan is in need of exploitation of all resources of power generation. Therefore, the option of "No Action" can not be adopted. This option will not only affect the domestic sector but also hamper the development of industrial, commercial and agriculture sectors of Pakistan.

10.8.2 Alternative Sources of Power Generation

The available resources of power generation in Pakistan are hydro, natural gas, coal, to some extent oil, wind in the coastal regions, nuclear and solar. Of these, hydro resources are of the prime importance for Pakistan. It is not only due to the fact that hydropower is the cheapest power generation source but also because the country is endowed with ample hydro resources for power generation up to 40,000 MW, out of which only about 7000 MW has been exploited so far, which forms about 30% of the total power generation capacity of the country while the remaining about 70% is thermal from oil, gas, coal and nuclear in the descending order. Two decades back, the power generation capacity was almost in the reverse order, hydropower contributing up to 70% and thermal about 30%. As a result of this, the power generation cost has increased tremendously. This is because of the fact that indigenous oil production is very low, the operation of oil-fired power plants are dependent on rather expensive imported oil. Natural gas resources of Pakistan are currently facing shortfall. Therefore, its further utilization for electric power generation will affect its domestic and industrial use unless it is imported at high cost. The poor economy does not allow the import of fossil fuels, particularly oil, on a large scale. Too much reliance on imported oil is critical from energy security point of view.

Apart from this, a large fraction of the population lives in remote areas and is still waiting to be connected to the national electricity grid. To help these remote communities in particular, and to overcome energy shortages in general, Pakistan needs to develop its indigenous energy resources like hydropower, solar and wind. More than 1000 km long coastline in south and some places in northern mountainous areas provide an excellent resource of wind energy. This vast potential can be exploited to produce electricity on both community and wind farm scales.

In spite of the fact that Pakistan has recently discovered large reserves of coal in Thar Desert in Sind Province, its development and exploitation for electric power generation would take long time. The use of wind and solar energy for electric power generation is still at a preliminary stage in Pakistan. Pakistan lacks technology in these sectors, thus much reliance has to be made on technical and logistic assistance of the developed countries. Recently, the very first wind energy project has been launched in Thatta District of Sindh with power generation capacity of 45 MW to act as a pilot project. Still there is long way to exploit the full wind resources of the coastal area of Pakistan.

As far as use of solar energy for electric power is concerned, Pakistan's effort in this sector is almost negligible. This is because solar photovoltaic systems are prohibitively expensive in terms of installation costs. Power from them is also available intermittently; only when energy from the sun is available, unless large scale storage batteries are also installed. This will further escalate the installation cost.

In the light of this, the only option left with Pakistan is the exploitation of vastly available renewable and cheap resource of hydro-energy. WAPDA has prepared a plan for exploitation of this energy source under "Vision 2025". As a follow up, a number of projects have been undertaken both in public and private sectors. Some of these are at the implementation stage while others are in different stage of planning. The former category includes Khan Khwar (72 MW), Allai Khwar (121 MW), Duber Khwar (130 MW), Jinnah (96 MW) and Neelum-Jehlum (969 MW). The latter projects include Basha-Diameer (4500 MW), Dassu (5000 MW), Bunji (5200 MW), Golen Gol (106 MW), Palas Valley/Spat Gah Cascade Complex (about 2500 MW) and many more small hydel projects in Gilgit - Baltistan, Azad-Jammu and Kashmir and KP.

10.8.3 Project Location Alternatives

As referred in previous sections, the Project will be located in a narrow valley; therefore there is very limited scope of alternative consideration for the layout of the major project components.

The alignment of the tunnel will be determined by the fixation of the locations of weir axis and powerhouse. As this structure will be underground, the environmental hazards will be limited to the quantum of the excavated material that would need to be disposed off. Depending upon the locations of the two terminal structures, the length of tunnel will slightly vary resulting in change in the quantity of spoil material.

10.9 Environmental Management Plan and Institutional Requirement

The environmental management plan and its institutional requirements have been described in tabular form at Table-10.25 the table identifies the effects of the construction and operation of different project components on various environmental parameters. It also spells out mitigation/enhancement actions. The table also defines the responsibilities of various actors, viz. Proponent, Contractor and the Engineer in the implementation and monitoring of the mitigation actions.

SHYDO will also obtain approvals from Khyber Pakhtunkhwa-EPA and then monitor the project and forward monitoring reports on a regular basis to the Provincial EPA as per the requirements of the Federal EPA regulations. This IEE and the EMP can form the basis of a submission for environmental approval from the Khyber Pakhtunkhwa-EPA.

SHYDO will be responsible for ensuring that conditions are included in project construction contract documents. It will also ensure that during the construction phase, environmental mitigation measures, as per the EMP, are effective and are implemented by contractor. The EMP implementation will be coordinated with Government Agencies such as Forest, Fisheries and Wildlife Departments, for such activities as securing removal permits for trees.

As SHYDO does not yet have the expertise and capacity required for implementing the IEE and Abbreviated Resettlement Plan, it will have to depend on additional external technical assistance and will therefore hire the following additional expertise.

Purposed part time, Supervisory Consultants[1] who will be hired directly by SHYDO, to provide technical assistance in implementation of the Environmental Management & Monitoring Plan. Another part-time Consultant (External Monitoring) which conducts the external monitoring and evaluation of the implementation of the EMP and resettlement activities for the project.

10.9.1 Environmental Monitoring Plan

This section provides a monitoring plan that identifies the roles and responsibilities of project staff involved in environmental monitoring, and lists the parameters that will be used in the monitoring process. (Table-10.26) the main objectives of monitoring plans will be to:

- Monitor the actual project impact on physical, biological and socio-economic indicators. This will indicate the adequacy of the IEE in identifying and mitigating the project adverse effects.
- Recommend mitigation measures for any unforeseen impact or where the impact level exceeds than that anticipated in the IEE.
- Ensure compliance with legal and community obligations including safety on construction sites.
- Monitor the rehabilitation of borrow areas and the restoration of the construction campsite as described in the EMP.
- Ensure the safe disposal of excess construction materials.

The main objectives of monitoring during the construction and operation phase will be to:

- Appraise the adequacy of the IEE with respect to the project's predicted long-term impacts on the area of influence physical, biological and socioeconomic environment.
- Evaluate the effectiveness of the mitigation measures proposed in the EMP, and recommend improvements in the EMP, if required.
- Monitor the survival rate of compensatory plantations carried out for loss of vegetation by the project.
- Supervisory consultant hired by SHYDO will also engaged for social monitoring to verify the efficacy and ensure the transparency of land acquisition, compensation and resettlement process carried out by SHYDO with the assistance of concern local department.
- SHYDO will ensure two types of monitoring during the execution of the project with the help of part – time consultant for external monitoring.
- Compliance Monitoring - to ensure that proposed measures in the EMP are adhered to, and

[1] TORs will be decided later with M/S of SHYDO while cost is reflected in chapter 11 of Main Report, Volume I.

- Effects Monitoring - to establish baseline values for environmental parameters such as air quality, water quality and noise levels. Given the circumstances of the project, independent environmental monitoring consultant already engaged for the ongoing project shall be asked to conduct the monitoring program.

- The consultant engaged for monitoring will report their findings on a quarterly basis directly to the Project Coordinator, Deputy Director, federal D/Environment and the Resettlement and Social Committee.

In order to meet the above objectives the following parameters need to be monitored:

- Drinking Water Quality
- Waste Water Quality
- Air and Noise quality,
- Soil Conservation.

10.10 Abbreviated Resettlement Plan (ARP)

10.10.1 General

In accordance with established resettlement policy, if a project displaces less than 200[2] persons (about 40-50 families) or even more than 200 persons are affected with minor displacement, an Abbreviated Resettlement Plan instead of comprehensive Resettlement Action Plan may suffice. The EA (Environment Assessment) study of Karora Hydropower Project indicates that there is only one displacement occurs more ever there is impacts on other families due to land acquisition, thus an Abbreviated Resettlement Plan (ARP) is suggested for the Project. This is based on the socio-economic profile of project area as depicted in Section 10.5.13

10.10.2 Main Objective of Abbreviated Resettlement Plan

This ARP is designed to address all the limited impacts of the project. It provides an analysis of the impacts identifies the nature and types of losses and establishes an entitlement matrix as a guide to payments of compensation and resettlement benefits. It also contains a budget, institutional arrangement for implementing the ARP, implementation framework and monitoring arrangements. This has been described in the following sections of the chapter.

10.10.3 Potential Effects of the Project

The area to be consumed by the project structures i.e. reservoir, box channel sand trap powerhouse and camps& colony area plus access roads is given in Table-10.21 (a) for pre-flood conditions & Table-10.21 (b) for post-flood conditions.

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[2] The groups of population are considered socially vulnerable comprises of (a) those that are below the poverty line (BPL); (b) those who belong to scheduled castes (SC), scheduled tribes (ST); (c) female headed household (FHH); (d) elderly (above 65 year) and (e) disable persons

As per the survey, the cumulative adverse impacts associated with the land acquisition of 64.321 kanals will result in affecting about 18 titleholders/APs who are the owners of the land proposed for acquisition. While comparing with the project area with entire village there is only 0.14% and 0.11% land to be acquired at village Kuz Kana and village Ranial respectively. Table-10.27 describes comparative study of project area along with affected village.

A total of five families (47 persons) of the village Ranial will be affected by permanent land acquisition and one family (13 persons) affected with the temporary land acquisition at power house site. On the other hand seven families (58 persons) whose land is impacted within the reservoir, power channel and sand trap area and one family with a 7 family members will be lose their residential structure as well as land within power channel area are belongs to Kuz Kana Village. Four families (28 persons) is impacted with temporary land acquisition near the reservoir area also belong to Kuz Kana village.

These persons are title holder's landowners who cultivate their land near the future project sites. The investigations and surveys were conducted within a project area and impacts are presented in a Table-10.28 (a) describes the situation in pre – flood conditions while Table-10.28 (b) draw the after flood picture and Table-10.29 shows temporary land acquisition which is the same as before flood.

The entire affected persons are losing agricultural, forest/grazing and waste land. These affected persons have an average land holding size of 5 – 15 kanal, while land owners are resident owners as well as legal title holders. The detail of land holding in respect to their owners is given in Table-10.30 (a) for pre – flood conditions and 10.30 (b) for post – flood conditions and fore trees Table-10.31 with comparison of pre and post flood conditions.

There are no squatter households who will be affected.

The total loss of Tress in the project area before flood is 204 and after flood are 155 as per the survey. The cost per tree has been estimated for shade tree is at 500 Rs per tree and for fruit tree is 800 Rs per tree. The value of the shade tree has been estimated taking into consideration the prevalent market rates in the area while the value of fruit trees has been estimated from average fruit production for next ten years to be computed at current market value.

There is no vulnerable[3] group and no indigenous category of people that exist in the project area.

10.10.4 Land Acquisition Act (1984) and Practice in Khyber Pakhtunkhwa

The Government of Pakistan and the four Provinces, including Khyber Pakhtunkhwa, use the Land Acquisition Act of 1894 (the Act), with amendments, as the core legal document for acquiring private land for public purposes. The process of land acquisition is initiated by

[3] [1]The groups of population are considered socially vulnerable comprises of (a) those that are below the poverty line (BPL); (b) those who belong to scheduled castes (SC), scheduled tribes (ST); (c) female headed household (FHH); (d) elderly (above 65 year) and (e) disable persons

serving a preliminary notice under Section 4 of the Act by the District Revenue Officer (DRO), acting as the Land Acquisition Collector (LAC), expressing the government's intention to "enter upon" the identified private lands for surveying and soil-testing for a specified public purpose. The next activity is carried out under Section 5, which involves marking and measurement of the land and assessment of compensation. The final declaration for possession of the selected portions/strips of the lands is issued under Section 6 of the Act. Under this Act, only persons officially registered with the Revenue Department as owners with the Land Revenue Department or who possess formal lease agreements are considered "eligible" for land compensation. As per the provisions of the Act, cash compensation is assessed (Section 5) on the basis of the latest five to three years average registered land sale transfer rates, and is paid to the landowners for their lands being acquired. However, there have been instances in the recent past of taking average rates of the past one year, and even taking the current rates. For land acquisition for this Project, however, the current open-market rates / replacement value will be applied, as per the ADB Resettlement Policy, and the process of land acquisition will be shortened by replacing formal LAA methods with direct negotiations with the landowners and their village elders. Relevant sections of the LAA 1894 are summarized in Table-10.32.

10.10.4.1 ADB Policy on "Involuntary Resettlement"

The "Involuntary Resettlement Policy" of ADB addresses losses of land, resources, and means of livelihood or social support systems which people suffer as a result of ADB projects or project components. The "Involuntary Resettlement Policy" takes into consideration social and economic impacts that are permanent or temporary and are:

- Caused by acquisition of land and other fixed assets,
- By change in the use of land, or
- Restrictions imposed on land as a result of an ADB operation.
- An "affected person" (AP) is one who experiences such impacts.

10.10.4.2 Identification of Compensation Parameters

Affected people and communities will be fully compensated for their respective losses. The following compensation parameters will be utilized:

- Ideally the land for land option should be adopted but as no government land exists in the area this option cannot be applied.
- Cash compensation to be provided for land is to be based on current market /replacement value to landowners (including women), plus 15% Compulsory Acquisition Surcharge (CAS), as provided in the Pakistani Land Acquisition Act (LAA).
- Cash compensation for loss of crops is based on market value of mature crops. If sown or standing crops are damaged or uprooted, the eligible persons will be compensated in cash for the loss of un-harvested crops, at the mature crop value to be assessed on the basis of the local current market rates, regardless of the title or tenurial status.

- Compensation for loss of fruit-trees is based on the value of fruit for up to 10 years, to be assessed at current market prices, regardless of the title or tenurial status.

10.10.5 Entitlement and Eligibility

The ADB Resettlement Policy/Guidelines require compensation for the lost assets at replacement costs to both titled and non-titled landholders and resettlement assistance for lost income and livelihoods. Table-10.33 provides a matrix of entitlements for various types of losses and affected persons.

10.10.5.1 Compensation for Loss of Land, Standing Crops and Trees

Cash compensation to be provided for agricultural land is to be based on current market /replacement value to title holders or traditional land rights plus 15% Compulsory Acquisition Surcharge (CAS), as provided in the LAA. Compensation for fruit trees (for up to 10 years) to be assessed at the rate of current market prices. APs that are eligible for semi-skilled and unskilled labour will be given preference to employment opportunities in the Project's implementation works.

10.10.5.2 Restoration of Damaged Community Infrastructure and Installations

There is an existing hanging bridge near power house site which will be upgraded in order to access traffic to the power house site but existing bridge, at weir site have to be improved for the goodwill gesture to the community.

10.10.5.3 Relocation and Income Restoration Strategy

The Project will disrupt one house falling in the power channel area. The total population of the disrupted house is s. The total covered area of this house is about 6 Marla (1,748 ft^2). Loss of residential structure: shifting allowance will be paid to the household and affected people will be allowed to salvage materials from their demolished structures. Residential structure will be compensated on replacement cost basis; that is given in Table-10.34.

As no income generating businesses will be affected by the project, no additional income restoration needs were mentioned by the affected people during the consultation meetings. On site job opportunities however, will be offered to the community during the construction work and affected households will be given preference in employment opportunities.

10.10.6 Institutional Arrangements

10.10.6.1 Institutional Responsibilities and Monitoring Arrangements

SHYDO will be the executing agency (EA) for this Project. A Project Directorate, headed by a Project Director, will be established in SHYDO Regional Office in Peshawar, which will be responsible for the overall execution of the Project. The PD will recruit and appoint local NGO/s as required for resettlement activities. The EA will depute an Executive Engineer level officer as the Deputy Director (DD) in charge of the land acquisition and resettlement operations, who will report to the Project Director. He/she will work in close coordination

with the respective field-based offices and Project NGO/s on the day to day activities of the resettlement plan implementation.

The DD through the field offices, District Land Acquisition Collector/s (LACs) in KPK and Project NGO will execute and monitor the progress of the work. He will ensure coordination between the relevant departments, NGO, the Grievance Redress Committee (GRC) and the Project's affected people (APs). In addition, the Project Directorate will establish environment and social assessment units that will also be responsible for periodic internal monitoring and evaluation of the Project activities, including ARP implementation.

10.10.6.2 Land Acquisition Organization

The LACs are formally responsible for acquiring the identified land/s from the respective landowners and paying the due compensation money to the affected landowners according to procedures laid down in LA Act, 1894 and the Entitlement Matrix (Table-10.33). Once acquired and the compensation paid to the APs, LACs will hand over possession of the acquired lands to SHYDO for utilization in the project implementation.

Thus, as far as the land acquisition part of the RP is concerned, there exists a well organized system and time-tested process in Pakistan. However, with respect to other resettlement-related activities, the government officials lack the necessary know-how, as there exists so far no formal resettlement policy. Accordingly, SHYDO has no institutional mechanisms for resettlement planning, implementation and monitoring & evaluation within the present organizational set-up. Thus, the Project will have to depend mainly on external technical assistance for implementing the resettlement-related activities, side by side with their internal institutional capacity building in their Department for future self-sufficiency. This will be done by hiring the following additional expertise:

a) A Resettlement Specialist is being proposed in the team of Project Supervision

Consultants to provide technical assistance in resettlement planning, implementation and internal monitoring and evaluation;

b) A Local Panel of Experts is being proposed to conduct periodic monitoring and evaluation of implementation of the ARP activities.

10.10.6.3 Grievances Redress Committees

Various provisions under the Land Acquisition Act (1894) enable aggrieved "Affected Persons" (APs) at different stages of the land acquisition process to represent their cases to the Land Acquisition Collector (LAC) or even refer to the court of law for redressal and seek higher rate of compensation. However, the major grievances that might require mitigations include:

a) APs not enlisted;

b) Losses not identified correctly;

c) Compensation/assistance inadequate or not as per entitlement matrix;

d) Dispute about ownership;

e) Delay in disbursement of compensation/assistance; and

f) Improper distribution of compensation/assistance in case of joint ownership.

Thus, the main objective of the grievance redressal procedure will be to provide a mechanism to mediate conflict and cut down on lengthy litigation, which often delays such projects. It will also provide people who might have objections or concerns about their assistance, a public forum to raise their objections and through conflict resolution, address these issues adequately.

The project will establish a Grievance Redressal Committee for each contract, headed by the District LAC in KPK with two or three local councilors including at least one women councilor, local NGO/CBO and officials of SHYDO. The DD/RSDC or his nominee, a field-based Assistant Engineer will be the member-secretary of the committee and shall act as the Project's Grievance Officer. GRC will meet at least once a month and the decision of GRC would be final. The Committee shall deliver its decision within four to six (4-6) weeks of registration of the case. The functions of the Grievance Redressal Committee shall be to:

a) Provide support to APs on problems arising out of their land/property acquisition and/or eviction from the road ROW land;

b) Record the grievance of the APs, categorize and prioritize the grievances that need to be resolved by the Committee; and

c) Report to the aggrieved parties about the developments regarding their grievances and the decision of the Project authorities.

10.10.6.4 General Implementation Schedule

The land acquisition is a complex and lengthy process in Pakistan; it is expected to formalize the acquisition quickly due to priority given to the Project by the government. Generally, the process of land acquisition in Pakistan takes about a year The SHYDO should adopt the implementation schedule given in Table-10.35 to ensure the quick land acquisition process.

10.10.7 Monitoring and Evaluation

The SHYDO through EA will be responsible for internal monitoring of the resettlement through their field office. The Resettlement Specialist will provide necessary technical assistance in implementation and monitoring the temporary land acquisition. He will ensure the coordination between the relevant departments, the Grievance Redress Committee and the Project's affected people.

In addition, a part-time Monitoring Consultant will be responsible for independent external monitoring. He will evaluate the satisfaction of the affected people regarding their compensation for their temporarily affected land. Towards the end of the project both internal and external monitors will make sure that the farmland will be restored properly and

handed over to the original owners. Both consultants will submit a final report to SHYDO/ADB.

10.10.7.1 Indicators for Monitoring and Evaluation

The following will be considered as the basis for indicators in monitoring and evaluation of the project:

- Socio-economic conditions of the APs in the post-resettlement period
- Communications and reactions from APs on entitlements, compensation and options
- Alternative developments and relocation timetables etc.
- Changes in housing and income levels
- Valuation of property
- Grievance procedures
- Disbursement of compensation and
- Level of satisfaction of APs in the post resettlement period

10.10.8 Environmental Impacts of Resettlement Plan

The project will have limited environmental impacts with the mitigation and environmental management plan proposed in the section 10.7.

10.11 Estimated Environmental Cost

Environmental costs are based on the expenditures required to neutralize the impacts, due to the construction of the project, on the environmental settling, social aspect and ecology of the surrounding area. Flood has direct impact on the environmental cost of the project. Before flood environmental cost was 14.806 million rupees and after flood it is 13.567 million rupees.

10.11.1 Compensation for Trees plus Afforestation Cost

The main components covered in Afforestation cost is compensation for loss of trees and re-plantation of trees.

Before flood there is some 204 tree have to be removed with total compensation was 0.152million rupees. After flood there is only 155 trees have to be cut with compensation cost of 0.113 million rupees.

10.11.2 Environmental Monitoring Cost

Monitoring cost mainly consists of the equipment required for checking and testing of water quality, air quality and noise levels during construction and operation phase of the project.

10.11.3 Resettlement Cost Estimates

The replacement cost of land is based on current market prices. The market value was assessed on the basis of recent transactions and consultations with the affected persons and other community members as in most cases transactions are verbal and not documented.

Before flood resettlement cost was 12.67 million rupees and after flood is comes down to 11.47 million rupees because land category has been changed from agricultural to waste land.

Before flood agricultural land was 28 kanal, its estimated cost was 8.40 million rupees at the rate of Rs.300, 000 per kanal, forest land was 6 kanal with 1.20 million rupees for compensation at the rate of Rs. 200,000/ kanal and wastes land was 14 kanal with total value is 1.40 million rupees at the rate of Rs.100, 000 per kanal.

After Flood quantity of agricultural land is 24 Kanal with Rs. 7.20 million, forest land is 2 kanal with Rs. 0.40 million and waste land is 22 kanals with Rs. 2.20 million with same unit rate. Comparison of both costs is given in Table-10.36.

10.11.4 Recommended Environmental Cost

Recommend environmental cost is 14.776 million rupees (say 14.8) because it might be quite possible that, in near future, people will reclaim their flood affected land. Table-10.37 shows recommended environmental cost.

10.12 Conclusions and Recommendations

10.12.1 Conclusions

This report presents the results of an Initial Environmental Examination of the proposed Karora Hydropower Project (9.3 MW) in both pre – flood conditions and post – flood conditions.

Karora Hydropower Project falls in the IEE category according to the provision of Pak-EPA regulation (SRO 339 (I)/2000) which states that an IEE is required for Hydroelectric project less than 50 MW.

In spite of the fact that the project activities, at some components, have adverse effects of medium to high level in certain environmental areas, the overall environmental impact rating is low adverse. The benefits of the project operation and the compensation package proposed herein outweigh the adverse effects of the project.

Construction of Karora Hydropower Project will bring following impacts in the area;

Beneficial Impacts:

- Hydropower is a clean and renewable source of energy and avoids contributions to pollution loads, hence it is environment friendly.

- Creation of an impoundment of relatively shallow depth will be helpful for development of fishery.
- The construction of the project will open job opportunities for the local people. This will help in raising their living standard.
- The provision of electricity in the area will bring prosperity and improve the living standards of the local people.
- The creation of reservoir will open the area to tourism which will again be economically beneficial for the local communities.
- Two bridges will be improved and upgraded for access traffic and pedestrians for the well being of local community.
- Last but not least, prevent from floods.

Adverse Impacts:

Pre – Flood Conditions

- The Project is going to consume about 64.32 kanal of land which includes 44.32 kanals of agricultural land, 6 kanals of forest or grazing land and 14 kanals of waste land.
- The impact on vegetation is not high. About 204 trees (133 shade trees and 71 fruit trees) will have to be cut.
- The construction activities will affect air quality and cause noise-related hazards, which will be of concern, especially at the Powerhouse where some settlements are close by.
- Depletion of river flows when the water is diverted through Power Tunnel will affect the population of villages falling in the river stretch between the Weir and the Powerhouse. People use river water for irrigation purposes through cemented or non- cemented water channels, and for running grain grinding mills.
- The Project will disrupt one house falling in the power channel route. The total population of the disrupted house is 7. The total covered area of this house is about 6 Marla (1,748 ft^2).

Post – Flood Conditions

- After the flood land use status consumed by the project has been changed. Over all land requirements is same which is 64.32 kanals, which includes 40.32 kanals of agricultural land, 2 kanals of forest or grazing land and 22 kanals of waste land.
- About 112 of shade trees and 43 of fruit trees (155 trees) have to be cut.

10.12.2 Recommendations

During construction, setting up speed limits, in close consultation with the local stakeholders, is recommended. The movement of vehicles carrying construction material

should be restricted during daytime to reduce traffic load and inconvenience to the local people.

Maintenance of heavy machinery and vehicles should be of good order and engines well-tuned to avoid smoke emissions, oil leakages and other chemicals which may result in contamination of land and water.

The villages of the nearby project do not have any proper drainage and sewerage systems which contaminate the nearby Nullah water. It is necessary to provides proper drainage and sewerage system to the villages.

The proprietary land should be compensated in cash in accordance with the market rates currently prevailing or according to the Project Implementation and Resettlement of Affected Persons Ordinance 2001. The average market rates for agricultural land are Rs. 300,000 per Kanal for forest or grazing land Rs. 200,000/ Kanal and waste land is Rs. 100,000 per Kanal, plus 15% Compulsory Acquisition Surcharge.

The health and hygiene practices are primitive. Awareness projects should be conducted.

The project area should be rehabilitated after the completion of project. There should be proper disposal of residual muck material.

There should be proper supervision or monitoring for the environmental management and monitoring plan.

The existing utilities should be rehabilitated before construction, to avoid any inconvenience to the resident of the project area and provide them with alternative arrangement during the construction period.

The proponent should make arrangements in the operation of the project for release of 0.9.18 m^3/sec water from the Weir for downstream reach of the river because agricultural practices are dependent on river water.

It is strongly recommended that Rs. 14.806 million, instead of Rs. 14.765 million (say 14.8 million Rs.), should be consider for environmental cost because it might be possible in near future that people will rehabilitates their flood affected land whenever the project executes.

It is concluded that the Project activities at certain sites will have adverse effects of medium to high level, however, the overall environmental impact rating is "low adverse". The project adequately meets the prescribed environmental standards.

CHAPTER – 3

ENVIRONMENTAL BASELINE CONDITIONS

3.1 General

The environmental baseline conditions have been established on the basis of information gathered through structured interviews, formal and informal scoping sessions and group discussions with the communities of various settlements located along the river and in the vicinity of sites selected for construction of Project components. In addition, information was also gathered from officials of various departments including departments of Forestry, Wildlife, Agriculture and Revenue. The information available from the limited secondary source has also been used for drawing inferences.

3.2 Delineation of the Project Area

From environmental viewpoint the project area is defined as the areas of project influence. Some of these areas are directly impacted while others may be influenced indirectly. For this Project the areas of most concerns are as follows:

- Areas falling in the vicinity of the structures viz. Weir, Power house, Power channel and upstream and downstream portals of the Power Tunnel.
- Areas to be used for establishing construction camps and colony.
- Areas likely to be submerged by water impoundment.
- Areas likely to be used for dumping of spoil material from excavation of tunnel and the sites where weir and power house are going to be located.
- Areas to be used for developing haul tracks.
- Quarry areas.
- About 9 km stretch of the river reach from Weir up to the Power house that is going to be deprived from the river flows during low-flow season for its practical diversion into the Power Tunnel for power generation.
- Areas located on high-benches through which the Power tunnel is going to be excavated. These areas are not going to be directly affected, but it is likely that the settlements on these benches may be disrupted due to vibrations from blasting and drilling of the Power Tunnel.
- Majority of residential area is not going to be directly impacted by the Project; however, the area is likely to have indirect effects of mixed type. Primarily, the induction of heavy machinery and vehicles when transporting construction material from quarries falling on other side of the town will cause traffic congestions and hazards, while on the other hand the induction of outside workforce will be beneficial in boosting the local business.

3.3 Land Resources

3.3.1 Geology, Morphology and Soils

The project area is a part of land formations developed at the foothills of Himalayan Range through tectonic events subsequent to those that caused building of Himalaya. The rock formations include extremely folded beds of various types of sandstones, clay-stones and silt stones. Both the banks of Khan Khwar at weir site are almost fully covered with thick alluvial material having terrace cultivation, cluster of trees at places and self - grown grass and plants etc. The power channel will run along the left bank (Khan Khwar) hill slopes which are generally covered with vegetation, comprising cultivated terraces, self - grown grass and plants and trees. The geological conditions observed for the construction of an open channel did not seem favorable and thus a cut-and-cover concrete conduct had had to be selected. The geologic conditions at forebay, penstock and power house are almost similar and favorable.

Mostly the mountains are covered with primary soils, except along the river and nullahs where the beds are almost devoid of soil material either for steep slopes or for the scouring action of the river/ nullah flows. The texture of the primary soils varies from moderately fine to moderately coarse depending upon the rock type from which these have developed. The soils of the raised terraces in floodplains are generally devoid of the stony material whereas the soils of lower terraces generally contained varied quantities of pebbles, cobbles and boulders.

3.3.2 Seismic Hazards

Karora hydropower plant site is located on Khan Khwar about 4 km from Karora village (near Kuz Kana village), 20 km from Besham, Kohistan. It is located in a zone which is seismically active due to the continuing northward drifting of the Indian plate and its subduction under the Eurasian plate as shown in Figure-3.1. This tectonic activity has resulted in the production of a crustal accretion wedge; the Himalayan range. It is, therefore, evident that the geotectonics of the whole region is related to the collision of the two plates and subsequent formation process of the Himalayan ranges. This tectonic process is the origin of seismicity along the Himalayas and in particular where Northern Pakistan is located. The major regional faults related to the intercontinental collision and considered to be active and capable of generating earthquakes, include Main Karakorum Fault (MKF), Main Mantle Thrust (MMT), Panjal Thrust (PT), Main Boundary Thrust (MBT), Main Frontal Thrust (MFT), Himalayan Frontral Thrust (HFT) and Salt Range Thrust (SRT). Karora Hydropower project is located near the vicinity of Main Boundary Thrust (MBT), Main Frontal Thrust (Kashmir Thrust) and Main Mantle Thrust (MMT)

The Deterministic Seismic Hazard Analysis (DSHA) has revealed that for Karora Hydropower Plant, Kashmir Thrust could be the critical fault, capable of generating a magnitude 7.6 Earthquake (equivalent October 8, 2005 Kashmir Earthquake). Maximum Credible Earthquake (MCE) due to active faults in the region is calculated to be of the order of 0.35g due to an earthquake 7.5 magnitude, having hypocenter at 35 kms from the site.

As a first step, Operating Basis Earthquake (OBE) acceleration can be assumed to be about half of MCE value. The available seismic data has been analyzed to evaluate Peak Ground Acceleration (PGA) at the site. The calculated value of Peak Ground acceleration for Karora Hydropower plant site is 0.15g. After applying the necessary safety factor to the observed PGA, The OBE is calculated to be of the order of 0.21g. As per classification of ICOLD Bulletin 72 (1989) *"Selecting Seismic Parameters for Large Dams"*, the PGA value at Karora HPP site falls in Hazard Class II (Moderate).

Peak Ground Acceleration at Karora Hydropower Plant Site	0.15g
Operating Basis Earthquake value at Karora Hydropower Plant site.	0.21g

The seismic gap perpetually floats on the fault and wherever the situation is seismically suitable, a quake is triggered. Once an area experiences a quake, its epicenter volume is crushed and it becomes unable to accept any further geo-technical stress. This means that once an area has experienced an earthquake, it will not experience another earthquake of a similar magnitude for a long time. The time gap is usually about three to five times the return period of the earthquake. The return period calculated using Gutenberg Richter formula for a 7.6 magnitude earthquake comes out to be around 400 years.

3.3.2.1 The Muzaffarabad Earthquake of 8th October 2005

The Epicenter of the earthquake was at a place called Gori which was 20 km from Muzaffarabad. The epicenter of the earthquake was 10-20 Km below the ground surface (thus it is classified as shallow earthquake and the principal cause of wide spread damage to public and private property). The earthquake measured 7.6 on Richter scale at the Epicenter. The shock wave traveled out as shown in the Figure-3.2. The strength of the shock wave reduced as the diameter of circle of influence increased. The affected areas are shown in pink color. The strength of earthquake felt at various locations as analyzed by US Geological Survey is shown in Figure-3.2.

		Earthquake Strength
Location		**Modified Marcalli**
Intensity		**Scale (MMI scale)**
1.	Gori (epicenter: 20 Km from Muzaffarabad)	XII
2.	Mansehra, Bag and Rawalakot	X
3.	Battagram	IX
4.	Abbottabad	VIII
5.	Islamabad	VI
6.	Lahore	V

Significant loss was limited to areas 1 to 5 listed above. The earthquake of 8th October 2005 has been followed by more than 5 aftershocks above magnitude (Mw=5) and about 2000 of

lower magnitudes. A detailed seismic hazard study has been carried out during the feasibility stage and the project components have been designed accordingly.

3.4 Water Resources

3.4.1 Surface Water

The main surface water resource of the project area is Khan Khwar. It is a tributary of Indus River. The project will utilize the water of Khan Khwar that emerges from the northern part of the districts. The total catchment area of the Khan Khwar at the project weir site is about 230 km^2 and the hydraulic length is about 31 km. Besides the discharge of main trunk, the Khan Khwar receives discharge of many natural streams (Nullahs).Figure-3.3 shows Khan Khwar river passing through project area.

Khan Khwar and most of its tributaries originates from mountains ranging in elevation from 2000 m to 3000 m above mean sea level. Consequently the mountains remain covered with snow caps for parts of the year that contributes the river discharges. However, the major contribution in the annual flows comes from the monsoon rains that are spread from July to September. A minimum discharge observed in the Month of January 2003, is 1.86 m^3/s and maximum value 18.52 m^3/s in the month of April 1991 from weir site. These values depict that mean monthly flows vary between 3.45 m^3/s (9.25 MCM) in December to 11.26 m^3/s (29.19 MCM) in April.

A minimum of 2.03 m^3/s observed in the month of January 2003 and maximum value is 20.2m^3/s in the month of April 1991, at powerhouse area. These values depict that mean monthly flows vary between 3.77 m^3/s (10.09 MCM) in December to 12.29 m^3/s (31.85 MCM) in April.

3.4.1.1 Water Use in Project Area (Before Flood)

The local people use the water of Khan Khwar River for irrigation, micro hydel plant operations and running water mills. There were eight hydel power stations and six water mills falling in the river stretch between the Weir to the Powerhouse. During field survey measurement were conducting to calculate the water discharge. All of these hydel generators possess capacity of 11 kW and average intake discharge is 0.12 cumec. While six water mills are in operation in the project area. On average one mill require 0.08 cumec of water for operation. Detail of all micro hydel generators and water mills with respect to their location, name of the owner and discharge is given in the Table-3.1.

3.4.1.2 Water Use in Project Area (After Flood)

Flood 2010 washed away all irrigation schemes, water mills and micro hydel generators in project area. Now there is no such diversion exist between weir to powerhouse site.

3.4.2 Groundwater

Basically the Shangla district is devoid of any true aquifer. This is because of stony formation of the area and steep slopes of the mountains. The rain water seeped at the mountains comes out in the form of springs which is available in the area. The limited

quantity of water available is being used by the local communities to meet their consumptive and non-consumptive water requirements. The quality of spring water is reported by local to be good and being free from any contamination because of filtrating action of the strata through which it passes.

3.4.3 Water Quality

Water quality of the project area is safe for non domestic consumption because there is no industry exist which discharge their effluent in the river. Even household sewage waste is discharged into nearby nullah and did not reach to the river which causing degradation of river quality. Anyhow, the waters would require appropriate treatment, before these are used for drinking by non – local construction crew.

3.5 Biological Resources

3.5.1 Protected Areas in Khyber Pakhtunkhwa

Khyber Pakhtunkhwa as a whole is believed to possess nearly 17 percent of high hill coniferous forest cover. Various protected areas, spread across the province, are given in the following Table-3.2.

None of the protected areas indicated above are within close vicinity of Karora Hydropower Project.

3.5.1.1 Rare or Endangered Species

There is no rare or endanger species is the vicinity of Karora Hydropower Project.

3.5.2 Flora

The district is rich in natural vegetation. Besides the scattered vegetation in almost entire area, the hills are covered with forests of broad leaf and pine trees in accordance with the altitude. Fruit trees are generally found in the courtyards of the farming communities. Most common trees are Deodar, Pine, Poplar, Daroon, Kikar, Beri, Kahu and Bakain. Fruit trees of Apricot, Pear, Peaches, Persimmon, Walnut, Orange, Banana and Apple exist in area. Main flora in the District is shown in Table-3.3.

3.5.3 Main Flora in Project Area (Before Flood & After Flood)

Before flood, numbers of trees were spread over the project area. In plain areas or terraces shade trees, shrubs and some grasses were also present. Among shade trees Kikar, Deodar, Pine, Bakain, Poplar and Beri, while among fruit trees Orange, Walnut, Persimmon, Banana and Apple were common. Figure 3.4 and 3.5 shows vegetation in the project area, in pre – flood conditions.

After flood frequency of occurrence of flora has been changed, because flood washed away the number of trees in the project area. Among shade trees Kikar and Daraw are completely disappeared while rest of the other shows just decline in their frequency of occurrence in the project area. Detail of Flora in pre and post flood condition is shown in Table-3.4.

3.5.4 Fauna

Most of the fauna in the project area are local. During winter, however, a few migratory bird species visit the project area on route to further south. Owing to winter severity and moderately pleasant and short summers, no significant reptiles have been reported from the project area. Reptilian and amphibian fauna of the area is not well documented. However, local people have reported some snakes. Rock lizards are common in the region. The project area is devoid of any habitat for the migratory species. Some species however use local water resources as resting and feeding ground. Table-3.5 (a) and Table-3.5 (b) enlists the wildlife occurring in the mountains of the District and fauna in project area, respectively.

3.5.4.1 Aquatic Life

Fish diversity in the Khan Khwar River is limited. No definite data is available about the aquatic life and fisheries in the district. There is no commercial fishery observed in the area. Even traditional fishermen do not exist. However, some fishing is carried out for household use and recreational purpose.

Aquatic ecology and fisheries was discussed with the official of wild life department and it was declared that the project area has no natural habitat which impacted with the project implementation.

3.5.4.2 Avifauna

Bird life is scanty. The birds such as crow, kite and common sparrow, King Fisher, Little brown dove can be seen. The bird population is thin in project area.

3.6 Climate

3.6.1 General

District Shangla is at an elevation of 1800 to 3100 meters masl and as such the winter season remains extremely cold in the upper half of the district while in the lower half it remains moderate. Snow-fall generally starts by the end of November on the high peaks of the mountains and descends downwards as the temperature falls further. Snow fall also occurs in late February and continues sometimes up to the middle of the March after which the weather becomes pleasant and usually remains mild during the remaining period of the year. The area situated in Tehsil Besham and Martung remains very hot in the summer season. Detailed data of temperature and precipitation is not available directly for district Shangla.

3.6.2 Temperature

The data shows that the average monthly mean maximum temperature varies from 11.2° C in January to 32.5 ° C in June, whereas monthly mean minimum temperature ranges between (minus) -0.9° C in December and 19.3° C in July.

3.6.3 Precipitation

The average annual precipitation in the area is 1,415.9 mm. However, there is a great seasonal variation. The maximum rainfall occurs during the months of February and March

when the average precipitation is 172 mm and 242 mm, respectively. Minimum rainfall is experienced in November with the average of 50.7 mm

Data of mean temperature and rainfall recorded at Dir station for the period 1961-1990 is shown in Table-3.6.

3.6.4 Ambient Air Quality

The air quality of the project area and its vicinity is generally fresh and clear under normal condition. There is no major source of air pollution as there is 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 and major traffic movement which is an occasional occurrence.

3.6.5 Ambient Noise Levels

The project area is located in the valleys surrounded by steep slopes having vegetation. There are very few houses located near the sites of project component. Though the roads are available in the project area but the intensity of traffic is very low and the level of noise is obviously low. Generally, the ambient noise level in the project area is less than the permissible limits of 85 dB A as fixed by NEQS, 2000 and also as compared to the WHO noise guidelines that prescribe a limit of 55 dB A with respect to receptors in outdoor areas.

3.7 Human Resources/ Socio-Economic Set-up of the District

The findings of the Social Impact Assessment study has been made part of this subsequent section, however detailed and separate Social Impact Assessment (SIA) and their bearing on the population living in and around the vicinity of the project areas has been described in Volume II – B.

3.7.1 Political and Administrative Set-up

Shangla District covers an area of about 1,586 square kilometers and is administratively divided into five Tehsils namely, Alpuri, Besham, Chakisar, Puran and Martung. Politically, the district is governed by District Coordination officer (DCO) supported by Deputy District Officer (Revenue), The DCO is responsible for law & order and is custodian of state property. On the revenue side, each sub-division has a separate revenue setup consisting of Deputy District Officer (Revenue), officers, kanungo and patwaries.

3.7.2 Demography

The total population of Shangla district is 435,000 according to the census of 1998. The population of the same district was 252,000 in 1981 and an increase of 72.6 percent was recorded over the seventeen (17) years i.e. 1981-1998. The average annual growth rate of population is 3.3 percent in the district during inter censual period 1981-1998. The average household size of Shangla District is 8 persons per family with average population density of 274 persons per sq. km.

All of the population (100 percent) of Shangla District resides in rural areas while no population constitutes urban population.

The majority of population of the district is muslim, constituting 99.80 percent of the total population. Remaining population includes Christians, Hindus, Qadiani/Ahmedi, Scheduled Castes, etc.

The district has been provided with number of educational and health facilities both for males and females. Some private educational institutes and clinics have also been set up which are playing vital role. However, the Project Area settlements of Kuz Kana and Ranial are deprived of education and health facilities. The people have to go too far off places for schooling and health facilities.

3.7.3 Major Infrastructure exist in The District

Shangla District is devoid of any large scale industry. There is one flour mill namely Dubair Flour Mill situated at Besham. Woolen clothing, wool handicrafts and woolen blankets are produced manufactured on small scale as a cottage industry.

Shangla district is linked with the neighboring Districts vide metalled and non-metalled roads and foot-tracks where as inside the district the roads are somewhere metalled and some-where non-metalled. About 127 kilometers of metalled and 195 kilometers of non-metalled roads are spread throughout the district, out of which 40 kilometers long Shahrah-e-Karakuram Road also passes through the eastern boundary of the district.

One digital telephone exchange at Lilownai / Alpuri has been installed recently containing a total of900 lines while in Besham a telephone exchange system is in function. Besides, an old central battery telephone exchange containing a total of 134 local connections is also in function while two inter-district digital numbers have been allotted from Khawaza Khela telephone exchange (Swat) to this district.

As already stated, the health facilities are limited in the district. There is one Tehsil headquarter hospital at Alpuri, four Civil Hospitals at Chakisar, Puran, Besham and Karora, fifteen basic health units, eleven dispensaries and two leprosy centers. There is no District Education Officer (Male/Female) in the district. Mostly, the educational institutions belong to government however; some schools have also been established in the private sector. The district has been provided with two degree colleges at Alpuri and Puran, one intermediate college, three higher secondary schools, twenty eight high schools, twenty eight middle schools, five hundred and ninety nine primary schools and one vocation centre.

The villages are invariably supplied with electricity and telephone facilities except the ones that are located in difficult terrains, access point of view.

3.7.4 Socio-Economic Setup of the District

The socio-economic environment of the district is a mixture of rich and poor with a low percentage of middle income groups. Due to lack of economic activities in the area, the people of the area started migrating abroad in search of opportunities. The earning from abroad is being invested in different kinds of activities such as in purchase of land and

constructing houses. The trend of investment in industrial sector is generally non-existent, mainly because of non-availability of know-how, incentives and difficult terrain of the area. However, investment in commercial sector is quite common.

On the other hand, the people who could not avail the opportunity of migrating abroad or came back early from abroad due to family constraints are in poor condition. The people of latter category invariably spent their earnings from abroad on constructing houses instead of investing in economic sector. Both categories of people are relying for their earning from small agricultural land holdings and/or providing services on daily wages.

The main economic activity in the area remains in agriculture, livestock and service sectors. Of the total land area of about 391,742 acres of the District, 30% is available for cultivation while 70% of the land bears forest, settlements, infrastructures or lie in the form of uncultivable waste land. Wheat, maize and rice are cultivated on about 43,900 acres, 91,278 acres and 3,571 acres of land, respectively.

3.7.5 Availability of Social Amenities in the District

Electricity: Limited electricity supply network exists in the area.

Drinking water: Drinking water is usually from springs. The water is collected manually from the springs or it is piped to the settlement. It has been reported that spring water is of good quality. No person reported of disease due to poor quality of spring water.

Sewerage: There is no sewerage system in the project area.

Post office: The postal service exists in the towns of Shangla.

Telephone, Fax, internet and mobile phone: The extensive network of mobile telephone exists in the area while the project area is not well connected to the whole country and the world.

Television: The television service is available through satellite dish. At some locations the local TV signals are also received.

The picture of the project area is, however, somewhat different from the district statistics.

3.8 Human Resources/ Socio-Economic Set-up of the Project Area

3.8.1 Statistics of Population

Kuz Kana village (weir site) is located in Union Council Kuz Kana in Alpuri Tehsil of Shangla District. The population of Kuz Kana UC is 10,368. Kuz Kana with a population of 7,276 is the biggest village population wise amongst the two villages falling in the UC Kuz Kana. 51.7% of total village population belongs to male gender. Above 18 year population is 47.1% while 37.8% falls in the category of 21 year old and above. Out of women of marriageable age 80.6% are married.

Ranial village (power house site) is located in Union Council Ranial in Alpuri Tehsil of Shangla District. The population of Ranial UC is 11,731. Ranial with a population of 2,868 is

the 2nd biggest village population wise amongst the three villages falling in the UC Ranial. 52.4% of total village population belongs to male gender. Above 18 year population is 48.4% while 40.3% falls in the category of 21 year old and above. Out of women of marriageable age 82.4% are married.

Literacy rate of above 10 year plus population of Kuz Kana village is 12.1% and that of Ranial is 5.4%. The Project Area settlements of Kuz Kana and Ranial are deprived of education and health facilities. The people have to go far places for schooling and health facilities.

Project area is home to a diverse group of people including different tribes and clans as shown in Table-3.7.The Table shows, Shalmani Pathan are 48.3%, Sunar are 3.4%, Syed are 20.7%, Yousaf zai are 6.9% and Mian are 20.7%.

70% Pacca, 3% semi Pacca and 27% Kacha housing structure exist in Kuz Kana (weir site). While at Ranial (power house site) 83% Pacca, 10% semi Pacca and 7% Kacha housing structure exist. 5.6% houses of Kuz Kana village and 4.8% houses of Ranial village has potable water facility and only 0.2% of houses in Kuz Kana and 0.6% percent of houses in Ranial has electricity facility.

3.8.2 Land Ownership Status in Project Area

The lands in the project area are mainly proprietary and used for cultivation and settlements. The river and nullah beds along with side, slopes are also proprietary land .As such, the Project components, viz., Weir, Intake structure including intake portal of the Power Tunnel and Power Channel will be located on the proprietary land. The land required for construction camps and colony will be acquired from the land available along the river bank near village Ranial and Kuz Kana. Mostly people are resident owner having formal legal status. On the other hand, the reservoir will cover proprietary land and shamlat as well. It is also observed that the landholdings are small.

3.8.3 Land Use in Project Area

Of the total landholdings in the project area 50.79 % is available for cultivation, 23.62 % is forest land and 25.59% is waste land or lie in the form of uncultivable waste land. Different land types in the project area are shown in Table-3.8.

3.8.4 Major Crops Cultivated in Project Area

Wheat and Maize is cultivated on 100% and 80% of available agricultural land in project area, respectively. Wheat is cultivated for the individual families self needs and average cultivated land per family is about 2- 15 Kanals. Rice is not a common crop in project area. Detail of crop cultivated in project area with respect to their production in kgs/kanal and per kilogram price, is given in Table-3.9.

3.8.5 A. Detail of Affected Property (Before Flood)

The area to be consumed by the Project structures in pre – flood conditions viz, reservoir, channel, sand trap, power house, and camps & colony and approach roads is given in Table-3.10 (a) and also shown in Figures-3.6 and 3.7.

3.8.5 B. Detail of Affected Property (After Flood)

After the flood 2010, the land consumption by the project structures has been changed. Changed comes in the land use status not in due to ownership. The area to be consumed by the Project structures; reservoir, colony, and camp and approach roads in post – flood conditions is given in Table-3.10 (b) and also shown in Figure-3.8 and 3.9 at end of the chapter.

The Project is going to affect lands of about 18 families from villages Kuz Kana (12 No.) and from village Ranial (6 No.). Out of these, only one family will be losing their land as well as their structure while the rest of 17 families will lose cultivated or other land types.

3.8.6 Occupation, Income and Household Assets

Most of the people are following labour as occupation. Agriculture and business (shop or water mill) are other occupations. Generalized view of occupation in project area is given in Table-3.11.

3.8.6.1 Household Assets

Data was collected on the assets possessed by the households (HH) which reflect that 100% of households posses Radio. Cell phone is available with 13.8 of the households and vehicle is present within 20.7% households. Average % of assets with their average per unit price can be seen in Table-3.12.

3.8.6.2 Other Assets

Results of social survey show that 0.33% households own a shop/business, Water mill is owned by 0.3 % of HH and mature fruit and shade trees are possessed by more than half of the households. These results along with average number of assets available within a household and average per unit price are given in the Table-3.13.

3.8.6.3 Livestock

Socio economic data reflects that livestock holding per household is not very high. On the average, each household possess 0.83 Cow, 0.33 Buffalo and 6.23 Poultry/Chickens. (See Table-3.14).

3.8.7 Food Sufficiency and Security

Most of the respondents do not experience any shortage of food in any part of the year. However, according to less than one third of respondent households, food deficiency does occur in winter months.

3.8.8 Development Issues in Project Area

The most pressing problems currently faced by the respondents are lack of bridge crossings over the river and tributaries, health facilities and educational opportunities within the project area. They wanted the Project to bring physical infrastructure, educational, health and other facilities to the area and to improve the services and ultimately the living standards of the community.

3.8.9 Gender Situation in Project Area

Within the prevailing social culture, preference of a son over a daughter is predominant mainly for reasons of securing lineage and right to property. Women are infrequently consulted; usually men have the deciding power and even make purchases for the females. Rural women mostly remain inside the home. Young girls are born to be submissive and have to obey the rules laid down by the males.

The situation of women in the project area has been analyzed through Gender Survey conducted in the project villages. An overall situation of women in the project area based on the findings of this survey is summarized below.

Food Consumption: Women's share in the daily consumption of food was assessed in comparison with men. According to the opinion of 65 % of respondents, women's share in daily food consumption is somewhat less as compared to men. Protein in the form of meat, eggs, milk and beans are frequently consumed by women, i.e. there is no gender difference in the quality of food.

Housing: On the average each household share 3.11 rooms in which 1.5 rooms are used exclusively by women. Bathroom and toilet facilities within the house are available for women in most of the houses.

Decision Making: Decisions of marriage of children, sale purchase of property and purchase of household consumption items, largely rests with the men with a meager role of occasional consultation with women.

Responsibilities: Women's pressing responsibilities are maintenance of house followed by food arrangement for household, child rearing and treatment of ailing members both men and women.

Awareness of Project: The awareness of the project amongst women is quite low as only 6% women respondents had knowledge that a hydropower project is coming in their area. They however expect that project will be beneficial for the area and shall resolve their some of the economic and social problems. They are anticipating that project will bring schools and educational facilities and hospitals in the area and hoped that the problems of women shall also be addressed and resolved by the project.

3.8.10 Social Amenities in Project Area

The findings of the analysis of field survey on the provision of social amenities/infrastructure for the households reveals that drinking water and washing/bathing points, mosques, graveyards, electricity and primary and secondary schools for boys/girls, are those amenities which are available to either all or to a large proportion of households (see Table-3.15). Comparatively to these above services, dispensary, land telephone connections and disposal of solid and liquid waste, are available to lesser percentages. Availability of social amenities and the degree of efficiency according to residents is depicted in Table-3.15.

CHAPTER - 6

ENVIRONMENTAL MANAGEMENT & MONITORING PLAN

6.1 Environmental Management and Monitoring Plan

The environmental management plan and its institutional requirements have been described in tabular form at Table-6.1. The table identifies the effects of the construction and operation of different project components on various environmental parameters. It also spells out mitigation/enhancement actions. The table also defines the responsibilities of various actors, viz. Proponent, Contractor and the Engineer in the implementation and monitoring of the mitigation actions.

6.2 Objectives of Environmental Management and Monitoring Plan

The Environmental Management and Monitoring Plan (EMM_tP) will help SHYDO to address the adverse environmental impact of the project, enhance project benefits and introduce standards of good environmental practice. The primary objectives of the EMM_tP are to:

1. Define the responsibilities of project proponents, contractors and other role players, and effectively communicate environmental issues among them.

2. Facilitate the implementation of the mitigation measures identified in the IEE by providing the details of each project impact.

3. Define a monitoring mechanism and identify monitoring parameters to ensure that all mitigation measures are completely and effectively implemented.

6.3 Environmental and Social Issues

The social and environmental issues associated with this project were discussed in detail in Chapter 4 and 7 and include:

1. Permanent and temporary acquisition of land for project structures, access road and colonies of project operation and maintenance staff.

2. Appropriately locating temporary construction camps, site office, depots, workshops and concrete and asphalt batching plants.

3. Since excavation for project structures, tunneling and cutting hills for power channel will result in generation of large quantity of excavated spoil, disposal of which will be a matter of great concern.

4. Regulating the procurement of borrow material, soil erosion and land sliding during construction as well as at operation stage.

5. Enhancing and maintaining tree plantation in the project environ particularly on slopes for their stabilization as a compensatory action for loss of vegetation by the project.

6. Ensuring safety of construction crew and local communities during construction and operation.

6.4 Institutional Arrangements for Implementation of EMM$_t$P

Supervision and implementation of the EMM$_t$P will be undertaken by SHYDO management in conjunction with the proposed implementation specialists or supervisory consultant.

SHYDO will also obtain approvals from Khyber Pakhtunkhwa-EPA and then monitor the project and forward monitoring reports on a regular basis to the Provincial EPA as per the requirements of the Federal EPA regulations. This IEE and the EMM$_t$P can form the basis of a submission for environmental approval from the Khyber Pakhtunkhwa-EPA.

SHYDO will be responsible for ensuring that conditions are included in project construction contract documents. It will also ensure that during the construction phase, environmental mitigation measures, as per the EMM$_t$P, are effective and are implemented by contractor. The EMM$_t$P implementation will be coordinated with Government Agencies such as Forest, Fisheries and Wildlife Departments, for such activities as securing removal permits for trees.

As SHYDO does not yet have the expertise and capacity required for implementing the IEE and Abbreviated Resettlement Plan, it will have to depend on additional external technical assistance and will therefore hire the following additional expertise.

Purposed part time, Supervisory Consultants[1] who will be hired directly by SHYDO, to provide technical assistance in implementation of the Environmental Management & Monitoring Plan. Another part-time Consultant (External Monitoring) which conducts the external monitoring and evaluation of the implementation of the EMM$_t$P and resettlement activities for the project.

6.5 Environmental Monitoring Plan

This section provides a monitoring plan that identifies the roles and responsibilities of project staff involved in environmental monitoring, and lists the parameters that will be used in the monitoring process (Table-6.2). The main objectives of monitoring plans will be to:

- Monitor the actual project impact on physical, biological and socio-economic indicators. This will indicate the adequacy of the IEE in identifying and mitigating the project adverse effects.
- Recommend mitigation measures for any unforeseen impact or where the impact level exceeds than that anticipated in the IEE.
- Ensure compliance with legal and community obligations including safety on construction sites.
- Monitor the rehabilitation of borrow areas and the restoration of the construction campsite as described in the EMM$_t$P.

[1] TORs will be decided later with M/S of SHYDO while cost is reflected in chapter 11 of Main Report, Volume I.

- Ensure the safe disposal of excess construction materials.

The main objectives of monitoring during the operation phase will be to:

- Appraise the adequacy of the IEE with respect to the project's predicted long-term impacts on the area of influence physical, biological and socioeconomic environment.
- Evaluate the effectiveness of the mitigation measures proposed in the EMM_tP, and recommend improvements in the EMM_tP, if required.
- Monitor the survival rate of compensatory plantations carried out for loss of vegetation by the project.
- Supervisory consultant hired by SHYDO will also engaged for social monitoring to verify the efficacy and ensure the transparency of land acquisition, compensation and resettlement process carried out by SHYDO with the assistance of concern local department.
- SHYDO will ensure two types of monitoring during the execution of the project with the help of part – time consultant for external monitoring.

(i) Compliance Monitoring - to ensure that proposed measures in the EMM_tP are adhered to, and

(ii) Effects Monitoring - to establish baseline values for environmental parameters such as air quality, water quality and noise levels. Given the circumstances of the project, independent environmental monitoring consultant already engaged for the ongoing project shall be asked to conduct the monitoring program.

- The consultant engaged for monitoring will report their findings on a quarterly basis directly to the Project Coordinator, Deputy Director, federal D/Environment and the Resettlement and Social Committee.

In order to meet the above objectives the following parameters need to be monitored:

- Water Quality / Quantity
- Air and Noise quality,
- Soil Conservation, and
- Waste Disposal

CHAPTER - 9
ESTIMATED ENVIRONMENTAL COST

9.1 Estimated Environmental Cost

Environmental costs are based on the expenditures required to neutralize the impacts, due to the construction of the project, on the environmental settling, social aspect and ecology of the surrounding area. Flood has direct impact on the environmental cost of the project. Before flood environmental cost was 14.806 million rupees and after flood it is 13.567 million rupees.

9.1.1 Compensation for Trees plus Afforestation Cost

The main components covered in Afforestation cost is compensation for loss of trees and re-plantation of trees.

Before flood there is some 204 tree have to be removed with total compensation was 0.152million rupees. After flood there is only 155 trees have to be cut with compensation cost of 0.113 million rupees.

9.1.2 Environmental Monitoring Cost

Monitoring cost mainly consists of the equipment required for checking and testing of water quality, air quality and noise levels during construction and operation phase of the project.

9.1.3 Resettlement Cost Estimates

The replacement cost of land is based on current market prices. The market value was assessed on the basis of recent transactions and consultations with the affected persons and other community members as in most cases transactions are verbal and not documented.

Before flood resettlement cost was 12.67 million rupees and after flood is comes down to 11.47 million rupees because land category has been changed from agricultural to waste land.

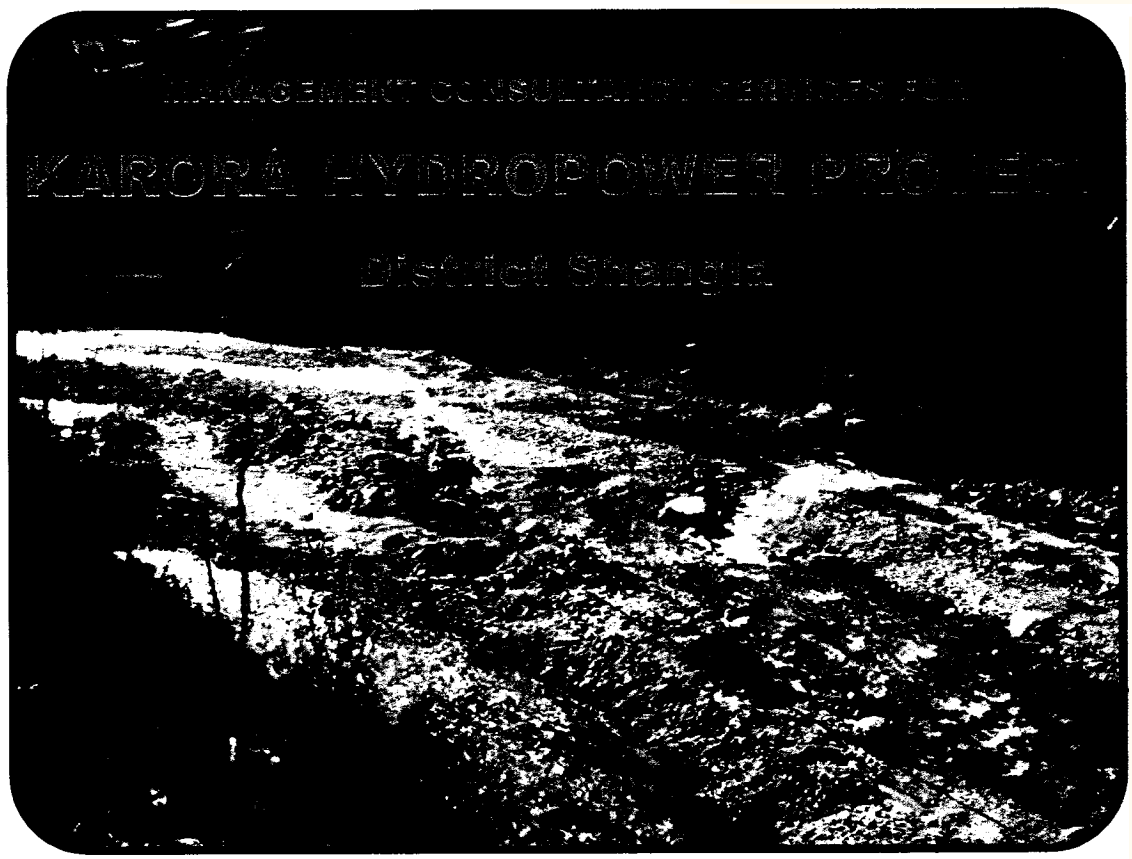
Before flood agricultural land was 28 kanal, its estimated cost was 8.40 million rupees at the rate of Rs.300, 000 per kanal, forest land was 6 kanal with 1.20 million rupees for compensation at the rate of Rs. 200,000/ kanal and wastes land was 14 kanal with total value is 1.40 million rupees at the rate of Rs.100, 000 per kanal.

After Flood quantity of agricultural land is 24 Kanal with Rs. 7.20 million, forest land is 2 kanal with Rs. 0.40 million and waste land is 22 kanals with Rs. 2.20 million with same unit rate. Comparison of both costs is given in Table-9.1.

9.2 Recommended Environmental Cost

Recommend environmental cost is 14.776 million rupees because it might be quite possible that, in near future, people will reclaim their flood affected land. Table-9.2 shows recommended environmental cost.

PAKHTUNKHAWA HYDAL DEVELOPMENT ORGANIZATION (PHYDO)
Government of Khyber Pakhtunkhwa



FEASIBILITY REVIEW REPORT

March - 2014

A Consortium of:
Pakistan Engineering Services (Pvt.) Ltd. (PES)
7-B, Street No. 12, Phase-V, DHA, Lahore Tel: 042-37182500-5, Fax: 92-42-37182508,
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Development & Management Consultants
in association with:
Nippon Koei Co. Ltd., Japan

KARORA HYDROPOWER PROJECT

UPDATION OF INSTALLED CAPACITY FROM 9.3 MW TO 11.8 MW

Hydrological and sedimentation studies in the Feasibility Study (2011) were based on hydrological data for the period 1975 - 2008. Management Consultants (MC) collected additional hydrological data from the Client (PEDO) and relevant agencies for the period 2009 – 2012. This data was incorporated in the hydrological analyses for review of Hydrological Studies and ultimate decision regarding the design discharge and the design flood, during the preparation of Basic Design for incorporation in EPC Bidding Documents.

The revised hydrological studies showed that minimum and maximum average 10 daily discharges were 2.13 Cumecs and 12.85 Cumecs, while average annual discharge was 7.44 cumecs. The design discharge in the new scenario was raised to 9.75 m^3/sec instead of 7.39 m^3/sec of F.S which was flow equivalent to 30% exceedance on the revised flow duration curve.

Utilizing design Discharge of 9.75 m^3/sec (F.S 7.39), design head of 143m (F.S 138m), keeping efficiency of turbine as 92% (F.S 92.4%) and efficiency of generator as 95.5% (F.S 98%), 11.8MW of Power can be generated.

Enclosure: Feasibility Review Report (March 2014)

KARORA HYDROPOWER PROJECT

DISTRICT SHANGLA

EXECUTIVE SUMMARY

FEASIBILITY REVIEW REPORT

EXECUTIVE SUMMARY

Associated Consultant Engineers- ACE (Pvt) Ltd; were assigned the task of conducting the Feasibility Studies of the project in August 2008. Feasibility Studies were completed in August 2011.

A consortium of Pakistan Engineering Services (Pvt) Ltd (PES) and Development & Management Consultant (DMC) in Association with Nippon Koei Co Ltd, Japan was appointed as Management Consultant on 4th day of November 2013.

During site visit it was observed that the proposed penstock alignment is passing through the houses made of concrete and bricks. In this context it was considered necessary to shift the alignment of penstock. Topographic Survey was carried out and revised alignment of Penstock was marked. Revised Centerline of Penstock and Power Houses is nearly 90 m U/s of original alignment. Revised survey also shows existence of houses at the location of Surge Tank, which necessitates shifting of Surge Tank location nearly 30 m towards west and joining the tunnel to Surge Tank.

Revised Penstock and Tunnel alignment alongwith revised Surge shaft locations are shown on Figure No- 6.1 (attached).

The revised hydrological studies show that minimum and maximum average 10 daily discharges are 2.13 Cumecs and 12.85 Cumecs, while average annual discharge is 7.44 cumecs. The design discharge in the new scenario will raise to 9.75 m3/sec instead of 7.39 m3/sec of F.S which is flow equivalent to 30% excedence on the revised flow duration curve. Consequently all other structures except Weir shall be redesigned keeping in view the revised design discharge of 9.75 m^3/sec.

Utilizing design Discharge of 9.75 m^3/sec (F.S 7.39), design head of 143m (F.S 138m) and keeping efficiency of turbine as 92% (F.S 92.4%) and efficiency of generator as 95.5 % (F.S 98%), 11.8MW of Power can be generated. Thus 2 horizontal Francis turbines each of capacity 5.9 MW can be installed.

Annual Energy of 71.39 GWh (F.S 53.44 GWh) can be produced with plant factor of 69.06% (F.S 65.61%). Working sheet on the basis of 10 daily average flows, outputs and Annual Energy is attached, comparison of Salient Features are attached for ready reference.

Karora Hydropower Project-Average 10 Daily Discahrges, Levels, Outputs and Annual Energy

Flows available for 30% of time are used	
Max. Gross Head with all units operating (m)	**152.0**
Max. Net Head with all units operating (m)	**142.0**
Total Design Discharge (cumecs)	**9.75**
Total Power Generation (MW)	**11.8**
Installed Capacity (MW)	**11.8**
Unit Capacity (MW)	**5.9**

Average Energy Produced (GWh)	71.39
Full Capacity Energy (GWh)	103.37
Plant Factor %	**69.06**

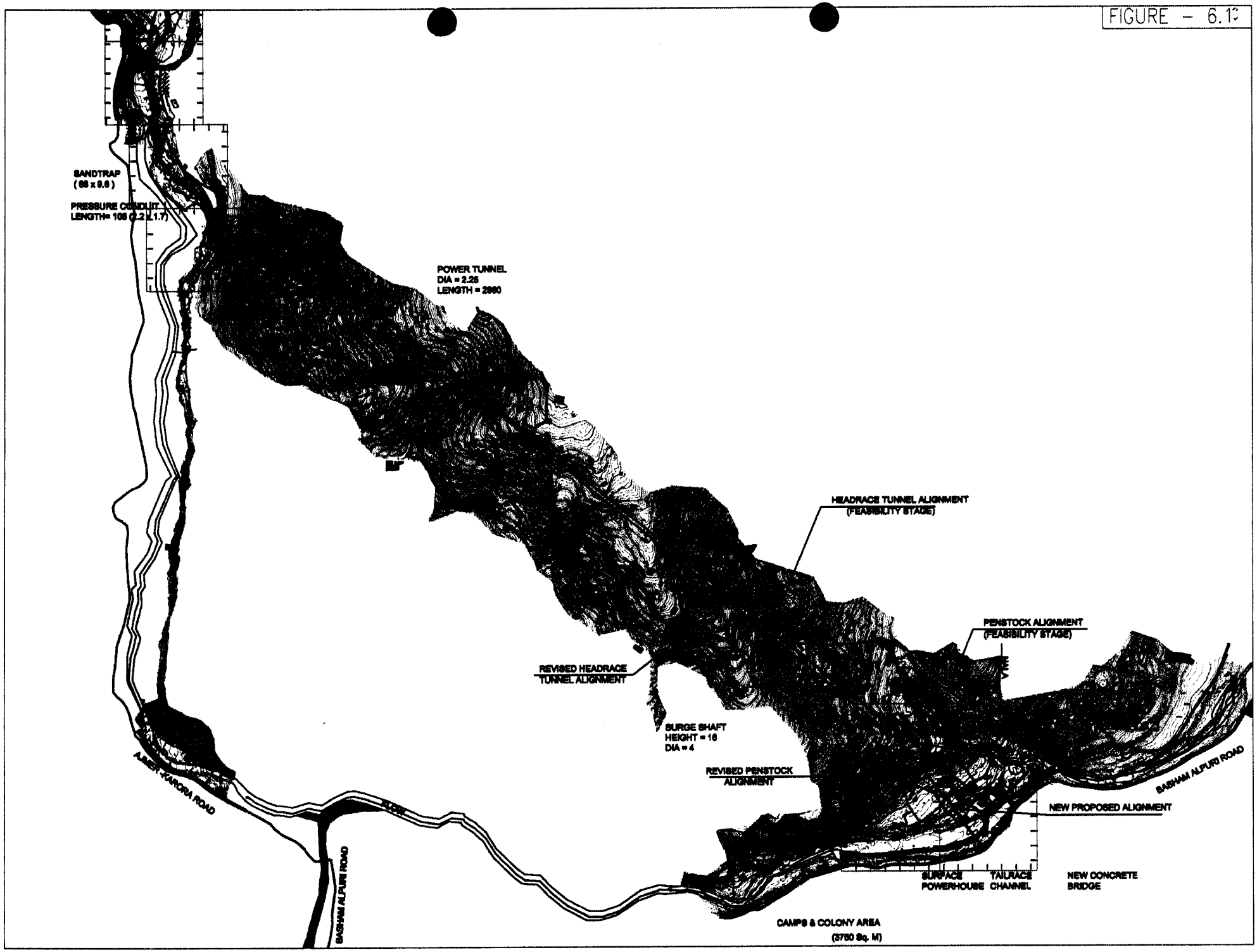
Month	Head Water Level (m)	Flows (cumecs)	Turbines Discharges (cumecs)	Spilled Flows (cumecs)	Tailrace Levels (m)	Gross Head (m)	Head Loss = $10.5 \times 10^{-2} \times Q_2^{\wedge}2$	Net Head (m)	Power Output P =9.81* H*C*0.86/1000 (MW)	No. of Days	Energy (GWH)
	A	B	C	D=B-C	E	F=A-E	G	H = F-G	I	J	K
Jan	1013	2.01	2.01	0.00	861	152.0	0.422	151.6	2.56	10	0.62
	1013	2.93	2.93	0.00	861	152.0	0.901	151.1	3.73	10	0.90
	1013	3.33	3.33	0.00	861	152.0	1.165	150.8	4.24	11	1.12
Feb	1013	4.23	4.23	0.00	861	152.0	1.880	150.1	5.36	10	1.29
	1013	7.47	7.47	0.00	861	152.0	5.856	146.1	9.21	10	2.21
	1013	7.39	7.39	0.00	861	152.0	5.734	146.3	9.12	8	1.75
Mar	1013	7.87	7.87	0.00	861	152.0	6.504	145.5	9.66	10	2.32
	1013	7.35	7.35	0.00	861	152.0	5.670	146.3	9.07	10	2.18
	1013	10.00	9.75	0.25	861	152.0	9.982	142.0	11.68	11	3.08
Apr	1013	10.11	9.75	0.36	861	152.0	9.982	142.0	11.68	10	2.80
	1013	12.19	9.75	2.44	861	152.0	9.982	142.0	11.68	10	2.80
	1013	11.77	9.75	2.02	861	152.0	9.982	142.0	11.68	10	2.80
May	1013	12.99	9.75	3.24	861	152.0	9.982	142.0	11.68	10	2.80
	1013	13.41	9.75	3.66	861	152.0	9.982	142.0	11.68	10	2.80
	1013	12.15	9.75	2.40	861	152.0	9.982	142.0	11.68	11	3.08
June	1013	11.32	9.75	1.57	861	152.0	9.982	142.0	11.68	10	2.80
	1013	10.14	9.75	0.39	861	152.0	9.982	142.0	11.68	10	2.80
	1013	11.01	9.75	1.26	861	152.0	9.982	142.0	11.68	10	2.80
July	1013	9.74	9.74	0.00	861	152.0	9.965	142.0	11.67	10	2.80
	1013	9.45	9.45	0.00	861	152.0	9.374	142.6	11.37	10	2.73
	1013	14.36	9.75	4.61	861	152.0	9.982	142.0	11.68	11	3.08
Aug	1013	12.35	9.75	2.60	861	152.0	9.982	142.0	11.68	10	2.80
	1013	8.43	8.43	0.00	861	152.0	7.459	144.5	10.28	10	2.47
	1013	6.93	6.93	0.00	861	152.0	5.048	147.0	8.60	11	2.27
Sep	1013	8.77	8.77	0.00	861	152.0	8.081	143.9	10.65	10	2.56
	1013	6.42	6.42	0.00	861	152.0	4.332	147.7	8.00	10	1.92
	1013	4.59	4.59	0.00	861	152.0	2.208	149.8	5.80	10	1.39
Oct	1013	3.62	3.62	0.00	861	152.0	1.372	150.6	4.59	10	1.10
	1013	3.23	3.23	0.00	861	152.0	1.092	150.9	4.11	10	0.99
	1013	3.57	3.57	0.00	861	152.0	1.336	150.7	4.53	11	1.20
Nov	1013	3.34	3.34	0.00	861	152.0	1.172	150.8	4.25	10	1.02
	1013	5.91	5.91	0.00	861	152.0	3.669	148.3	7.40	10	1.78
	1013	2.95	2.95	0.00	861	152.0	0.916	151.1	3.77	10	0.90
Dec	1013	2.21	2.21	0.00	861	152.0	0.512	151.5	2.82	10	0.68
	1013	2.39	2.39	0.00	861	152.0	0.602	151.4	3.06	10	0.73
	1013	1.78	0.00	1.78	861	152.0	0.000	152.0	0.00	11	0.00
											71.39

Salient Features Comparison

Feasibility Study Vs Reviewed Feasibility Study

Description	Feasibility Study	Reviewed Feasibility Study
Hydrology		
Catchment Area	230km^2	235km^2
Full Reservoir Level (FRL)	1013.00 masl	1013.00 masl
Mean Monthly Flows	3.24 m^3/s to 11.07 m^3/s	2.13 to 12.85m^3/sec (based on 10-daily)
Design Flow (Q_{30})	7.39 m^3/s	9.75 m^3/sec
Flood Discharge (Q_{100})	719 m^3/s	826 m^3/sec
Flood Discharge (Q_{1000})	1,090 m^3/s	1196 m^3/sec
Flood Discharge ($Q_{10,000}$)	1,475 m^3/s	1565 m^3/sec
Power Facilities		
Powerhouse Type	Surface	Surface
Gross Head	150.58 m ~ 145.92 m	152 m
Net Head	138.00 m	142 m
Installed capacity	9.3 MW	11.8 MW
Design Discharge	7.39 m^3/sec	9.75 m^3/sec
No. of units	2 No	2 Nos.
Turbines Type	Horizontal Francis	Horizontal Francis
Turbine Capacity (each)	4.63 MW (3.7 m^3/sec)	5.9 MW (4.875 m^3/sec)
No. of Generators	2 No.	2 Nos.
Generator Capacity (each)	5.33 MVA	6.27 MVA
Power factor	0.85	0.85
Average annual energy	53.44 GWh	71.39GWh
Plant Factor	65.61%	69.06%
Transmission Facilities		
Transmission line	132 KV-20 Km	132 KV-20 Km
	at Khan Khwar HPP grid station)	at Khan Khwar HPP grid station)

FIGURE – 6.1


SANDTRAP
(66 x 8.6)
PRESSURE CONDUIT
LENGTH= 108 (2.2 X 1.7)
POWER TUNNEL
DIA = 2.25
LENGTH = 2660
HEADRACE TUNNEL ALIGNMENT
(FEASIBILITY STAGE)
PENSTOCK ALIGNMENT
(FEASIBILITY STAGE)
REVISED HEADRACE
TUNNEL ALIGNMENT
SURGE SHAFT
HEIGHT = 16
DIA = 4
REVISED PENSTOCK
ALIGNMENT
NEW PROPOSED ALIGNMENT
BASHAM ALPURI ROAD
ABDI KHAROA ROAD
BASHAM ALPURI ROAD
SURFACE
POWERHOUSE
TAILRACE
CHANNEL
NEW CONCRETE
BRIDGE
CAMPS & COLONY AREA
(3750 Sq. M)

Chapter - 1

INTRODUCTION

CHAPTER – 1

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INTRODUCTION

1.1 BACKGROUND

Associated Consulting Engineers-ACE (Pvt) Ltd were assigned the task of conducting Feasibility Studies of Karora Hydropower Project.

Agreed duration of task, including extensions was from 1st August 2008 to 31st August 2011.

1.2 FEASIBILITY STUDY

1.2.1 Hydraulic Design Considerations

ACE submitted the Feasibility Study in August 2011. According to Feasibility Study, the hydraulic design studies of Karora Hydropower Project include design of weir, intake, sand trap, power tunnel, surge chamber, penstock, powerhouse and tailrace.

The hydrological studies show that minimum and maximum estimated mean monthly net discharges in Khan Khwar are 3.24 and 11.07 cumecs respectively. Based on economic evaluation and optimization, it was decided that powerhouse equipment would be designed for a rated discharge of 7.39 cumecs that will require approximately 9.3 MW of installed capacity.

The main weir structure is proposed to be built in concrete. The overall weir length is 95 m comprising an overflow section of 46.3 m. The full reservoir elevation is 1013 m giving a live storage volume of 121,876 m3. The top of weir is at El. 1021.2 m and 4 m wide bridge is provided above the crest of the weir. The average river bed level is at El. 1005 m. The total height of the weir is 19.10 m above the average bed. The ogee weir, undersluices and bottom outlets are designed to pass a flood of 1,500 cumecs which has a return period of 10,000 years. The main weir is divided in four parts each 10m long and is separated from each other by 1.6 m thick piers. The undersluices have been placed under the piers of the bridge. There are 3

undersluices which have an opening of 1m x 1m and 3 bottom outlets again having an opening of 1m x 1m. The stilling basin is 18 m long. The detail of the main weir is shown on Figures 6.6, 6.7 and 6.8 of the main report.

The intake structure offtakes from the left bank of Khan Khwar. Connecting conduit, 2.8 m x 1.5 m, offtakes from the intake structure. Inlet for the conduit will be 4.0 m wide and 2.1 m high. The inlet is provided with trashrack, stoplog and bulkhead gate grooves. The inlet structure is shown on Figure-6.13 of the main report.

The sand-trap is 9.6 m wide and 70 m long. It has two compartments each 3.9 m wide. It is designed to retain 0.2 mm and bigger size sediment. Complete arrangement of the sand-trap is shown on Figure-6.15 of the main report.

The power tunnel is designed as a horseshoe conduit of 2.25 m equivalent diameter. It is 2960 m long, and has a slope of 1 in 1000. At start of the power tunnel the invert has an elevation of 1001.89 m and at end the elevation is 998.66 m. The velocity in the power tunnel will be 1.86 m/sec. The longitudinal section of the power tunnel and its intake, are shown on Figures-6.3 and 6.16 of the main report.

Surge shaft has been provided at the end of concrete lined tunnel. Based on hydraulic considerations, the cylindrical surge shaft has been designed to have an internal diameter equal to 4 m and a height of 16 m.

Penstock of diameter 1.5m is about 408 m in length, finishing at the inlet valves of the turbines after bifurcation.

A combined Tailrace channel will be provided for the two units. The draft tubes will open up in tailrace channel which will join the river with proper transitions.

Tailwater calculations at the site of weir have been carried out by means of HEC-RAS computer programme. To facilitate calculations and correctness of results, 5 no. river cross-sections have been used

at the weir site and 5 no. cross-sections used at the powerhouse site. The rating curves downstream of weir and at the location of powerhouse are shown on Figures-6.18 and 6.19 of the main report.

The diversion arrangements on the Khan Khwar for constructing the main weir, cater for fourteen months of construction period. The diversion discharge will be equivalent to 10 years return period which is 301 cumecs. The arrangement of cofferdams in two seasons of construction is shown on Figures-6.20 and 6.21 of the main report.

The total head loss in the power system including all the components involving flow, would be 9.0 m at full discharge. The calculation showing head loss in each component is given in the main report.

1.2.2 Mechanical Equipment Studies

Mechanical equipment and systems will include turbines, governors, inlet valves, gates, stoplogs, trashracks, cranes and hoists etc. The turbine selection was made considering 138 m as rated head. As stated earlier, for the installed capacity of power plant, 7.39 m3/sec of flow at 30% exceedence has been selected. From the comparative study of various turbine sizes and combinations, two turbines each with 3.7m3/sec flow have been selected. During 60% of the total time all of the two turbines will operate simultaneously, for 38% of the time one machine will operate, while for 2% of the total time none of the machine, will operate. Considering turbine efficiency of 92.4% for the net head of 138m and design flow of 3.7m3/s, the power will be 4,628 KW for each turbine. These values will result in the turbine specific speed (Ns) of 107.4 rpm. An average runner diameter is considered as 771 mm.

For determining appropriate unit capacity, both technical as well as economic aspects have been examined in a comparative study taking into account equipment dimensions, transport limitations, power and energy benefits, manufacturing experience, power system regulation, and cost estimates etc. Considering generator efficiency as 98%, the total turbine output will be 9,256 KW corresponding to total rated

discharge of 7.39 m3/s and rated head of 138m.

1.2.3 Electrical Equipment Studies

The most important components of the main electrical equipment are the 11 kV synchronous generators of capacity matching with the turbine output, connected to three phase step-up transformers with 132 kV secondary voltage and an outdoor switchyard for connection to outgoing 132 kV transmission lines. Two generators with capacity of 5.33 MVA each have thus been selected.

For transmission of electrical power, two number three-phase step up power transformers with rated capacity of 5.0/7.5 MVA each have been proposed. The proposed switchyard scheme for this hydropower station is of standard configuration i.e. single bus with single circuit breaker arrangement. The electric power generated at Karora hydropower station will be fed to nearby Khan Khwar Grid Station through single circuit 132KV transmission line.

1.2.4 Main Components of the Project

Following are the main components of the project:-

- Weir and Intake
- Power Channel
- Sand trap
- Surge Shaft
- Power tunnel and Penstock
- Power House
- Transmission line

1.2.5 Cost Estimate

The total project construction cost of civil works has been estimated on the basis of rates of various items of work as provided on the web site of Government of KP for 1st quarter of year 2009 for Shangla District. Difficulty factor has also been included therein. Appropriate escalation factor has also been applied to meet with current market prices. In case of cost of E&M equipment, due considerations have

been given to recession in the market. Equipment which can be manufactured in Pakistan has also been appropriately utilized and provided for.

Summary of the Project Cost

Summary of estimated project base cost is tabulated hereunder:

Sr. No.	Description	Local Pak. Rs. (Million)	Foreign Pak. Rs. (Million)	Total Pak. Rs. (Million)
1	**Direct Cost**			
	Civil Works	1,070.15	-	1,070.15
	Permanent Equipment			
	Electro-Mechanical Works	115.58	73.79	189.55
	Hydro-Mechanical Works	-	358.00	358.00
	Transmission Line	31.00	-	31.00
2	**Indirect Cost**			
	Preliminary Works	146.50	-	146.50
	Environment & Resettlement Costs	14.78	-	14.78
	Detailed Design and Tender Documents	27.56	8.64	36.20
	Client Expenses, Administration and Legal Costs	41.34	12.96	54.30
3	**Engineering and Supervision Costs**	55.12	17.28	72.40
4	**Physical Contingencies**	68.90	21.60	90.50
5	**Base Cost of Project**	**1,570.93**	**492.45**	**2,063.38**
6	**Duties & Taxes Costs**	20.57	-	20.57

Price Level and Rate of Exchange

For converting US dollars to Pak. Rupees, the prevailing exchange rate as in **June 2011** has been adopted **viz ., US$ 1.00 = Rs.86.00**.

1.2.6 Recommendation of ACE

Collection of hydrology data be continued at SHYDO Gauge station located at approximately 0.5 km downstream of the proposed weir site.

Additional Geotechnical Investigations as elaborated in Chapter-13 of

the main report are recommended at detail design / construction stage.

Engineering, economic and financial studies have established Karora Hydropower Project as viable. The project is recommended for detailed engineering design and execution.

1.2.7 Salient Features

Salient features of the Project as per Feasibility Study are described below

Salient Features

Project	**Karora Hydropower Project**
Location	Karora (Dist. Besham) KP, Pakistan
WGS 84 coordinates	Weir (E 3177700, N 1191566)
River	Khan Khwar
Type	Run-of-River
Purpose of Project	To supply electricity to National Grid
Hydrology	
Catchment Area	230 km^2
Full Reservoir Level (FRL)	1013.00 masl
Mean Monthly Flows	3.24 m^3/s to 11.07 m^3/s
Design Flow (Q_{30})	7.39 m^3/s for power yield
Flood Discharge (Q_{100})	719 m^3/s
Flood Discharge (Q_{1000})	1,090 m^3/s
Flood Discharge ($Q_{10,000}$)	1,475 m^3/s
Diversion Dam	
Type	Low height concrete diversion weir
Crest Elevation	1018.50 masl
Crest Length	95.0 m
Total Height of Weir	19.10 m
Length of overflow section	46.3 m
Height of overflow section	8.0 m
Spillway	
Type	Ogee, Overflow weir
Crest elevation	1013 masl
No. of Bays	4 No.

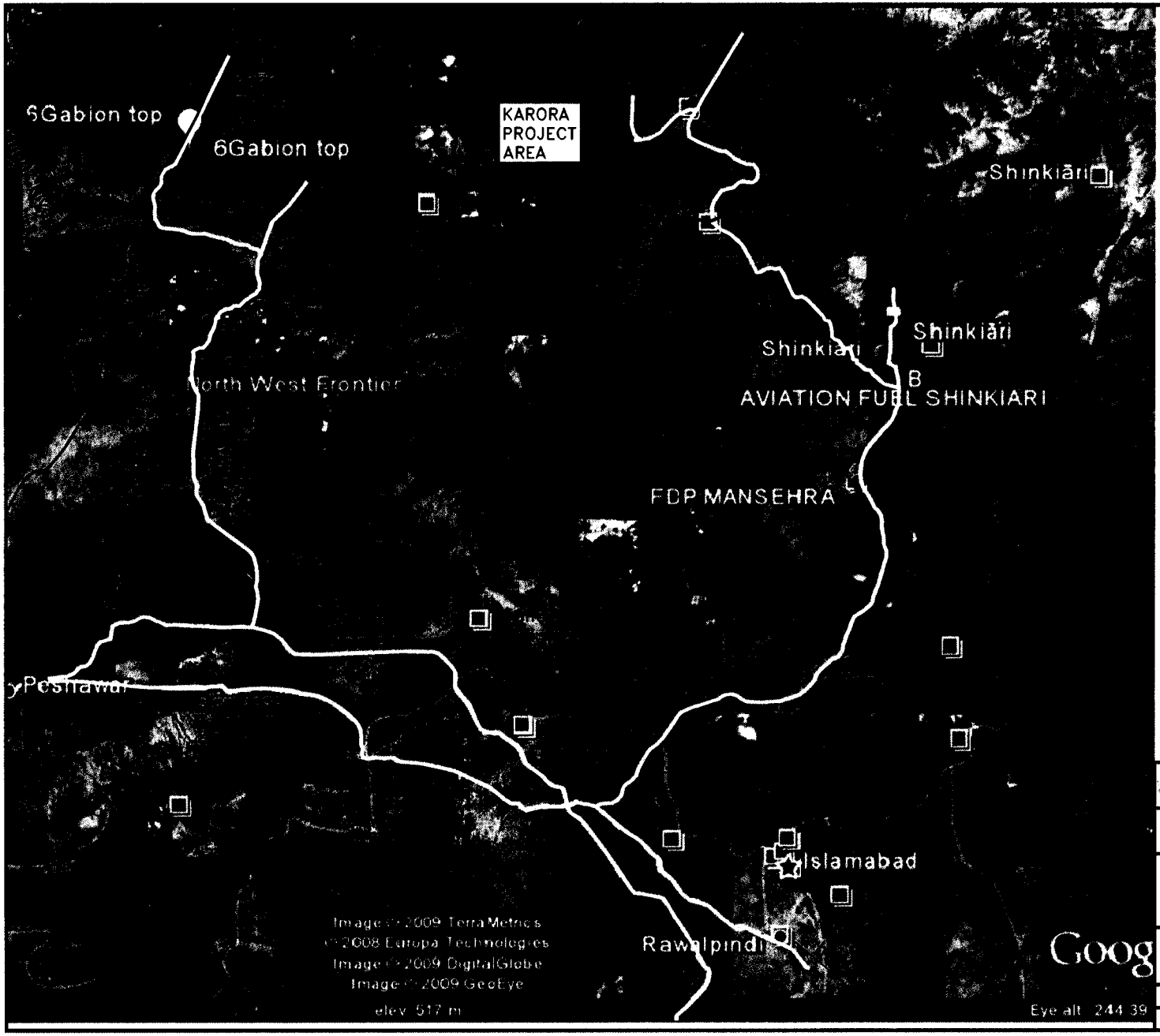
Width of each Bay	10.0 m
Size of Stilling Basin	15.0 m X 35.6 m
Design Flood (Q_{1000})	1,090 m^3/s
Flood passing through Ogee	1423.67 m^3/s
(at El. 1019.8)	
Outlets	
No. of Under Sluices	3 No.
Size of Under Sluices	1.00 m x 1.00 m
Flood passing through Sluices	38 m^3/s
(at El. 1019.8)	
No. of Bottom Outlets	3 No.
Size of each Bottom Outlet	1.00 m x 1.00 m
Flood passing through Bottom Outlets	38 m^3/s
(at El. 1019.8)	
Intake + Box Channel	
Type	Side intake – gate controlled
Conduit Length	430 m
Conduit Size	2.80 m x 1.80 m (Rectangular)
Sand Trap	
Size of Sand Trap	70.0 m X 9.6 m
No. of chambers	2 No.
Particle size to be settled	0.2 mm
Pressure Conduit	
Type	Reinforced concrete
Conduit Length	108 m
Conduit Size	2.20 m x 1.70 m (Rectangular)

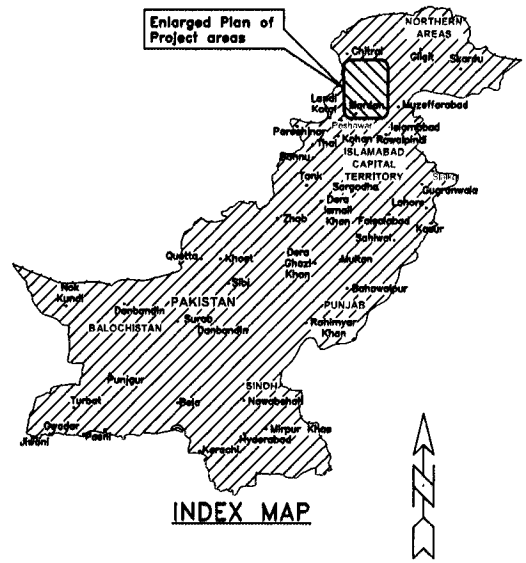
Power Tunnel	
Length	2,960 m
Type	Reinforced concrete lined
Diameter	2.25 m
Tunnel slope	1:1000
Tunnel invert level	1001.89 masl
Velocity in tunnel	1.86 m/sec
Surge Shaft	
Height	16.0 m
Type	Circular, Reinforced concrete lined
Diameter	4.0 m
Penstock	
Type	Mild steel
Length	408 m
Diameter	1.5 m
Thickness	16.00 to 18.00 mm
Velocity	4.18 m/sec
Tailrace	
Type	Rectangular concrete channel
No. of tailrace channels	2 No.
Length of each channel	52 m
Size of tailrace	2.7 m x 2.1 m
Velocity	1.50 m/sec
Power Facilities	
Powerhouse Type	Surface
Dimensions	36.50 m x 16.40 m x 22.79 m(L x W x H)

Gross Head	150.58 m ~ 145.92 m
Net Head	138.00 m
Installed capacity	9.3 MW
Design Discharge	7.39 m^3/sec
No. of units	2 No.
Turbines Type	Horizontal Francis
Turbine Capacity (each)	4.63 MW (3.7 m^3/sec)
No. of Generators	2 No.
Generator Capacity (each)	5.33 MVA
Power factor	0.85
Average annual energy	53.44 GWh
Plant Factor	65.61%
Transmission Facilities	
Transmission line	132 KV-20 Km
	(at Khan Khwar HPP grid station)

1.2.8 Review of Feasibility

Each chapter of Feasibility Study will be reviewed by concerned expert of Management Consultant, and any change or deviation shall be pointed out at the end of Section.





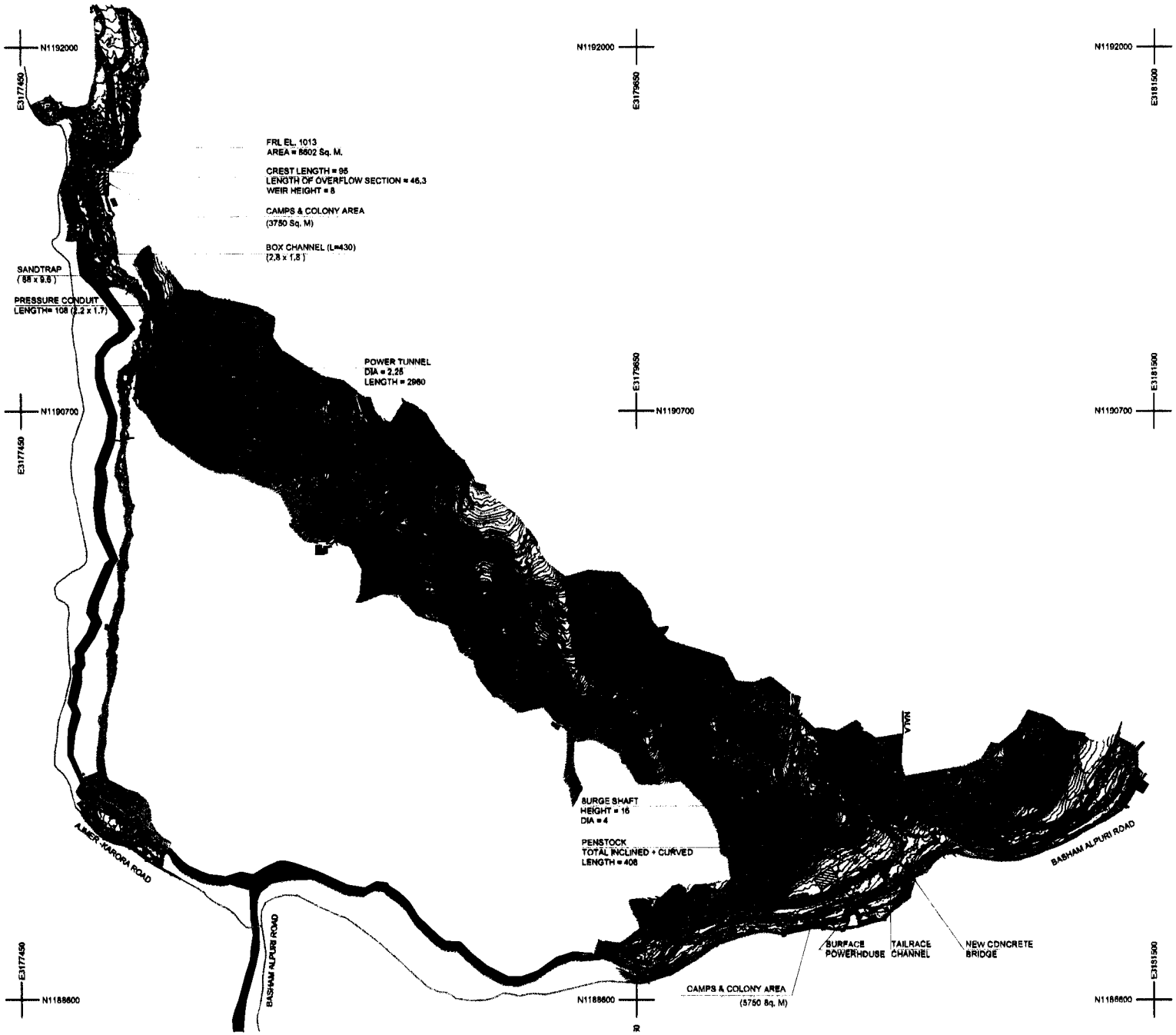
SARHAD HYDEL DEVELOPMENT ORGANIZATION (SHYDO)
GOVERNMENT OF NWFP

FEASIBILITY STUDIES OF THREE HYDROPOWER PLANTS
(KOTO, JABORI AND KARORA)

KARORA HYDROPOWER PROJECT
LOCATION PLAN

ASSOCIATED CONSULTING ENGINEERS ACE (Pvt) Ltd
36-CIVIC CENTRE, M BLOCK MODEL TOWN EXTENSION
LAHORE

DESIGNED	AZHAR MAQSI	CHECKED	M. I. GILL	APPROVED	----
DRAWN	IMTIAZ	DATE	APR. 16, 2010	FIGURE	D-1



NOTE:-

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. MAJOR CONTOUR INTERVAL = 05 m
3. MINOR CONTOUR INTERVAL = 01 m
4. WEIR SITE COORDINATES:
   LEFT SIDE N 1191566.45, E 3177600.83
   RIGHT SIDE N 1191566.12, E 3177627.00
5. POWER HOUSE CORNER COORDINATES:
   N 1189046.67, E 3180520.70

0 100 200 300 400
SCALE

SARHAD HYDEL DEVELOPMENT ORGANIZATION (SHYDO)
GOVERNMENT OF NWFP

FEASIBILITY STUDIES OF THREE HYDROPOWER PLANTS
(KDTO, JABORI AND KARORA)

KARORA HYDROPOWER PROJECT
SELECTED LAYOUT PLAN

ASSOCIATED CONSULTING ENGINEERS ACE (Pvt) Ltd
36-CIVIC CENTRE, M BLOCK MODEL TOWN EXTENSION
LAHORE

DESIGNED	CHECKED	APPROVED
FAROOQ	M. I. GILL	
DRAWN	DATE	FIGURE
IMTIAZ	MAY 27, 2010	D-2

NOTE:-

ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.

SARHAD HYDEL DEVELOPMENT ORGANIZATION (SHYDO)
GOVERNMENT OF NWFP

FEASIBILITY STUDIES OF THREE HYDROPOWER PLANTS
(KOTO, JABORI AND KARORA)

KAROKA HYDROPOWER PROJECT
FEASIBILITY STUDY
L-SECTION OF POWER TUNNEL

ASSOCIATED CONSULTING ENGINEERS ACE (Pvt) Ltd
36-CIVIC CENTRE, M BLOCK MODEL TOWN EXTENSION
LAHORE

DESIGNED	CHECKED	APPROVED
FAROOQ	M. I. GILL	-----
DRAWN	DATE	FIGURE
IMTIAZ	21-04-2010	D-3

Chapter - 2

TOPOGRAPHIC SURVEY AND SATELLITE IMAGES (GIS)

CHAPTER – 2

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TOPOGRAPHIC SURVEY AND SATELLITE IMAGES (GIS)

2.1 GENERAL

Topographic survey has been carried out in the project area for establishing the ground levels, location of existing physical features like rivers, streams, roads and communication systems using modern equipments. Consultants also established control points at locations easily accessible and identifiable at a later stage. The field survey data has been acquired in digital format and then processed using appropriate computer software for preparing the drawings on desired scales.

2.2 SCOPE OF WORK

The scope of work involved was:

- Detailed river X-section survey at alternative weir sites
- Detailed topographic survey of the project area
- Establishing Temporary Bench Marks (BM).
- Construction of Permanent BMs near the existing buildings (Mosque, School, Hospital etc.).

The topographic survey was carried out to achieve the following objectives:

- Cover Intake area and area of all appurtenant structures, with contour interval of 1m on a scale of 1:500
- Power Tunnel with 1 m contour interval on a scale of 1:500.
- Identification of head race tunnel alignment and definition of both portal axes with contour interval of 1 m on a scale of 1:500.
- Penstock area with contour interval of 1 m on a scale of 1:1000
- Power House area including tailrace canal with contour interval of 1 m on a scale of 1:500.

- Area of access road to surge tank and the weir with contour interval of 1 m on a scale of 1:2000

2.3 INSTRUMENTS USED

The following instruments have been used for topographic survey at site.

2.3.1 Total Station TOPCON PT 3000 LN

The instrument works on a unique pulse laser technology which allows measurements upto 250m in reflector-less mode with complete safety and confidence.

2.3.2 E-Trex Ground Positioning System (GPS)

E-Trex GPS is used for finding out approximate co-ordinates of various features in the project area. The instrument has an accuracy rating of ± 3 meter in locating coordinates.

2.3.3 Establishing Horizontal Control

Survey of Pakistan (SOP) grid is always used as reference datum. One SOP bench mark was found in Karora rest house and consultant has used the bench mark values for establishing the control points in the project area. These values are given hereunder

Elevation:	765.675m
Coordinates:	N = 1182206.342 m
	E = 3096904.916 m

2.4 COMMENTS AND RECOMMENDATIONS

2.4.1 List of BM's in and their

Coordinates in tabulated from is attached.

2.4.2 During field visits it was observed that the alignment of penstock decided during the Feasibility Study, parses through houses constructed after 2010 floods.

Alignment of penstock had to be changed and additional survey was

carried out. Revised alignment of penstock is marked accordingly to save houses, graves etc.

2.4.3 Survey Drawings

Drawings showing additional survey are placed as Drawing No. 2.1, 2.2 (A) and 2.2 (B).

LIST OF SURVEY CONTROL POINTS

1	3177622.843	1191587.590	1034.128	11Z
2	3177697.356	1191702.330	1023.388	13Z
3	3177750.012	1191735.012	1014.182	13ZA
4	3177750.020	1191735.017	1014.182	13ZA
5	3177651.558	1191790.008	1037.207	14Z
6	3180423.787	1188928.674	863.651	32Z A
7	3180206.113	1188890.728	867.322	32Z B
8	3180668.452	1188970.844	919.438	35Z
9	3180321.370	1188741.274	947.847	35Z F
10	3180576.416	1189221.611	878.481	35Z A
11	3180597.935	1189177.450	872.607	35Z B
12	3180446.216	1189375.245	990.846	35Z C
13	3180401.543	1189431.492	1005.386	35Z D
14	3180379.620	1188735.900	949.540	35Z E
15	3180414.903	1188860.087	879.096	35Z Q
16	3180572.415	1189028.058	858.090	K 31
17	3177702.351	1191575.583	1022.702	K12
18	3177653.744	1191492.569	1008.409	K12A
19	3177641.500	1190916.250	1018.014	K6
20	3177644.927	1190978.315	1024.117	K6AA
21	3177628.810	1191038.088	1027.550	K6AB
22	3177691.420	1191073.350	1024.034	K6AC
23	3177691.418	1191073.349	1024.041	K6AC
24	3177700.155	1191147.682	1016.154	K6AD
25	3177751.207	1191247.788	1008.700	K6AE
26	3177628.989	1191054.658	1029.890	K7
27	3180624.447	1189005.148	871.380	P29
28	3179907.397	1188782.139	889.976	P41

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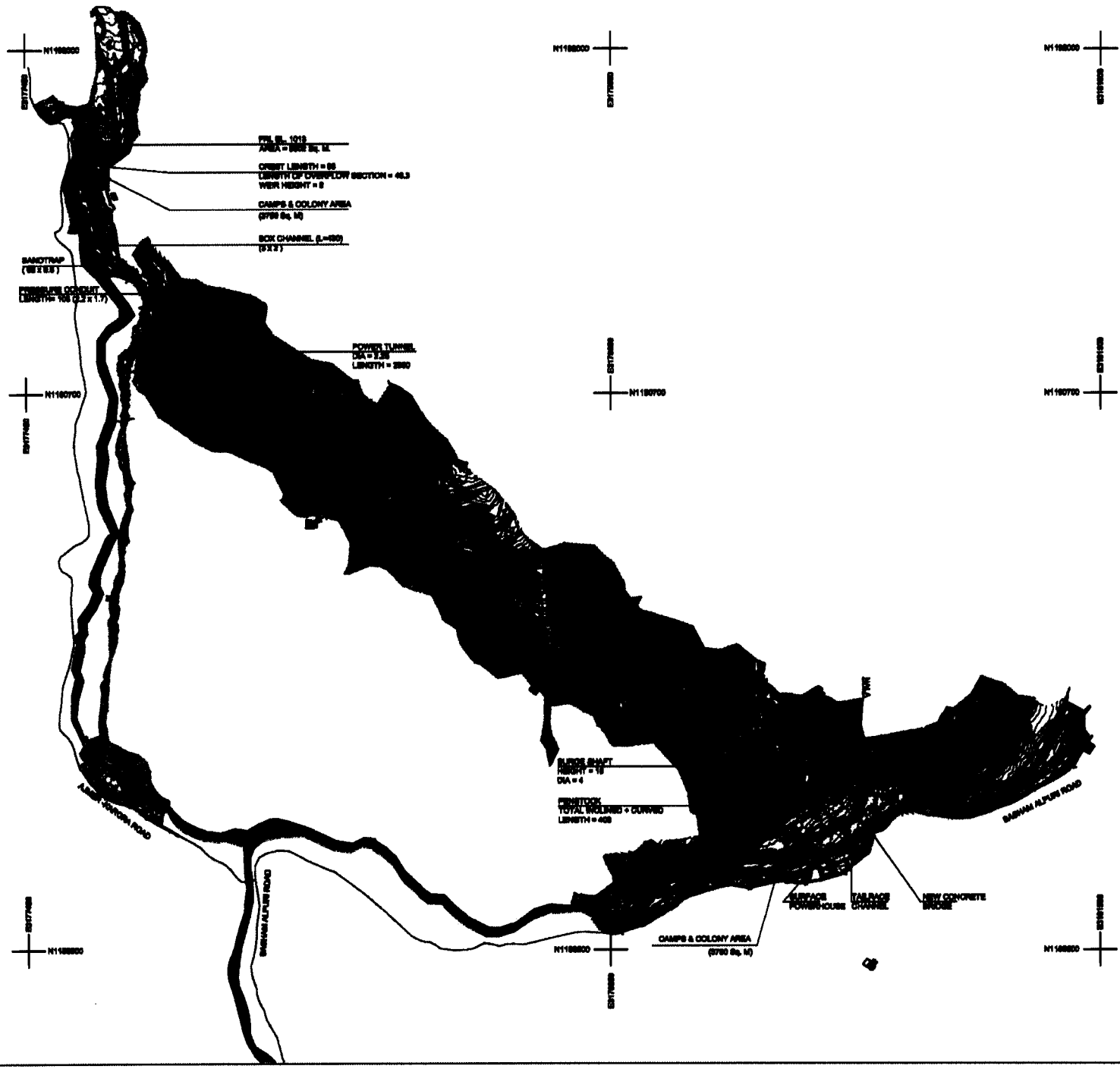

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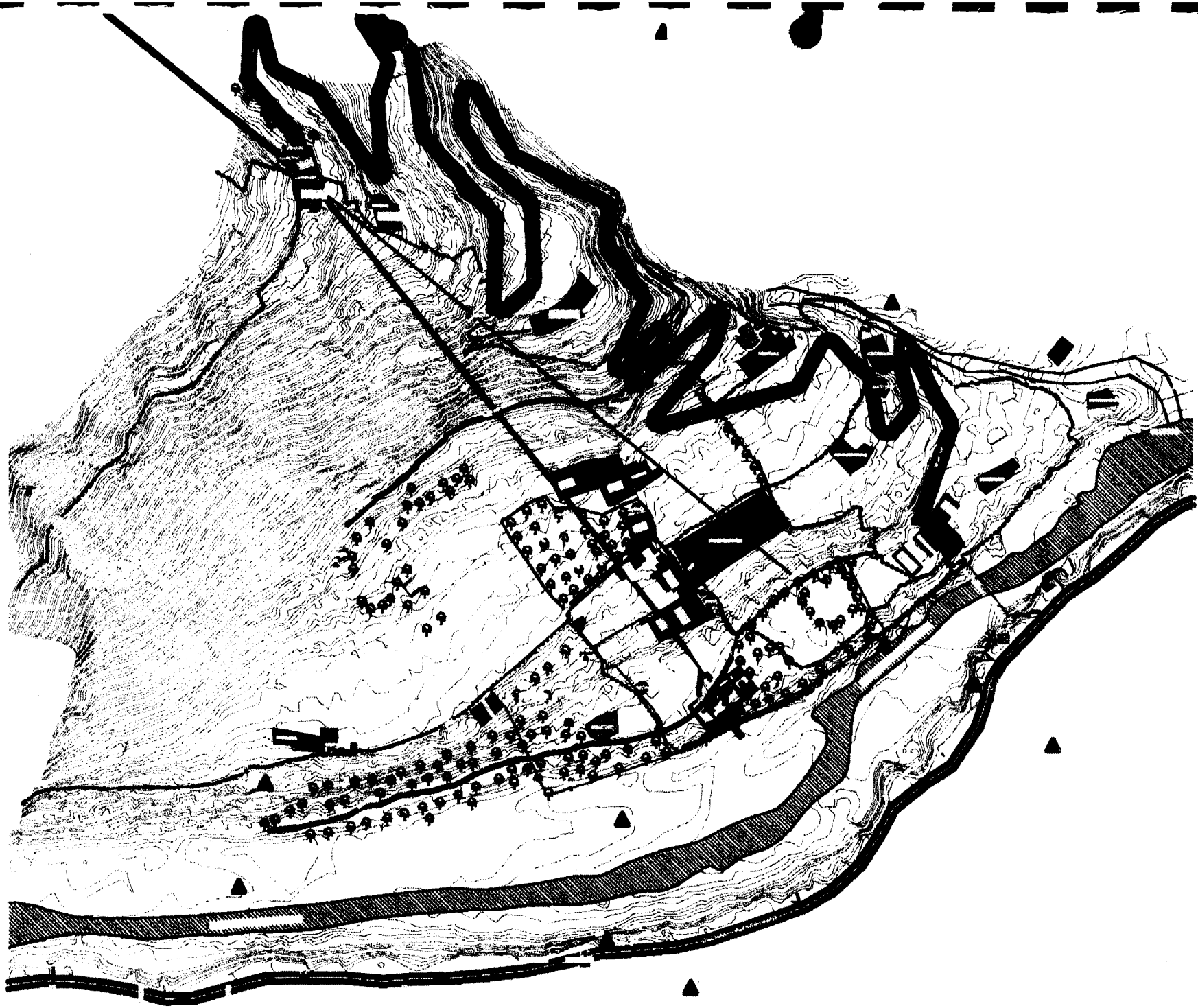

Chapter - 3

GEOLOGICAL AND GEOTECHNICAL INVESTIGATIONS

CHAPTER – 3

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CHAPTER – 3

GEOLOGICAL AND GEOTECHNICAL INVESTIGATIONS

3.1 GENERAL

This section covers the geological and geotechnical investigations of Karora Hydropower Project and the tasks of feasibility studies have been reviewed throughout the geological and the geotechnical investigation.

For developing a complete understanding of the geology and geotechnical aspects of the project area especially at the structure locations, detailed geological and geotechnical investigations are studied and were reviewed, additional geological investigation are added were it was needed.

Detailed geological mapping at the sites of the project components has been carried out to identify the rock exposures and have demarcated the discontinuities such as fault zones, shear zones, bedding and joints. Other geologic structural features such as folds, anticlines and synclines are also and others geological structure and feature such as fault anticline, synclines have been mapped.

Site specific engineering geological mapping were reviewed for the interpretation of discontinuities existing near the selected Weir site, intake area, de-sanders, along the proposed tunnel alignment, surge shaft, powerhouse area and the tailrace tunnel.

Geotechnical information to evaluate the suitability of rock and alluvial materials as foundations, assess the permeability of Weir foundations and abutments, assess the configuration of stable cut slopes, and forecast the construction problems during tunnelling, selection of appropriate tunnelling techniques, tunnel lining design, powerhouse construction planning, and identification of construction materials. Field testing and sampling carried out in the investigation boreholes for determination of engineering characteristics of the underlying stratum at all structural locations.

3.2 TOPOGRAPHY AND GEOMORPHOLOGY OF THE PROJECT AREA

The Project area is situated amongst moderate to high relief Mountains of the Lesser Himalayas. The mountain chains are oriented in variable directions, from East to West and North to South. As a result, the tributaries

and the main rivers of the area flow in different directions and frequently negotiate right angle bends in the Project and its surrounding areas. The Khan Khwar, which is the main artery of the Project area, flows in North to South direction in the weir site area, but in the downstream side segment after its confluence with Ghorband Khwar which joins from the Alpuri side, it takes a right angle turn and starts flowing from west to east until it joins the Indus river some 20 km downstream of Karora. This right angle meander of the Khan Khwar in the Project area has provided promising site for the tunnel and the power potential for this Project.

The relief of the surrounding mountains is quite high, however, in the Project area it is of moderate level, particularly on the left bank of Khan Khwar. The mountain rise moderately to highly from elevation 1000 m in the weir site area to nearly 1600 m in the East (i.e. towards Marin village) forming a high ridge in the middle, through which the tunnel shall lead to the outlet area in Marin.

3.2.1 Regional Geology

The tectonic setting of Northern Pakistan is characterized by the collision of Eurasian Plate in the North and Indian Plate in the South. This collision started in Late Eocene (50 Ma) and is still continuing in the region. The continuous subduction of the Indian plate under the Eurasian plate has given rise to the mega features called Main Karakoram Fault (MKF) in the North and the Main Mantle Thrust (MMT) in the South. The area between these two mega features is occupied by the Kohistan Island Arc (KIA). The Project area is situated in the south close to the MMT and in the rock mass belonging to the Indian Plate as shown in the Regional Tectonic Map-Figure-3.1. The major tectonic feature existing close to the Project site is the MMT, which passes about 20 km North of the Project area.

The Himalayan orogeny in the form of northward movement and subduction of the Indian Plate has resulted into the formation of major tectonic blocks / nappes in this region. The Regional Geological information available in William, M.P. (1989) and Treloar, P.J. (1989) has identified three nappes / tectonic blocks in the southern region of Main Mantle Thrust (MMT) all separated from each other through major shears / fault zones. The three nappes are;

- The Besham Nappe in the centre of the region
- The Swat Nappe in the West and the
- Hazara Nappe in the East.

The Khan Khwar Project site is situated in the Besham Nappe / tectonic block, which is separated from the Hazara Nappe in the East by Thakot shear zone and in the West from Swat Nappe through Puran shear zone. The Indus River flows through the Besham Nappe.

The Besham area geological and tectonic set up has been shown in "The local area Geological Map" reproduced from the available literature and presented in Figure-3.2. This map shows that the Project area is dominantly occupied by the Besham Group of rocks of pre – Cambrian age and the Karora Group of Jurassic age. The Karora Group was originally deposited on the Besham Group, which later on got metamorphosed due to the orogenic process in the region. The geological features belonging to the Besham and Karora Groups are summarized below;

The Besham group consists of the basement rocks subjected to various degrees of metamorphism. The ortho and para metasediments now have resulted into the formation of Granitic Gneisses, quartz mica schists and the graphitic schists with some carbonates (marbles) etc. This group is characterized by the tight isoclinal folds that plunge steeply towards North. Foliation strikes predominantly northwards and dips steeply towards West or East.

The Karora group is a sequence of marine meta-sediments that was deposited un-conformably on top of the rocks of the Besham group. The unconformity is marked by the metamorphosed pebble conglomerates that grades into a thick unit of graphitic phyllite and the carbonates (marble). Foliation in the Karora group is north - trending with steeply dipping towards east and west. This group represents low grade of metamorphism.

3.2.2 Structure of the Besham Area

The Besham basement block is bounded on the east and west by the high angle north – trending Thakot and Puran Faults / shear zones. The structure found within the basement include tight upright to

recumbent isoclinal folds. The discontinuous tectonic lenses, pods etc are aligned parallel to foliation. The major north trending folds affect all the units of the Besham group. The Karora group was deposited unconformably on the top of Besham group which enveloped and preserved within synclines formed by these folds. The western limbs of these synclines are cut by high angle north trending faults, some of them offset the MMT zone. The strata belonging to Besham and Karora groups exhibit a predominantly North trending foliation that dips steeply to the East or West.

As a result of frequent folding and faulting resulting into the formation of anticlines and synclines, the Project area is occupied by both the rock units belonging to the Besham and Karora groups. The Project area exhibits at least one major anticline in the weir site area and one major syncline in the middle of the tunnel area, followed by a series of anticlines and synclines in the Marin area downstream of powerhouse location.

3.2.3 Site Specific Geology

- **Weir Site**

  The weir site area is marked with moderately to high rising hill faces on both the banks, with flat and wide terraces generally occurring along the left bank of Khan Khwar. The Khan Khwar in the weir site is flowing from N to S direction, meanders tightly into S-shaped bend (Plate- 3.1) just 100 m upstream of the proposed weir axis. The weir axis is placed in a straight reach of the river downstream of this bend marked with footbridge. The width of river bed at the weir axis is 20m. Weir site area has been geologically mapped and shown in Figure-3.3. This map shows that the Khan Khwar at the weir location flows through the Western limb of a large anticline, whereas the Eastern limb of the anticline is present along the left bank hill face some distance away from the weir axis after crossing the alluvial terraces.

  At weir axis, continuous rock exposures belonging to Granitic Gneiss are present along the right bank from river level to the area road and above (Plate-4.5). On the left bank, however the rock

exposures are present in the form of thin outcrop along the toe of flat alluvial terrace (Plate-3.4). This strip of rock runs almost parallel to the river for a distance of about 500m. The foliation on the rock on both the sides of the weir is almost parallel to river in N-S direction with high angle dip ranging from 50-70 degree towards West.

- **Tunnel**

  The tunnel starts about 400m downstream of the weir and the alignment is located in Granite / Gneiss. The granite/ Gneiss belong to the Kohistan Island arc Sequence.

  Powerhouse, Surge Shaft and Tailrace

  The Power house surge shaft and Tailrace is approximately 4 km downstream from Weir site in Village Marin. Rock is poorly exposed at Powerhouse site and covered by a thick veneer of overburden. Thick cover of colluvial material is present at left bank where tailrace ends in a nallah. Rock is exposed at places under the Penstock alignment.

3.3 SITE INVESTIGATION PROGRAM

The site investigations program for Karora HPP has been carried out and prepared during the feasibility studies considering the size of project components. In general, geotechnical investigations/ studies carried out are reviewed, namely , surface geological mapping, field investigations (i.e. subsurface exploration and testing, geophysical investigations) and finally, analysis and evaluation, interpretation, and presentation of results. A systematic programme of geological fieldwork carried out by the Consultants including geological mapping and core drilling. The objectives of the geological / geotechnical field investigations have been obtained after reviewed of feasibility evaluation to gain a better understanding of the geological setting of the project area and the particular conditions at each individual site. These include the foundation conditions for the proposed structures, sources of construction materials, reservoir tightness and seismicity of the project area and to produce evidence of potential problems such as the presence, character and extent of deep weathering, fault and fracture zones and potentially unfavourable structural patterns. This studies

presents a satisfactory geotechnical scenario.

The geological fieldwork include detailed mapping of major structure sites, such as the weir site and powerhouse area. The reservoir rim slopes mapped for their slope stability and potential flow paths to adjoining areas. Geological mapping serve as a basis for the location of drill holes. Furthermore,

The following sections briefly describe the main tasks under the above activities.

3.3.1 Geological Mapping

Geological mapping has been based on the interpretation of remote sensing information including satellite imageries and provide a basic regional map identifying the regional structure, faults, joints etc.

Detailed geological mapping carried out for the major project structures relevant to the probable project layouts. Areas of individual project components mapped at appropriate scales, such as 1:1000. On these maps, rock-outcrops, soil-talus cover, alluvial deposits, dip and strike faults and fracture zones are shown along with any unstable areas. Additionally, springs, ravines and streams are mapped. The mapping also include geological cross-sections and longitudinal sections along all relevant structures, borrow and quarry areas, the reservoir and unstable zones affecting the design of project components.

Surface geological maps already prepared have been checked and reviewed along the alignment of the proposed tunnel. These studies include:

- Rock and soil type
- Lithological description
- Structural details
- Faults, thrusts, foliation, shear zones etc.

There is a need to concentrate on the width of faults and characteristics of the material available through its entire width crossing the tunnel. Rock mass classification will also be carried out according to RMR and Q System classification methods to calculate the required data for support system in the proposed tunnel. Rock

and soil samples will be taken at various locations to assist in the cataloguing of outcrops through petro graphic analyses of these samples.

3.3.2 Geophysical Survey

Geophysical survey through Seismic Refraction Profiling at the Project site has been conducted by M/s PEGS. The main purpose of this survey was to determine the bed rock configuration under various structures and also to determine the density of the material in the areas of interest. The seismic data was collected in the field through spreads of 120 m and 240 m in length. Seismic dynamic waves were artificially generated through sledge hammer drop.

In all, 16 Nos of spreads with cumulative length of 3970 m have been executed in the field. The seismic refraction data collected in the field was analyzed, processed and interpreted in the form of sections showing the bed rock configuration along the lines of executed profiles. This information has been used in evaluation of foundation conditions of various structures.

3.3.3 Test Pits Excavation

The test pits were excavated both for the purpose of foundation material evaluation and for the construction material studies. The bulk soil samples were collected from these pits for laboratory testing purpose. Additional test pits excavation will be carried out to firm up the findings if required.

3.4 GEOLOGY AND TECTONICS OF THE PROJECT AREA

The geology and tectonics of the Project area have been picked in the field through survey and is presented in the form of a Composite Geological Map-Figure-3.4 and Figure-3.5 (03 sheets). The soil and rock units have been identified and mapped during the field studies and are described below;

- **Lithology**

  The field studies have revealed that the Project area is occupied by both the loose overburden materials and the rock formations. These consist of the following;

3.4.1 Overburden

- **River bed alluvium**

  The river valley of Khan Khwar at weir site and in the upstream area occupies a rather wide valley; however it is relatively narrow in the downstream side of the weir. The river bed material consists of the gray, loose, sandy gravel cobble with boulders generally of rounded to sub rounded and strong to very strong in nature. This material is of metamorphic and igneous origin. The sand present as matrix is fine to medium grained and is micaceous in nature.

- **Lower Terrace**

  These alluvial terraces generally occur at the lower levels on the banks of river and consist of the old river deposits. At places these are covered with the sitly / clayey material deposited by the river. These consist of light gray to gray colored sandy gravels with varying sizes of coarse fractions of angular, rounded to sub-rounded cobbles and boulders, strong to very strong in nature.

- **Upper Terrace**

  These terraces are present at the higher levels from the river bed and generally consist of both the alluvial and the colluvial (slope wash) material. These normally posses thin to thick cover of silty / clayey material and are under agriculture use. The terrace material is light gray to yellowish brown, firm to stiff, silty clay / clayey silt, overlying the material of varying size from gravel to boulders and occasionally of rock blocks. The coarser fractions are strong to very strong, angular and rounded to sub-rounded gravels, cobbles and boulders of metamorphic and igneous origin.

- **Scree / Slope Wash Deposits**

  This material is situated on the hill slopes as loose angular rock fragments detached from the hill faces above and generally accumulated at the toe of the hill face. Often these extend towards the old river terraces forming colluvial cover. This

material also occupies the nallah beds extending into the main river valley.

3.4.2 Bed Rock Description

- **Granitic Gneiss**

  This rock type represents the highly metamorphosed rock units, generally the acid igneous rock existing in this area have been metamorphosed to this type. This rock type forms the major rock unit in the Project area. It is exposed along both the banks of the Khan Khwar at the weir site, along the conveyance channel and along the tunnel route. This rock type is light gray to milky white, weathered at places to brownish material, medium to coarse grained, massive to blocky and strong to very strong in nature (Plate-3.10). The rock shows prominent jointing system. A few prominent joints are also observed in the rock exposures.

  Besides, this rock also consists of a band of meta – conglomerates, of quartzo felspathic nature, which is exposed along the Kuz Kana road just above the right side of the weir axis. In available literature this has been described as representing the uniformity between Besham Group and the Karora Group.

- **Tectonized Zone**

  This is a unique and significant lithic cum tectonic feature, which has been exposed about 200m from the Intake Portal along the tunnel route. This feature shows complex tectonics and structural changes in the trend and the degree of shearing and fracturing in the Granite Gneiss rock unit frequently intruded by the doloritic dykes / sills. The rocks have been pulverized to the degree that the locals are using this material for concrete. This zone has been described as "Tectonized Zone" in this report and is shown in photographs (Plates 3.11, 3.12 & 3.13). This zone has been given special attention during the design of tunnel excavation and support, however it shall require further studies during next phase of the project.

- **Graphitic Schist**

  The graphitic schist is present generally as moderately thick layers and bands in the country rock i.e. Granite Gneiss. At a few places however, thin bands and lenses of 1 – 2 m thickness are also observed. In the Project area, the graphitic beds have been identified at 2 places along the tunnel route, which range in thickness from 08 m to 25 m, while the third bed nearly 30 to 35 m thick is recorded in the vicinity of the tunnel outlet area. The powerhouse area may also encounter this rock unit which is covered with the overburden terrace materials.

  The graphitic schist is a moderately to highly metamorphosed rock consisting dominantly of the carbonaceous and graphitic material with micaceous and biotitic thin layers and patches. It is dark gray to black in color, weak to moderately strong, fine grained, thinly bedded, highly weathered, jointed, sheared and banded in nature. The main rock mass shows intricate and tight folding with some quartz veins ptygmatically folded at places.

- **Marble**

  The marble / dolomitic rocks are present in the form of thin to thick bands alternating with other rock types in the vicinity of the Powerhouse area. The marble is light gray to light yellow, fine grained, massive, thinly bedded, moderately strong to strong and jointed in nature.

- **Dolerite**

  The dolerites are present as thin to thick injected igneous bodies in the form of dykes and sills with in the country rock. Often these are observed injected into the rock along the foliation planes and week shear zones. The surface exposures of these bodies have been observed at a few places along the tunnel route. These bodies are generally 1.0 m to 5.0 m thick, dark green to black in color and are weak to moderately strong in nature. These bodies have particularly been noted in the "Tectonized zone" described above.

- **Shear Zone**

  Thin to thick shear zone located at site with gaugic bracciated material and silkenside are observed in the area. Local community uses this material for construction etc.

3.5 TECTONICS

The tectonic and structural features have been studied in the Project area. The Project area stretches for distance of about 04 km from the weir site to the powerhouse on the left bank of the Khan Khwar. The regional Geological map Figure-3.1 shows that the area under study is situated among various rock units consisting of moderately to highly metamorphosed rocks belonging to Besham and Karora Groups (as described above). The contacts between various major units are of sheared, brecciated and fractured nature. The tectonic features are reflected through foliation trend of the various rock units.

Field studies have indicated that the area from Kuz Kana to Marin, having a length of nearly 04 km is distinctly marked with the variable attitude of the various rock units. This is also supported by the regional tectonic set up described in the above section and shown in the Composite Geological Map of the Project area (Figure-3.4). The field evidences indicate that the Granite Gneiss rock type forming the country rock of this area has N – S trend with moderate dips towards the West in the Kuz Kana i.e. weir site area. This trend is noted on both the banks of the Khan Khwar. However, towards the Intake Portal area, the same rock types have different trend. These strike in N – S direction, but dip towards the East. These evidences show that an anticlinal feature is present in the Kuz Kana area and the Khan Khwar may be flowing through the core of the anticline.

Similarly along the tunnel route, starting with the Intake Portal the trend is N – S and the dip is towards East i.e. towards the downstream side. However, in the middle of the tunnel route and at the top of the ridge, the trend of the strata again changes at the surface. The strike here remains almost the same in N – S direction, but he dip of the strata changes towards the Intake Portal area i.e. towards upstream side. This is an indication of presence of a synclinal feature. This feature is exposed at high level in the middle of the ridge and is expected that this feature may be encountered during the tunnel excavation. From this point upto the out let portal area and

below up to near the powerhouse this trend shall continue. However, in the vicinity of the Powerhouse area, the rocks become thinly bedded and in alternating sequence, which shows frequent variation in the trend of the strata – indicating that the rocks are frequently folded and faulted in the vicinity of the powerhouse area.

Besides the folding characteristics, a few shear zones are also observed in the Project area and particularly along the tunnel route. These shear zones are 3 to 5 m thick, and show highly fractures, sheared and brecciated nature of the rocks involved. These shears contain the gougic and brecciated materials. A unique and significant feature has been noted along the tunnel route about 200 m from the Intake portal. This feature indicates complex tectonics and structural change in the trend and the degree of shearing and fracturing in the Granite Gneiss rock unit injected by doloritic bodies. The rocks have been pulverized to the degree that the locals are using this material for concrete. This zone has been described as "Tectonized Zone" in this report. This is shown in the geological maps (Figures-3.4 & 3.5) and the inferred traces of these tectonic features are tentatively shown in geological section along tunnel (Figure-3.6).

The major joint sets and the discontinuity data at various components of the Project (weir site, conveyance channel and particularly along the power tunnel route) has been collected in the field through discontinuity survey and spot readings in the field. This data is being plotted on the rose diagram and pole plots and shall be used in the design of the major structures of the Project.

3.6 GEOLOGY OF RESERVOIR AREA

The Karora Hydropower Project shall operate on run - of - river basis .The reservoir created by 8m height weir with FRL 1013.0m shall be of low height and limited extent. The width of the reservoir area shall range from 50-80m with a length of about 300 m along the main khan Khwar (Plate-3.2). Reservoir shall also be created along a right side tributary present about 80 m upstream of the weir, however, being steep in gradient and relatively narrow in shape, the reservoir volume for this tributary shall be almost insignificant and shall extend only for about 30 m upstream from the river bank (Plate-3.3).

The reservoir area has been geologically mapped and is presented in

Figure-3.5. The reservoir shall be aligned generally in N - S direction along the river course. However, about 80m from the weir, the river negotiates S-shaped bend (Plate-3.1) in its course and continues further upstream in N – S direction. On the left bank the area is covered with flat alluvial terraces and at places with the colluvial (slope wash) materials. The rock exposures are present at the toe of the terrace along the river bank and extend from the weir site upto some distance upstream of footbridge. The left bank area, after the rock exposure, is occupied by near vertical, thick terrace alluvium consisting of silty clay/sandy gravels with cobbles. This cut is nearly 10m high and stands vertical in the reservoir area. One hole No.KKL-02 drilled on the top of terrace and just downstream of this cut indicated the top of bed rock at elev.1013.7 m at a depth of 9.5 m. Therefore, possibility exists that the rock shall be present under the left bank terrace up to the hill face and the leakage from the reservoir may not occur through this terrace.

The right bank of the weir shows prominent exposure of the rock belonging to Granitic Gneiss, abruptly rising from above the weir tie in area and extending from upstream to downstream sides. The rock is massive and blocky and strong to very strong in nature. However, the jointed rock shows some chances of rock fall through wedge-failure etc. The stabilizing measures shall be required for the rock cut in this area.

3.7 FOUNDATION CONDITIONS

- **Weir Axis**

  The Khan Khwar in the weir site is flowing from N to S direction, meanders tightly into S-shaped bend (Plate- 3.1) just 100 m upstream of the proposed weir axis. The weir axis is placed in a straight reach of the river downstream of this bend marked with footbridge. The width of river bed at the weir axis is 20m. Weir site area has been geologically mapped and shown in Figure-3.5. This map shows that the Khan Khwar at the weir location flows through the Western limb of a large anticline, whereas the Eastern limb of the anticline is present along the left bank hill face some distance away from the weir axis after crossing the alluvial terraces.

  At weir axis, continuous rock exposures belonging to Granitic Gneiss are present along the right bank from river level to the area road and above (Plate-3.5). On the left bank, however the rock exposures are

present in the form of thin outcrop along the toe of flat alluvial terrace (Plate-3.4). This strip of rock runs almost parallel to the river for a distance of about 500m. The Granitic Gneiss rocks are describing in section 4.4.2. The foliation on the rock on both the sides of the weir is almost parallel to river in N-S direction with high angle dip ranging from 50-70 degree towards West.

The surface and subsurface investigations have revealed that bed rock is present under the foundation area of weir in the river valley, however it is about 12m deep at elev. 997m as noted in borehole KKV-01. The right abutment can safely be tied in the rocky strata consisting of massive and blocky Granite Gneiss, whereas the left bank area is occupied by upper alluvial terrace material mixed with colluvial (slope wash, angular in nature) materials. The borehole No. KKL-02 has indicated that bed rock is present at 9.8m depth (at elev. 1013.73 m). The results of the boreholes are lacking enough information so additional boreholes will be suggested to have clear picture of the foundation conditions. The proposed plan will be submitted in due course of time that will be helpful to refine the previous studies.

3.8 CONVEYANCE CHANNEL AND SAND TRAP

Conveyance Chanel and sandtrap are located on the left bank alluvial terrace close to the River.

The Geological map of the channel area (Figure-3.5) shows that about 130m of the box channel in the upstream reach shall be located between the river edge and the toe of the alluvial terrace. A hole No. KKL-04 has been drilled in this reach, which shows that bed rock shall be encountered at 12.0 m depth at elev. 995.6 m .The invert level of the box channel shall be 1006.0 m. Next 170m part of the channel in the middle shall be located in the rock outcrop comprising Granite Gneiss exposed in the toe area of the upper terrace. The remaining 130m of the channel in the downstream reach up to sand trap shall be located again in the upper terrace comprising silty / clayey sandy gravels with cobbles and boulders. The channel shall require excavation in overburden material and rock strata to reach the foundation level.

The sand trap shall be placed in the middle section of the upper terrace. No rock is present in the vicinity; therefore the structure shall be built in the

terrace material consisting of silty/clayey sandy gravel with cobbles and boulders. Similarly the pressure conduit shall also be built under the same material condition except the last 20-30m reach which may encounter rock strata before reaching the portal area. Currently this part is covered with the terrace material and is under agriculture use.

3.9 POWER FACILITIES

The power facilities shall be located on the left bank of Khan Khwar and shall stretch from Kuz Kana (with intake structure) to Marin village almost opposite to Karora town. These shall include intake portal, power tunnel, surge shaft, outlet portal, and surface penstock leading to powerhouse followed by tailrace channel. The area has been investigated through geological mapping, drilling of three No of boreholes, geophysical profiling and test pits. The geological map is presented in Figures-3.4 & 3.5.

3.10 THE INTAKE PORTAL

The intake portal is located at the toe of moderately steep hill face at the end of power conduit. The hill face is situated in North-South direction almost parallel to the River. The downstream ledge of left bank terrace with agricultural land is present between River and the intake portal area (Plate-3.6).

As shown in geological map (Figure-3.4 & 3.5), the intake portal area is occupied by the Granitic Gneiss rock type (description given in Section 4.4.2). The area is covered with a thin veneer of slope wash material/scree. One borehole No. KKP-05 has been drilled inclined to a depth of 25 m. The investigation results indicate that the lithology consists of massive and blocky Granite Gneiss and is considered well competent for surface and subsurface excavations. The rock strata at the intake portal area strikes almost parallel to the hill face (i.e. N-S Direction) and dips 55-60 degrees towards East i.e. towards the downstream side of tunnel route. The portal cuts shall be situated in a moderately inclined hill face therefore no stability problem is envisaged. The foundation of the intake structure shall be placed on granite gneiss rock which is considered quite suitable for bearing the loads of the structure.

3.11 THE POWER TUNNEL

The power tunnel shall off–take from the intake portal in almost East

direction for a distance of about 200 m then it takes a smooth wide bend towards SE and shall be aligned in NW-SE direction till the surge shaft / outlet portal area covering a total length of 2982 m. The tunnel shall be horseshoe in shape with a finished equivalent diameter of 2.25 m. The excavated diameter shall be about 3.0 m.

The tunnel route corridor nearly 400 m wide, has been geologically mapped picking up various lithological and structural features. The geological map is shown in Figure-3.5. The sub surface conditions have been determined through two bore holes Nos KKP-05 in the intake and KKP-06 in the outlet area. A geological section (Figure-3.6) along the tunnel alignment has also been developed. The geological information shows that the following rock types shall be expected along the tunnel route.

Granitic Gneiss: This rock type is the dominating rock unit along the tunnel and shall constitute nearly 80% of the rock strata.

Tectonized Zone in **Granitic Gneiss:** Covering nearly 10% of the rock strata

Graphitic Schist: Covering nearly 10% of the rock strata

The lithological detail of these rock types is given in Section 4.4.2.

The geological map also indicates that a synclinal feature is present almost in the middle of the tunnel route. As a result of this feature, the rock strata from intake portal to nearly 1+600 m generally dips towards the downstream side i.e. SE side while the Eremaining length from chainage 1+600 to the outlet portal dips towards upstream side i.e. in NW direction. This is shown in the geological section (Figure-3.6)

- Total length of tunnel = 2980 m
- Total length of Good Rock mass (Type-A) = 1700 m
- less 70 m of V. Poor quality due to anticipated shear / weak zones
- Net length = 1630 m (55 %)
- Total length of Fair Rock mass (Type-B) = 780 m
- less 30 m of v. poor quality due to anticipated shear / weak zones
- Net length = 750 m (25 %)
- Total length of Poor Rock mass (Type-C) = 150 m (05 %)
- Total length of V. Poor Rock mass (Type-D) = 450 m (15 %)

The above table indicates that about 80% of the tunnel length shall pass through Good to Fair rock types while only 05 % shall cross through the weak and poor strata. However the tunnel sections passing through the tectonized zones, graphitic rocks, sheared & highly fractured zones have been grouped into very weak rock types which shall cover about 15% of the tunnel length.

3.12 SURGE SHAFT / OUTLET PORTAL AREA

The surge shaft area shall be located in the granitic gneiss rock mass with its foliation dipping towards NW i.e. upstream side. The surge shaft shall be 16 m high having 4 m diameter. The granitic gneiss rock appears competent for the vertical and circular excavation, however, the foliation dipping in the NW in conjunction with the dominant joint sets may pose problems in the form of rock falls and wedge failures. The excavation of the shaft is recommended from top to bottom down to the tunnel crown.

Bore hole No. KKP-06 has been drilled vertically to a depth of 28.5 m in close vicinity of the outlet area. This hole encountered two doloritic dykes and one layer of graphitic schist. The ground water conditions have not been encountered in this hole up to the bottom of hole at elev. 977.5 m.

3.13 PENSTOCK

The surface penstock shall be 408 m long steel pipe of 1.5 m diameter. The geological map of the area (Figure-3.5) indicates that nearly upper half of the penstock length shall pass through the area occupied by rock strata comprising mainly of Granite Gneiss with some possibility of inter layers of thin graphitic schist. The lower half of the penstock length shall be placed on overburden material consisting of slope wash and alluvial terraces at places, presently under agriculture use. The foundation for the penstock pedestals / anchor blocks etc can safely be constructed on the rock strata, however, special preparation of foundation in the overburden material is needed which involves blasting of larger size blocks and boulders, placing of granular material and its proper compaction etc.

3.14 POWER HOUSE

The power house has been proposed on the left bank of Khan Khwar in Marin area. It shall be placed on the alluvial terraces mixed with slope wash material comprising large rock boulders and blocks extending towards the

river side (Plate-3.8). Besides geological mapping, the area has been investigated through one hole No. KKP-07 (with 28.5m depth up to elevation 853.64m), drilled in the vicinity of the proposed location. The bed rock has been encountered in this hole at 18.7m depth at elev. 863.4 m. The foundation excavation level of the powerhouse shall be about 848 m.

The surface geological map of the area (Figure-3.5) and the projected borehole data indicates that rock excavation of 10 to 15 m may be required to reach the foundation level of powerhouse. However it is evident that the powerhouse foundation can safely be placed on rock strata consisting of alternating beds of the granite gneiss, graphitic schist and / or marble etc.

The tailrace channel nearly 50 m long shall lead the water from powerhouse to the Khan Khwar River. The geology determined through bore hole No KKP-07 indicates that the top of tailrace shall be excavated in the overburden material and the bottom of tailrace channel shall be excavated in rock strata comprising alternating beds of Granite Gneiss, Graphitic schist and marble / dolomite bands. However the tailrace end section near the River bank shall be excavated in alluvial terraces.

3.15 CONSTRUCTION MATERIALS

Construction material studies have revealed that the Project and its vicinity areas are almost devoid of any suitable construction material particularly the concrete aggregates. The bed load of the Khan Khwar and the country rocks of the area are dominantly composed of the Granite Gneiss rock type which is considered deleterious to concrete when used with Ordinary Portland Cement "OPC". As observed, the under–construction Khan Khwar Hydropower Project of WAPDA is importing concrete materials from outside the Project area. Therefore it is assumed that the construction materials for the Karora Project shall have to be procured from outside the Project.

However, the detailed study and testing of the available materials shall confirm this. The possibility of using the local materials with low alkali cement or using slag cement shall be judged after the availability of the testing results.

The details of investigations concerning the availability and suitability of the materials are discussed below:

- **Concrete Materials**

  Large quantities of concrete shall be required for nearly all the project structures. The Project area has been investigated for the availability of concrete materials through identifying the potential areas and test pits excavated for the sampling purposes. In all 05 Nos of test pits for aggregate materials have been excavated and 05 Nos of samples collected in the field.

- **Coarse and Fine Aggregate Sources**

  The following sources have been studied and considered for the concrete materials;

- The Khan Khwar River bed possesses some flat terraces comprise the sandy gravel material with cobbles, dominantly of Granite Gneiss. The rock type is considered as strong to very strong in nature, but deleterious to concrete as regards Alkali Silica Reaction (ASR). However, locally the bed material is being mined and processed for coarse and fine aggregates for meeting partially the local requirements. The river bed material has been investigated through 02 Nos of test pits for the collection of samples for laboratory testing.

- Materials from the Required Excavation. Large quantities of materials shall be available **from** the required surface and underground excavations like the weir abutment, portal areas, tunnel and surge shaft etc. The material dominantly available from the required excavations will be the Granite Gneiss which is apparently not suitable for the aggregate as discussed above. Therefore this material is not recommended for use as coarse aggregate with the OPC.

- **Borrow Area Sources for Concrete Aggregates**

  Borrow areas have been identified for concrete aggregates. These areas are situated downstream of Besham towards Thakot along KKH on the right bank of Indus River.

  These sources are being already exploited by contractors engaged at various WAPDA's Projects like Khan Khwar Hydro power Project and Allai Khwar Hydro power Project. Also FWO - the contractors for up gradation of KKH is using these sources. The use of these sources for such major projects indicates that these are considered safe for their

use in mega projects, therefore these sources are recommended for Khan Khwar / Karora hydropower project. However, a few samples have been collected to check and evaluate its potential reactive nature independently for this project. The sources are:

Shang Borrow Area: This area is currently being exploited for the manufacturing of coarse aggregate. The material is being obtained from the Indus terraces (close to river flow) and is brought to Project sites like Khan Khwar for crushing and manufacturing aggregates. This source is present about 6 km from Besham.

- Besides, a large crushing plant has been installed by private party in Shang about 8 km from Besham just close to the KKH, which is using the rock boulders and blocks (after blasting) originating from above the hill face for producing coarse and fine aggregates. This material is being used in the up-gradation of KKH.
- **Maira / Dandai Sand Deposit:** This is a famous and established source of materials, where natural sand deposits are present in large extent area, covering about 5 -7 km length along KKH (Plate-3.14). The sand is being used by local contractors. However, our background knowledge shows that this sand is reactive in nature regarding ASR potential. Therefore should be used with certain caution and low alkali cement shall be required for good quality and long life of the Project.
- **Manufactured Aggregate**

  The coarse and fine (sand) aggregates can also be obtained through crushing and manufacturing the Indus river gravels obtained through the existing river terraces down stream of Besham, as discussed above. The Khan Khwar Hydro power Project of WAPDA is adopting the same methodology for manufacturing of the aggregates at site.
- **Cohesive Material**

  The cohesive (silt / clay) materials are available at the Project site in limited quantities and can only be obtained from the left bank terrace on the weir site. This terrace has been investigated through 03 Nos of test pits, however, only one test pit No. TP-06, encountered silt / clay material suitable for use. This shows that the site area shall also be deficient in this type of material. Therefore, the borrow area for this

material was also searched in the vicinity of the Project – which is described below;

- **Borrow Area for Cohesive Material**

  The borrow area for this material has been found near the village Maira / Nawababad about 15 km downstream of Besham. The material cuts are exposed along the KKH, which indicate that sufficient quantity of cohesive material shall be available in this area. This area is investigated through 02 Nos of test pits for sampling purpose.

- **Cement**

  Our background knowledge about the types of rocks and the mineralogy of aggregate material belonging either to the Project site or from borrow areas indicates that the available material may not be suitable for use with the Ordinary Portland Cement (OPC), due to the potentially reactive nature of the materials as regards the Alkali Silica Reaction (ASR). Therefore, it will be safe to use the low alkali cement or some alternate like slag cement.

  The cement in the local market in Besham and Karora is being procured from the nearest cement factories situated in Hasanabdal to Islamabad areas. These are;

  - Wah Cement Factory – Hasanabdal
  - Dewan Cement Factory – Hattar Taxila
  - Bestway Cement Factory – Islamabad and
  - Also from other numerous cement factories in Hasanabdal, Taxilla and Islamabad. All these cement factories are situated 250 to 300 km from Karora Project Site.

  Although these factories are big and large producing OPC, yet on request certain factories are capable of producing the low alkali cement.

- **Water**

  Water in general seems quite suitable for construction purposes, however 03 Nos of samples from the Khan Khwar at weir site (Kuz Kana area) and 02 Nos from the power house (Marin area) have been collected for testing its suitability for use in the construction of the Project.

- **Steel**

  Steel is not locally available and shall have to be procured from the markets in Peshawar, Rawalpindi and Lahore.

RECOMMENDATION

- One borehole is recommend at revised Power House site
- Contractor may propose additional boreholes, which he considers are necessary for design of the Project.

NOTE: Figures and Plates mentioned in the Review Report are available at end of Chapter 3 of feasibility Study, therefore it was not considered necessary to include these in this Chapter.

Chapter - 4

HYDROLOGY AND SEDIMENTATION STUDY

CHAPTER – 4

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CHAPTER – 4

HYDROLOGY AND SEDIMENTATION STUDY

4.1 COMMENTS ON HYDROLOGY

Hydrological and sedimentation studies in the Feasibility Study (FS) are based on hydrological data for the period 1975 - 2008. M.C has collected an additional hydrological data from the Client and relevant agencies which is for the period 2009 – 2012. This data has been incorporated in the hydrological analyses for review of Hydrological Studies and ultimately deciding the design discharge and the design flood, during the preparation of Basic Design for incorporation in EPC Bidding Documents.

- In the F.S Flows at the weir site were generated by developing correlation between mean monthly flows of river Khan Khwar at Kuz Kana (2005-2008) and mean monthly flows of river Khan Khwar at Karora (1975-2008). M.C Consider that the relationship should be on 10-daily basis.
- Daily flows data of Khan Khwar at Kuz Kana for the period of 2005-2008 and Khan Khwar at Karora for the period of 1975-2008 are not provided in the report as Annexure.
- Flow duration curve (Figure 4.11 of the F.S) developed on the monthly basis from the monthly data given in the Table 4.11 are not matching with the FDC curve as given in the report
- Instantaneous peaks at project site were not given in the report for the estimation of flood.
- Suspended sediment rating curves shown in the Figure 4.15 and 4.16 the are plotted in the reverse order. These figures will be returned as soon as data from ACE is received.
- Gradations of the particle size are also not given in the report.
- The daily suspended sediment data of Gorband river at Karokh for the period of 1975-2006 and the Khan Khawar at Kuz Kana were not provided in the feasibility report as Annexure.
- Estimated bed load (130,948 tons) at project site is given in the feasibility report (Table 4.26) is greater than the suspended sediment load (54,234

tons) shown in the Table 4.22. In general practice the bed load should be the percentage of the suspended sediment load.

- Diversion flood against the low flow season is not provided in the feasibility study.
- X-sections used to develop the Tail Water Rating curve at weir and powerhouse site are not provided in the report (as Annexes).

4.2 REVIEW OF THE HYDROLOGICAL STUDY:

4.2.1 Catchment Area:

In the feasibility study the catchment area at the weir site was estimated as 230 km^2 which was recalculated in the current review study.

The G T sheets of the project area, 43-A/12, A/16, B/9 and B/13 have been collected from the survey of Pakistan for recalculate the catchment area of the Karora HPP at weir site. The recalculated catchment area of the Khan Khawar upto the proposed weir site is about 235 sq. km. The catchment area is shown in Figure 4.1 The point of maximum elevation in the catchment area is at El. 3840 m while elevation at proposed weir site is 1005 m amsl. The length of main channel is 29.1 Km. Khan Khawar bed slope is 104.6 m per km or 9.7%.

4.2.2 Collection of Hydro-meteorological data:

The following data have been collected from different agencies for the review of hydrological study:

- The daily rainfall data of Besham Qila for the period of 2007 -2012 from SWHP, WAPDA
- Daily flows data of Gorband river at Karora for the period of 2007 - 2010 from SWHP, WAPDA
- Daily flows data of Khan Khawar at Kuz Kana for the period of 2007 -2012 from PHYDO
- Suspended Load of Gorband river at Karora for the period of 2007-2010 from SWHP, WAPDA

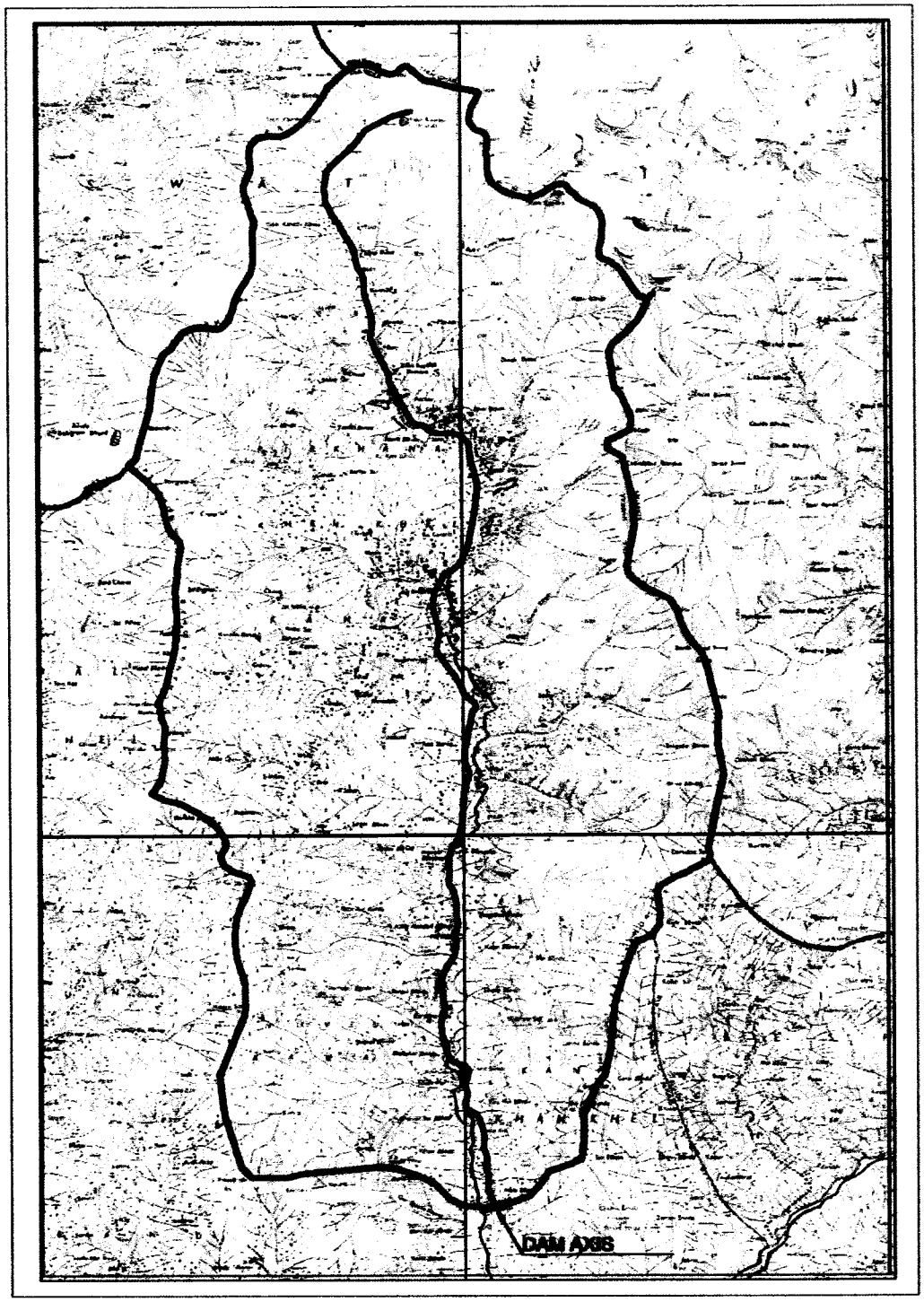

Figure 4.1: Catchment Area

4.2.3 Water Availability

In the feasibility study the flows at the weir site were generated by

developing correlation between mean monthly flows of river Khan Khwar at Kuz Kana (2005-2008) and mean monthly flows of river Khan Khwar at Karora (1975-2008).

In the current review study the water availability at the project site was refined from the flows data of Khan Khawar at Kuz Kana for the period of 2006-2012 and the flow series were extended from the Gorband river at Karora for the period of 1975 -1997, 2001-2010.

For the estimation of water availability the value of the flow of Khan Khawar at Kuz Kana on 29-jul-2010 was taken as 84 cumecs instead of 984 cumecs.

In review study two approaches were used to estimate the water availability at the project site.

- Water Availability Based on Regression Analysis
- Water Availability Based on Stochastic Model

4.2.3.1 Water Availability Based on Regression Analysis

In this method water availability was estimated by developing the correlation on the basis of 10-daily flows between the specific flow data of Gorband river at Karora and Khan Khawar at Kuz Kana for the period of 2006-2010 as shown in the **Figure 4.2**. The ecological flows and water usage for community is taken as 0.918 cumecs same as given in the feasibility study.

The net extended and the observed flows for the power generation for the period of 1975 to 1997 and 2001 to 2012 at the weir site are given in the **Table 4.1**. The mean 10-daily flows at project site vary from 2.34 to 15.67 cumecs while the mean annual flow at project site is about 8.73 cumecs. The mean net 10-daily flows and the annual flows at project site are shown in the **Figures 4.3 and 4.4** respectively.

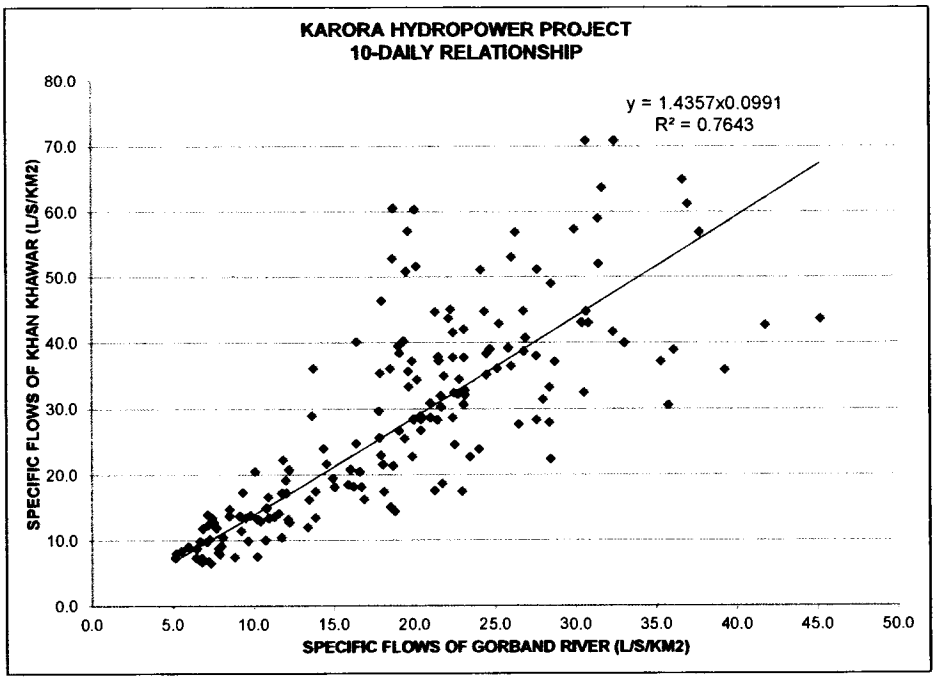

Figure 4.2 10-Daily Correlation of Flows

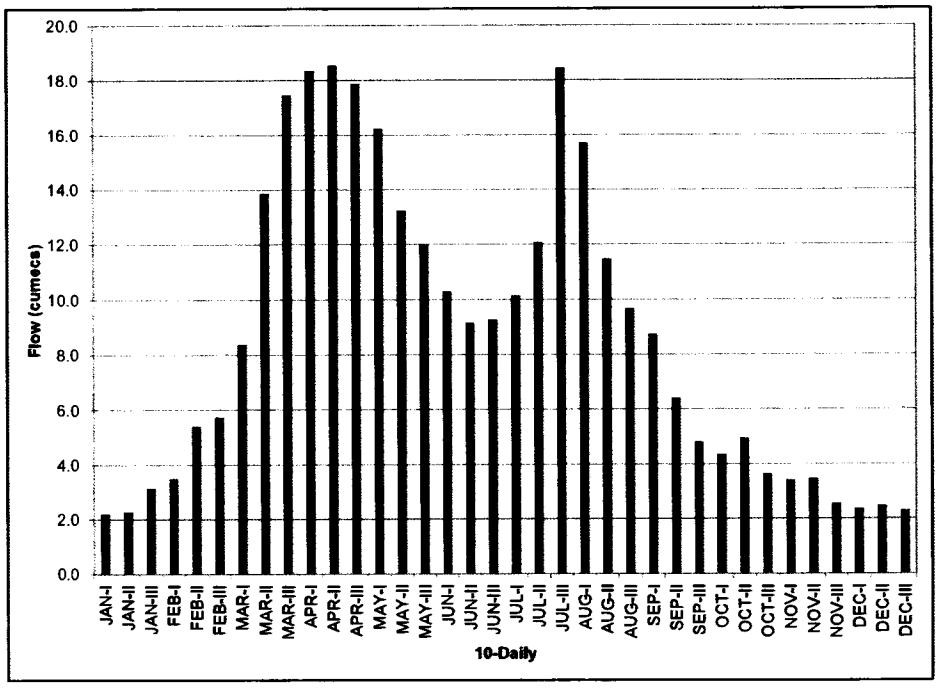

Figure 4.3 Mean 10-Daily Flows at Weir Site (1975-2012)

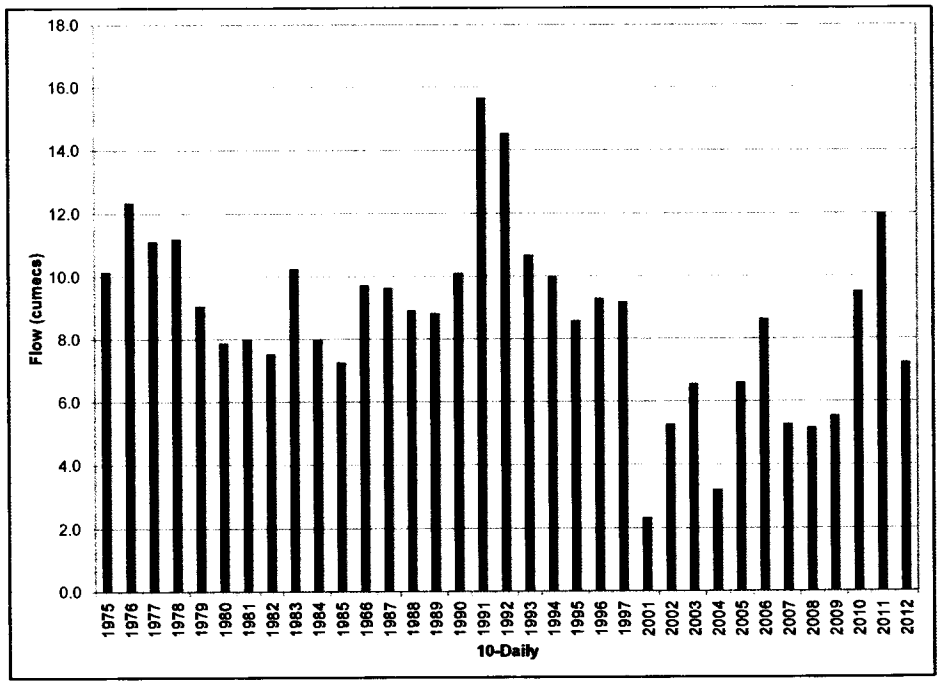

Figure 4.4 Net Annual Flows at Weir Site (1975-2012)

Table 4.1: Net Mean 10-Daily Flows at Weir Site

10-DAILY	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	AVERAGE
JAN-I	1.69	0.96	1.68	3.07	2.15	1.07	1.07	0.65	2.53	0.86	1.37	2.58	3.11	1.34	2.62	2.25	4.30	2.88	6.19	3.54	4.35	3.11	4.27	0.92	0.42	0.26	0.83	5.12	2.30	2.33	0.89	3.67	1.08	1.89	1.92	2.21
JAN-II	1.22	1.71	1.64	3.83	2.93	0.99	1.07	0.50	2.02	0.73	1.87	1.99	2.32	1.09	2.29	3.39	3.74	0.64	5.18	3.59	4.08	3.28	4.16	0.92	1.59	0.25	1.61	2.24	3.74	2.14	1.48	8.68	0.84	2.26	1.42	2.27
JAN-III	1.08	1.91	1.76	4.25	2.62	1.79	1.24	0.88	3.44	0.60	3.75	1.74	2.09	1.67	2.38	5.23	21.44	3.07	5.10	4.71	3.79	3.51	4.06	0.92	1.01	0.33	2.09	2.19	3.42	2.24	0.97	9.51	0.85	4.64	1.74	3.15
FEB-I	1.48	3.94	3.78	4.74	2.63	2.51	2.91	1.14	3.85	0.92	3.85	1.77	2.26	2.31	2.80	8.91	9.03	3.10	6.58	5.01	4.10	4.58	3.99	0.32	0.84	0.59	1.95	3.30	4.51	4.84	1.59	8.70	3.57	4.69	1.79	3.51
FEB-II	2.68	8.54	5.17	4.28	7.35	4.63	7.21	1.61	4.15	1.65	4.06	4.09	3.04	2.46	2.46	9.13	11.91	5.25	8.07	5.14	9.41	6.67	3.67	0.55	2.09	2.75	2.31	7.01	11.33	11.72	3.99	8.34	9.77	5.77	1.46	5.42
FEB-III	5.66	6.32	5.18	6.87	5.02	10.34	8.09	2.03	6.07	1.37	4.43	5.59	8.39	3.41	2.88	9.61	10.94	7.48	6.78	6.86	5.32	8.28	3.99	1.24	3.21	6.43	3.25	4.90	9.37	8.53	3.26	6.00	7.50	4.95	1.40	5.74
MAR-I	12.53	11.02	5.32	9.03	6.60	11.00	11.81	4.12	13.10	3.35	5.77	6.99	14.20	12.29	6.25	9.66	17.66	9.88	6.57	10.33	6.13	10.21	5.52	1.40	4.83	9.21	3.75	9.92	6.77	9.02	4.97	7.06	13.72	11.05	2.61	8.39
MAR-II	8.10	14.18	8.64	40.06	9.57	9.40	15.85	8.32	19.22	13.47	3.60	10.38	19.19	18.53	11.13	27.45	33.52	13.90	32.57	16.07	6.54	27.21	7.97	2.11	10.88	10.96	5.48	29.50	7.31	9.79	6.33	6.62	8.65	7.03	5.82	13.87
MAR-III	28.87	18.16	7.49	19.39	33.82	18.74	21.45	19.34	16.88	13.45	10.35	27.03	26.98	15.71	24.53	28.08	40.97	21.88	17.91	13.30	41.21	13.02	8.97	2.31	15.13	18.20	5.36	12.43	6.81	11.53	7.99	14.62	7.96	8.41	12.81	17.46
APR-I	23.92	28.30	21.31	21.74	28.56	25.67	18.51	14.49	25.44	23.62	13.26	22.43	24.30	16.08	18.82	22.08	66.45	23.15	12.62	29.49	15.19	18.01	11.43	3.06	13.46	12.90	6.34	11.21	12.81	9.06	12.69	9.30	7.98	7.46	11.61	18.36
APR-II	15.32	35.32	11.16	32.21	24.34	18.13	24.59	19.39	25.10	13.07	10.39	29.42	19.32	18.96	13.49	17.61	43.16	26.20	37.50	12.76	17.19	15.40	23.79	5.35	12.02	26.94	5.79	9.63	8.12	9.36	14.32	5.42	13.20	20.43	14.62	18.54
APR-III	33.47	33.50	19.64	20.09	23.86	16.40	30.76	21.98	30.26	14.24	8.90	24.04	26.92	16.35	12.87	18.56	25.21	48.41	19.14	12.39	13.80	13.46	12.62	4.24	13.20	15.16	6.13	13.84	9.81	8.46	8.11	6.39	10.81	19.47	13.26	17.88
MAY-I	16.64	19.46	24.36	26.04	28.12	15.43	20.59	18.65	24.96	11.65	9.85	20.51	18.41	13.47	24.84	20.40	23.37	25.66	13.25	13.59	10.58	10.48	18.39	4.10	11.26	16.70	3.50	12.80	11.78	9.34	8.00	9.53	16.04	21.32	15.11	16.23
MAY-II	19.29	19.76	13.25	13.31	13.48	12.67	11.38	9.87	26.25	10.18	9.10	14.56	15.72	9.58	16.21	21.98	22.56	23.78	8.19	10.84	10.39	9.07	13.58	3.31	10.81	9.55	2.33	8.75	11.32	9.13	5.49	8.40	16.04	23.15	20.53	13.25
MAY-III	13.25	16.46	12.80	9.91	15.25	9.11	12.45	11.88	17.74	8.47	6.89	11.97	16.84	7.18	13.83	13.77	21.63	30.01	8.54	10.00	8.88	15.05	12.50	1.49	8.99	9.80	2.29	7.57	8.14	8.28	9.80	6.87	12.68	21.62	17.85	11.99
JUN-I	11.23	13.08	8.08	8.65	8.69	8.34	10.01	9.70	12.37	8.58	6.44	11.49	14.24	5.99	12.29	10.01	18.81	19.98	10.11	9.53	8.10	10.99	13.97	2.33	8.00	10.05	2.50	7.04	6.18	5.88	7.06	8.19	11.25	26.16	14.68	10.29
JUN-II	10.38	12.33	6.87	7.42	8.84	8.21	7.09	8.67	11.52	7.20	4.93	12.38	9.79	4.94	10.87	7.03	13.70	18.69	11.20	8.78	6.78	13.07	12.13	4.45	7.04	6.58	2.31	6.66	5.01	7.31	5.72	5.93	12.74	23.67	10.75	9.17
JUN-III	8.11	10.24	7.66	9.14	7.07	8.79	7.34	8.34	11.43	8.04	4.94	13.08	8.34	6.11	9.56	17.67	11.01	17.62	10.80	8.59	5.94	11.80	10.02	3.05	10.96	6.41	3.52	7.41	13.57	4.80	6.93	7.62	10.16	16.28	12.08	9.27
JUL-I	9.46	12.21	11.48	26.31	7.49	7.45	7.67	7.47	11.03	8.36	8.25	12.77	7.45	10.26	8.81	10.54	10.19	14.71	24.01	9.42	7.62	10.51	11.93	4.03	9.61	6.76	4.00	6.66	13.52	7.72	5.79	7.46	11.43	11.17	11.26	10.14
JUL-II	11.28	25.44	41.67	14.25	8.05	14.37	7.51	6.51	7.70	10.91	38.63	10.20	6.98	17.44	9.08	7.67	24.66	12.81	14.17	13.13	6.84	9.37	11.61	5.88	2.50	6.79	3.16	7.87	16.86	5.88	7.80	6.42	7.69	12.44	9.19	12.08
JUL-III	11.93	22.20	66.64	16.43	10.99	11.19	11.37	7.27	13.70	18.14	17.82	12.46	9.27	37.38	24.01	7.72	14.80	21.89	34.28	26.63	25.75	9.06	12.73	10.84	4.36	4.73	3.20	7.28	30.78	5.94	8.83	6.85	92.24	18.57	8.72	18.46
AUG-I	14.74	56.21	23.22	22.53	10.36	15.53	7.31	21.67	13.15	13.51	37.19	24.40	5.91	23.15	27.90	12.97	17.71	22.41	8.72	24.80	13.71	11.38	12.12	2.50	2.66	7.59	2.99	6.80	26.86	5.21	5.87	5.47	11.62	18.04	13.59	15.71
AUG-II	38.62	15.33	15.94	13.18	21.00	12.84	8.58	18.02	12.54	11.80	7.34	10.85	5.49	15.13	11.49	8.76	10.33	11.94	7.31	15.00	9.12	15.12	18.66	1.51	9.10	7.43	3.22	6.75	8.26	5.18	6.47	4.44	7.69	15.03	12.06	11.47
AUG-III	19.38	17.13	19.11	11.96	11.53	6.54	7.64	5.94	16.32	21.05	5.62	10.26	4.71	16.10	11.43	6.00	10.45	9.35	6.26	18.46	8.68	11.56	13.61	1.94	7.52	4.57	2.08	4.84	8.42	4.07	6.73	2.69	4.53	15.54	6.67	9.68
SEP-I	10.97	11.28	17.54	9.49	5.33	5.64	5.20	3.98	15.15	20.76	4.28	5.53	6.03	8.65	6.31	4.71	10.66	32.06	6.97	8.25	7.15	8.97	7.99	3.21	8.16	4.50	1.91	3.87	9.88	4.25	5.87	3.28	4.59	28.34	5.35	8.75
SEP-II	7.53	5.79	6.86	9.28	3.93	6.39	3.49	3.27	6.02	10.19	3.99	6.82	4.06	7.55	4.72	4.46	17.26	15.32	7.54	5.97	5.85	7.42	6.94	3.75	3.04	4.42	3.42	4.34	3.98	3.43	3.27	4.28	7.53	18.36	4.21	6.42
SEP-III	5.68	6.57	5.56	6.02	2.76	4.32	2.74	5.00	3.44	7.52	3.10	4.39	2.59	5.14	4.34	3.93	10.11	8.64	5.64	5.13	5.43	6.06	7.04	2.38	2.37	7.96	2.68	2.97	2.94	3.51	1.59	2.28	7.72	8.21	3.17	4.83
OCT-I	4.28	3.40	4.59	4.07	1.88	2.61	2.74	2.92	2.79	3.93	3.73	3.66	9.07	4.85	2.60	2.79	7.50	13.01	6.04	5.36	4.74	6.76	7.04	1.81	1.01	3.73	7.50	3.26	2.33	3.07	4.40	2.37	4.06	6.37	2.77	4.37
OCT-II	3.49	3.06	3.91	3.18	2.00	2.74	2.90	2.12	2.73	2.72	3.05	3.67	26.34	3.55	4.08	11.70	5.89	16.45	5.33	6.55	5.91	6.26	6.35	1.14	0.96	2.57	6.56	5.53	2.18	1.82	2.46	2.30	3.20	7.83	2.84	4.95
OCT-III	2.59	2.83	4.27	2.73	1.82	1.75	2.06	4.83	2.13	2.18	2.21	2.43	7.92	2.66	2.24	4.81	5.27	8.58	4.32	7.71	4.56	6.12	7.00	0.91	0.56	1.28	2.68	4.25	2.25	1.27	1.45	1.91	2.65	10.98	4.52	3.65
NOV-I	3.09	1.68	3.53	6.61	1.84	2.47	1.44	2.81	1.54	2.08	1.88	1.63	4.83	2.27	1.94	6.96	4.63	5.33	6.51	5.88	3.96	5.37	6.02	4.31	0.59	2.08	2.64	2.65	2.61	1.04	0.87	1.93	3.22	10.88	2.90	3.43
NOV-II	1.89	1.50	2.64	2.98	1.69	1.79	1.34	5.48	1.18	2.66	1.50	1.73	2.90	1.99	1.76	4.46	4.08	5.44	5.39	5.22	3.60	5.05	5.82	1.16	0.27	1.88	2.04	2.55	23.22	0.64	1.96	2.04	2.37	8.08	3.15	3.47
NOV-III	1.38	1.34	2.73	2.09	1.55	1.35	1.05	3.01	0.94	3.75	1.45	3.98	2.20	1.82	1.46	3.33	3.14	4.95	4.92	4.08	3.54	4.64	5.59	0.76	0.56	1.57	1.60	1.93	6.01	0.71	2.39	1.18	2.41	4.26	2.07	2.56
DEC-I	1.73	1.62	1.69	3.05	1.11	1.27	0.86	2.93	0.70	2.26	1.38	4.30	2.27	1.58	1.56	2.85	2.17	5.83	4.05	5.01	3.77	4.62	5.18	0.64	0.31	1.51	1.63	1.93	2.53	1.42	3.21	1.19	2.14	2.36	2.65	2.38
DEC-II	1.39	1.21	1.59	2.94	1.07	1.13	0.66	3.90	0.87	2.13	2.97	5.36	1.91	1.66	1.60	3.03	2.72	6.42	3.56	4.08	3.65	4.47	5.06	0.51	0.28	2.80	1.31	1.72	3.42	0.83	4.19	1.51	1.43	3.03	2.40	2.48
DEC-III	1.25	1.01	1.80	2.35	1.13	1.27	0.64	2.52	0.73	1.69	3.45	3.91	1.53	2.37	2.37	4.60	3.04	6.45	3.23	4.45	3.27	4.50	4.63	0.47	0.47	1.40	2.04	1.56	2.97	0.68	3.29	1.24	1.00	1.22	2.10	2.30
ANNUAL	10.16	12.36	11.13	11.21	9.07	7.89	8.02	7.53	10.25	7.98	7.27	9.73	9.64	8.92	8.83	10.11	15.67	14.53	10.68	9.99	8.58	9.29	9.18	2.34	5.28	6.57	3.22	6.62	8.65	5.29	5.17	5.55	9.51	11.97	7.25	8.73

4.2.3.2 Water Availability Based on Stochastic Model

The water yield was tested under a probabilistic approach where the runoff estimated by the deterministic equation was conditioned by a probable/ stochastic / random process between the minimum and maximum scatter range.

The flow series was developed by finding serial correlation coefficient and then by using 1st order Markov chain process as under:

$$X_t = (1 - r_1)\overline{X} + r_1 X_{t-1} + \sqrt{1 - r_1^2}\, s\, \varepsilon_t$$

Where X_t is the estimate at time t, X_{t-1} is the value at previous time t-1, r1 is the lag-1 serial correlation coefficient, $\overline{X}$ and s is mean and standard deviation of the historic series, respectively and εt is the N[0,1] uniform normal random deviate at time t with mean zero and standard deviation of 1. The N[0,1] random number was calculated by using inbuilt statistical function in the excel computer program.

In this approach the ecological flows were estimated by using the same equation described above and the net flows were determined by subtracting the ecological flows from the total flows. The net generated flows for the power generation for the period of 40-years at the weir site are given in the **Table 4.2**. The mean 10-daily flows at project site vary from 3.68 to 12.90 cumecs while the mean annual flow at project site is about 7.44 cumecs. The mean 10-daily flows and the annual flows at project site are shown in the **Figures 4.5 and 4.6** respectively

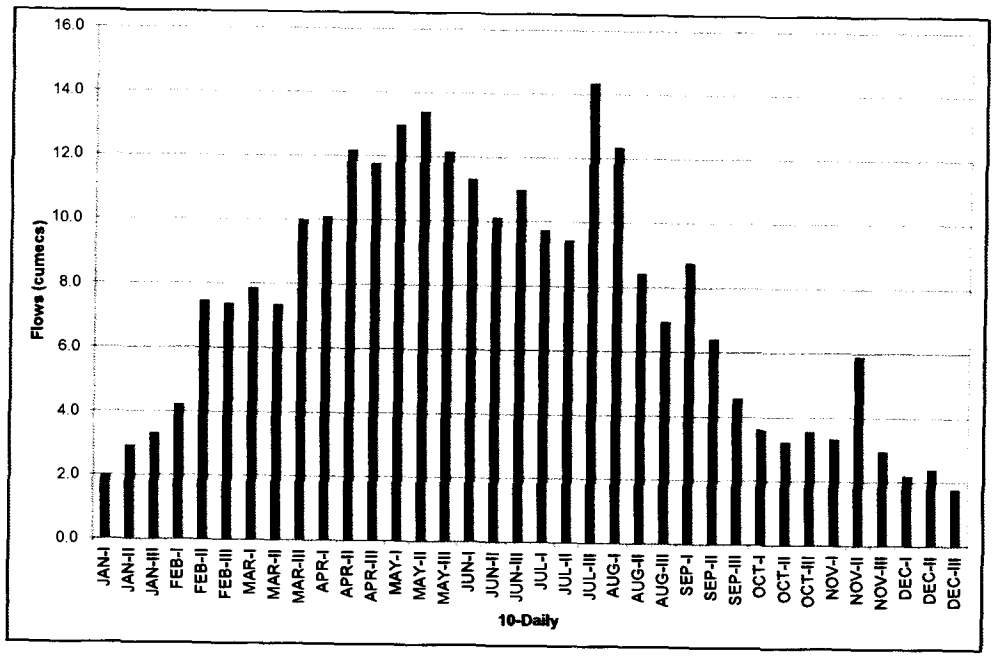

Figure 4.5 Mean 10-Daily Flows at Weir Site

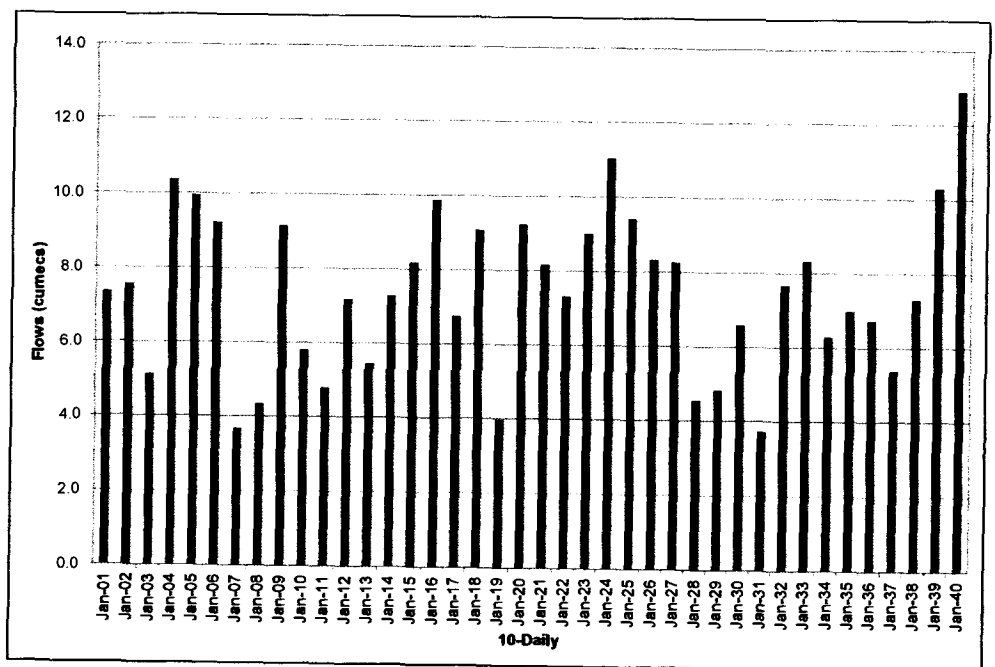

Figure 4.6 Net Annual Flows at Weir Site

Table 4.2: Net Annual Flow at Weir Site

10-Daily	Jan-01	Jan-02	Jan-03	Jan-04	Jan-05	Jan-06	Jan-07	Jan-08	Jan-09	Jan-10	Jan-11	Jan-12	Jan-13	Jan-14	Jan-15	Jan-16	Jan-17	Jan-18	Jan-19	Jan-20	Jan-21	Jan-22	Jan-23	Jan-24	Jan-25	Jan-26	Jan-27	Jan-28	Jan-29	Jan-30	Jan-31	Jan-32	Jan-33	Jan-34	Jan-35	Jan-36	Jan-37	Jan-38	Jan-39	Jan-40	AVERAGE
JAN-I	1.98	2.05	1.20	3.03	2.88	2.63	0.69	0.92	2.60	1.43	1.08	1.92	1.31	1.95	2.27	2.86	1.77	2.58	0.79	2.64	2.26	1.96	2.56	3.26	2.70	2.32	2.29	0.99	1.09	1.71	0.71	2.09	2.32	1.60	1.85	1.76	1.28	1.96	3.00	3.92	**2.01**
JAN-II	2.89	2.99	1.87	4.28	4.08	3.76	1.20	1.50	3.72	2.17	1.71	2.82	2.01	2.86	3.28	4.05	2.61	3.69	1.33	3.76	3.26	2.88	3.66	4.59	3.84	3.34	3.31	1.60	1.73	2.54	1.22	3.04	3.34	2.40	2.72	2.60	1.98	2.87	4.25	5.45	**2.93**
JAN-III	3.29	3.40	2.16	4.82	4.61	4.25	1.42	1.75	4.20	2.50	1.98	3.20	2.32	3.26	3.72	4.57	2.98	4.17	1.56	4.25	3.70	3.27	4.14	5.16	4.34	3.79	3.75	1.86	2.00	2.90	1.44	3.45	3.79	2.74	3.10	2.97	2.28	3.27	4.78	6.11	**3.33**
FEB-I	4.18	4.31	2.81	6.03	5.78	5.34	1.92	2.32	5.29	3.22	2.60	4.08	3.00	4.14	4.70	5.73	3.81	5.24	2.09	5.35	4.68	4.16	5.21	6.45	5.46	4.78	4.74	2.45	2.62	3.71	1.94	4.38	4.78	3.52	3.95	3.79	2.96	4.15	5.99	7.60	**4.23**
FEB-II	7.38	7.60	5.15	10.40	9.98	9.27	3.70	4.35	9.19	5.82	4.81	7.22	5.46	7.32	8.23	9.92	6.78	9.11	3.98	9.28	8.20	7.35	9.05	11.08	9.46	8.37	8.29	4.57	4.85	6.62	3.74	7.71	8.37	6.31	7.02	6.75	5.40	7.34	10.33	12.96	**7.47**
FEB-III	7.30	7.52	5.09	10.30	9.88	9.18	3.65	4.30	9.09	5.76	4.76	7.14	5.40	7.24	8.14	9.82	6.71	9.02	3.94	9.19	8.11	7.27	8.96	10.97	9.36	8.28	8.21	4.52	4.79	6.55	3.70	7.63	8.28	6.24	6.94	6.68	5.34	7.27	10.23	12.83	**7.39**
MAR-I	7.78	8.00	5.44	10.95	10.50	9.76	3.92	4.60	9.67	6.15	5.09	7.61	5.77	7.71	8.67	10.44	7.15	9.60	4.22	9.77	8.63	7.75	9.53	11.65	9.96	8.81	8.74	4.83	5.12	6.98	3.96	8.12	8.81	6.65	7.40	7.12	5.71	7.74	10.87	13.62	**7.87**
MAR-II	7.26	7.47	5.06	10.24	9.83	9.13	3.83	4.28	9.04	5.73	4.73	7.10	5.37	7.20	8.10	9.76	6.67	8.97	3.91	9.14	8.07	7.23	8.91	10.91	9.31	8.23	8.16	4.49	4.78	6.51	3.67	7.59	8.23	6.20	6.90	6.65	5.31	7.23	10.17	12.76	**7.35**
MAR-III	9.89	10.16	6.98	13.82	13.27	12.35	5.09	5.94	12.23	7.86	6.54	9.67	7.39	9.80	10.99	13.18	9.10	12.14	5.46	12.36	10.94	9.84	12.06	14.70	12.59	11.17	11.07	6.22	6.58	8.89	5.14	10.31	11.17	8.49	9.41	9.07	7.31	9.84	13.73	17.14	**10.00**
APR-I	9.99	10.27	7.06	13.97	13.41	12.48	5.15	6.01	12.37	7.94	6.61	9.78	7.47	9.91	11.11	13.32	9.20	12.27	5.52	12.49	11.06	9.95	12.19	14.85	12.73	11.29	11.19	6.29	6.66	8.99	5.20	10.43	11.29	8.58	9.51	9.17	7.39	9.94	13.87	17.32	**10.11**
APR-II	12.05	12.39	8.56	16.78	16.11	15.01	6.29	7.32	14.87	9.61	8.03	11.79	9.05	11.95	13.38	16.01	11.11	14.76	6.74	15.02	13.32	12.00	14.66	17.83	15.30	13.59	13.48	7.65	8.09	10.86	6.36	12.57	13.59	10.37	11.48	11.07	8.96	11.99	16.67	20.76	**12.19**
APR-III	11.64	11.97	8.26	16.22	15.58	14.50	6.07	7.06	14.37	9.28	7.75	11.39	8.74	11.55	12.93	15.48	10.73	14.26	6.50	14.52	12.87	11.59	14.17	17.23	14.79	13.13	13.02	7.38	7.80	10.49	6.13	12.14	13.13	10.02	11.09	10.69	8.65	11.58	16.11	20.08	**11.77**
MAY-I	12.85	13.20	9.14	17.86	17.16	15.98	6.74	7.82	15.84	10.26	8.58	12.57	9.66	12.74	14.25	17.05	11.85	15.72	7.21	16.00	14.20	12.79	15.62	18.97	16.29	14.48	14.36	8.18	8.64	11.58	6.80	13.39	14.48	11.06	12.24	11.81	9.56	12.78	17.74	22.09	**12.99**
MAY-II	13.26	13.63	9.45	18.42	17.70	16.49	6.97	8.08	16.34	10.60	8.87	12.98	9.98	13.15	14.71	17.59	12.23	16.22	7.45	16.51	14.65	13.21	16.12	19.57	16.81	14.94	14.82	8.45	8.93	11.96	7.04	13.82	14.94	11.42	12.63	12.19	9.88	13.19	18.30	22.78	**13.41**
MAY-III	12.02	12.35	8.54	16.73	16.07	14.96	6.28	7.29	14.83	9.59	8.01	11.76	9.03	11.92	13.34	15.97	11.08	14.72	6.72	14.88	13.28	11.97	14.62	17.78	15.26	13.55	13.44	7.63	8.06	10.83	6.34	12.53	13.55	10.34	11.45	11.04	8.93	11.96	16.62	20.70	**12.15**
JUN-I	11.19	11.50	7.93	15.60	14.99	13.95	5.82	6.77	13.83	8.92	7.44	10.95	8.39	11.10	12.43	14.89	10.32	13.72	6.23	13.96	12.38	11.14	13.63	16.58	14.23	12.63	12.52	7.08	7.49	10.08	5.88	11.67	12.63	9.62	10.66	10.28	8.30	11.14	15.50	19.32	**11.32**
JUN-II	10.03	10.31	7.08	14.01	13.46	12.52	5.17	6.03	12.41	7.97	6.64	9.81	7.50	9.94	11.14	13.37	9.23	12.31	5.54	12.53	11.10	9.98	12.23	14.90	12.77	11.32	11.23	6.31	6.68	9.02	5.22	10.46	11.32	8.61	9.54	9.20	7.42	9.98	13.92	17.38	**10.14**
JUN-III	10.88	11.19	7.71	15.18	14.58	13.57	5.65	6.58	13.45	8.67	7.23	10.65	8.16	10.79	12.09	14.49	10.03	13.35	6.05	13.59	12.04	10.84	13.26	16.14	13.84	12.28	12.18	6.88	7.28	9.80	5.70	11.35	12.28	9.36	10.36	9.99	8.07	10.83	15.08	18.81	**11.01**
JUL-I	9.63	9.90	6.79	13.48	12.94	12.04	4.95	5.78	11.93	7.65	6.36	9.42	7.19	9.55	10.71	12.85	8.87	11.84	5.31	12.05	10.67	9.59	11.76	14.33	12.28	10.88	10.79	6.05	6.41	8.67	5.00	10.05	10.88	8.27	9.17	8.84	7.12	9.58	13.39	16.72	**9.74**
JUL-II	9.34	9.61	6.58	13.08	12.56	11.68	4.79	5.60	11.57	7.41	6.16	9.14	6.97	9.26	10.39	12.47	8.60	11.48	5.14	11.69	10.35	9.30	11.41	13.91	11.91	10.56	10.47	5.86	6.21	8.40	4.84	9.75	10.56	8.01	8.89	8.57	6.89	9.29	12.99	16.23	**9.45**
JUL-III	14.20	14.59	10.13	19.71	18.94	17.64	7.49	8.68	17.49	11.36	9.52	13.90	10.70	14.09	15.74	18.82	13.11	17.36	8.01	17.66	15.68	14.14	17.25	20.93	17.99	15.99	15.86	9.07	9.58	12.81	7.56	14.80	15.99	12.24	13.53	13.06	10.59	14.13	19.58	24.35	**14.38**
AUG-I	12.22	12.55	8.68	17.00	16.33	15.21	6.39	7.42	15.07	9.75	8.15	11.96	9.18	12.12	13.56	16.23	11.27	14.96	6.83	15.22	13.50	12.17	14.86	18.06	15.51	13.77	13.66	7.76	8.20	11.01	6.45	12.74	13.77	10.52	11.64	11.22	9.08	12.16	16.89	21.04	**12.35**
AUG-II	8.33	8.57	5.84	11.70	11.23	10.44	4.23	4.96	10.34	6.59	5.47	8.15	6.19	8.26	9.28	11.16	7.66	10.26	4.54	10.45	9.24	8.30	10.20	12.45	10.65	9.43	9.35	5.19	5.51	7.48	4.27	8.70	9.43	7.13	7.92	7.63	6.13	8.29	11.62	14.54	**8.43**
AUG-III	6.85	7.05	4.76	9.68	9.29	8.62	3.40	4.02	8.54	5.39	4.45	6.70	5.06	6.79	7.65	9.23	6.29	8.48	3.67	8.63	7.61	6.82	8.42	10.31	8.80	7.77	7.71	4.22	4.48	6.14	3.44	7.16	7.77	5.85	6.51	6.27	5.00	6.82	9.62	12.07	**6.93**
SEP-I	8.67	8.92	6.09	12.17	11.68	10.86	4.42	5.17	10.76	6.87	5.70	8.48	6.46	8.60	9.65	11.60	7.98	10.68	4.74	10.87	9.61	8.64	10.61	12.94	11.08	9.81	9.73	5.42	5.74	7.79	4.46	9.05	9.81	7.43	8.25	7.95	6.39	8.83	12.09	15.11	**8.77**
SEP-II	6.35	6.54	4.39	8.99	8.62	8.00	3.12	3.70	7.93	4.98	4.10	6.20	4.67	6.29	7.09	8.57	5.82	7.87	3.37	8.01	7.06	6.32	7.81	9.58	8.17	7.21	7.15	3.88	4.13	5.68	3.16	6.64	7.21	5.41	6.03	5.80	4.61	6.31	8.93	11.23	**6.42**
SEP-III	4.53	4.67	3.06	6.51	6.24	5.77	2.11	2.54	5.71	3.51	2.84	4.42	3.27	4.49	5.09	6.19	4.14	5.67	2.30	5.78	5.06	4.51	5.63	6.95	5.89	5.18	5.13	2.68	2.87	4.03	2.14	4.75	5.17	3.82	4.29	4.12	3.23	4.50	6.47	8.19	**4.59**
OCT-I	3.57	3.68	2.36	5.20	4.97	4.59	1.58	1.93	4.54	2.73	2.18	3.48	2.53	3.53	4.03	4.94	3.24	4.51	1.73	4.60	4.01	3.55	4.47	5.57	4.69	4.10	4.06	2.05	2.20	3.16	1.60	3.75	4.10	2.99	3.37	3.23	2.50	3.55	5.17	6.58	**3.62**
OCT-II	3.18	3.29	2.08	4.68	4.47	4.12	1.36	1.69	4.07	2.41	1.91	3.10	2.23	3.15	3.60	4.44	2.89	4.04	1.50	4.12	3.58	3.17	4.01	5.01	4.21	3.67	3.63	1.79	1.93	2.81	1.38	3.35	3.67	2.65	3.00	2.87	2.20	3.16	4.64	5.94	**3.23**
OCT-III	3.52	3.64	2.33	5.14	4.91	4.53	1.55	1.90	4.49	2.69	2.15	3.43	2.49	3.49	3.97	4.88	3.20	4.45	1.70	4.54	3.96	3.50	4.42	5.50	4.63	4.05	4.01	2.02	2.17	3.11	1.57	3.70	4.05	2.95	3.33	3.19	2.46	3.50	5.10	6.50	**3.57**
NOV-I	3.30	3.41	2.16	4.83	4.62	4.26	1.43	1.76	4.21	2.51	1.99	3.21	2.32	3.27	3.73	4.58	2.99	4.18	1.57	4.26	3.71	3.28	4.15	5.17	4.35	3.80	3.76	1.87	2.01	2.91	1.45	3.46	3.80	2.75	3.11	2.98	2.29	3.28	4.80	6.13	**3.34**
NOV-II	5.84	6.02	4.02	8.30	7.96	7.38	2.84	3.37	7.31	4.57	3.75	5.71	4.28	5.79	6.53	7.91	5.35	7.25	3.07	7.39	6.50	5.82	7.20	8.85	7.53	6.64	6.58	3.55	3.78	5.22	2.87	6.11	6.64	4.97	5.54	5.33	4.23	5.81	8.25	10.38	**5.91**
NOV-III	2.91	3.01	1.88	4.31	4.12	3.79	1.21	1.52	3.75	2.19	1.73	2.84	2.03	2.89	3.31	4.08	2.64	3.71	1.34	3.79	3.29	2.90	3.69	4.62	3.87	3.37	3.34	1.61	1.74	2.56	1.23	3.07	3.37	2.42	2.75	2.62	2.00	2.90	4.28	5.49	**2.95**
DEC-I	2.18	2.25	1.34	3.30	3.14	2.88	0.80	1.05	2.85	1.59	1.22	2.11	1.46	2.15	2.49	3.12	1.95	2.82	0.91	2.88	2.48	2.16	2.80	3.55	2.95	2.54	2.51	1.13	1.23	1.89	0.82	2.30	2.54	1.77	2.04	1.94	1.44	2.16	3.28	4.25	**2.21**
DEC-II	2.36	2.45	1.48	3.56	3.39	3.11	0.91	1.16	3.07	1.74	1.35	2.30	1.60	2.34	2.70	3.36	2.12	3.05	1.02	3.11	2.68	2.35	3.02	3.82	3.18	2.75	2.72	1.25	1.36	2.06	0.92	2.49	2.75	1.94	2.22	2.11	1.58	2.35	3.53	4.56	**2.39**
DEC-III	1.75	1.82	1.03	2.72	2.59	2.36	0.57	0.78	2.33	1.25	0.92	1.70	1.13	1.73	2.02	2.57	1.56	2.31	0.66	2.36	2.01	1.74	2.29	2.94	2.42	2.07	2.04	0.85	0.94	1.51	0.58	1.86	2.07	1.41	1.63	1.55	1.11	1.74	2.70	3.54	**1.78**
ANNUAL	7.35	7.56	5.13	10.36	9.94	9.23	3.68	4.33	9.15	5.80	4.79	7.19	5.44	7.29	8.19	9.87	6.75	9.08	3.96	9.24	8.16	7.32	9.02	11.03	9.42	8.33	8.26	4.55	4.82	6.59	3.72	7.68	8.33	6.28	6.99	6.72	5.38	7.31	10.29	12.90	**7.44**

4.2.3.3 Recommendation

The flows estimated on the basis of regression analysis are on higher side and the flow pattern is not exactly matched with flows of Khan Khawar at Kuz Kana. So the flows estimated from the statistical method are recommended for the energy and power generation.

4.2.4 Comparison of Flow Data

Comparison of flows estimated in the feasibility study and estimated in the review study is summarized below (**Table 4.3**)

Table 4.3: Summary of Flows

Description		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Gorband River at Karora (1975-2010)		6.7	10.9	28.4	37.9	27.3	18.9	25.9	25.5	14.1	9.9	7.2	6.6	18.3
Khan Khawar at Kuz Kana (2006-2012)		4.3	7.5	10.8	13.7	15.8	13.1	18.2	11.6	8.4	5.1	5.6	3.5	9.8
Feasibility Estimated Flows at Weir Site (1975-2008)		3.2	4.6	9.0	11.1	8.8	6.8	8.4	8.2	5.4	4.2	3.4	3.1	6.35
Review Study Estimated Flows at Weir Site	Method-1 Regression Analysis	2.5	4.9	13.2	18.3	13.8	9.6	13.6	12.3	6.7	4.3	3.2	2.4	8.73
	Method-1 Statistical Approach	2.8	6.4	8.4	11.4	12.8	10.8	11.2	9.2	6.6	3.5	4.1	2.1	7.44

4.3 FLOW DURATION CURVE

Flow duration curve at the project site has been estimated from the 10-daily flows data estimated from the statistical approach.

Summary of the flow duration curve is given in the **Table 4.4** and shown in the **Figure 4.7.**

Table 4.4 Flow Duration

% of Time	Flow (Cumecs)	% of Time	Flow (Cumecs)
0.1%	24.35	55.0%	6.13
5.0%	15.62	60.0%	5.31
10.0%	13.73	65.0%	4.61
15.0%	12.52	70.0%	4.12
20.0%	11.58	75.0%	3.64
25.0%	10.61	80.0%	3.15
30.0%	**9.75**	85.0%	2.68
35.0%	9.02	90.0%	2.16
40.0%	8.23	95.0%	1.69
45.0%	7.48	100.0%	0.57
50.0%	6.79		

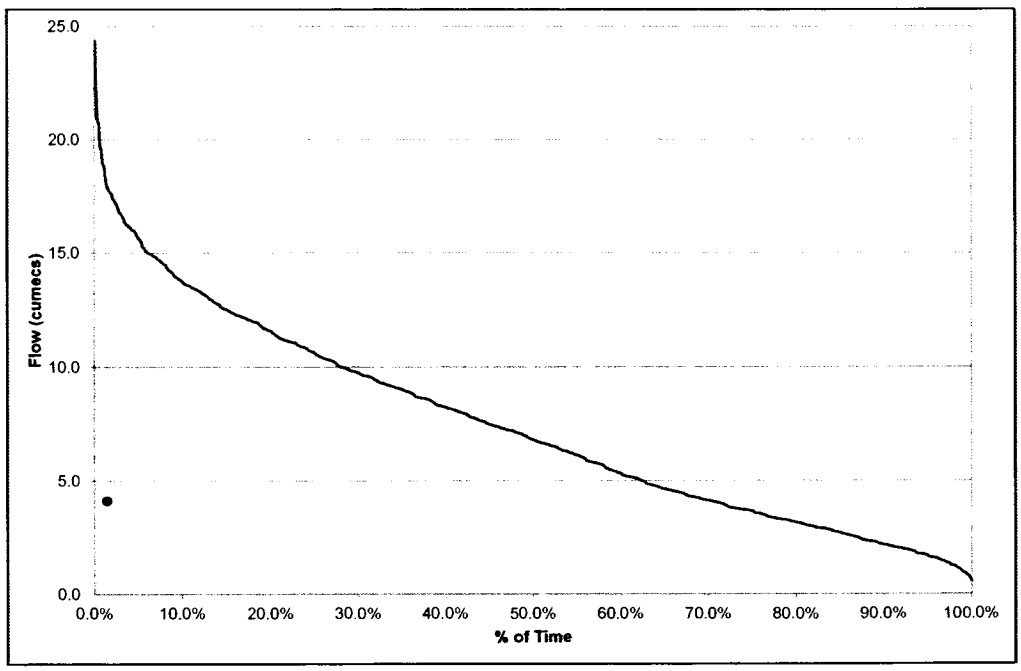

Figure 4.7 Flow Duration curve

4.4 DESIGN DISCHARGE

The fixing of a specific value for the 'Design Discharge' is the most important task of the hydrological analyses and similarly the Power, Energy and Plant Factor calculations are also based on the design discharge. In the feasibility study the design discharge has not been discussed and fixed against 30% of time. The feasibility report uses the value of 7.39 m3 /s for the 'Design Discharge' against 30% of time. In the current review study 9.75 cumecs discharge is selected against 30% of availability of flow.

4.5 DESIGN FLOODS

Return period of 1000 years has been taken in the feasibility study for the design flood for weir which is acceptable.

In the feasibility study the flood at the project site have been estimated for the 1975 to 2008 by using statistical as well as hydro-meteorological approach.

In the current review study the same approaches were used to update the flood study upto the year 2012.

4.5.1 Statistical Approach:

4.5.1.1 Flood Data

Flood data in the form of instantaneous peak flows of Gorband river at Karora are available for the period 1975-1997, 2001-2010 (30-Years). These values are extended for Karoa weir site by using ratio method.

4.5.1.2 Flood Frequency Analysis

In this approach, frequency analysis of annual instantaneous peak floods for the thirty years of record at Weir site has been carried out. Gumble and Log Pearson Type-III distributions are used on the extended peak flood data of project site. The results are shown in **Figure 4.8** and summary of results in **Table 4.5**.

Table 4.5: Summary of Result of Flood Frequency Analysis

Return Period	Flood (Cumecs)	
	Log Pearson Type-III	Gumble
2	165	184
10	429	467
25	584	610
50	704	715
100	826	820
200	951	925
1000	**1256**	**1167**
10000	1645	1514

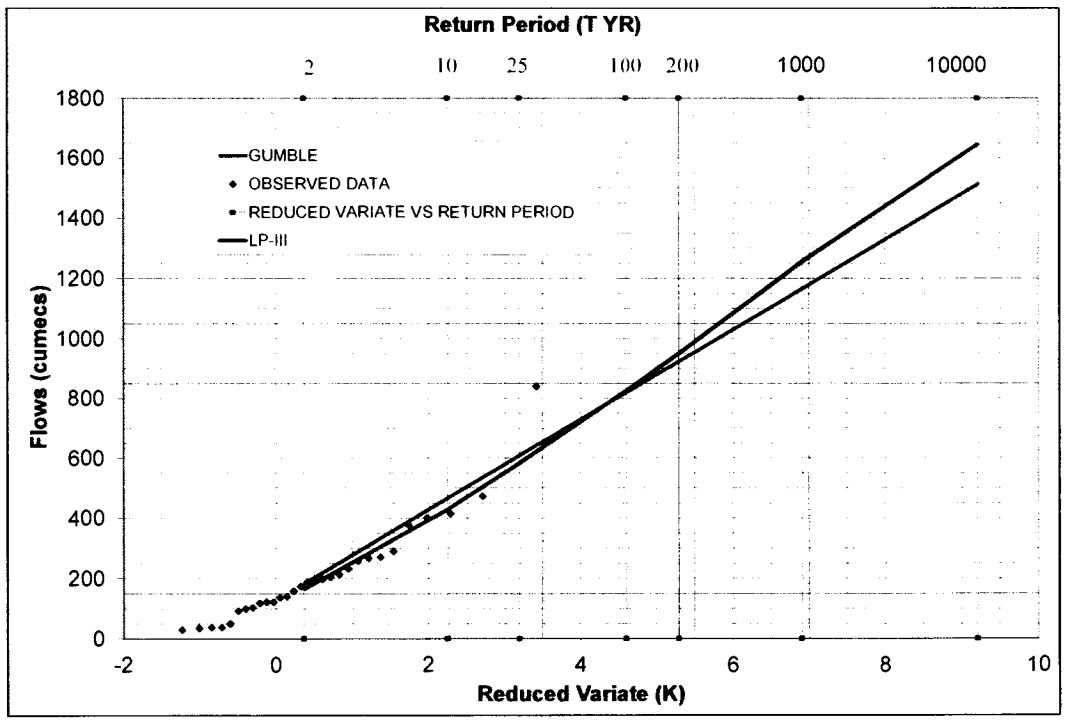

Figure 4.8: Flood Frequency Analysis at Weir Site without Higher Outlier

4.5.2 Hydro-Meteorological Approach

In this approach the rainfall-runoff model, HEC- HMS was used to estimate the design flood against 1000 and 10000 year return periods. HEC-HMS is a rainfall-runoff model in which catchment area characteristics in terms of loss rate, unit hydrograph description (lag time) and time distribution of rainfall are assigned as input and flood hydrographs at different junctions are determined as output. The SCS unit hydrograph method was used to estimate the flood at project site.

4.5.2.1 Rainfall Data and Frequency Analysis

In the feasibility study the rainfall frequency analysis have been carried out on the rainfall data of Besham Qila for the period of 1964-2006.

In the current review study the latest rainfall data of Besham Qila for the year 2007-2012 have been collected form surface water hydrology project (SWHP), WAPDA. Frequency analysis of the data was carried out. Extreme Gumbel probability paper was used and

shown in the **Figure 4.9** .Rainfall against different return periods were extracted and listed in Table 4.6

Table 4.6 Summary of Result of Rainfall Frequency Analysis

Sr. No.	Return Period (Years)	Rainfall (mm)
1	2	67
2	10	110
3	25	132
4	50	148
5	100	164
6	200	180
7	1000	216
8	10000	269

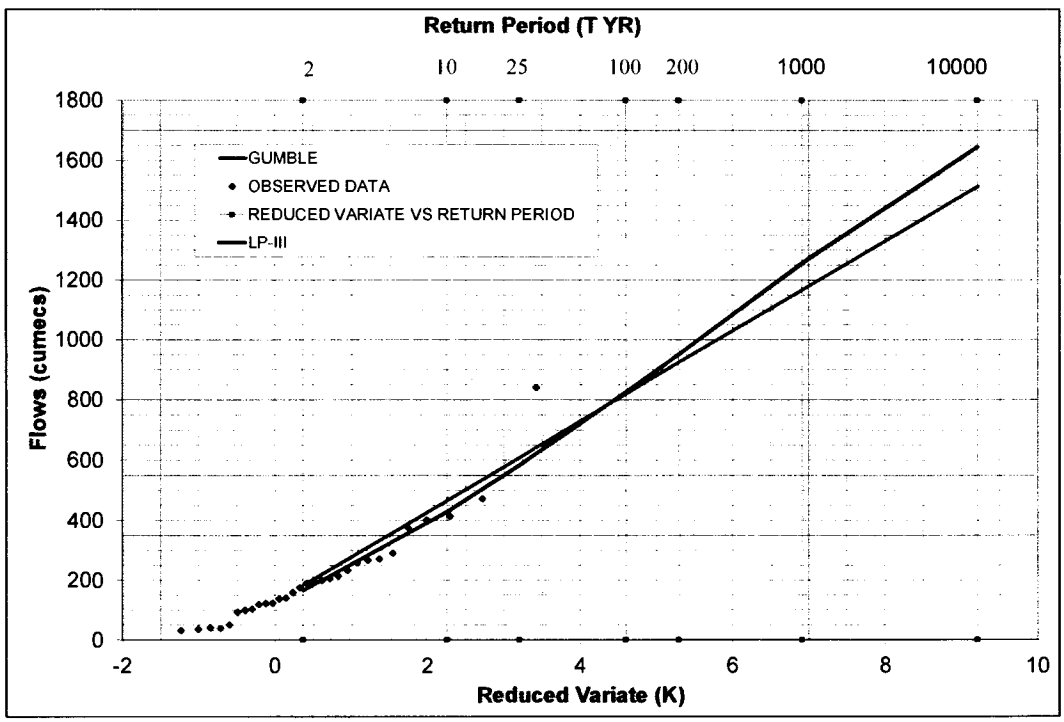

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Table 4.6Summary of Result of Rainfall Frequency Analysis (1964-2012)

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1	2	67
2	10	110
3	25	132
4	50	148
5	100	164
6	200	180
7	1000	216
8	10000	269

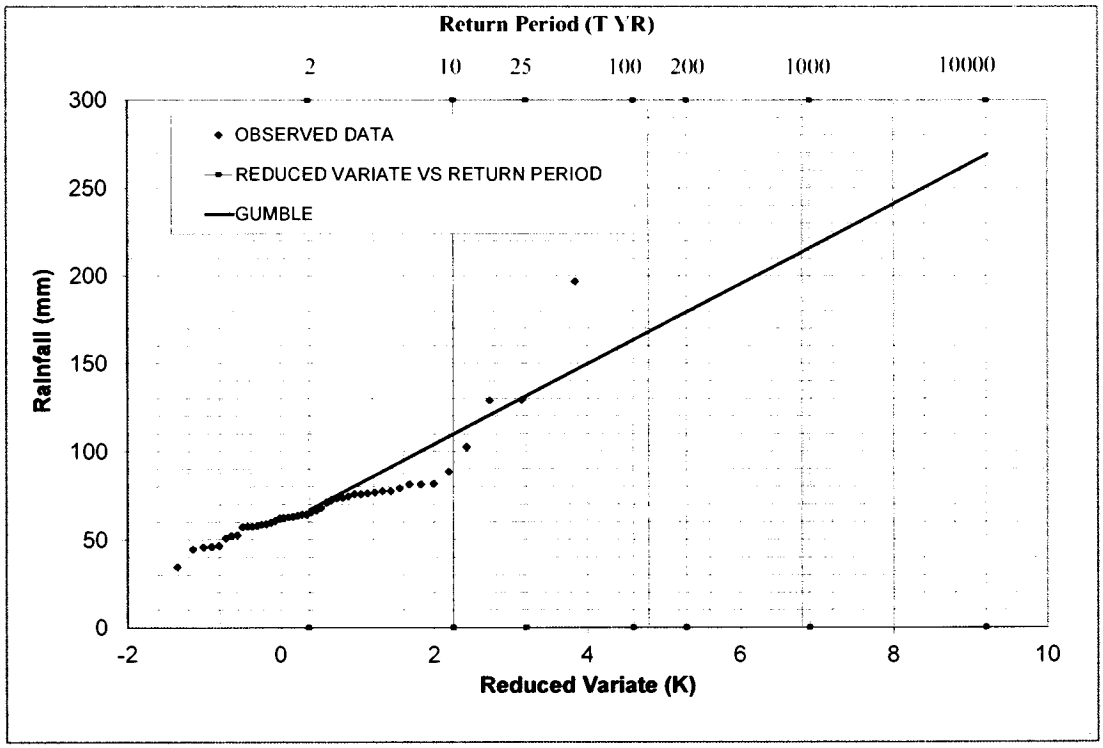

Figure 4.9 1- Day Maximum Rainfall Frequency Analysis

Synthetic unit hydrograph for Karora catchment has also been developed using Soil Conservation Service (SCS) curvilinear dimensionless unit hydrograph. It requires estimation of the time of concentration, for which Kirpitch formula was used and the resultant inflow hydrograph were estimated as 1196 cumecs and 1565 cumecs against 1000 and 10,000 year return period respectively.

4.6 CONCLUSIONS AND RECOMMENDATIONS

Discharge at 30% exceeded has been worked out as 9.75 m^3/sec instead of 7.39 m^3/sec mentioned in Feasibility Study thus installed capacity and Annual energy will considerable increase. Details are provided under chapter 6.

Chapter - 5

SEISMIC HAZARDS

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SEISMIC HAZARDS

This chapter of Feasibility Study has been reviewed in detail. Management consultants agree with the following conclusions mentioned in the Feasibility Study.

5.1 CONCLUSIONS

- The Karora HPP site lies in a seismically active zone which might experience seismic hazard of significantly high magnitude.
- The latest event of October 08, 2005 earthquake of Muzaffarabad-Balakot produced an Intensity of around IX with a Magnitude of 7.6. Therefore, on the basis of felt intensity data of recurring events, an intensity range of VII to VIII would be reasonable for the region under study.
- On the basis of felt intensity data and the instrumental record of macro and micro seismicity, the faults of Main Boundary Thrust (MBT), Kashmir Thrust (KT), Main Mantle Thrust (MMT) and Indus Kohistan Seismic Zone (IKSZ), are considered to be active in the Project area.
- With Deterministic Seismic Hazard Analysis (DSHA), value of 0.39g for Maximum Credible Earthquake (MCE) has been calculated. The available 635 seismic events around this site indicate OBE values of the order of 0.21 for Karora HPP.
- The return period as per Gutenberg-Richter Law for a 7.6 magnitude earthquake is calculated to be of the order of 421 years, and for a Magnitude 7 earthquake is 81 years for Karora HPP site.
- The values calculated are considered adequate for structures of the relatively small Hydropower Projects involving diversion weirs and small structures.

Tables provides in the F.S are also reproduced below for ready reference.

Table-5.1

Intensity Values and Acceleration Relationship

M.M. Intensity	NEUMANN	GUTENBERGER & RICHTER	HERSHBERGER	Average
V	0.032	0.015	0.018	0.22
VI	0.065	0.032	0.048	0.048
VII	0.133	0.07	0.128	0.11
VIII	0.27	0.15	0.345	0.255
IX	0.549	0.32	0.925	0.598

Table-5.2

PGA Values for Magnitude 6, 7 & 7.6 Earthquake with Hypocenter Depth as 15 & 25 Kilometers

Earthquake Magnitude (M)	Hypocentral Depth (Km)	Acceleration "a"				
		ORPHAL	DEVEN PORT	ESTEVA	DENO-VAN	Average
6	15	0.376	0.391	0.224	163	0.289
7	15	0.946	0.871	0.499	269	0.646
7.6	25	0.825	0.622	0.590	0.276	0.578
8	25	1.192	0.856	0.812	0.337	0.799

Table - 5.3

Evaluation of PGA in Pakistan Using Different Formulae

Station	Mag (Mw)	Dist. (Kms)	ORPHAL	DEVEN-PORT	ESTEVA	DENOVAN	Observed PGA
Abbottabad	7.6	37	0.4783	0.3268	0.4201	0.2079	0.087
Murree	7.6	53	0.2903	0.1813	0.2880	0.1535	0.069
Nilor	7.6	82	0.1583	0.0886	0.1674	0.1011	0.023
Tarbela	7.6	80	0.1638	0.0923	0.1730	0.1037	0.1
Brotha	7.6	125	0.0881	0.0444	0.0915	0.0648	0.04

Table-5.4

Maximum Credible Earthquake of Different Tectonic Features in the Region

Fault	Fault Rupture Length (km)	Magnitude		Source to site distance	Peak Horizontal Acceleratio
		Full length	Half length		
		(M)	(M)	Kms	PHA
Main Boundary Thrust (MBT)/MMT	100	7.66	7.36	40	0.338
Kashmir Thrust (KT)/Bagh Balakot Fault	75	7.53	7.23	35	0.351

Table-5.5

Earthquake Distribution Using USGS Database around Karora

Distance (kms)from Karora	1	3	5	7	10	15	20	30	40	50	70	100	150	200
No. of Earthquake Events	0	0	0	0	3	6	13	65	193	354	566	726	991	1513

Table-5.6

ICOLD Recommendations on Return Period

				Rule of Thumb		Exact
NEP	T	r	r*	Calculation	RP	RP
0.9	**50**	**0**	**0.11**	**50/0.105**	**476**	**474.6**
0.9	100	0	0.11	100/0.105	952	949.1
0.9	250	0	0.11	250/0.105	2381	2373

Conclusion and Recommendations

Seismic Hazard Data shall become part of the Bidding Document, so that bidders can use and check the values for establishing his design parameters.

Chapter - 6

PROJECT LAYOUT STUDIES

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PROJECT LAYOUT STUDIES

6.1 PROJECT LAYOUT

6.1.1 General

Karora Hydropower Project is located on Khan Khwar near Besham in Shangla District of KP. The proposed weir site is located approximately 300 m upstream of village Kuz Kana. The site for the powerhouse is located 2.5 Km downstream of village Karora near Ranial. As the main road from Besham to Alpuri town runs parallel to Khan Khwar, accessibility is easy. Average river bed elevation above sea level in this reach is approximately 1005 m. This project will be connecting two limbs of the river loop by means of a weir, a channel, sandtrap, power tunnel and powerhouse. A gross head of approximately 152 m is available for power production because of long loop and steep slope of the river.

6.1.2 Review of Layout

Management Consultants and Project Director during the field visit on 30th Nov. 2013 observed that alignment of penstock (proposed during the Feasibility Studies) was passing through the existing expensive houses. It was proposed to shift the alignment of penstock U/s of proposed penstock.

Survey was carried out and revised alignment was marked. Revised Survey also shows cluster of houses just on the location of Surge shaft. This situation necessitates shifting of alignment of tunnel and surge shaft. Figure No 6.1 showing Feasibility Layout of the Project and revised layout by M.C is placed at the end of chapter.

6.1.3 Review of Hydrology

Review of Hydrology Studies in the light of data collected upto December 2013 shows that a discharge 9.75 m$^{3/}$sec is available 30% of time. This discharge has been taken as Designed discharge which

is higher than feasibility level design discharge (7.39 m^3/sec) by 23%.

6.1.4 Review of Components of the Project

Keeping in view design discharge of 9.75 m^3/sec and 1000 years return period flood of 1196 m^3/sec (feasibility 1000 Years return period flood = 1090 m^3/sec), the size of Intake, box conduit, sand trap, power tunnel, powerhouse and Tail race shall increase. Each component of the Project along with its revised size is being discussed below.

- **Diversion weir and spillway**

  Weir shall be able to pass the revised 1000 year return period flood of 1196 m3/sec. no change in the width of the weir however; the design of the stilling basin shall be revised.

- **Intake and connecting conduit**

  Size of Intake will increase to 4.4 m wide and 2.7 m high as compared to 4 m x 2.1 m in F.S. The design discharge of intake is 11.7 m^3/sec (power flows 9.75 m^3/s + 20% additional flows for sandtrap flushing).

  Size of connecting conduit will increase to 3.2m x 2.1m instead of 2.8m x 1.5m.

  Sizes of the Trash Rack, Stop logs and Bulkhead gates shall also increase accordingly.

- **Sandtrap**

  After the box channel 2 chamber sandtrap shall be provided with the length of sedimentation basin 90 m (Appx). Due to increased design discharge 11.7 m^3/sec of sandtrap, the width of the each chamber is 5m and depths are from 8 to 10 m.

  Due to error in the Feasibility report regarding the water level in box channel, the alignment of the box channel has to be revised to avoid excessive filling underneath. This will also result in revised

location of sandtrap at higher NSL. Consequently additional land acquisition is envisaged along box channel and at sandtrap locations.

- **Pressure conduit**

  Pressure conduit 108 m long will be connected to intake of Power tunnel. Due to increased Designed Discharge (9.75 m^3/sec), the size of Cut & Cover conduit will be 3.2m x 2.1m.

- **Power tunnel**

  To maintain velocity of 1.86 m/sec and providing slope of 1:1000, the cross sectional area required is 5.24 m^2. Dia of tunnel will increase to 2.60 meter. A horseshoe shaped tunnel shall be designed during Basic Design Stage. For early completion and to facilitate construction of tunnel, two adits are also recommended to be provided.

- **Surge Tank**

  At the end of headrace tunnel, a surge tank circular, reinforced concrete lined will be constructed.

Cross Section/Alignment	Circular/ Vertical
Diameter (Finished)	8.0 m Approximately
Thickness of Concrete Lining	0.5 m Approximately
Height of Surge shaft	25.0 m Approximately (Open to surface)

  The walls should be raised above natural surface level to protect from falling debris and safe from other determinately hazards events. A reinforced concrete roof with side opening shape or other arrangement can be made.

- **Penstock**

  At the end of the power tunnel, there will be one steel penstock of wall thickness 16-18 mm. recalculated diameter of Penstock is

1.72m for 9.75 m^3/sec discharge and keeping velocity at 4.18m/sec.

- **Tail Race**

  On the basis of 9.75 m^3 /sec, the revised Tail Race dimensions are 4.0m wide and 2.0m deep. Velocity in the tailrace is taken as 1.50 m/sec.

- **Installed Capacity, Energy and Power**

  On the basis of Q_{30} = 9.75 and net head of 142 m when all units are operating, the installed capacity works out as 11.8 MW.

  It is recommended to install two Francis Turbines each having installed capacity of 5.9 MW and Designed Discharge of 4.875m^3/sec.

  Annual Energy generated is 71.39 GWh while plant factor is 69.06%.

  A table showing Project Average 10 Daily Discharges, Level, outputs and annual Energy is placed on next page.

  To facilitate the readers to know the deviations from Feasibility Studies, a comparison of salient Features is attached.

Salient Features Comparison

Feasibility Study Vs Reviewed Feasibility Study

Description		
Hydrology		
Catchment Area	230km^2	235km^2
Full Reservoir Level (FRL)	1013.00 masl	1013.00 masl
Mean Monthly Flows	3.24 m^3/s to 11.07 m^3/s	2.13 to 12.85m^3/sec (based on 10-daily)
Design Flow (Q_{30})	7.39 m^3/s for power yield	9.75 m^3/sec
Flood Discharge (Q_{100})	719 m^3/s	826 m^3/sec
Flood Discharge (Q_{1000})	1,090 m^3/s	1196 m^3/sec
Flood Discharge ($Q_{10,000}$)	1,475 m^3/s	1565 m^3/sec
Power Facilities		
Powerhouse Type	Surface	Surface
Gross Head	150.58 m ~ 145.92 m	152 m
Net Head	138.00 m	142 m
Installed capacity	9.3 MW	11.8 MW
Design Discharge	7.39 m^3/sec	9.75 m^3/sec
No. of units	2 No	2 Nos.
Turbines Type	Horizontal Francis	Horizontal Francis
Turbine Capacity (each)	4.63 MW (3.7 m^3/sec)	5.9 MW (4.875 m^3/sec)
No. of Generators	2 No.	2 Nos.
Generator Capacity (each)	5.33 MVA	6.27MVA
Power factor	0.85	0.85
Average annual energy	53.44 GWh	71.39GWh
Plant Factor	65.61%	69.06%
Transmission Facilities		
Transmission line	132 KV-20 Km at Khan Khwar HPP grid station)	132 KV-20 Km at Khan Khwar HPP grid station)

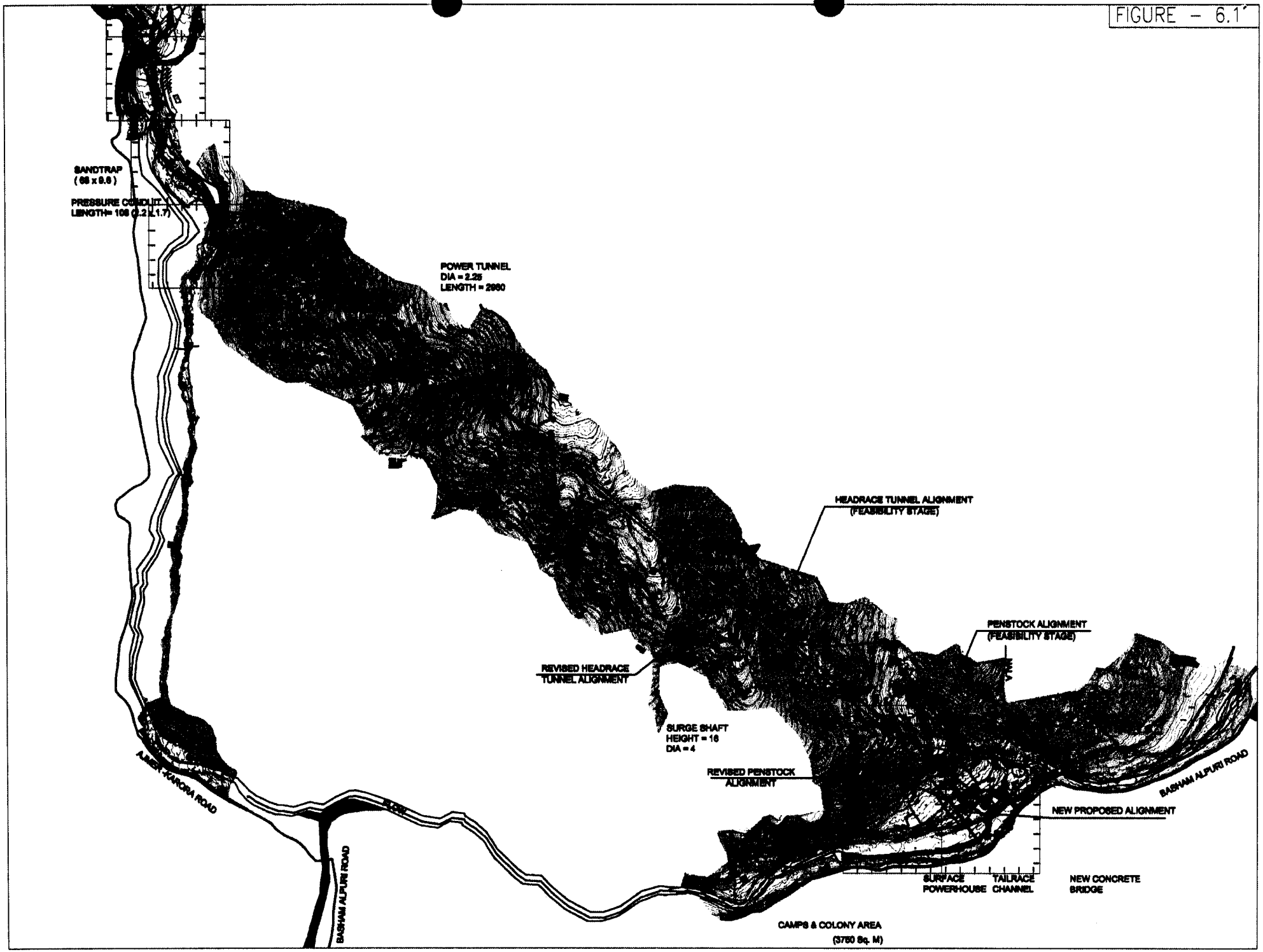
Karora Hydropower Project-Average 10 Daily Discahrges, Levels, Outputs and Annual Energy

Flows available for 30% of time are used	
Max. Gross Head with all units operating (m)	**152.0**
Max. Net Head with all units operating (m)	**142.0**
Total Design Discharge (cumecs)	**9.75**
Total Power Generation (MW)	**11.8**
Installed Capacity (MW)	**11.8**
Unit Capacity (MW)	**5.9**

Average Energy Produced (GWh)	71.39
Full Capacity Energy (GWh)	103.37
Plant Factor %	**69.06**

Month	Head Water Level (m)	Flows (cumecs)	Turbines Discharges (cumecs)	Spilled Flows (cumecs)	Tailrace Levels (m)	Gross Head (m)	Head Loss = $10.5 \times 10^{-2} \times Q_2^{\wedge}2$	Net Head (m)	Power Output P =9.81* H*C*0.86/1000 (MW)	No. of Days	Energy (GWH)
	A	B	C	D=B-C	E	F=A-E	G	H = F-G	I	J	K
Jan	1013	2.01	2.01	0.00	861	152.0	0.422	151.6	2.56	10	0.62
	1013	2.93	2.93	0.00	861	152.0	0.901	151.1	3.73	10	0.90
	1013	3.33	3.33	0.00	861	152.0	1.165	150.8	4.24	11	1.12
Feb	1013	4.23	4.23	0.00	861	152.0	1.880	150.1	5.36	10	1.29
	1013	7.47	7.47	0.00	861	152.0	5.856	146.1	9.21	10	2.21
	1013	7.39	7.39	0.00	861	152.0	5.734	146.3	9.12	8	1.75
Mar	1013	7.87	7.87	0.00	861	152.0	6.504	145.5	9.66	10	2.32
	1013	7.35	7.35	0.00	861	152.0	5.670	146.3	9.07	10	2.18
	1013	10.00	9.75	0.25	861	152.0	9.982	142.0	11.68	11	3.08
Apr	1013	10.11	9.75	0.36	861	152.0	9.982	142.0	11.68	10	2.80
	1013	12.19	9.75	2.44	861	152.0	9.982	142.0	11.68	10	2.80
	1013	11.77	9.75	2.02	861	152.0	9.982	142.0	11.68	10	2.80
May	1013	12.99	9.75	3.24	861	152.0	9.982	142.0	11.68	10	2.80
	1013	13.41	9.75	3.66	861	152.0	9.982	142.0	11.68	10	2.80
	1013	12.15	9.75	2.40	861	152.0	9.982	142.0	11.68	11	3.08
June	1013	11.32	9.75	1.57	861	152.0	9.982	142.0	11.68	10	2.80
	1013	10.14	9.75	0.39	861	152.0	9.982	142.0	11.68	10	2.80
	1013	11.01	9.75	1.26	861	152.0	9.982	142.0	11.68	10	2.80
July	1013	9.74	9.74	0.00	861	152.0	9.965	142.0	11.67	10	2.80
	1013	9.45	9.45	0.00	861	152.0	9.374	142.6	11.37	10	2.73
	1013	14.36	9.75	4.61	861	152.0	9.982	142.0	11.68	11	3.08
Aug	1013	12.35	9.75	2.60	861	152.0	9.982	142.0	11.68	10	2.80
	1013	8.43	8.43	0.00	861	152.0	7.459	144.5	10.28	10	2.47
	1013	6.93	6.93	0.00	861	152.0	5.048	147.0	8.60	11	2.27
Sep	1013	8.77	8.77	0.00	861	152.0	8.081	143.9	10.65	10	2.56
	1013	6.42	6.42	0.00	861	152.0	4.332	147.7	8.00	10	1.92
	1013	4.59	4.59	0.00	861	152.0	2.208	149.8	5.80	10	1.39
Oct	1013	3.62	3.62	0.00	861	152.0	1.372	150.6	4.59	10	1.10
	1013	3.23	3.23	0.00	861	152.0	1.092	150.9	4.11	10	0.99
	1013	3.57	3.57	0.00	861	152.0	1.336	150.7	4.53	11	1.20
Nov	1013	3.34	3.34	0.00	861	152.0	1.172	150.8	4.25	10	1.02
	1013	5.91	5.91	0.00	861	152.0	3.669	148.3	7.40	10	1.78
	1013	2.95	2.95	0.00	861	152.0	0.916	151.1	3.77	10	0.90
Dec	1013	2.21	2.21	0.00	861	152.0	0.512	151.5	2.82	10	0.68
	1013	2.39	2.39	0.00	861	152.0	0.602	151.4	3.06	10	0.73
	1013	1.78	0.00	1.78	861	152.0	0.000	152.0	0.00	11	0.00
											71.39

FIGURE – 6.1


SANDTRAP
(6B x 9.6)
PRESSURE CONDUIT
LENGTH= 108 (3.2 x 1.7)
POWER TUNNEL
DIA = 2.25
LENGTH = 2660
HEADRACE TUNNEL ALIGNMENT
(FEASIBILITY STAGE)
PENSTOCK ALIGNMENT
(FEASIBILITY STAGE)
REVISED HEADRACE
TUNNEL ALIGNMENT
SURGE SHAFT
HEIGHT = 16
DIA = 4
REVISED PENSTOCK
ALIGNMENT
AMER-KAHORA ROAD
BASHAM ALPURI ROAD
BASHAM ALPURI ROAD
NEW PROPOSED ALIGNMENT
SURFACE
POWERHOUSE
TAILRACE
CHANNEL
NEW CONCRETE
BRIDGE
CAMPS & COLONY AREA
(3750 Sq. M)

Chapter – 7

STRUCTURAL DESIGN STUDIES

CHAPTER – 7

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CHAPTER – 7

STRUCTURAL DESIGN STUDIES

7.1 GENERAL

This chapter deals with structural Design of Project structures and Components Hydraulic Design of each structure has been reviewed under chapter – 6.

7.2 DESIGN REFERENCES

Following design references are motioned in the Feasibility Report

[1] ACI 318-95 Building Code Requirements for Structural Concrete

[2] ACI 350R-89 Environmental Engineering Structures

[3] ACI 207.2 Effects of Restraint, Volume Change and Reinforcement on Cracking of Massive Concrete Structures

[11] USBR Engineering Monograph No 14 – Begg's Deformeter Stress Analyses of Single Barrel Conduits

[12] US Army Corps of Engineers EM 1110-2-2901, Tunnels and Shaft in Rock

[21] Raynolds C E – RC Designer's Handbook

[22] Nilson A H – Design of Concrete Structures

Bids shall be invited on ICB basis. Many countries such as China, Japan and European Countries have their own codes. Therefore Bidders shall not be restricted to use only above mentioned codes, but shall be allowed to use their own code, if internationally acceptable.

7.3 SIZING OF STRUCTURES

Sizing of structures and components is established in consideration of their hydraulics, construction, functional and operational requirements. Effects of the dead and imposed (live) loads, impact, probable contact of the structure with water, water tightness under hydrostatic head, uplift forces, buoyancy

effect, structural (movement) joint location; are considered; to ensure the structure's durability and serviceability. In view of the considerable hydrostatic head, the design of powerhouse unit bays shall be based on a minimum ratio of the mass of stationary sub-structure to the mass of revolving machinery, of 5 to 10, according to the provisions contained in standard references.

7.4 DESIGN EARTHQUAKE FACTORS

Factor for pseudo-static stability analyses in the OBE and MDE (MCE) condition given below is adopted from Chapter 5 – Seismic Hazards. 'Seismic Factor' considered in the stability analyses of the weir and other structures, is adopted after modification made in the 'Value at Site', considering (a) – Damping of ground motions, (b) – Structures ductility, and (c) – Incoherence of earthquake vibrations in the structures whole base width and along the height, and surrounding water mass (in water retaining structures).

Table-7.4.14 – Seismic Factor considered for Pseudo-static Stability Analyses

Description	Factor for OBE	Factor for MCE
Value at Site as per Report	0.24	0.35
Seismic Factor considered	0.14	0.22

A Operating Basis Earthquake (OBE)

Operating Basis Earthquake represents a level of ground motions which, the powerhouse, its equipment, and related facilities should withstand while remaining functional. Damage, if any, should be non-structural and easily repairable. It implies that the stresses should not increase by more than about 20 percent compared to the normal operation condition.

B Maximum Credible Earthquake (MCE)

Principal structural plant components should withstand MCE level of motions without collapsing. However, occurrence of significant structural or non-structural damage could be acceptable under MCE,

as long as such damage would present no risk (by sudden collapse) to life of plant operation personnel. It implies that the stresses in reinforcement shall not exceed the yield point. There shall be no uncontrolled release of impounded water in the reservoir.

All the Codes and Requirements shall be listed in the EPC Bidding Documents.

7.5 It is recommended that EPC Contractor after carryout Detailed Design of weir and its components will be required to get the Model Study carried out.

Chapter – 8 & 9

MECHANICAL & ELECTRICAL EQUIPMENT

CHAPTER – 8 & 9

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CHAPTER – 8 & 9

MECHANICAL & ELECTRICAL EQUIPMENT

1. GENERAL COMMENTS

- As per our working using mean monthly flows at Karora Weir (Table-4.11), for 30% exceedance of time the discharge comes out to be 8 cumecs which is higher than the value mentioned in the report (i.e.7.39 cumecs) By utilizing 8 cumecs flows substantially higher annual energy can be produced.
- Review of Hydrology after adding data upto December 2013, and Calculating average flow on 10 Daily bases. Design flow at 30% exceedence increase to 9.75 m^3/sec from 7.39m^3/sec.
- We have worked out that for 750 rpm machines, there should be positive setting of turbines i.e. centreline of the turbine higher than the tail water level. However, negative setting of (-1.886 m) has been mentioned in the report with respect to minimum tail water level which needs to be revised.
- Water hammer analysis for partial and full load rejection is missing in the report which needs to be carried out.
- Tail water rating curve/data is required for getting information on normal, maximum and minimum tailwater elevations to determine design head and to determine the appropriate turbine setting.
- Generator rated efficiency of 98% as mentioned in the report is considerably on higher side for such rating of generators. According to our working and generator data of different manufacturers for such rating machines, it should be in the range 95.5 - 96%.
- Fault level, detailed protection and equipment specification shall be decided at design stage.
- Rotating parts of the proposed generators shall be able to withstand the stresses at runaway speed for thirty minutes.

- Both step up transformers shall be of same capacity.
- 11/11kV interposing transformer is not needed.
- Protection and Switchgear control DC voltage level should be 110V.

CONCLUSION

Taking Design Discharge as 9.75 m3/sec. Efficiency of Turbine as 92% while efficiency of Generator 95.5%. Net Design Head also increases as M.C have calculated head from construction level of Reservoir i.e 1013m amsl table showing working and calculation of Power and Energy is attached.

Following Revised Parameters Are Recommended as a recent of following data.

Designed Discharge	=	9.75m3/sec
Design Head	=	142m
Efficiency of Turbine	=	92%
Efficiency of Generator	=	95.5%
Revised Installed Capacity	=	11.8MW
Two turbines each	=	5.9MW (Q = 4.875m3/sec)
Revised Energy	=	71.39 GWh
Revised Plant factor	=	69.06%

Estimated average annual energy has been worked out considering the following:

- *Flat efficiency of 86% has been taken for turbine and generator*
- *Auxiliary load is not deducted*
- *Average 10-Daily flows were used*

Karora Hydropower Project-Average 10 Daily Discahrges, Levels, Outputs and Annual Energy

Flows available for 30% of time are used	
Max. Gross Head with all units operating (m)	**152.0**
Max. Net Head with all units operating (m)	**142.0**
Total Design Discharge (cumecs)	**9.75**
Total Power Generation (MW)	**11.8**
Installed Capacity (MW)	**11.8**
Unit Capacity (MW)	**5.9**

Average Energy Produced (GWh)	71.39
Full Capacity Energy (GWh)	103.37
Plant Factor %	**69.06**

Month	Head Water Level (m)	Flows (cumecs)	Turbines Discharges (cumecs)	Spilled Flows (cumecs)	Tailrace Levels (m)	Gross Head (m)	Head Loss = $10.5 \times 10^{-2} \times Q_2^{\wedge}2$	Net Head (m)	Power Output P =9.81* H*C*0.86/1000 (MW)	No. of Days	Energy (GWH)
	A	B	C	D=B-C	E	F=A-E	G	H = F-G	I	J	K
Jan	1013	2.01	2.01	0.00	861	152.0	0.422	151.6	2.56	10	0.62
	1013	2.93	2.93	0.00	861	152.0	0.901	151.1	3.73	10	0.90
	1013	3.33	3.33	0.00	861	152.0	1.165	150.8	4.24	11	1.12
Feb	1013	4.23	4.23	0.00	861	152.0	1.880	150.1	5.36	10	1.29
	1013	7.47	7.47	0.00	861	152.0	5.856	146.1	9.21	10	2.21
	1013	7.39	7.39	0.00	861	152.0	5.734	146.3	9.12	8	1.75
Mar	1013	7.87	7.87	0.00	861	152.0	6.504	145.5	9.66	10	2.32
	1013	7.35	7.35	0.00	861	152.0	5.670	146.3	9.07	10	2.18
	1013	10.00	9.75	0.25	861	152.0	9.982	142.0	11.68	11	3.08
Apr	1013	10.11	9.75	0.36	861	152.0	9.982	142.0	11.68	10	2.80
	1013	12.19	9.75	2.44	861	152.0	9.982	142.0	11.68	10	2.80
	1013	11.77	9.75	2.02	861	152.0	9.982	142.0	11.68	10	2.80
May	1013	12.99	9.75	3.24	861	152.0	9.982	142.0	11.68	10	2.80
	1013	13.41	9.75	3.66	861	152.0	9.982	142.0	11.68	10	2.80
	1013	12.15	9.75	2.40	861	152.0	9.982	142.0	11.68	11	3.08
June	1013	11.32	9.75	1.57	861	152.0	9.982	142.0	11.68	10	2.80
	1013	10.14	9.75	0.39	861	152.0	9.982	142.0	11.68	10	2.80
	1013	11.01	9.75	1.26	861	152.0	9.982	142.0	11.68	10	2.80
July	1013	9.74	9.74	0.00	861	152.0	9.965	142.0	11.67	10	2.80
	1013	9.45	9.45	0.00	861	152.0	9.374	142.6	11.37	10	2.73
	1013	14.36	9.75	4.61	861	152.0	9.982	142.0	11.68	11	3.08
Aug	1013	12.35	9.75	2.60	861	152.0	9.982	142.0	11.68	10	2.80
	1013	8.43	8.43	0.00	861	152.0	7.459	144.5	10.28	10	2.47
	1013	6.93	6.93	0.00	861	152.0	5.048	147.0	8.60	11	2.27
Sep	1013	8.77	8.77	0.00	861	152.0	8.081	143.9	10.65	10	2.56
	1013	6.42	6.42	0.00	861	152.0	4.332	147.7	8.00	10	1.92
	1013	4.59	4.59	0.00	861	152.0	2.208	149.8	5.80	10	1.39
Oct	1013	3.62	3.62	0.00	861	152.0	1.372	150.6	4.59	10	1.10
	1013	3.23	3.23	0.00	861	152.0	1.092	150.9	4.11	10	0.99
	1013	3.57	3.57	0.00	861	152.0	1.336	150.7	4.53	11	1.20
Nov	1013	3.34	3.34	0.00	861	152.0	1.172	150.8	4.25	10	1.02
	1013	5.91	5.91	0.00	861	152.0	3.669	148.3	7.40	10	1.78
	1013	2.95	2.95	0.00	861	152.0	0.916	151.1	3.77	10	0.90
Dec	1013	2.21	2.21	0.00	861	152.0	0.512	151.5	2.82	10	0.68
	1013	2.39	2.39	0.00	861	152.0	0.602	151.4	3.06	10	0.73
	1013	1.78	0.00	1.78	861	152.0	0.000	152.0	0.00	11	0.00
											71.39

Chapter – 10

ENVIRONMENTAL AND SOCIAL ASSESSMENT

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CHAPTER – 10

ENVIRONMENTAL AND SOCIAL ASSESSMENT

10.1 GENERAL

Hydropower is a primary domestic and renewable source of energy. Pakistan is endowed with a hydel potential of approximately 40,000 MW, most of which lies in the Khyber Pakhtunkhwa, Gilgit Baltistan, Azad Jammu & Kashmir and some parts of Punjab. In spite of this, Pakistan's energy market investment in hydel power generation has, unfortunately, been caught up in confusion and paradoxes for many decades and no significant progress has been achieved so far. The Government is also trying to facilitate private investors to promote hydel power generation in the country but the efforts have so far not succeeded. Electric power is a major stimulator for the socio-economic uplift of the country. However, only half of the country's population has access to electricity. After the creation of Pakistan, the country faced numerous problems including dearth of electrical power.

Fortunately, abundant hydel potential remains untapped which needs to be harnessed. The total installed capacity of the hydropower stations in the country is about 6,595 MW, out of which 3,767 MW is in Khyber Pakhtunkhwa, 1,698 MW in Punjab, and 1,036 MW in AJK and 93 MW in the Gilgit Baltistan, which represents merely 15 % of the total identified potential.

10.2 NEED FOR THE ENVIRONMENTAL STUDY

The law makes it mandatory to carry out Initial Environmental Examination (IEE) or detailed Environmental Impact Assessment (EIA) of the development projects depending upon the nature and magnitude of the impacts. Pakistan Environmental Protection Agency (Pakistan-EPA) regulatory guidelines (Pakistan Environmental Assessment Procedure; 1997; Policy and Procedures for filling, review and approval of environmental assessment (pp15 & 17)), exempt a hydropower and dam project from being put to EIA only when:

- The dams and reservoir have a water storage volume less than 50

million m3 or the surface area is less than 8 km².

- Hydropower generation capacity is less than 50 MW.

The Karora Hydropower Project is generally a run-of-the river project wherein the reservoir storage capacity and areal spread is for less than the limits identified above and even power generation capacity is less than 50 MW. Moreover, the project does not induce significant environmental and social disruption. On these grounds the project does not qualify for Environmental Impact Assessment (EIA), rather an Initial Environmental Examination (IEE) will suffice. As the Project falls in the jurisdiction of Pak-EPA, for that matter Environmental Protection Agency of Khyber Pakhtunkhwa and Asian Development Bank, therefore, it desirable that regulatory requirements for environmental protection and social safeguards of both Government of Pakistan and Asian Development are adhered to.

All ADB projects are assigned one of four categories (A, B, C, or FI) for environmental assessment. The category is assigned based on the project's potential for environmental impact. The proposed Project is classified by the Asian Development Bank (ADB) as categories B – a project which has some adverse environmental impacts, but of lesser degree and/or significance than those for category – A projects.

This chapter has been prepared keeping in view the regulatory requirements of both Pak-EPA and ADB.

10.3 M.C COMMENTS

Project is not funded by ADB, therefore IEE Study has been reviewed on the basis of Pak-EPA, guidelines.

Study has been carried out in detail and covers every aspect of Pak EPA guidelines.

Chapter –11

CONSTRUCTION PLANNING AND COST ESTIMATE

CHAPTER – 11

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CHAPTER –11

CONSTRUCTION PLANNING AND COST ESTIMATE

11.1 GENERAL

ACE have rightly pointed out that work on most of the components can be carried out independently.

We agree with the construction period of 35 months. Increase in installed capacity as well as increase in sizes of project components can be completed in 35 months.

11.2 COST ESTIMATE

Cost Estimates provided in feasibility Study is based on June-2011 rates. The US$ rate being US$ 1.00 = Rs 86.00. Present (28-02-2014) US$ rate is US$=Rs 105.00. Cost of construction material has also considerably increased as compared to June 2011 rate.

11.3 ENGINEER'S ESTIMATE

An Engineers Estimate shall be prepared on the rates prevailing 28 days prior to Bid submission date so that reasonability of Bid Price could be checked.

International Bidders are expected to participate therefore; increased in overheads shall be included in the Engineers Estimate.