BEFORE

NATIONAL ELECTRIC POWER REGUALATORY AUTHORITY ISLAMABAD

FOR

MODIFICATION IN THE GENERATION LICENSE NO. IGSPL/39/2014 FROM 3.24 MW GROSS ISO (DATED: 08-01-2014) TO 3.6 MW GROSS ISO

UNDER SECTION 26 OF THE REGULATION OF GENERATION, TRANSMISSION AND DISTRIBUTION OF ELECTRIC POWER ACT 1997, READ WITH REGULATION 10(2) OF THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY LICENCING (APPLICATION AND MODIFICATION PROCEEDURES) REGULATIONS, 1999

BY

M/S KARIMI ENERGY (PRIVATE) LIMITED

ADDRESS : CHAMBER OF COMMERCE AND INDUSTRY, G.T. ROAD, PESHAWAR, KHYBER PAKHTUNKHWA

THROUGH

SYED IBRAHIM AHMAD

EXECUTIVE DIRECTOR

M/S NASIR ABSAR CONSULTING (PRIVATE) LIMITED

The Registrar,
National Electric Power Regulatory Authority,
NEPRA Tower, Ataturk Avenue,
G 5/1, Islamabad.

Subject: **Application for modification to the Generation License No. IGSPL/39/2014 from 3.24 MW Gross ISO (dated: 08-01-2014) to 3.6 MW Gross ISO**

The undersigned, Executive Director of M/s Nasir Absar Consulting (Pvt) Limited, being authorized representative of M/s Karimi Energy (Private) Limited (the "Company"), with its principal office at Chamber of Commerce and Industry, G.T. Road, Peshawar, Khyber Pakhtunkhwa, Pakistan, owners and developers of Jabri Bedar Hydro Power Project. The Company by virtue of its Board of Directors' Resolution dated: August 15, 2014 (copy Attached), hereby apply to the National Electric Power Regulatory Authority for modification to the Generation License No. IGSPL/39/2014. of 3.24 MW Gross ISO Dated: 08-01-2014, issued in favour of M/s Karimi Energy (Private) Limited for Jabri Bedar Hydro Power Project, pursuant to the section 26 of the Regulation of Generation, Transmission and Distribution of Electric Power Act 1997, read with Regulation 10(2) of the National Electric Power Regulatory Authority Licencing (Application and Modification Proceedures) Regulations, 1999 and all other applicable provisions of Law and submits as under:

Statement of Facts:

1. That M/s Karimi Energy (Private) Limited a company incorporated under the laws of Pakistan, with its principal office at Chamber of Commerce and Industry, G.T. Road, Peshawar, Khyber Pakhtunkhwa, is in a process of developing a Hydropower project namely Jabri Bedar Hydro-Electric Power Generation Complex on Haro River, Near Village Peena, District Haripur, Province Khyber Pakhtunkhwa.

2. That the Authority was pleased to issue the Generation License No. IGSPL/39/2014 of 3.24 MW Gross ISO Dated: 08-01-2014 to the M/s Karimi Energy (Private) Limited instead of the requested 3.6MW whereby inadvertently due to typographical error in the Feasibility Study Report showing four turbines of a capacity of 811 KW each instead of 900 KW each.

3. That at the time of the Public Hearing for the Determination of the Feasibility Stage tariff, which was pleaded on the Plant Capacity of 3.6 MW, the typographical error mentioned supra was pointed out by the Authority with the advice to come back after correcting and making consistency in both the tariff petition and the generation license.

4. That the Company approached the Pakhtunkhwa Energy Development Organization (PEDO) for the correction of the said typographical error in the Feasibility Study Report.

5. That the Pakhtunkhwa Energy Development Organization (PEDO) was pleased to accept the said correction and communicated the same to the Authority vide letter # 3622-24/PEDO/DPP/NEPRA dated 24.07.2014.

Proposed Modification:

That Generation License No. IGSPL/39/2014 of 3.24 MW Gross ISO Dated: 08-01-2014 issued to the M/s Karimi Energy (Private) Limited may kindly be modified to 3.6 MW. That is "Four turbines of 811 KW" is modified as "Four turbines of 900 KW".

Statement of Reasons for Modification:

1. That the Authority was pleased to issue the Generation License No. IGSPL/39/2014 of 3.24 MW Gross ISO Dated: 08-01-2014 to the M/s Karimi Energy (Private) Limited instead of 3.6MW whereby inadvertently due to typographical error in the Feasibility study report showing four turbines of a capacity of 811 KW each instead of 900 KW each.

2. That at the time of the Public Hearing for the Determination of the Feasibility Stage tariff, which was pleaded on the Plant Capacity of 3.6 MW, the typographical error mentioned supra was pointed out by the Authority with the advice to come back after making consistency in both the tariff petition and the generation license and the same has now been amended and communicated vide their letter No.3622-24/PEDO/DPP/NEPRA dated 24-07-2014.

3. That the said error was neither intentional nor deliberate, rather it was typographical one.

4. That such modification does not affect in any manner the licensee to perform its obligation.

5. That there is no omission on part of the licensee in any manner and such modification is not inconsonance with the provision of the Act or the rules or regulations made pursuant to the Act.

6. That the said modification is necessary and based on the facts of the case and indispensable to effectively perform its obligation and to ensure the continuous, safe and reliable supply of electric power to the consumer, keeping in view the financial and technical viability of the licensee, and in the larger interest of the nation.

Statement of impact on tariff:

That it is humbly submitted that the Authority has yet not determined any tariff for this project, therefore, impact on the tariff is not possible to be computed.

Prayer:

It is respectfully prayed that the Generation Licence No. IGSPL/39/2014 of 3.24 MW Gross ISO Dated: 08-01-2014 may kindly be modified from 3.24 MW to 3.6 MW.

Dated: August 18, 2014

Syed Ibrahim Ahmed

Executive Director

KARIMI
ENERGY

Khyber Pakhtunkhwa Chamber of Commerce
& Industry, G.T. Road, Peshawar - Pakistan.
Ph: (091) 2218881-3 Fax: (091) 2218880
E-mail: karimienergy@hotmail.com

BOARD RESOLUTION

CERTIFIED TRUE COPY OF THE RESOLUTION PASSED BY THE BOARD OF DIRECTORS OF THE COMPANY IN ITS MEETING HELD ON AUGUST 15, 2014, AT ITS REGISTERED OFFICE.

RESOLVED THAT Syed Ibrahim Ahmad

of **M/S NASIR ABSAR CONSULTING (PVT.) LTD.** is authorized representatives on behalf of the Company for the purpose of filing an application for modification of Generation License for 3.6 MW Jabri Bedar Hydro Power Project and to submit before NEPRA. The representatives are also authorized to attend any/ all meeting(s) and discussions related to the Generation License and to provide any information and documents needed in this regard.

This resolution will remain in force unless revoked; a notice in writing be forwarded to NEPRA of any such effect(s).

KARIMI ENERY (PVT) LTD.

SYED ZAHIR ALI SHAH
Chief Executive

SYED ZAHID HUSSAIN
Director

SYED ASHFAQ HUSSAIN
Director

SYED FAROOQ ALI SHAH
Director

Attested:

ASHIQ HUSSAIN
Secretary

ASHIQ HUSSAIN
Secretary
Karimi Energy (Pvt) Ltd.
Sarhad Chamber House
Peshawar. Ph:2218881-3

CERTIFICATE

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 undertakes to abide by the terms and provisions of the above-said Regulations. Further undertake and confirm that the information provided and attached documents-in-support is. true and correct to the best of my knowledge and belief.

A Pay order # DD383502/43 dated 15/08/2014 drawn on The Bank of Khyber, G.T. Road Branch, Peshawar, of a sum of Rs.135,200/- (Rupees One Hundred Thirty Five Thousand Two Hundred Only), being the non-refundable lisence application modification fee calculated in accordance with Schedule-II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, is also attached herewith.

Dated: August 18, 2014

Syed Ibrahim Ahmed
Executive Director

PEDO

PAKHTUNKHAWA ENERGY DEVELOPMENT ORGANIZATION

Government of Khyber Pakhtunkhwa Peshawar

No. 3622-21/PEDO/DPP/NEPRA
Dated. Peshawar the 24/7/2014

To

Registrar,
National Electric Power Regulatory Authority,
2nd Floor,OPF Building,G-5/2,Islamabad

SUBJECT: **ISSUANCE OF STAMPED COPY OF FEASIBILITY STUDY ALONG WITH APPROVAL LETTER FOR DEVELOPMENT OF 3.6 MW JABRI BEDAR HYDROPOWER PROJECT**

I am directed to refer to M/S Karimi Energy(Pvt)Ltd letter No.KE/2014/PHYDO/098 Dated 3.7.2014**(Annex-I)** and to state that M/S Karimi Energy (Pvt) Ltd approached your good office for issuance of generation license for 3.6MW. NEPRA while issuing the generation license pointed out an error in the feasibility study report that four turbines of 811KW have been considered mounting to the plant capacity of 3.24MW.This error was due to typographic mistake and has been corrected in the Feasibility Study.

Therefore, you are requested to consider the M/S Karimi Energy (Pvt) Ltd case for issuance of generation license please.The corrected copy of Feasibility Study is enclosed.

Encl: aa

Assistant Director-I
(Private Power)

CC:

1. PS to Chief Executive Officer/GM(Hydel)PEDO, Peshawar.
2. M/S Karimi Energy(Pvt) Ltd,Karimi Plaza,1st Floor,Melad Chowk,Peshawar

Assistant Director-I
(Private Power)

325-26-PEDO House, 38/B-2, phase-V, Hayatabad, Peshawar. Tel:(+92-91) 9217488, Fax (+92-91) 9217489

KARIMI ENERGY (PVT) LTD

JABR [illegible]DAR HYDROPOWER PROJECT
ON
HARO RIVER
DISTRICT HARIPUR KHYBER PUKHTUNKHWA

FEASIBILITY STUDY

VOLUME II: MAIN REPORT

JANUARY 2013

Directorate of Private Power (PHYDO)
ATTESTED
Ltr. No. 3622-24
Dt. 24-07-2014

DESIGNMEN Consulting Engineers (Pvt) Ltd
1st Floor Block-9, Rizwan Plaza, Jinnah Avenue F-6,
Islamabad Tel: 92-51-2828577-2829002 Fax: 2307615
E-mail: ***designmn@isb.comsats.net.pk*** ***najib@isb.comsats.net.pk***
Web Site: ***www.designmen.com.pk***

JABRI BEDAR HYDROPOWER PROJECT

Feasibility Study

MAIN REPORT

TABLE OF CONTENTS

1 INTRODUCTION

Proposed Jabri Bedar Hydropower is a 3.6 MW Hydropower project located on Haro River in the upper reach of Haro River (about 15 to 20 kilometer upstream of khanpur Dam) starting just downstream of Jabri Bridge on Lora-Murree Link. The proposed project site is upstream of khanpur Dam and is approximately 45 kilometer from Murree, about 45 kilometers from Hassan Abdal to Lora Chowk (about 10 kilometers from Haripur city on Karakoram Highway) and then 26 Kilometer to proposed project site.This report presents the project feasibility; prepared by DESIGNMEN Consulting Engineers (Pvt) Ltd for Karimi Energy (Pvt.) Ltd.

1.1 Project background

Pakistan has hydroelectric power potential of more than 60000 MW. To date only 11% of the hydropower potential has been harnessed and 10-15% is under various stages of development. Thus around 75% of the potential remains unexploited. According to the latest demand/supply projections it is foreseen, with a growth rate of ± 7.5%, additional power up to 13000 MW would be needed by the end of 2014-2015.

To accommodate these shortages, the government of Pakistan announced the policy for power generation project in 2002, which provides a clear set of incentives, with the participation of the hydropower plants to bridge the projected gap foreseen in the demand and supply of electricity.

A raw site with an estimated design capacity of 4.5 MW was identified on Haro River by Karimi Energy Pvt. Ltd. And a concession start just upper reach of Haro River (about 15 to 20 kilometer upstream of khanpur Dam) starting just downstream of Jabri Bridge on Lora-Murree Link.

The Hydrology of the proposed power project allows for water availability of 9.91m³/s for 30 % of the time. Therefore 4 Vertical axis francis Turbines of 900 kw capacity each have been proposed to generate a 18.129 GWH energy annually with a plant factor of 58.73 %., The Jabri Bedar hydropower plant can be connected to nearest at Haripur Grid station that will carry low transmission cost & provide high degree of reliability and system security

The responsibility for the feasibility study preparation was transferred by Karimi Energy Pvt. Ltd. to Designmen Consulting Engineers of Islamabad.

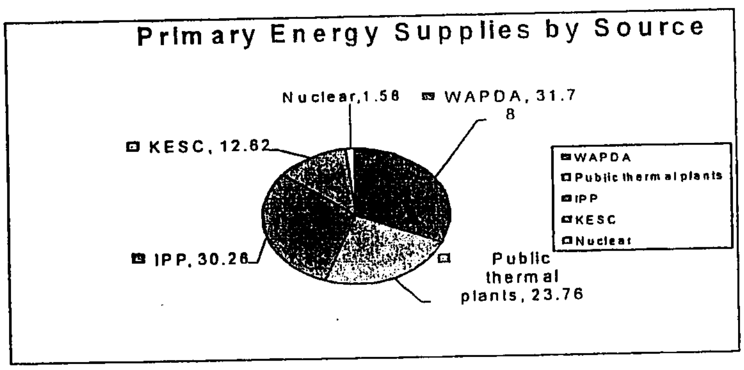
Technical issues in development of the project potential include choice of riverbank for development, choice of powerhouse site, choice of intake, choice of design head and flow and choice of installed capacity. Seismic design and sediment management are also major concerns. This Feasibility report summarizes the available technical data on the site, evaluates development alternatives and describes the proposed optimum development.

1.2 POWER MARKET

Pakistan, despite the enormous potential of its energy resources, remains energy deficient and has to rely heavily on oil imports to satisfy its requirements. Pakistan spends $3.5 billion every year on the import of oil. 38.3 percent of the electric power currently consumed in Pakistan is generated from oil (largely imported), while 43.8 percent is generated by natural gas, from domestic sources. During fiscal year 2009-10, the total installed capacity of electricity generation stood at 20,707MW. The share of power generated by the WAPDA system is 31.78 percent, public thermal plants is 23.76 percent, IPPs accounts for 30.26 percent, KESC at 12.62 percent, and nuclear at 1.58 percent. **Figure 1.1** depicts the position.

The Water and Power Development Authority (WAPDA), Pakistan Electric Power Company (PEPCO), the Karachi Electric Supply Company (KESC), the Pakistan Atomic Energy Commission are the four main public sector power utility organizations and are involved in power generation, transmission, and distribution of electricity. Independent power producers (IPPs) are involved only in power generation that is sold to NTDC for onwards to distribution companies.

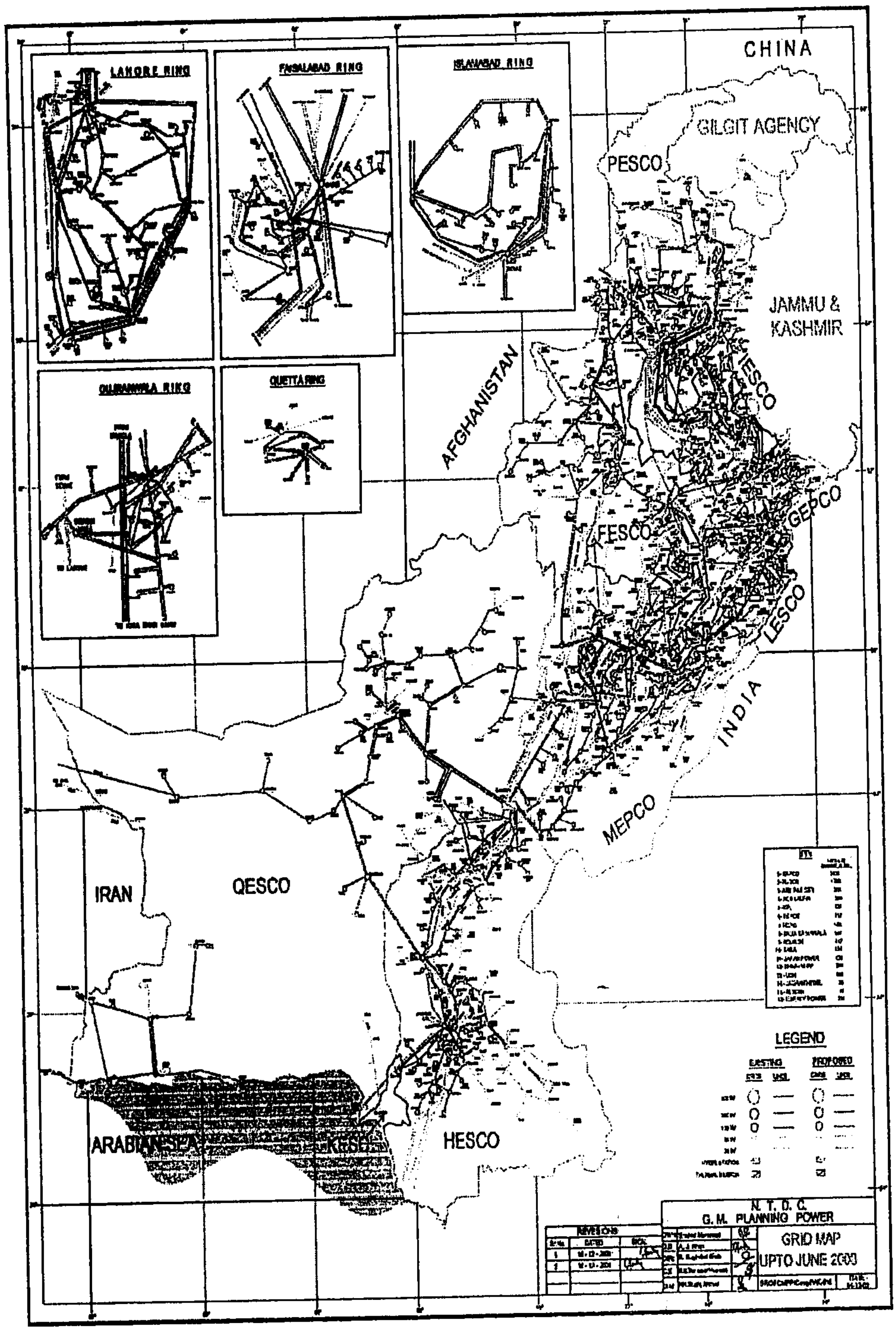
Figure 1-1: Share of various power sources in system 2009-10



Source: Electricity Marketing Data (Power System Statistics), 2009, PEPCO

The NTDC operates and maintains a very sophisticated transmission system and all power plants in the country are connected to NTDC's transmission system. The NTDC's transmission system is further connected with transmission and distribution system of Distribution Companies and KESC system. **Figure 1.2** provides the national transmission and distribution system at a glance.

Figure 1-2: NTDC Electrical Network



1.3 Pakistan Power Demand and Supply

The country suffers from large demand-supply gap of electricity of the order of 3000 to 4000 MW due to lack of adding generation capacity to match the growing demand. The current installed power generation capacity is about 20,707 MW. The maximum capability (MW) of these power stations is 18,267 MW and minimum capability is 15,023 MW. Pakistan is short of indigenous fuel except coal and is likely to remain deficit for a long time.

Our power generation mix of Hydel-Thermal has undergone to an undesirable change from 70:30 in the 1960s to 37:63 at present raising the cost of generation tremendously.

A major part of the solution lies in generating more power from the abundant hydel resources that nature has bestowed upon the country and also in tapping renewable energy resources like wind and solar power besides development of Thar coal reserve which is one of biggest coal reserves in the world.

So far not much attention has been given to these valuable sources of energy which not only provide energy security but also are more environmental friendly than other energy resources.

Pakistan is heavily dependent on gas and oil for its energy requirement. With the trend of indigenous gas reserve on decline and oil prices rising sharply, Pakistan needs to urgently address its energy balance and bring it into line with a balance international generation mix. Coal is used for 39% of world electricity generation and plays no role in Pakistan's generation mix.

The Government of Pakistan while realizing this issue has planned to improve future energy mix plan of the country that aims to be implemented by the year 2022 which provide greater self sufficiency, and energy reliance on indigenous resources. The present and projected energy mix in power generation is presented in **Figures 1.3** and **1.4** respectively.

Figure 1-3 Energy Mix of Pakistan 2009

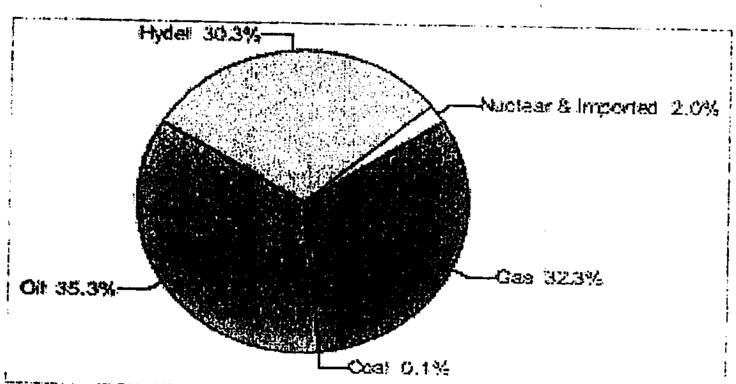
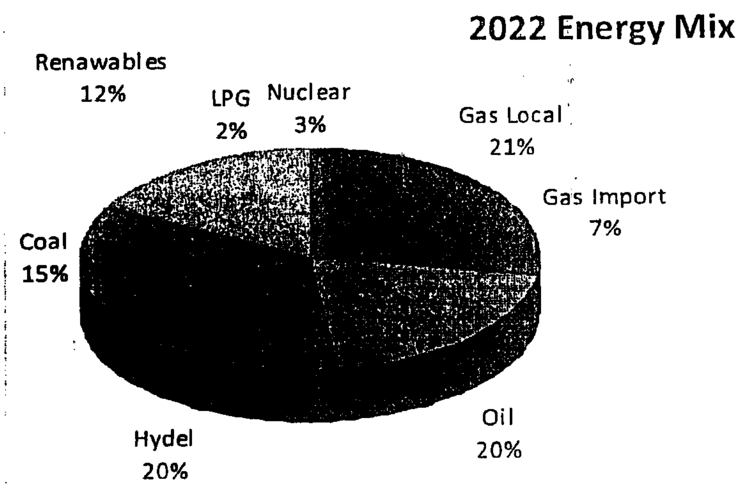


Figure 1-4: Energy Mix of Pakistan 2022



Source: Electricity Marketing Data (Power System Statistics

Various studies conducted in the past have established that Pakistan has a hydropower potential of above 50,000 MW and identified hydel power sites for more than 41,700 MW out of which 70% are located in NWFP. Currently our installed hydel power capacity is only 6600 MW. Again, about 66% of this lies in NWFP. To meet the ever increasing electricity shortage in the country the Water and Power Development Authority (WAPDA) is vigorously carrying out feasibility studies and engineering designs for various hydropower projects with a cumulative generation capacity of more than 25,000 MW.

In keeping with the national policy and need, the Government of Khyber Pakhtunkhwa has also been according high priority to hydropower development in the Province. Government of Khyber Pakhtunkhwa had set-up Sarhad Hydel Development Organization (SHYDO) in 1986 that worked under the administrative control of Irrigation and Power Department, NWFP. Subsequently the SHYDO was transformed in to a body corporate under the Provincial Government of Khyber Pakhtunkhwa.

The Govemment of Pakistan's Power Policy of 1998 allowed the provinces to make their own policies for projects up to 20 MW. The Power Policy 2002 framed by Ministry of Water and Power, Govemment of Pakistan, as modified subsequently, allowed the Provincial Governments to develop small hydropower projects of up to 50 MW capacity. Accordingly the Government of NWFP also issued a revised Policy for Hydro Power Generation in 2006 allowing for development of projects up to 50 MW. In line with this Policy, SHYDO has completed the feasibility reports of several hydel projects besides identifying 12 sites for small hydel projects with the capacity of 80 MW power generations in district Chitral.

1.4 Power Supply Source

Power need of the province is met by NTDC through Peshawar Electric Supply Company (PESCO). Accordingly PESCO is responsible to supply electric power to the area.

Major hydropower plants in the country including Tarbela, Ghazi Barotha and Malakand III with total power generation capacity of about 4,500 MW is situated in the Province of KPK. All these power plants are connected with the national grid system of NTDC. Therefore all the power generated from these power plants are transmitted to all parts of the country including KPK. Transmission and distribution network of PESCO is presented at **Figure 1.5**

Salient features of the power network of KPK are:

- The existing load demand of KPK is about 4083 MW.
- The province imports the extra power from the other provinces of the country.
- The current mismatch in supply and demand results in load shedding as a regular feature to prevent the existing system from total collapse.
- Another reason of load management is due to the increasing supply and demand gap, both at country and regional levels.

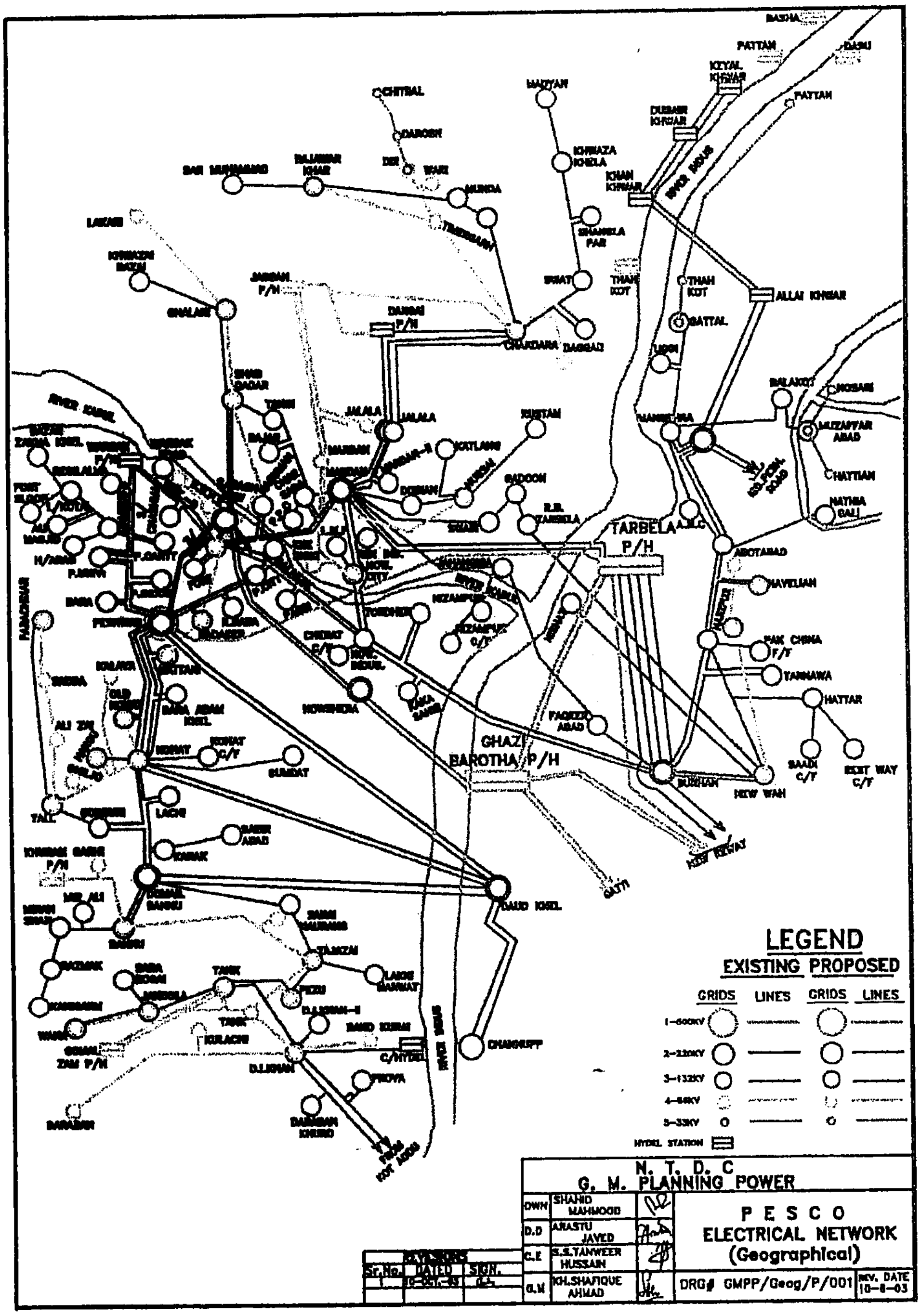


Figure 1-5: PESCO Power Transmission and Distribution Network

1.5 Power Policy

In this section of the report national as well as provincial power policies have been discussed briefly.

1.5.1 Power Policy 2002

A new power policy was announced by the Government of Pakistan in 2002, it closely resembles its predeceasing power policy dating 1994, but it has a broader range of application. Entitled "Policy for Power Generation Projects – Year 2002", the new power policy applies both to public, private and public-private partnerships investment. The policy also makes it possible for investors not only to participate in public tendering, but also to propose power plant projects on their own.

Under the policy, the respective Provincial Governments are allowed for approving plants with ratings below 50 MW. A two-component system of tariff has been defined for power providers: the capacity purchase price, CPP, and energy purchase price, EPP. The new provisions from 2002 give preference to projects involving the use of domestic energy resources, i.e. mainly water, coal and natural gas. This manifests itself primarily in the exemption of all such power plant projects from income taxes, turnover taxes and capital gains taxes on imports (with oil-fired power plants constituting an exception). Moreover, import duties on plant components have been reduced to a mere 5% of the standard rate.

1.5.2 Khyber Pakhtunkhwa Power Policy - 2006

The GOP's Power Policy of 1998 allowed the provinces to make their own policies for projects up to 20 MW. Accordingly, the Government of Khyber Pakhtunkhwa issued its policy in October 2001.The policy narrates in its outlines that the sponsors shall establish captive hydel power units for industry with equity from their own resources or as a joint venture with public sector or foreign investors. Moreover, the electricity so produced shall be utilized for operation of integrated industrial units, offices and allied facilities only. It did not envision installation of power plants for supply of electricity to any utility or power purchaser like WAPDA or PESCO. Thus, the government of Khyber Pakhtunkhwa, after thorough deliberation, has revised its own Power Policy of 2001 by offering more incentives and concessions to attract private sector investments with a goal of developing several hydropower plants that would supply electricity for use by domestic, agricultural and industrial consumers not only in Khyber Pakhtunkhwa but also in other parts of Pakistan.

Enlarging the industrial base in Khyber Pakhtunkhwa is one of the important aims of the Policy.

Under this Policy for Hydropower Generation Projects, the size has been increased from 20 MW to 50 MW. Also the new projects will not necessarily be captive power plants as envisioned in the Policy of 2001. They can supply power to any power purchaser.

Thus hydel power projects under the revised Hydropower Policy of Government of Khyber Pakhtunkhwa (2006) will not only produce low cost power for use by domestic and commercial consumers but can be utilized for poverty alleviation through integrated agro-based industrial projects.

1.5.3 Objectives of the Khyber Pakhtunkhwa Power Policy - 2006

The main objectives of the Policy are:

- To provide sufficient capacity for power generation at the least cost.
- To encourage and ensure exploitation of indigenous resources, which include renewable energy resources, human resources, participation of local engineering and manufacturing capabilities;
- To ensure that all stakeholders are looked after in the process
- To be attuned to safeguarding the environment.
- To encourage the private sector to develop hydel potential and utilize the power generation for the industry as well as for other purposes in accordance with the Interim Power Procurement (Procedures and Standards) Regulation 2005, which is the basis of the standard power needs of the DISCO's operating in Khyber Pakhtunkhwa or in other parts of the country, through NTDC by paying wheeling charges.

1.6 Existing Power Generation Resources in the Area

1.6.1 Existing Hydel Power stations

- Tarbela Weir
- Warsak
- Ghazi Barotha

- Malakand III

1.7 Hydro

Hydro power is generated by using electricity generators to extract energy from flowing water. Historically people used the power of rivers for agriculture and wheat grinding. Today, rivers and streams are re-directed through hydro generators to produce energy, although there are pros and cons as far as local ecosystems are concerned.

Hydropower is perceived as an environment-friendly, low-cost source of electricity that relies on proven technology. The installed electricity generation capacity is 20,707 MW presently out of which 6,444 MW comes from hydropower. The identified hydropower potential in the country is approximately 41,722 MW. The Government is accordingly giving priority to hydropower generation projects in both public and private sectors. Recent power policies have attracted good response from private entrepreneurs. Several projects are in different stages of implementation. Micro-hydropower development in the northern part of the country is benefiting the previously under-privileged communities·

1.8 Alternative and Renewable Energy

Pakistan is blessed with abundantly available and inexhaustible renewable energy resources, which if tapped effectively can play a considerable role in contributing towards energy security and energy independence of the country. Sporadic efforts and initiatives have been undertaken by the Govemment in the past leading to lacklustre result due to non-commitment, improper and disjointed planning and lack of focused, integrated efforts on part of the stakeholders involved. This is evident from the current installed capacity of renewable energy sources in the country which is limited to a few mega watts.

Given the current global energy scenario in general and Pakistan's energy scenario in particular, the adoption and deployment of alternate energy technologies makes perfect sense as it inherently favours indigenous, inexhaustible energy resources which also happen to be the most energy efficient by default. This is also in line with the objective of this document. However a major shift in Government's policy and planning is required to favour deployment of alternate energy technologies.

Another unique feature associated with the development of alternate energy technologies is that it has various direct & indirect positive impacts on poverty alleviation and accruing social benefits. These technologies can easily be deployed in areas where conventional grid electricity cannot be extended due to technical and / or economic reasons. The lowest strata of the society can thus benefit from altemate energy technologies thereby improving the livelihood and quality of life; meaning alternate energy technologies can play an efficient role for meeting the millennium development goals (MDGs) as well.

Adoption of altemate energy offers following advantages:

- Energy Security & Independence
- Diversity of Supplies
- Social Cohesion (by development in remote, off – grid areas)
- Environmental Benefits
- Job Creation
- Growth of local Engineering industry
- Image – building of the country as a socially conscious / responsible nation.

1.9 Power Supply Source to the Project Area

The Power requirement of Haripur city is partially fulfilled by 66 kV grid station Haripur, which is very old and situated in the city area. The 66 kV Haripur, 66 kV Havaillian and 66 kV Abbottabad grid stations all are connected with the bus bar of 132/66 kV Wah grid station through 66 kV circuit. The proposed power plant is located at the village Peena on the tributary of Haro river in the Hazara Division of Khyber Pakhtunkhwa. The surrounding area of the proposed power plant is under the administrative jurisdiction of Peshawar Electricity Supply Company (PESCO).

Present power requirement of the proposed project area is fulfilled by PESCO through 132 kV Haripur grid station located at about 40 km from the proposed site. This grid station is connected with National Grid system through 132 kV transmission lines at 220/132 kV grid station Burhan directly through 132kV dual transmission lines. Mostly the conductors used in these transmission lines are Lynix which have maximum current carrying capacity of about 550 Ampere

2 PROJECT DESCRIPTION

2.1 Salient Features of the Project

Name of Project: 3.6 MW Jabri Bedar Hydropower Project			
Region: District Haripur , KPK, Pakistan			
General			
1	**Location of project**		
	a	Intake	73^0 09' 8.50" E 33^0 53.42' 55" N Near Village Jabri
	b	Powerhouse	73^0 06' 26.18" E 33^0 52' 42.24" N Near Village Sari Baang
2	**Stream / Tributary**		Haro River a tributary of Indus River
3	**Point of confluence**		140 kilometers before its confluence with River Indus
4	**Access route to site**		
	a	Islamabad – Hassanabdal	45 kms
	b	Hassanabdal – Lora Chowk (Haripur)	45 Kms
	c	Lora Chowk - Intake	26 kms
	Total		**116 kms**
5	**Approximate travel time**		LTV
	a	Islamabad – Hassanabdal	¾ hrs
	b	Hassanabdal – Lora Chowk (Haripur)	¾ hrs
	c	Lora Chowk - Intake	1¼ hrs
	Total		**2 ¾ hrs**
6. Surface Geological features			Hazara Thrust fault System, Margala hill
7. Stream Hydrology			
	a	Catchment area at intake	393km²
	b	Mean elevation in the catchment area	1695 masl
	d	Average monthly precipitation in the catchment	33.65 mm
	e	Long term mean flow	9.86 m³/s
	f	Design discharge	9.91 m³/s
	g	Flow available 40% of time (Q_{40})	7.94 m³/s
	h	Flow available 50% of time (Q_{50})	6.44 m³/s
	i	Flow available 60% of time (Q_{60})	5.41 m³/s
	j	Flow available 70% of time (Q_{70})	4.22 m³/s
	k	Flow available 80% of time (Q_{80})	3.4 m³/s

	l	Flow available 90% of time (Q_{90})	2.38 m^3/s
	m	Flow available 95% of time (Q_{95})	1.84 m^3/s
8. Structural features			
	Intake		
	a	Diversion Structure Type	Inundation Intake
	b	Material	Concrete & Stone gabions
	c	Intake Regulator	Bulkhead Gates and Radial Gates
	Approach channel		
	a	X section (inside)	Rectangular
	b	Bed Width (inside)	4 to 12 m
	c	Height of channel (inside)	1.45 m
	d	Free Board	0.6 m
	Desanders (Silt Excluder)		
	a	Length	69 m
	b	Width	11 m
	c	Height	7.8 m
	d	Structure	Stone Masonry & Concrete
	Power channel		
	a	X section (inside)	Rectangular
	b	Bed Width (inside)	4 m
	c	Height of channel (inside)	1.45 m
	d	Depth of water	1.45 m
	e	Free board	0.3 m
	f	Flow velocity	1.75 m/s
	g	Bed slope	1:800
	h	Length of headrace	6455 m
	i	Structure	RCC
	Forebay		
	a	Length of main Forebay	38 m
	b	Storage capacity	912 m^3
	b	Max depth of Forebay	4 m
	c	Width of Forebay	6 m
	d	Structure	RCC
	Penstock		
	a	No. of main Line	1
	b	Outside diameter	1.75 m
	c	Thickness	12 mm – 14 mm
	d	Length of penstock	170 m

	e	No. of main anchor blocks	5
	g	No. of expansion joints	2
	Power house		
	a	Floor area	40 m x 12 m
	b	No. of units	4
	c	Span of gantry crane	10m
	d	Height of roof	10 m
	e	Structure	RCC frame with brick filler panels
	Tailrace		
	a	Type	Lined Channel
	e	Structure	RCC with Steel lining
9	Electro-mechanical plant		
	a	Type of turbine	Vertical Axis Francis Turbine
	b	Runner diameter	0.65 m
	c	Shaft Power	1000 kW
	d	Number of units	4
	f	Voltage of generation	3300 V
	g	Speed	750 RPM
	h	Governor Type	Electro-pneumatic
	i	Power transformers	3300 / 11000 volts, 1400 kVA

2.2 Description of the Project Works

2.2.1 Intake Structure

The intake structure consists of the following:

- Intake
- Desanders (Desilting structure)

The intake is proposed to be located at 73^0 09' 8.50" E 33^0 53.42' 55" N near Village Jabri.

Main dimension of the Intake are:

- Normal water level 810.20 m
- Upstream flood level: 812.60 m
- Downstream flood level: 755.00 m
- Height of Right Bank Spurs 2 m
- Length of Right Bank Spurs 20 m and 30 m Respectively

• Inundation Concrete Apron	31 m (Width) 33 m (Length)
• Length of Left bank guide wall	85 m (Stone Gabion)

The desanders (desilting structure) are provided to flush out the sediment load and sand that passes through the trash rack of the intake structure.

The dimensions of the main component of the structure are as follows:

No. of Intake Regulator Gates	3
Intake Regulator Gate Width	4 m (Each)
Intake Regulator Gate Height (Full Open)	2.5 m
No. of Taintor Gates	3
Taintor Gates Skin Plate Height	3 m
Taintor Gates Skin Plate Width	4 m
Strut Arms Length each	3 m
Intake Sill level	809.30 m
Approach Channel Width	4 m
Approach Channel Depth	1.45 m
Trash rack opening width:	12 m
Trash rack opening length:	3 m
Trash rack sill elevation:	809.30 m

Stability of the intake dam under condition of stress has been examined and the following characteristics values determined:

• Factor for sliding:	K=I. 1 (Normal Operation)
	K$\geq$ 1.0 5 (Abnormal Conditions)
• Stress due to volume of concrete:	23.50 KN / m^3
• Stress due to volume of sediment:	10.20 KN / m^3
• Internal friction angle of sediment:	18°
• Friction coefficient, concrete & rock:	0.60
• Cohesive force, Concrete & rock:	0.1 Mpa.

2.2.2 Desander

The sediment trap is provided to allow precipitation of whatever sediment load that passes through the intake and is located further 122 meter downstream of intake structure. The sediment trap is a stone masonry structure and of double chamber type having a bypass channel to allow continuous running of the powerhouse during maintenance / flushing of the sediment trap. The bottom of the sediment trap is inclined both in the direction of length and width to allow flushing of the sediment.

Dimensions and other characteristics of the sediment trap are as follows:

- Width 11m.
- Length 69 m
- Depth 7.8 m
- Desilting structure sill elevation(entrance): 807.18 m
- Bottom elevation at starting point 801.43 m
- Bottom elevation at ending point 801.30 m
- Normal water level 808.72 m
- Gradient of longitudinal section 0.04
- Desilting velocity 2.5 m / s
- Desilting discharge 4.95 m^3 / s
- Gate dimensions 4 (width) x 2 m (height)
- Size of desilting opening 0.5m (width) x 0.60m (height)

2.2.3 Power Channel

The headrace is of open channel type and is proposed to take off immediately after the outlet gate of the sediment trap along the left bank of the river except for a stretch of about 600 m where RCC cover has been considered in the design to take care of social issues of local population.

The main dimensions of the headrace are as follows:

- Length of Headrace 6455 m
- Cross section Rectangular
- Width of Channel 4 m
- Depth of Channel 1.45 m
- Free Board 0.3 m
- Depth of Water at design flow 1.45 m
- Thickness at top of walls 0.45m
- Thickness at bottom of wall 1.35 m
- Gradient 1/1200
- Flow velocity 1.75 m/s

2.2.4 Forebay

The main objective of the fore bay is to regulate water flow during load variations and the dimension of the fore bay were decided with following main objectives

- Precipitate the sediments from headrace.

The fore bay is inclined in the directions of length and width and has an overflow spillway and a desilting opening to flush out the sediment load. A movable trash rack is also provided to allow removal of floating materials.

Dimensions of the fore bay are as follows:

• Storage capacity	912 m^3
• Depth	4 m
• Length	38 m
• Width	6 m
• Length of Spillway chute	50m
• Structure	RCC

2.2.5 Penstock

The penstock is the pressure steel pipe for conveying the discharge to hydraulic turbines in the powerhouse. Route of the penstock pipe has been selected to avoid slides. The penstock pipe is supported on anchor blocks and on intermediate supports located at intervals of 6 meters and placed at an approximately height of 0.60 meters above the ground. However, the branch pipes will be completely buried in the concrete. The route width along the length of the penstock pipe is three (03). The penstock is made of ordinary carbon steel in order to minimize the head loss. An emergency valve is installed for closing during routine examinations or repairs. The main dimensions of the penstock structure are as follow:

• Length of penstock	170 m
• Diameter of the main pipe	1.75 m
• Thickness of the steel	12 mm to 14mm
• No. of main Line	1
• No. of main anchor blocks	5

2.2.6 Powerhouse

The powerhouse is located at 73^0 06' 26.18" E 33^0 52' 42.24" N near Village Sari Baang. The floor elevation of the powerhouse has been decided to avoid immersion during maximum flood of the main stream. The powerhouse is comprised of the following sub-structures:

- Machine hall
- Loading/Unloading Bay
- Office/Record Room

The machine hall of the powerhouse shall accommodate all hydro mechanical and electrical control Installations comprising of inlet valve, governor, lubricant feeder, turbine, generator and distribution / control panels.

The Loading/Unloading Bay will be built to provide work space for the Loading/Unloading or repair / maintenance of machinery. The main entrance door to the assembly shop will be located close to the access bridge.

The office and record room will be provide for staff and to record important data of power house like operational data drawings and etc.

The main dimensions of the powerhouse are as follows:

- Floor area: 40 m x 12 m
- No. of units: 4
- Height of roof: 10 m
- Structure: RCC frame with brick filler panels

Electro -Mechanical Equipments

Reaction type of hydro turbines is recommended for the proposed project. Four vertical axis Francis turbines will be install in the power house having runner diameter of 0.65m. Each unit has shaft power of 1000 kw and the total power at designed flow will be 3622 kw or 3.62 MW. The speed of the each runner is 750 rpm and electro-pneumatic type of governor will be used.

3 PROJECT LOCATION AND ACCESSIBILITY

3.1 General

Proposed Jabri Bedar Hydropower is a 3.6 MW Hydropower project located on Haro River in the upper reach of Haro River (about 15 to 20 kilometer upstream of khanpur Dam) starting just downstream of Jabri Bridge on Lora-Murree Link

3.2 Location and accessibility

The proposed project site is upstream of khanpur Dam and is approximately 45 kilometer from Murree, about 45 kilometers from Hassan Abdal to Lora Chowk (about 10 kilometers from Haripur city on Karakoram Highway) and then 26 Kilometer to proposed project site

The intake is proposed to be located at 730 09' 8.50" E 330 53.42' 55" N near Village Jabri. The powerhouse is located at 73^0 06' 26.18" E 33^0 52' 42.24" N near Village Sari Baang.

The general area of the project is 71 km from Hassanabdal.Road distances leading to the project site are shown in **Table 3-1**.

Table 3-1 : Road Distances to Jabri Bedar Project Area

Route	Distance
Islamabad – Hassanabdal	45 kms
Hassanabdal – Lora Chowk (Haripur)	45 Kms
Lora Chowk - Intake	26 kms
Total	**116 kms**

From Islamabad to Hassanabdal via GT road (45 kms), From Hassanabdal to Lora chowk and then from Lora Chowk to site again there is metalled road.

Table 3-2: Travel Time to Jabri Bedar Project Area

Approximate travel time	LTV
Islamabad – Hassanabdal	¾ hrs
Hassanabdal – Lora Chowk (Haripur)	¾ hrs
Lora Chowk - Intake	1¼ hrs
Total	**2 ¾ hrs**

4 TOPOGRAPHY SURVEY

4.1 INTRODUCTION:

This Topographic Survey Report is a part of the detailed feasibility study for development of raw site 3.6 MW Jabri Bedar Hydropower project at Haripur District KPK. It contains documentation on topographic survey and mapping. The work activity described surveying and mapping of the project site covering head race, headwork's area, power house, tail race channels, and general surrounding area of the project.

Topographic mapping control points for the project were established in September 2010. This work included of establishing a survey control benchmark (SBM) at Jabri. The work was done through precise levelling using 8 intermediate temporary benchmarks (TBM) placed at suitable points in the project area.

4.2 LOCATION OF THE WORK:

The Jabri Bedar Hydro Power Project is proposed on Haro River at a distance of approximately 45 kilometer from Murree, about 45 kilometers from Hassan Abdal to Lora Chowk (about 10 kilometers from Haripur city on Karakoram Highway) and then 26 Kilometer to proposed project site.

The Project has been planned as a cascading project with Intake intake located 200 to 300 m downstream of Gojra Bridge and the two power stations Phulra and Trappi to be located 850m and 2300 m downstream of Intake intake respectively

4.3 PURPOSE OF THE WORK:

Surveying was carried out for preparing basic site plan mapping. Mapping was used for project planning; preparation of construction material quantity, estimates for detailed design evaluation, construction cost estimation and preparation of design documents for the project.

4.4 SCOPE OF SERVICES.

The Scope of Services is outlined as hereunder:

1. Project area to be surveyed is approximately 1268 Acer and covers the space required for the proposed intake, proposed channel route, forebay, Power House area and the Tail race Channel. The survey work is to be carried out considering the following requirements.
2. The topographic survey maps prepared on 1:1,000 scales with a contour interval of 5m.
3. All exisiting features located in the area also marked including edges of River route natural and man-made land features such as road building / huts, boundary wall /

fence, gates, water houses, electric poles, telephone lines, depressions and drains etc.

4.5 DESCRIPTION OF THE WORK:

4.5.1 Surveying and Mapping:

In the feasibility study, the Global Positioning System (GPS) has be used for establishment of the reference stations at each location in the project area, extending over the concession area from Intake site to powerhouse site. This technology enables acquisition of coordinates (x, y and z) of any position to be determined with accuracy and independent of any benchmark or the triangulation point. Its utility is ideal for the pre-design studies of project in a remote area of difficult topography.

The use of precise GPS technology also enables the reference beacons to be established much more rapidly, than using the traditional survey techniques, by transferring the Survey of Pakistan (SOP) beacons to establish benchmarks in the project area.

Maps in sufficient detail for the feasibility level design are required for all the structures of the selected layout of the power project enabling determination of the available heads and provide the basis for the preparation of design drawings and cost estimates.

A hydrographic survey was required for the assessment of river bed profile in the vicinity of Intake. The area to be surveyed for Intake axis alternative extended from a point at least 500 m upstream of the structure located farthest upstream, to a point approximately 500 m downstream of the tailrace or diversion tunnel outlets in order to generate the river profile data for tailwater rating curves.

Carrying out the hydrographic survey by conventional surveying equipment and plumb lines would be subject to inaccuracy in depth measurements in the deep high velocity flows due to the tendency for the plumb line to be dragged downstream.

Ground survey has been carried out for the Intake, sand traps, and power channel and powerhouse sites. The existing GT topographic maps give adequate detail.

4.6 Longitudinal Profile of Jabri Bedar Nullah

The length of the profile is approximately 8-10 km. The profile has drawn on the longitudinal scale 1:5,000 and vertical scale 1:500. The longitudinal profile provides following information:

- In the project area, a jeepable track is running along the left bank. The longitudinal profile also indicates the location of perennial and the non - perennial nullahs/tributaries joining the Jabri Bedar Nullah.

- Similarly, villages along the Jabri Bedar Nullah have been indicated on the profile. Any type of bridge or river crossing are also indicated.
- Besides elevation, coordinates in horizontal have been recorded to show the plan view of Jabri Bedar Nullah River to the scale 1:5,000.
- Profile of nullahs on the right bank where power channel may require construction of aquaducts.

4.7 River Cross-Sections

One cross section have been taken at each of the alternate Intake axis sites, two upstream and two downstream cross sections at an interval of 50 m each.

4.8 Characteristics of the Field Survey

The survey marked all features, both natural and manmade on the survey map. These survey pillars have been tied in with the Survey of Pakistan (SOP) benchmarks to establish triangulation network for the proposed project layout.

This includes a plan of triangulation network to be established across the project to link with the SOP benchmarks, and a sketch of the triangulation pillars to be constructed.

During survey work, all the features, both natural and man-made, are recorded; which included but not limited to the following information as outlined hereunder:

- Rock Outcrops
- Breaks in Slope
- Cliffs
- Boulder Fields
- Slips or Slides
- All Streams and Nullah (indicate running water or dry)
- Springs and other Water sources
- Terraces and Fields
- Forest Plantation Areas
- Roads, Tracks and Paths
- Fences and Boundaries
- Houses, Buildings and other Monuments

- Cultural Areas, Mosques and Cemeteries
- Bridges and other River Crossings
- Property boundaries with reference to land records

4.9 PROJECT CONTROL POINTS:

4.9.1. CONTROL POINTS:

For the purpose of horizontal & vertical control in the project area surveyed, 52 control points were established at the surrounding of the project area. A tabulation of the locations of these control points is shown in Table 4.1.

Table-4.1 Control Points Data.

S.NO	EASTING	NORTHING	ELEVATION
1	3219945.564	1080533.614	826.389
2	3219877.794	1080459.877	818.558
3	3219748.588	1080442.494	816.56
4	3219553.364	1080482.42	816.906
5	3219371.748	1080332.142	815.94
6	3219109.424	1080368.994	811.346
7	3218970.124	1080350.16	809.874
8	3218858.898	1080509.862	808.526
9	3218872.264	1080628.973	807.123
10	3218410.924	1080796.284	804.465
11	3218319.064	1080747.315	804.236
12	3218258.501	1080660.956	802.945
13	3218127.179	1080528.995	801.231
14	3218019.297	1080473.961	789.012
15	3217836.326	1080425.569	800.267
16	3217831.53	1080334.796	795.899
17	3217724.258	1080213.59	795.748
18	3217626.994	1080158.119	794.213
19	3217533.518	1079889.141	792.611
20	3217409.391	1079791.339	792.013
21	3217310.985	1079726.308	792.013
22	3217107.532	1079710.982	785.326

23	3216947.804	1079733.038	786.987
24	3216888.026	1079762.237	786.894
25	3216684.119	1079768.978	781.987
26	3216487.854	1079731.54	780.125
27	3216211.859	1079647.775	778.553
28	3215704.232	1079649.222	772.686
29	3215531.336	1079560.021	771.564
30	3215403.078	1079469.076	770.516
31	3215413.167	1079313.413	771.799
32	3215362.942	1079236.468	773.015
33	3215401.047	1079143.029	768.983
34	3215273.931	1078976.134	766.455
35	3215209.836	1078948.303	766.128
36	3215043.47	1078883.404	764.492
37	3215103.177	1078651.579	760.146
38	3215224.02	1078533.045	761.025
39	3215234.206	1078395.052	758.773
40	3215092.957	1078351.97	761.254
41	3214970.257	1078231.253	756.371
42	3214938.349	1078092.248	757.487
43	3214798.017	1078093.931	752.012
44	3214777.163	1078144.559	762.854
45	3214634.803	1078193.463	751.907
46	3214341.88	1078211.334	755.899
47	3214260.445	1077623.947	744.511
48	3214189.225	1077277.766	740.557
49	3213808.701	1077362.86	738.134
50	3213685.991	1077380.145	735.866
51	3213368.437	1077121.298	741.874
52	3213325.608	1077028.716	731.149

4.10 PROJECT BENCH MARKS:

4.10.1. BENCH MARKS:

For the purpose of horizontal & vertical control in the project area surveyed, 14 bench marks were established at the surrounding of the project area. A tabulation of the locations of these bench marks is shown in Table 4.2.

Table-4.2 Bench Marks Data.

S.NO	EASTING	NORTHING	ELEVATION
1	3219929.96	1080578.517	827.201
2	3218645.676	1080773.84	806.55
3	3217566.79	1080045.343	793.77
4	3215956.395	1079693.818	800.17
5	3215110.022	1078776.544	766.94
6	3214963.639	1078136.265	762.87
7	3214654.357	1078215.61	751.38
8	3214424.837	1078221.427	751.537
9	3214362.87	1078109.463	749.035
10	3214250.112	1077722.483	745.069
11	3214331.314	1077457.549	743.37
12	3214027.872	1077311.323	739.931
13	3213552.466	1077267.728	736.08
14	3213305.998	1076998.355	730.767

5 GEOLOGY & GEOTECHNICAL INVESTIGATIONS

5.1 INTRODUCTION

The proposed Jabri Bedar Hydropower Project has been identified on the Haro River District Haripur, Khyber Pukhtunkhaw (KPK). Haro River a tributary of river Indus originates from the high altitudes of galliyats, draining the area of Siribang and Dubran and flows through a length of about 140 kilometers before its confluence with River Indus downstream of tail race of Ghazi Barotha Hydropower Project in District Attock. The site identified for Jabri Bedar Hydropower Project is located upstream of khanpur Dam and is approximately 45 kilometre from Murree, about 45 kilometres from Hassan Abdal to Lora Chowk (about 10 kilometres from Haripur city on Karakoram Highway) and then 26 Kilometre to proposed project.

This report is based mainly on the field observations and geological mapping carried out in the proposed project area, for the assessment of the geotechnical parameters. Laboratory studies has been carried out on soil samples collected from pits at Material Testing Laboratory, Central Design Office, Islamabad for the assessment of Bearing Capacity of Intake site, forebay site and power house site.

5.2 GENERAL

The intercontinental collision between the Eurasian and Indian plates has resulted in intense deformation with complex folding involving strike-slip and thrust faulting and crustal thickening expressed as a series of thrust faults accompanied by a continental subduction process.

The major regional thrust faults, related to the intercontinental collision include Main Karakorram Thrust (MKT), Main Mantle Thrust (MMT), Main Boundary Thrust (MBT), Panjal Thrust (PT), Main Central Thrust (MCT), Himalayan Frontal Thrust (HFT) and Salt Range Thrust (SRT). The planes of these faults run nearly parallel to the collision boundary.

On the basis of these regional thrust faults related to intercontinental collision, five major fault zones have been recognized in Northern Pakistan including AJ&K as indicated in Fig. 11. These fault zones include the Northern Suture Zone _Z) or MKT, the MMT or Indus Suture Zone (ISZ), MCT, MBT, HFT and SRT.

These fault zones generally trend E-W, dividing the Himalayan organic belt in the five main tectonic zones. The Asian Plate, the Kohistan Island Arc (KIA), the tigher Himalayan Crystalline Unit (HHC), the Lesser Himalayan Crystalline Unit -HC) and the Sub-Himalayan Unit (SH).

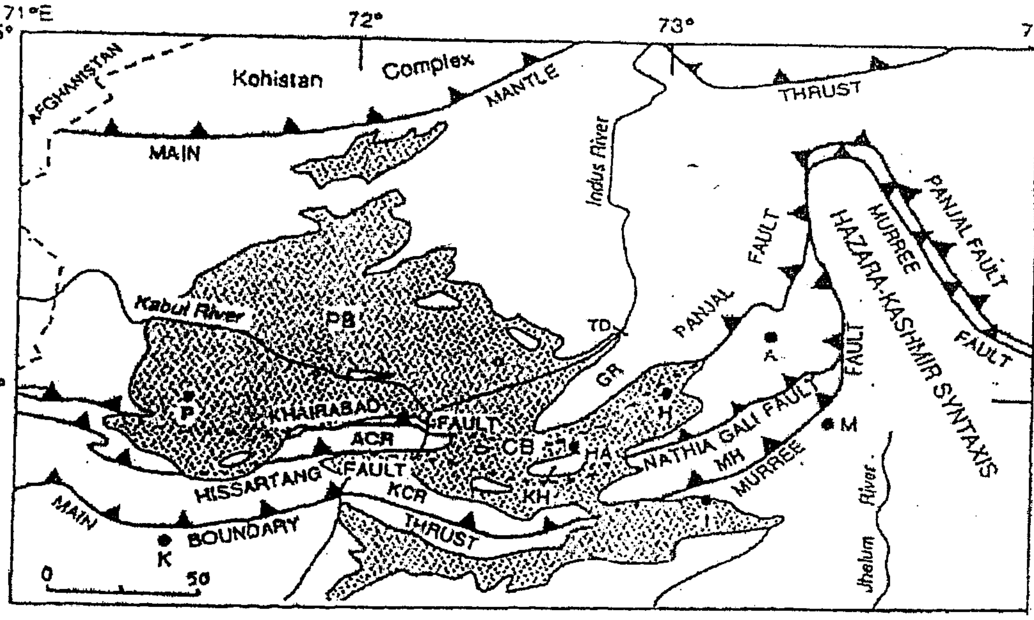
5.3 GEO-TECTONIC SETTING OF HAZARA

According to wadia (1931) the Punjal thrust demarcates two zones; the tethyan and Himalayan. The Peer-Panjal range in Kashmir is the type section of thrust along which the Permo- Triassic sequence thrust was regarded as an analogue of the main central thrust (MCT) in the Himalaya. The discovery of another deep level thrust called the shontargali thrust by Tahirkheli(1988,1989) in Kashmir and Astor area, located on the southern margin of the Nanga Parbat massif, has overlapped the earlier contention.

The Panjal Thrust (PT) extends uninterrupted from the Panjal Range towards NNE through Poonch, Reshian and follows the eastern limb of the Hazara-Kashmir syntaxis and terminates at its apex in Kaghan valley. In all the sections examined in Kashmir, the tectono-stratigraphic frame of the PT appears alike and exposes very wide sacrificial characteristic fractures which can be observed easily.

During recent years Calkins et al. (1975) followed by other geologists have extended the tectonic domain of the PT towards west of the syntaxis (fig.1), making it through Galiat; along Saklhad stream in Abbottabad; on the eastern margin of the Gandgar Range; across the Indus River near Attock and terminating it on the northern margin of the Nizampur valley in the Attock Cherat Range. The PT domain, west of the syntaxis does not provide a clear picture about its stratigraphic setup and tectonic frame for correlation with the reference sections in Kashmir.

Fig 5.1 Tectonics of Kashmir



5.4 REGIONAL GEOLOGY

5.4.1 GENERAL

The project area is located in the vicinity of main boundary thrust (MBT) in the south east, Hazara Syntaxes as sharp bend in the orogenic belt of Mansehra lies on its north west limit and Jhelum fault runs in north south direction at eastern limit of the project.

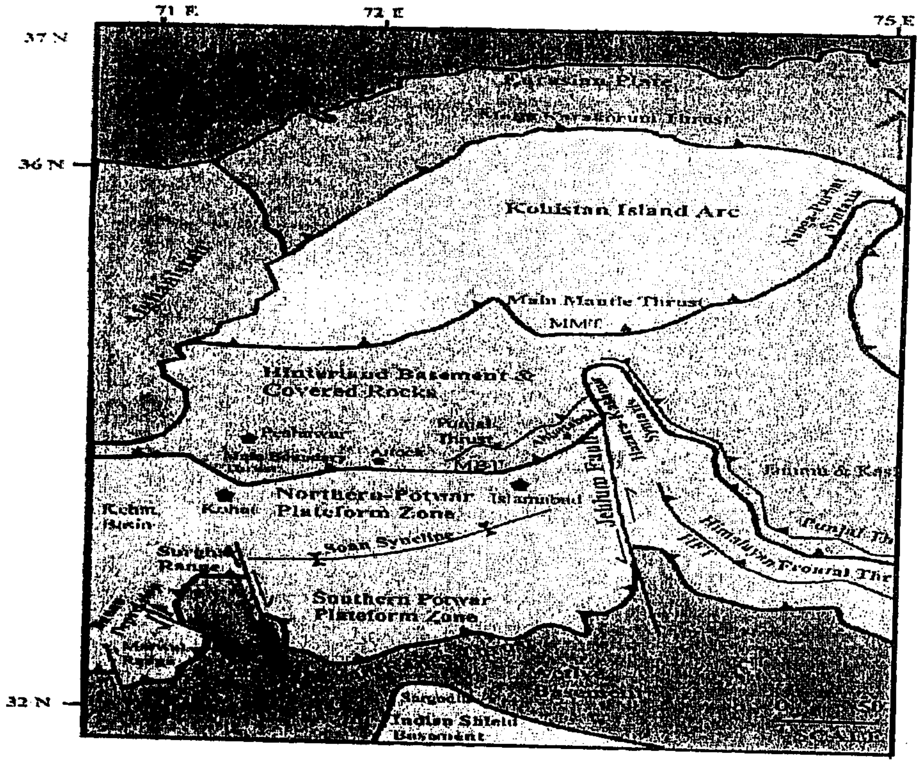


Figure5.2 Regional Tectonic Maps of Northwest Himalayas of Pakistan

The stratigraphic sequence in the catchment of Haro River is as follows:

1	RECENT	Sub recent to recent	Alluvium; sand, silt and gravels
2	CANEOZOIC	Miocene	Standstone and shales. (Murrees)
3	MESOZOIC	Cretaceous Jurassic	Sandy Limestone, sandstone, Spitti Shale and Limestone
4	PALAEOZOIC	Cambrian or Precambrian	Slate Series

5.4.2 SAMANA SUK FORMATION

The Samana Suk Formation (Shah, 1977) generally represents an epicontinental intertidal environment. The formation is generally medium grey on fresh surface. However, fine-grained horizons give darker shades of medium grey. At places, the limestone shows a brownish tinge on weathered surface. It is well bedded and the individual beds being generally 40 cm to 60 cm in thickness. Some parts show thick intercalations of thinly bedded marl or shale between massive beds. The bedding planes of some massive beds in south at Kundla are particularly irregular with pits and protuberances. The limestone is medium grained but fine-grained horizons towards top break with conchoidal fracture. The occasional fine-grained texture and lighter grey weathering may be confused with Kawagarh limestone. Yellow dolomitic patches, streaks, and bands are present especially towards the lower and middle parts. Oolites, pellets and intraclasts are common alongwith or without bioclasts. They are generally difficult to recognize in the Ayubia area. Oolites are well developed near the base and top. At places, medium grained quartz bearing beds are exposed. A 30 cm thick bed composed of flat pebble conglomerate occurs near Thai. The pebbles are generally 4 cm to 5 cm long. The matrix contains sub-rounded to subangular detritial quartz grains. Gastropods and pelecypods oyster-bearing beds occur frequently. Horizontal, inclined, vertical and U-shaped burrows are common. Burrow infill has been dolomitized and shows positive relief. Other sedimentary structures such as ripple marks and cross bedding are common. Laterite encrustations are dark brown to blackish brown and occur at most places. Scours are now filled with dolomite and are augen shaped. Towards the top, near Neil Gadri, Khanpur Dam area, Margala Pass section and Fauji cement factory belemnites are pricked in the beds. Flat pebble conglomerate beds occur in Thai and Khanpur Dam areas. Some carbonaceous layers also occur at places. The formation is highly folded. Its estimated thickness is about 160m near Biran Gali.

As described earlier the formation contains oolites, pellets, intraclasts and bioclasts. These allochems occur in many combinations in the formation. Thus, this limestone, of all the limestones exposed in the Hazara Basin, contains maximum number of microfacies (Chaudhry et al. 1998a). Besides this, angular to subrounded detrital quartz occurs in association with pellets, ooides and intraclasts in some cases in the in the Samana Suk Formation. The oyster topped beds and hard grounds represent slow rates of deposition and subareal exposures (Latif, 1970a). The average lithified rates of sedimentation according to Chaudhry et al., (1998a) were about 6mm/1000 years. The low rates of sedimentation may be due to frequent breaks in deposition. On the basis of fauna it ranges in age from Toarcian to Collovian. The lower contact of the Samana Suk Formation with Datta Formation is sharp but normal. The upper contact with Chichali Formation shows minor disconformity and lateritization. One such horizon is exposed around Thandiani. In the Kashmir Basin the Samana Suk Formation is absent.

5.4.3 CHICHALI FORMATION

It is separated by Callovian disconformity (Shah, 1977) in the Hazara Basin from the underlying Samana Suk Formation. The unit is exposed at a number of places in the studied area as thin bands. However, near Kundla the exposure is fairly wide. The formation is composed of blackish grey to grey splintery shale. It weathers to brownish black to rusty grey shades. However, khaki colored shale belonging to this formation is exposed near Hamo. Ferruginous concretions, silver yellow pyrite nodules with rusty brown to rusty black weathering are also present. At places, shale contains rounded or elliptical variegated clayey nodules with concentric layers. At places, subordinate beds of sandstone are present. Petrographically, sandstone is composed of arenites that are cemented with quartz, calcite, clay or glauconite. Quartz is fine to coarse grained. Glauconitic horizons are also present at places. Parts of Chichali Formation are fossiliferous (Iqbal and Shah, 1980) and in Hazara Basin it hardly contains fossils. However, near Margalla Pass and Brahama Bhater it contains belemnites. Because of its incompetent nature, the shale is commonly squeezed and forms topographic depressions. Its thickness may vary from 33 m to 64 m (Shah, 1977; Iqbal and Shah, 1980). The formation was deposited in a restricted anoxic environment during Oxfordian to Kimmeridgian time (Shah, 1977). The lithified sedimentation rates are 2.3mm/1000 year (Chaudhry et al., 1998a). The Chichali Formation has not developed in the Kashmir Basin and Khanpur Dam area. In Khanpur Dam area, Lumshiwal Formation rests unconformably over Samana Suk Formation.

5.4.4 LUMSHIWAL FORMATION

Being absent in the Kashmir basin, the Lumshiwal Formation comprises four principal lithologies that include sandstone/quartzite, marl/shale, arenaceous limestones and arenaceous dolomite in the Hazara basin. Some impure glauconitic sandstone, brownish grey on fresh surface and yellowish brown on weathered surface alongwith some shales occur also. Towards the base, where the formation has gradational contact with the underlying formation (at

Borian and Kundla) belemnite, ammonite and brachiopod rich horizons occur at places. The shaly/marly horizons are rusty brown to maroon purplish and black in colour. At places, intraformational breccias and conglomerate with angular monocrystalline and polycrystalline quartz clasts occour that range in size from a few millimeters to 20 cm or even more in size. One such horizon is exposed in Toot Gran village on Abbottabad Nathia Gali Road. The conglomeratic zone is followed towards the top by siltstones and shales. The siltstones and shales are dark grey on fresh surface and yellowish brown on weathered surface. The shales are splintery while the siltstones occur as relatively massive beds, some of which are lenticular and grade into shale. In the Kahnpur Dam area, the formation is about 1m thick and is composed of coarse grained ferruginous quartz arenites. It contains paleo-channels at the base and elsewhere elongated clasts of Samana Suk Formation are embedded in coarse grained sandy matrix. Here, this unit appears to show time transgression. In Margalla Pass area the formation contains a number of hard grounds marked by intact and abraded pelecypod shell lags that occur at the top of every bed. The formation here is composed of medium to coarse grained quartz arenites cemented with silica and iron oxides. The beds vary in thickness from 30cm to more than 1m. Minor shaly horizons also occur at places. Chaudhry et al. (1998b) and Ali et al. (2000) described twelve lithofacies from Kundla that include lower grey sandstone facies, fossiliferous limestone facies, phosphatic glauconitic sandstone facies, sandy shale/carbonaceous sandstone facies, lower grey sandstone facies, silty sandstone facies, green sandstone facies, light grey sandstone facies, carbonaceous sandstone facies, hard-ground facies, upper grey sandstone facies and grey arenaceous carbonate facies. Ahsan et al., (1999a) described fourteen microfacies from Jhameri Village section. They grouped these microfacies into three fancies on the basis of grain size. According to Chaudhry et al. (2000), the Lumshiwal Formation is composed mainly of quartz arenites at Karlan Bazar. Fine-grained quartz arenites are represented by 57% of samples. Fine to medium grained quartz arenites were minor and represented by 14% of the samples. Remaining samples were medium grained.

Ahsan and Chaudhry (1999) presented a comprehensive study of the Lumshiwal Formation of Hazara Basin. According to them the formation is composed of glauconitic arenite, quartz wackes, arenaceous limestone, arenaceous dolomites and oolitic limestones. Shales/marls are minor. Diastems at places are marked by submarine hard-grounds. These horizons are cemented with iron oxides and may occasionally contain collophanite or dahalite. Heavy mineral suit indicates derivation from a low relief area on the Indian Shield to the south. Strongly reducing conditions changed to mildly reducing environment with better circulation in the Thithonian to deposit the Lumshiwal Formation (Ahsan et al. 2001c). The ubiquitous glauconite indicats slow rates of deposition. The average lithified rates of deposition were about 0.96mm/1000 years (Chaudhry et al. 1998a). Frequent breaks in deposition are responsible for low rates of sedimentation. The age of the formation is Thithonian to Lower Turonian. In Khanpur Dam area it can be recognized as a time trangressive unit.

5.4.5 KAWAGARH (JABRI) FORMATION:

One of the tectonically significant formations of the Hazara Basin, the Kawagarh Formation, shows two distinct facies (Ahsan and Chaudhry, 1998) north and south of the Nathiagali Fault. The northern facies are exposed near Giah (Chaudhry et al., 1992a), Borian (Ahsan et al., 1993a) and Kala Pani (Ahsan et al., 2001a) whereas the southern facies outcrop at Changla Gali (Ahsan et al., 1994) Jabri (Ahsan et al., 1993b) and Khanpur Dam area. In Kashmir basin and Margala Pass (Ahsan et al. 2000) section and Fauji Cement factory setion at Brahama Bhater the formation has not developed. The Kawagarh Formation in the sections north of the Nathiagali Fault is mainly thick bedded, fine gained and medium to dark grey limestone. The basal part is relatively coarse grained on fresh surface. It is whitish grey or yellowish grey on weathered surface. The middle part is medium to thick bedded, medium to dark grey and breaks generally with conchoidal fracture. The basal portion at Kala Pani is nodular. The upper part of the Kawagarh Formation at Giah is generally coarse grained and somewhat arenaceous. A few yellow dolomitic bands are also present within Kawagarh Formation. In the Khanpur Dam area the formation contains centimeter sized solution holes that indicate the effects of subareal weathering at Cretaceous Paleocene boundary. In this area the top portion of the formation is dolomitized and shows sugary texture with distinctive brownish to blackish weathering coloures whereas base is marly.

South of the Nathia Gali Thrust the upper part of Kawagarh Formation is marly and intercalations of marl are also present. This part is especially well developed on the Dunga Gali pipeline road and at Changla Gali. The marly part is dark grey to yellowish grey on fresh surface and relatively more yellowish on the weathered surface. The marly part has a dark grey colour on the fresh surface. Near Kundla the base of the Kawagarh Formation has a slightly irregular surface with some pebbles and few inches to about one foot long worm tracks. In the Khanpur area the formation contain cleaved marls at the base. The topmost beds of the formation that underlie the Cretaceous Tertiary unconformity contain iron stained solution holes. These holes are 5 to 6cm in radius and penetrate downwards in the underlying beds. The Kawagarh limestones contain millimeter sized burrows that can easily be recognized on the outcrop. It contains dolomite beds at the base and at places top beds are also dolomitized. Plankton foraminifera, shelly fauna and calcispheres are the major skeletal components of the Kawagarh Formation. Filaments, echinoids, ostracods, bryozoans and textularia constitute the shelly fauna that occur as skeletal debris. Three genera, Pithonella sphaerica, Pithonella ovalies and Pithonella perlonga, of calcispheres are recognized (Ahsan, 2008). The study of the Kawagarh Formation in the Hazara Basin shows that it is generally composed of seven microfacies (Ahsan, 2008) that include Planktonic foraminiferal-calcispheres wackestone (and Packstone), Planktonic foraminiferal-shelly faunal wackestone (and packstone), Shelly faunal mudstone and wackestone (and packstone), Calcispheres-planktonic foraminiferal wackestone (and packstone), Dolostone, Planktonic foraminiferal wackestone (mudstone and packstone) and Marl. The Kawagarh Formation, according to Ahsan (2008) needs a new nomenclature as existing type locality and division into two members (Shah, 1977) is indistinct. By itself, the designated type section is structurally disturbed and the two members indicated by Shah (1977) could not be recognized in Hazara Basin. Two lithologies, carbonates and marls occur in parts of the study area. The Jabri section (73° 10' 1.5" E; 33° 5' N, 43G/1) with good lithological contacts may be preferred as type section in Hazara Basin with a new nomenclature as Jabri Formation (Paper in preparation by Ahsan and Chaudhry) instead of Kawagarh Formation. Moreover all the 7 established microfacies outcrop at Jabri.

The petrographic analyses indicate that the Kawagarh Formation carbonates have undergone a complex diagenetic history encompassing compaction, minor cementation and dolomitization (Ahsan, 2008). Depletion in $\delta^{18}O$and $\delta^{13}C$ as well as Sr and Na and elevated Fe and Mn content confer a meteoric diagenetic environment with minor contribution from an outside source (Ahsan, 2008). Ambient sea surface temperature of about 27°C to 33°C is estimated for warm tropical waters in which Kawahgarh Formation was deposited. Trace elemental variations and stable isotopes compositions are interpreted to reflect meteoric and burial diagenetic processes for the precipitation of dolomite at 38°C to 54°C temperature (Ahsan, 2008). According to Ahsan (2008) the base of the Kawagarh (Jabri) Formation is marked by the occurrence of Globotruncana helvetica followed by Globotruncana sigali at Turonian, at Giah, Borian and Kala Pani sections. Lower Coniacian is recognised by the presence of Globotruncana sigali in Jabri and Changla Gali sections. Last zone of the Kawagarh (Jabri) Formation is Globotruncana gansseri in the Lower Maastrichtian. On the basis of paleoecological information rendered by planktons, shelly fauna (especially filaments) and calcispheres the formation was deposited on a homoclinal ramp, (middle to outer ramp settings) at about 23°S (Ahsan, 2008). The average lithified rates of sedimentation were about 9mm/1000 years that compares favorably with the American and European chalks (Chaudhry et al. 1998a).

5.4.6 HANGU FORMATION:

Laterite and fireclay are predominant lithologies of the Hangu Formation. However, subordinate carbonaceous shales and sandstones are also present at places. The laterite is reddish brown to reddish black or reddish grey or even grayish on fresh surface and reddish brown, dark grey and rusty brown on weathered surface. The fire clay is pale white and earthy grey on fresh surface and yellowish brown to rusty brown on weathered surface. Horizons of ball clay are present near Khaira Gali. Well-developed pisolites also occur in laterites. Carbonaceous shales are dark grey to black. Quartzites are dominantly white but variegated coloured quartzite may occur also. In the Kashmir area the basal microfacies, black shale, marks the on set of a transgression that deposited 227 cm thick black shale. The formation consists of coarse to fine grained clay/iron oxides cemented quartz arenites at the base which grades to silty coal to the top. The top of the Hangu Formation contains bauxitic clays that vary in color from off-white to black and weathers to rusty grey to orange. In Khanpur Dam area, the Hangu Formation is maroonish to red coloured laterites and khaki to grey coloured shales. Poorly developed pisolites can be recognized associated with laterites. At places, it contains about 35cm thick coarse grained sandstone beds. The laterites are mined for use in nearby cement factories.

The upper and lower contacts of the formation are unconformable. It does not contain fossils however some plants remains are present. The Lockhart Formation unconformably overlies the Hangu Formation. The lithified rates of sedimentation were 1.77mm/1000years (Chaudhry et al., 1998a).

5.4.7 Lockhart Formation

The formation is light grey, pale grey, bluish grey and blackish grey on fresh surface while the weathering colours are generally dirty grey with dark patches but pale grey and rusty grey patches are also seen. On the outcrop it is fine to medium grained and gives foeted smell on freshly broken surface. The limestone has a fair amount of marly intercalations. These marly intercalations are generally upto 8 cm thick and weather pale grey. Southeast of the Nathiagali Fault, in the section between Kuza Gali and Changla Gali, the limestone is found frequently intercalated with marls. Shales have not developed. In the areas northwest of the Nathiagali Fault, the limestone is dark grey and weathers to bluish grey. At the base the limestone is massive (upto 2m thick), coarse grained and does not contain marly intercalations. The middle part is medium bedded and marly horizons are absent. However, towards the top the formation is highly nodular and contains marls around the nodules. Limestones are composed of foraminiferal mudstones, wackestones and packstones. The lithified rates of sedimentation were 30mm/1000years (Chaudhry et al., 1998a). Ahsan et al.

(2000a) have described one such outcrop near Ghumawan. Lockhart Formation, according to Ahsan et al., (2001e), near Chahla Bandi, in Neelum Valley Azad Kashmir, is light grey, pale grey to khaki grey, bluish grey and blackish grey on weathered surface and dark grey on fresh surface. It is about 72.80 m thick nodular limestone with intercalations of marl/shale. Nodules vary in size and are poorly developed. These nodules are smaller than that of Margala Hill Limestone. At places the intercalations of grey colored carbonaceous material occur within the limestone. Lithologically, the formation can be divided into two parts: i) Nodular limestone that contains marl and shale intercalations. The nodules vary in size. The calcite veins occur in the marl between the poorly developed nodules; and ii) Massive to thick-bedded limestone having no intercalations of shale or marl. In this part the nodules are not clearly visible. At the contact with the Hangu Formation the formation is splintery and contains orange patches, and upward it grades into thin-bedded limestone.

5.4.8 PATALA FORMATION

In the Hazara and Kashmir Basins the conditions changed from carbonate shelf to siliciclastic depositional environment that deposited Patala Formation. The formation is composed of shale and occasional limestone bands with abundant larger benthic foraminifera of upper Paleocene to lower Eocene age. The shales are khaki, yellowish brown to yellowish grey on weathered surface and on the fresh surface they are khaki to grey. At other places, the shales are greenish brown or greenish grey on fresh surface and brown to dark brown on the weathered surface. They have been called khaki shales after their colour (Latif, 1970). Pyrite nodules 1 to 2 cm across are present at some horisons. The shales are splintery and some marly bands near the contact with the Lockhart limestone are present. Some times splinters take on the shape of small brittle flakes. Within the body of the shale's subordinate lithologies, both arenaceous and calcareous, occur in the form of thin bands. In the Khanpur area it contains various hard grounds. The lithified rates of sedimentation were 30mm/1000years (Chaudhry et al., 1998a).

5.4.9 MARGALA HILL LIMESTONE:

During Ypresian the siliciclastic basin developed into a carbonate platform and deposition of the Margala Hill Formation took place. The formation (Shah, 1977) is mainly a fossiliferous, medium grained to fine grained nodular limestone with marly horizons. It is bluish grey and yellowish grey on the weathered surface and on the fresh surface is generally dark to blackish grey. The lower part may contain frequent marly horizons. The nodularity of Margala Hill Limestone is more prominent as compared to the Lockhart limestone. Generally the limestone is medium grained but fine-grained horizons occur which may break with sub-conchoidal fracture. Some pyritic nodules are observed which contain weathered limonitic powder. Sometimes they show hollow cavities. Ahsan et al. (1998a, 200b) described the Margala Hill Limestone from Khaira Gali that contains twelve lithofacies units, separated by eleven marly horizons. These lithofacies contain 45% foraminiferal wackestone facies, foraminiferal mudstone and foraminiferal packstone facies (19% each) and 17% marly facies. The entire formation is free of oolites and pellets. Sedimentary structures like ripple marks and cross bedding are absent. Basal beds are bioturbated. The lithified rates of seimentation were 62.5mm/1000years (Chaudhry et al., 1998a).

The Margala Hill Limestone at Chahla Bandi, Azad Kashmir (Chaudhry et al., 2001) is composed of light grey to dark grey limestone. The formation at the base is thinly bedded. It is overlain by calcirudite that contains abundant pelecypode shells. Some shells are reworked. Highly fissile dark grey shale overlies the shelly beds and contains marcasite nodules. The shale is followed by highly nodular limestone. The nodules are upto 30 cm x 50 cm x 13 cm and contain very thin shale partings. This zone is 29m thick. It is very dark grey in color and gives very strong fetid smell. An argillaceous marly limestone that is 28 meters thick overlies the dark grey limestone. It is overlain by medium bedded to highly nodular limestone towards the top of the formation. This zone is grey and weatheres to light grey. On the basis of petrographic and field observations the formation is divided into six facies.

5.4.10 CHORGALI FORMATION

The Margala Hill formation passes upwards with a gradual change of facies into the Chorgali Formation. The formation outcrops near Khaira Gali and Rati Gali, south of the Nathiagali Fault in the Hazara Basin. The formation comprises of limestone, marls and shales. The shale is khaki to off-whitish grey. The limestones are light grey on fresh surface, weather to pale grey and are nodular. The size of the nodules is smaller than that of Lockhart limestone or Margala Hill formations. They generally contain marl around the nodules. The nodule size is generally 2 cm x 4 cm at places. The limestone is rarely massive and generally shows a flaggy habit. The beds are usually less than 8 cm in thickness. The flaggy habit is due to the increasing marly intercalations. At places, the limestones are fine grained and break with conchoidal fracture. Occasionally, these limestones weather to a chalky appearance. The marls are generally cream to off-white in color and sometimes give light shades of grey. The argillaceous content increases upwards, which may range from argillaceous limestone to calcareous mudstone. The Chorgali Formation in Neelum valley, Azad Jammu and Kashmir

(Ahsan et al., 1998b) is 60.75m thick. It is mainly composed of medium grey shale and silty shale, light grey to dark grey foraminiferal mudstone to packstone, dolomitic limestone and dolomite. No grainstone was observed. The limestone is thin to thick bedded and contains occasional nodules. According to Ahsan et al. (1998b) this formation can be divided into 3 facies. The lower unit is composed of intercalated limestone and shale. This unit is 31.04 m thick. The shale of this unit is medium grey to grey splintery and fissile. The limestone is thin to thick bedded and nodular. Nodules are poorly to well develop. The middle unit is composed entirely of thin to very thin-bedded limestone. Limestone is grey poorly nodular and the nodules are generally small and elongated. The upper unit is composed of intercalated dolomite, calcareous shale and shale. The dolomite horizons are fine grained and greenish in color. The shale and calcareous shale are light grey to greenish grey and splintery. This unit is 19.51 m thick. The lithified rates of sedimentation were 83.3mm/1000years (Chaudhry.et.al. 1998a).

5.4.11 KULDANA FORMATION

The formation (Shah, 1977) is exposed in the southeast of Hazara Basin from Kalabagh Cantonment to Islamabad. The formation consists of crimson, brown, purple, chocolate, green, grey and khaki shales interbedded at places with khaki to pale grey marl and marly limestone bands and lenses. The clays are gypsiferous near Bansara Gali and Kalabagh (Latif, 1976). The formation is generally calcareous at the base and arenaceous towards the top. Chaudhry et al. (1998a) measured the Kuldana Formation at Ratri Gali on Murree Ayubia Road and reported 17 lithofacies. According to them it is composed of splintery marl, calcareous shale, sandstone, sandy shale, sandy marl, clayey sandstone, oolitic grainstone, pisolitic limestone, bioclastic wackestone to grainstone and intraclasts bearing wackestone. Some lithic arenites contain clasts of limestone and abundant haematitic specks. Clayey siltstones contain stylolites. In the Khanpur area the formation is composed of maroonish red to greenish grey shales. Here, the formation contains grey to white gypsum bands that are being mined for use in cement industry. At places, the formation contains maroonish red to greenish beds of coarse grained sandstone that are about 30cm to 90cm in thicknesss. At Jab, these beds contain mm to cm sized angular limestone clasts. Generally, in the Khanpur area, the Kuldana Formation outcrops along the Nathia Gali Thrust (in contact with the Pre-Cambrian Hazara Formation). The Kuldana Formation in Neelum Valley is composed of greenish to maroonish coloured shales with occasional limestone and calcirudite facies. According to Chaudhry et al. (1998a) the upper contact of Kuldana Formation with Murree Formation is transitional and they place the contact between the Kuldana Formation and the Murree Formation at the base of a sandstone bed, which has a Himalayan (northern) rather than Indian Shield (southern) provenance in the Murree area. As a whole the contact is either transitional or slightly disconformable but the break, if present, is likely to be minor. The formation contains macrofossil and microfossils. Latif (1976) on the basis of fossils assigned middle Eocene age to the formation. The lithified rates of sedimentation were 71.1mm/1000years (Chaudhry et al., 1998a).

5.5 GEOLOGY OF THE PROJECT AREA

The proposed project site is upstream of khanpur Dam at Harro river and is approximately 45 kilometer from Murree, about 45 kilometers from Hassan Abdal to Lora Chowk (about 10 kilometers from Haripur city on Karakoram Highway) and then 26 Kilometer to proposed project site. Which is located between Longitudes 73^0-09'-40" to 73^0-09'-23" and Latitudes 33^0-53'-45" to 33^0-53'-43" North.

The surface formations in the area belong to Margala Hill Limestone of Eocene age. These comprise alternate beds of limestone and shale. The rocks exposed on both banks of the Haro River in the project area up to a height of 15-20 meters provide a competent support to the abutments of the proposed concrete Intakes.

The bed rock in the project area at places is covered by the alluvial materials which were explored by the Electrical Resistivity Survey. The river banks consist of shale and limestone at places but generally it will provide favorable slopes for construction of the power channels. At places a few aqueducts may be required to cross the gullies.

The characteristics of shale exposed in the area are typical of the Eocene formation which swells when exposed to water and air loses strength. Since the power channel will have to be concrete lined at places and coursed rubble stone masonry sections at major places

The stratigraphy as presented in Regional Geological Map is described below:

Age	Formation
Early to Middle Eocene	Kuldana Formation
Early Eocene	Chor Gali Formation
Early Eocene	Margala Hill Formation
Late Palaeocene	Patala Formation
Middle Palaeocene	Lockhart Formation
Early Paleocene	Hangu Formation
	UNCONFORMITY
Late Cretaceous	Kawagarh Formation
Early Cretaceous to Middle Cretaceous	Lumshiwal Formation
Late Jurassic to Early Cretaceous	Lumshiwal Formation
Middle Jurassic	Samana Suk Formation
Early Jurassic	Datta Formation

The lithological description of rock formations mentioned in above stratigraphic sequence can be studied through Momeir "12" stratigraphy of Pakistan published by GSP. Only Murree formations is of our interest as our project lies in Rocks of Margalla Hills Limestone lithological description of its rock is given below

5.5.1 MARGALA HILL LIMESTONE

During presian the siliciclastic basin developed into a carbonate platform and deposition of the Margala Hill Formation took place. The formation (Shah, 1977) is mainly a fossiliferous, medium grained to fine grained nodular limestone with marly horizons. It is bluish grey and yellowish grey on the weathered surface and on the fresh surface is generally dark to blackish grey. The lower part may contain frequent marly horizons. The nodularity of Margala Hill Limestone is more prominent as compared to the Lockhart limestone. Generally the limestone is medium grained but fine-grained horizons occur which may break with sub-conchoidal fracture. Some pyritic nodules are observed which contain weathered limonitic powder. Sometimes they show hollow cavities. Ahsan et al. (1998a, 200b) described the Margala Hill Limestone from Khaira Gali that contains twelve lithofacies units, separated by eleven marly horizons. These lithofacies contain 45% foraminiferal wackestone facies, foraminiferal mudstone and foraminiferal packstone facies (19% each) and 17% marly facies. The entire formation is free of oolites and pellets. Sedimentary structures like ripple marks and cross bedding are absent. Basal beds are bioturbated. The lithified rates of seimentation were 62.5mm/1000years (Chaudhry et al., 1998a). The Margala Hill Limestone at Chahla Bandi, Azad Kashmir (Chaudhry et al., 2001) is composed of light grey to dark grey limestone. The formation at the base is thinly bedded. It is overlain by calcirudite that contains abundant pelecypode shells. Some shells are reworked. Highly fissile dark grey shale overlies the shelly beds and contains marcasite nodules. The shale is followed by highly nodular limestone. The nodules are upto 30 cm x 50 cm x 13 cm and contain very thin shale partings. This zone is 29m thick. It is very dark grey in color and gives very strong fetid smell. An argillaceous marly limestone that is 28 meters thick overlies the dark grey limestone. It is overlain by medium bedded to highly nodular limestone towards the top of the formation. This zone is grey and weatheres to light grey. On the basis of petrographic and field observations the formation is divided into six facies.

5.6 GEOLOGY ALONG THE PROJECT STRUCTURES

5.6.1 GENERAL

The Project area lies in the Hazara Thrust fault System. The Margala hill ranges are traversed by a system of nearly parallel northeast/southwest trending faults. These faults join the Himalayan thrust along a syntexial bend towards northeast and Kirthar, Suleiman fault zone, towards southwest.

The area around Haro is tectonically disturbed and is severely folded on both the abutments are parallel to sub-parallel and have east west orientiation.The folding and faulting is attributed to the post Eocene major regional tectonic activity. The folds are plunging towards west and their axial planes dip towards south.

5.6.2 GEOLOGICAL INVESTIGATIONS

Geological investigations at this stage were limited to mapping of surface geology and excavation of seven test pits. The lithological units were mapped by the handheld G.P.S and were marked on the detailed toposheet, of the project generated at 5m contour intervals.

Surface geological map of project area is presented in appendix-5.I.

Two test pits at Powerhouse and four test pits at Intake site were excavated. The location plan of test pits is presented in appendix-5.4, and logs of Test Pits are presented in appendix-5.3.

The proposed powerhouse area is covered by the sub-soils and alluvial deposits. Two test pits were conducted to explore the sub-soil strata

5.6.3 INTAKE AND SEDIMENT EXCLUDERS

These structures are located at the toe of left bank slopes along the road and in nullah bed.The foundation of the structures shall be laid over boulders gravels of limestone, shale and siltstone etc. The voids between gravels boulders are partly chocked with sand. Loose boulders which have moved down the slope shall have to be removed to prepare stable foundation bed for the structures. Protective works will be needed along nullah side to check the River Erosion and scarving. This can be done without difficulty by placing gabions.

5.6.4 POWER CHANNEL

The power channel starts from the downstream end of the sediment excluder and end at the forebay at RD 7+050.It passes through the colluvial/talus material consisting of angular gravels boulders of limestone, siltstone and shale, with varing amount of sands and fines and it also passes through the rocks of Margalla Hill Limestone formation. Although there is limited cohesion between different grades of the overburden material but the slopes are generally stable at angles ranging between 30^0 and 36^0. Where slide material may become unstable due to rains or earthquake.

5.6.5 FOREBAY AREA

Forebay area starts at RD: 8+050m and extends horizontally for 45 m with a width of about 6 m and with a depth of 4m. It is located in rocks (under a thin layer of overburden). The slope is covered by cultivation overburden is generally AGM with trace boulders.

Excavations 940m^3 shall be required to get required space for a storage capacity of about 912m^3.

The proposed fore bay area is located on the river terrace deposit. the terrace deposit consist of silty sandy gravels and boulders of angular to sub angular in nature. the river site slopes were protected by retaining walls and the gabion should be placed on the hill side.

5.6.6 PENSTOCK ALIGNMEN

The penstock area at its half of the up hill area slope is covered by the thin cover of RBGM overburden where as the half length of penstock area comes on the alternating bands of shale and limestone.

The attitude of bedding at down hill is provided as N20E/50NW to N70E/64NW

5.6.7 POWERHOUSE / SWITCHYARD AND ANCILARY STRUCTURES

The power house location is proposed near the RD: 8+100. The power house location is proposed on the alternating beds of limestone and shale, at the downhill of power house location three electrical resistivity survey probes were conducted near the Haro river bed to evaluate the depth of bed rock below the overburden cover. The depth of overburden material ranges from 0.00 m to 10.0 m over the bed rock.

5.7 THE SEISMOTECTONIC CONTEXT OF THE OCTOBER 8TH 2005

Seismic activity in South Asia is a direct result of the collision of the Indian and the Eurasian plates, which result from the north-western motion of the Indian plate at a rate of 4 – 5 cm / year. The resulting collision has fractured the Indian plate into several slices beneath the Kashmir Basin known as the Indus-Kohistan Seismic Zone (IKSZ).

The IKSZ is a basement thrust which extends northwestwardly beyond the nose of the HKS and terminates in the vicinity of Pattan in Kohistan. Its tectonic relationship with the MMT is not well defined but it is believed that the increase in its seismicity close to its north-western termination may be due to its interference with the active part of the MMT. This megacrustal structure is about 120 km long, 25 km wide and the majority of its earthquakes emanate at 12 to 14 km depth. It trends NNW-SSE for about 40 km, connecting the Hazara-Kashmir Syntaxis with the MMT in the vicinity of Pattan.

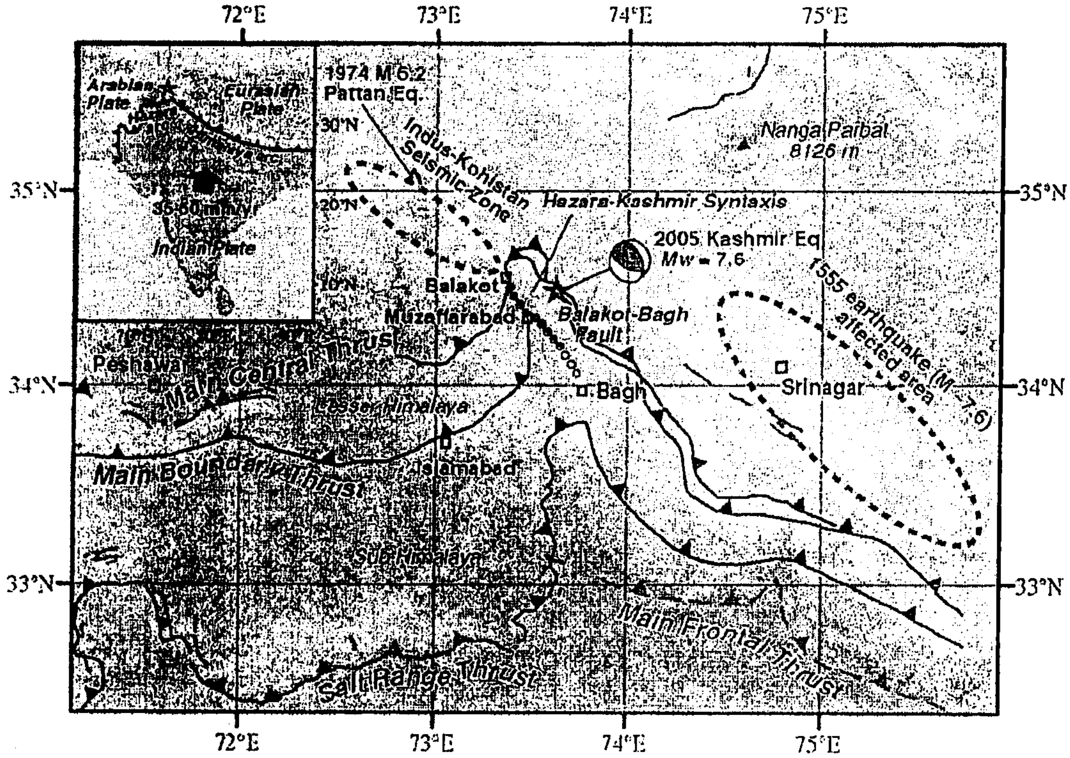


Figure 5.3 Regional tectonic map of the westernmost part of the frontal Himalaya. Solid black lines are major tectonic lines from Burg et al. (2005). Red lines show active faults from Nakata et al. (1991) and Avouac et al. (2006). The 2005 surface rupture is denoted by aligned red circles. Affected area of the 1555 earthquakes (Ambraseys and Jackson, 2003) and IKSZ (zone of high microseismicity; Armbruster et al., 1978; Seeber and Armbruster, 1979) are also shown by blue dashed ellipse.

Three tectonically active faults, the IKSZ, the PT and the MBT converge in the northem tip of the HKS, constituting a very active seismic zone which display cluster of epicentres of variable magnitudes. The IKSZ shows host of epicentres distributed all along its domain. Magnitude of earthquake in this zone vary from 3, to 5,5 and the higher level concentration are confine in the vicinities of its terminations neat the MMT and the HKSZ.

The Panjal Thrust, on the eastern limb of the HKS has had a large number of isolated epicentres in the range of magnitude from 3,0 to 3,9 with some events culminating to 4,9. The MBT is mostly inactive.

The source of October 8th 2005 earthquake of Mw 7.6 was the northwest-striking (N33°W) Balakot-Bagh (B-B) fault[1] (BBF) composed of three active fault segments located within the

Sub-Himalayas and showing a total length of more than 70 km. It had been mapped on the eastern limb of the Hazara-Kashmir Syntaxis by the Geological Survey of Pakistan prior to the earthquake but had not been recognized as an active fault except for a 16 km section near Muzaffarabad (Tanda Fault). The Balakot-Bagh Fault (BBT) was formerly known as the Murree Fault / Muzaffarabad Fault / Main Boundary Thrust. It is close to the MBT and in close proximity with the alignment of the Pattan, Pir Panjal, Jhelum and Margalla faults. Stratigraphically the BBT is running between the Late Cambrian Abbottabad Formation and the Miocene Murree Formation from Balakot to Muzaffarabad. Afterward it continues in the SE direction within the Murree Formation up to Bagh. The shales of the underlying Middle Eocene Kuldana Formation have acted as a decollement plane. The name was chosen by the Geological Survey of Pakistan for the Murree-Tanda-Muzaffarabad faults system. It extends from north of Balakot to the northwest of Bagh.

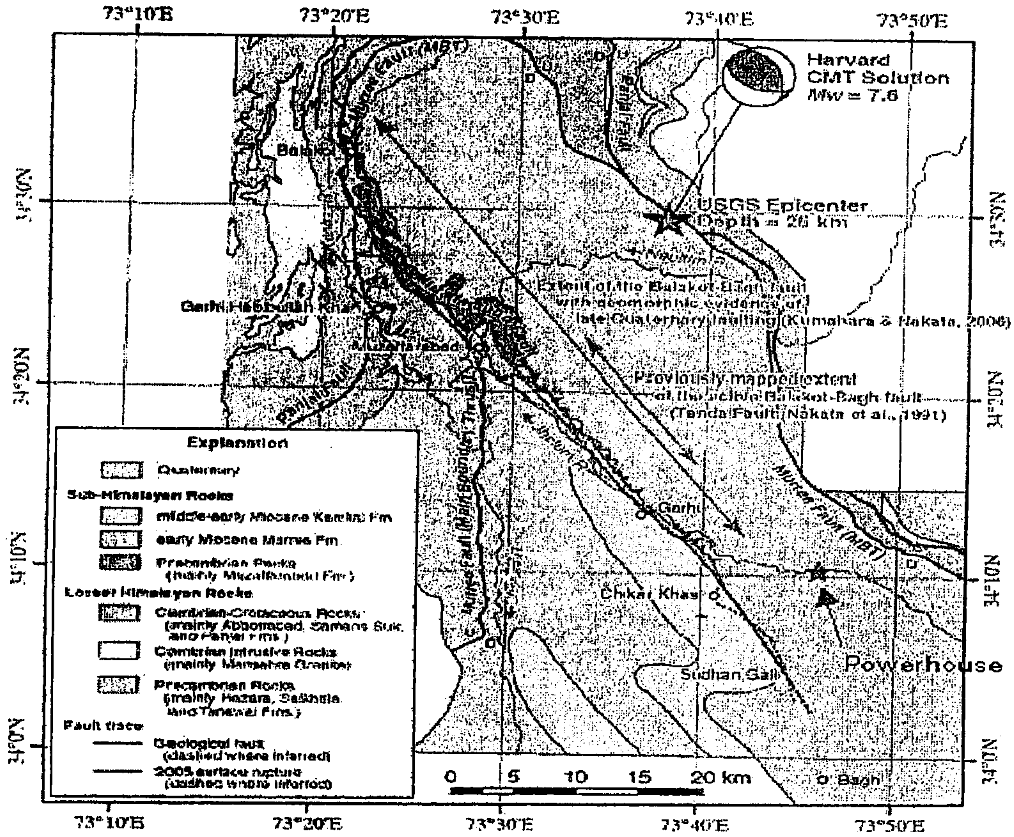


Figure 5.4 Geology in and around the epicentral area of the 2005 Kashmir earthquake. Complied and simplified from the Geological Survey of Pakistan 1:50,000 geological map quadrangles (Akhtar, Saeed, and Haussein, 2004; Akhtar, Waliullah, et al. 2004; Anwar et al, rupture is also shown by red lines with teeth on the upthrown side.

These faults follow the Indus-Kohistan Seismic Zone (IKSZ), a northwest trending belt of high microseismicity. It cut across and locally offset the Hazara-Kashmir Syntaxis defined by the Main Boundary Thrust (MBT) and the Panjal Thrust (PT). It also offset Pleistocene terrace surfaces in the Azad Jammu & Kashmir province. This fault shows thrusting of the northeast side over the southwest part along a low angle thrust fault plane (± 37°) with a minor strike-slip component. Focal depth was estimated at 26 km. Steeper stream gradients and higher topography is found on the northeast overriding block. No surface expression of this fault have been found north of the syntaxis but some authors suggests a connection with the northwest extension of the IKSZ and the Pattan earthquake of 1974 (M 6.2) located on the Pattan Fault. To the southeast, the Geological Survey of Pakistan has mapped northeast dipping thrust faults up to Bagh. Between Chikar Khas and Bagh the fault is a discontinuous surface rupture with relatively small displacement passing through mountainous terrain. Vertical separation was up to 1 m in this area. Some authors suggest connections with the southern Kiasi and Son thrusts and the Kangra earthquake of 1905 (M 7.8).

The 2005 earthquake occupied the transitional zone between the northwest trending Himalaya arc and the east-west trending Hazara arc. Strike of the BBF indicates that the fault is a member of the Himalaya arc, which further extends to northwest beyond the HKS as the IKSZ. The BBF and the IKSZ thus may be interpreted as the dying-out parts of the Himalaya arc.

The hypocenter determined by the USGS suggests that the rupture initiated at the deep portion of the northern-central segment boundary and propagated bilaterally to eventually break the three segments. The distribution of subsequent aftershocks suggests that the fault rupture extended in the NW direction toward the IKSZ.

The tremors were felt at XII on the Modified Mercalli intensity scale at the epicentre in Gori, 20 km from Muzaffarabad, X in Mansehra, Bagh and Rawala Kot, IX in Batgram, VIII in Abbottabad and VI in Islamabad. Signs of damages seemed fairly minor outside the narrow (5-10 km) width of the rupture zone. The Synthetic Aperture Radar (SAR) data showed a 90 km long NW-SE trending belt of deformation with a general displacement of more than 1 m, reaching a maximum of 5-6 m north of Muzaffarabad. Many lines of geomorphic evidence document repeated surface rupture along the trace of the Balakot-Bagh Fault. Based on these evidences the estimate recurrence interval for this earthquake was evaluated between 1000 and 3 300 yrs and the shortening rate between 1.4 and 4.1 mm/yr. The most recent large earthquake known in and around the 2005 epicentre area is the 1555 Kashmir earthquake of M ± 7.6 but the damage from the earthquake was reported to have been concentrated around Srinagar to the east suggesting that these earthquakes were on different fault systems.

The earthquake triggered several thousand landslides covering an area of some 7 500 km^2These were mainly (90 %) rock falls and debris falls of small extent (<1 000 m^2), although some (10 %) transitional rock and debris slides and flows also occurred. Most failures were shallow, typically involving the top few meters of weathered bedrock, regolith and soils. They occurred mainly in the footwall rocks of the MBT and on slopes where the gradients are generally less than 20^{o}, either on forested or deforested slopes. There were concentrated along the fault trace and rapidly diminished with distance (< 2 km) from the rupture zone. The failures were highly concentrated and associated with specific geomorphologic-geologic-anthropogenic settings. Road construction and human activities have often helped initiated these failures. In addition, the Hattian debris avalanche (sturzstrom) of some 80 000 000 m^3 occurred in Parhore valley, burying four villages (Nainan, Buthsher, Bale, Lodhiabad) and blocking streams to create two lakes. This landslide was located some 36 km southeast from the epicentre and some 3 km from the estimated fault-trace.

A follow-up of the evolution of earthquake-triggered landslides from November 2005 to August 2007 has confirmed that the vast majority of landslides has shown very little or no change. Landslides areas that showed changes were located along rivers or roads. Potentially dangerous extensive fissures and ground cracks were however noticed in many localities.

5.8 FIELD INVESTIGATION

5.8.1 TEST PITS

SCOPE OF WORK

The six no's of test pits were digged. The 08 no's of soil samples were taken for the soil classification of the overburden material. The field density tests were conducted at the Intake site and power house sites (PH-1). The test pit logs are present in the Appendix-VIII of Volume-V of this Feasibility Report.

The samples obtained from the test pits were subjected to numerous tests and are presented below:

CLASSIFICATION TEST

This test is combination of three tests as follow:

a. Particle Size Analysis (AASHTO T 27)
b. Determining of Liquid Limit (AASHTO T-89&T90)
c. Determining of Plastic Limit (AASHTO T T-89&T-90)
d. Modified AASHTO Compaction test
e. Specific Gravity

A total of 13 samples of sub grade were subjected to classification tests from project site and their results are attached in the appendix-IX. The classification of sub grade material reveals that samples are classified as A-4, A-2-4. Generally A-4 type of soil is considered as fair. The summary of these test results is given in the Appendix.3.0

GRAIN SIZE ANALYSIS WITH HYDROMETER SEDIMENTATION TESTS

Grain size analysis has been performed on the disturbed samples. The oven dried material retained on the No. 200 sleve after washing was placed on the top sieve included in the most of sieves ranging from 5mm to 0.074mm, and shaken for 10 minutes.

For determination of smaller fraction, the wet method must be used. A soil sample is dispersed thoroughly in distilled water. The soil-water moisture is well shaken so that all soil grains are in suspension. By means of a hydrometer, the density of the suspension is determined. Correlation between the density of the suspension and the diameter of the grains has been worked out on the assumption that all grains are spherical in shape.

The grain size analysis curves have been drawn and attached with report in (Appendix- 5.1 of Volume-V of this Feasibility Report).

5.8.2 ATTERBERG LIMITS

Liquid Limits

The liquid limit of a soil is the water content at the boundary between the liquid and plastic states. The standard equipment for liquid limit test is a dish. A soil sample (with grains passing No. 40 sieve) is thoroughly mixed with water and is placed in the dish to a thickness of 1 inch at the bottom of the dish. A groove of ½ inch width is cut in the middle of the sample. The dish is lifted and dropped by turning the crank. The number of drops required to close this ½ inch groove is recorded. The liquid limit is the water content at which 25 drops of the dish will close the ½ inch groove. The liquid limit of the subsoil is non plastic.

Plastic Limit

The plastic limit of a soil is the water content at the boundary between the plastic and semi-solid states. The water content at the boundary is arbitrarily defined as the lowest water content at which the soil can be rolled into threads 1/8 inch in diameter with out the threads breaking into pieces. The plastic limit of subsoil is non plastic.

Plasticity Index

The plasticity index is the difference between liquid limit and plastic limit. The plasticity index is non plastic.

Field Density Test

A total of 8 Field Density test were conducted on the project site for Jabri Bedar Hydropower Project. Four field density tests were conducted at Intake site and two at PH-1 and two at PH-2. The compaction% achieved is ranges from 71 – 90.

Fig-5.5: Field density test conducted at the Project site

Fig-5.6: Field density test conducted at the Project site

5.8.3 SCHMIDT HAMMER TEST

SCOPE OF WORK

Schmidt hammer is a valuable tool to assess characteristic compressive strength in large structures by means of indirect methods. However, some relevant aspects such as of the precision of rebound hammer test results and the confidence level should be clarified.

APPARATUS

The Schmidth hammer which determines the rebound hardness of a test material. The plunger of the hammer is placed against the specimen and is depressed in to the hamper by pushing the hammer against the specimen. Energy is stored in a spring which automatically releases at a prescribed energy level and impacts a mass against the plunger. The height of rebound of the mass is measured on a scale and is taken as the measure of hardness. The device is port able and may be used both in the laboratory and field.

Table No. 5.1 Schmidt Hammer Test at Jabri Hpp

Schmidt Hammer Test

Sr. No.	Schmidt Hammer Stoke No.	Schmidt Hardness MPa)	Average Hardness (MPa)	UCS (PSI)	Element of Structure
1	i	40	44	6380	Outcrop of Limestone
	ii	44			
	iii	48			
	iv	44			
2	i	20	23	3443	Outcrop of Shale
	ii	25			
	iii	28			
	iv	22			
3	i	50	46	6670	Outcrop of Limestone
	ii	46			
	iii	44			
	iv	44			
4	i	42	44	6452	Outcrop of Limestone
	ii	44			
	iii	48			
	iv	44			
5	i	20	24	3480	Outcrop of Shale
	ii	24			
	iii	30			
	iv	22			
6	i	15	23	388	Outcrop of Shale
	ii	25			
	iii	30			
	iv				
7	i	48	46	6670	Outcrop of Limestone
	ii	44			
	iii	46			

Schmidt Hammer Test

Sr. No.	Schmidt Hammer Stoke No.	Schmidt Hardness (MPa)	Average Hardness (MPa)	UCS (PSI)	Element of Structure
9	i	36	38	5510	Outcrop of Limestone
	ii	38			
	iii	40			
	iv				
10	i	18	20	2996	Outcrop of Shale
	ii	20			
	iii	24			
	iv				
11	i	26	30	4446	Outcrop of Shale
	ii	30			
	iii	36			
	iv				
12	i	54	54	7830	Outcrop of Limestone
	ii	52			
	iii	56			
	iv				

5.9 GEOTECHNICAL ANALYSIS

Exploration Targets and Problems

The Rocks exposed on the Project area are limestone & shale of Margallah Hills limestone. The limestone is moderately strong to strong but its engineering properties are highly influenced by its lithological composition, discontinuity, distribution over its mass.

Foundations for Intake site

The Intake site is proposed to construct on the limestone bed rock, of Margallah hill limestone. The limestone bedrock at Intake site is moderately weathered.

The Schmidt rebound tests are conducted on the different scarps walls and are presented in Table. No.5.3 Strength properties of the Intake site are presented in the table No. 5.12.

The depth of bed rock ranges from 10m to 30m in subsurface at Intake site.

Table: 5.2 Strength properties of Rock

Rock Type	Density Dry t/m	Porosity	Dry UCS range Mpa	Dry UCS Mpa	Allowable bearing pressure	Modulas of elasticity Gpa	Tensile strength Mpa	Friction Angle Φ
Limestone	2.3	15	15-70	25	2Mpa-5Mpa	15	2	35°

Therefore it is recommended that the allowable bearing pressure at the bed rock limestone will be taken as 2Mpa.

Concrete dams should be placed on sound rock of weathering grades I or possibly II. Permeability of the bedrock within the jointed mass becomes a serious problem because of numerous enlarged joints, which may be filled with highly erodable material. All seams will have to be cleaned using "dental work" and back-filled with concrete so that there is no chance of the reservoir feeding into conductive cracks. It may be difficult to grout this zone of the bedrock and if grouting tests show that impermeabilization cannot be achieved, the excavation has to be deepened to reach satisfactory rock.

The electric resistivity test results reveals that lime stone in the sub surface jointed & fractured therefore grouting would be required.

Spillways running out into weathered Granitic rock can be damage by scour as the water moves over fissures, fault. Careful and complete protection is necessary to isolate the moving water from the susceptible rock surfaces.

Fig-5.7: Schmidt hammer tested at the site

5.10 ELECTRICAL RESISTIVITY SURVEY

INTRODUCTION

This chapter presents the findings of the geoelectrical soundings conducted at Haro river tehsil Jabri district Haripur for Jabri Bedar Hydro Power Project. The main objectives of the survey were to determine soil overburden/alluvium and obtained general information of bedrock material in the following areas:

i. Power House

ii. Intake Site

The survey was carried out for the purpose, to ascertain the thickness of alluvium /overburden material, type of different lithological units encountered in the sub surface. In this regard, four Vertical Electrical Soundings (VES) were carried out using Schlumberger electrode configuration in the above three mentioned areas. Each sounding was done up to a current electrode spacing (A/B) **30 to 60 meters** not less than **60 meters** to facilitate investigation up to the bedrock depth. The locations of sounding sites of each area were selected in the field keeping in view the surface gradient and other related features. These locations are also mentioned in the appended computer data sets.

In-addition to the findings of the resistivity survey, a brief account of field operations and data processing has also been included in the report to provide the basis of the method. It includes the interpretation of VES data presented in the form of models, to show the depth / thickness of different layers and their respective resistivities. Based on the interpretation of the resistivity data, the sub-surface material has been classified into different resistivity zones as abridged in the text. Each resistivity zone signifies typical geological conditions, which are defined under the heading of the respective zone. Based on the results of resistivity survey, conclusions and recommendations have been framed.

PURPOSE AND SCOPE OF WORK:

Geoelectrical survey is often useful on the slopes of study area, helps to distinguish interface of the slided rock material or overburden and rock i.e., before planning the exploitation of core sampling from the area, it is important to have diagnostic scientific information regarding the sub-surface geological conditions like:

- Lithological nature of the area of interest.
- Determine the depth and thickness of the bedrock.
- Differentiate the alluvium / overburden layers overlying the bedrock.

Electrical resistivity survey by vertical electrical sounding (VES) method is by far the most widely used technique to obtain the requisite information, which in turn help to make cost effective and technical decisions like:

- Selection of the prospective sites for the dam axes and powerhouse axes.
- Determination of target drilling depth to avoid un-necessary exploratory drilling.
- Identification of the nature and thickness of the lithological units in the areas of interest.

PRINCIPLES OF RESISTIVITY METHOD:

During resistivity survey a direct current is introduced into the ground through two current electrodes A and B inserted in the ground surface. The potential electrodes M and N are inserted in the ground between the outer current electrodes A and B where the potential difference is measured across these two potential electrodes. By measuring the current (I) between the two current electrodes A and B and the associated potential difference (V) developed between the potential electrodes M and N, resistivity of the corresponding subsurface medium enclosed between the current electrodes is obtained.

Normally, the medium is inhomogeneous and anisotropic therefore, the resistivity is known as apparent resistivity and is computed by the following formula:

$$\rho a = K \times V / I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

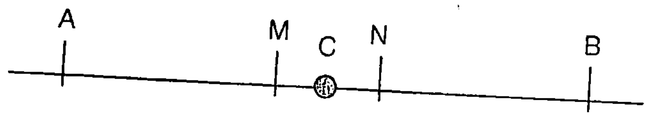
Where:

ρa	=	apparent resistivity in ohm-meter
K	=	geometric factor of the electrode arrangement
V	=	potential difference in milli volts
I	=	current passing through ground in milli amperes

In case of Schlumberger electrode configuration, the geometric factor K is calculated as:

$$K = \pi x \frac{(AB/_2)^2 - (MN/_2)^2}{MN}$$

Equation (1) is the general equation for calculating apparent resistivity in electrical resistivity prospecting.



Schlumberger Electrode Configuration

LIMITATIONS:

The method has some limitations.

- It measures apparent resistivity not true resistivity of the subsurface formations and change of resistivity at greater depth have only slight effect an apparent resistivity as compare to these of shallow depths. Thus this method is seldom effective for determining actual resistivity below few hundred feet.
- The true resistivity cannot be obtained, but only be obtained from homogeneous and isotropic medium and in nature such conditions impossible to exist in the subsurface. Actually the condition found in the subsurface are inhomogeneous, which is an isotropic so the resistivity thus obtained from that source is called as apparent resistivity.
- It is not possible that the value of resistivity of a given type of rock will remains at different locations. Resistivity varies with locations because change in environment, change in lithology, change in temperature and other such controlling parameters.

FIELD PROCEDURE:

Signal averaging resistivity-measuring equipment (SAS-300) is used for measuring direct apparent resistivity values in the field.

In the case of the Schlumberger array, the electrodes are placed in a straight line symmetrically about the center point. The two outer electrodes A and B are used for the current, and the resulting potential difference is measured across the two inner electrodes M and N. The distance of the current and potential electrodes from the center, which are referred to AB/2 and MN/2 respectively, characterizes the array. MN/2 is always kept sufficiently small relative to AB/2. The average potential gradient measured between M and N is a close approximation to the potential gradient at the center of the array.

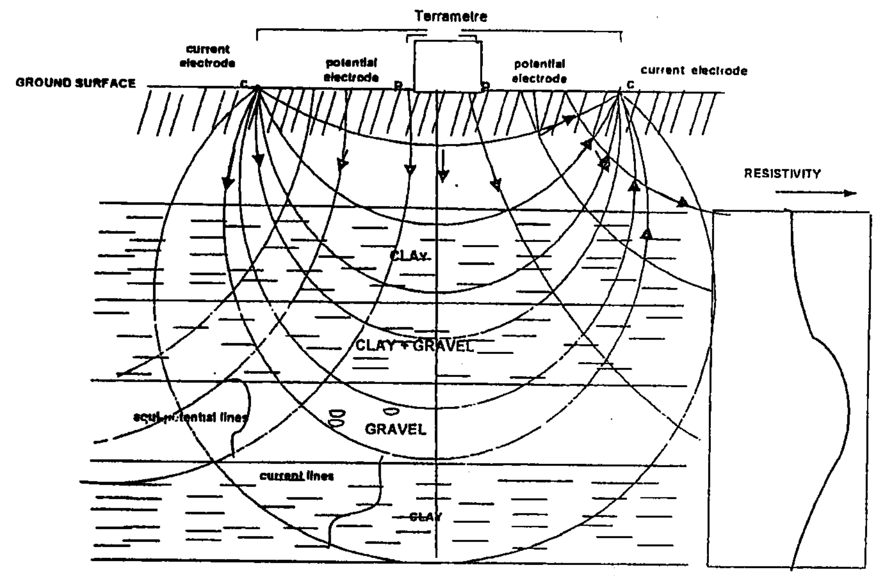


Figure 1: Setting of Current and Potential Electrodes

Fig. 5.8 Setting of Current and Potential electrodes

METHOD OF EVALUATION:

The resistivity field curves are obtained by plotting the apparent resistivity values against depths on a bi-log graph paper. After smoothing the plotted curves all the field data is registered to computer. The interpretation of sounding is done with the help of computer and direct interpretation software. The resistivity sounding data collected from the area is interpreted by computer-aided techniques using **INTERPEX USA software, IXID**. The layer models are calculated by iterative procedure during each iteration the model parameters are adjusted and the deviation of the corresponding curve from the measured curve is checked. The deviation is defined by the RMSE (root mean square error), which is displayed after each iteration. At the end of calculations, the model, which results in the smallest error, is plotted showing layer's true resistivity and corresponding thickness.

In practice, interpretation of resistivity sounding is invariably subjected to the principle of equivalence i.e. any resistivity sounding can be matched with several slightly deviating model curves, representing different sub-surface resistivity stratification depending upon lithology behavior of the area. The interpreter of the data is therefore, confronted with hundreds of options for a single field curve to make his selection of the most consistent model of the sub-surface conditions.

INTERPRETATION OF V.E.S. DATA:

The measured apparent resistivities of the field when subjected to interpretation process had yielded subsurface electrical layers. These electrical layers need a correlation with the subsurface geological conditions. This transformation of interpreted layer into lithologic units is essentially based on the geological information obtained from core bore holes and other data of previous investigations conducted on Mansehra area. Interpreted models of each sounding have been separately appended in this report.

ALLUVIUM / OVERBURDEN:

The alluvium deposit that is almost, as a reworked deposition of large boulders of igneous and metamorphic rocks, with sandy gravels. angular to sub angular in texture.

The thickness of the alluvium /over burden deposits varies from few meters to more than 6 meter in some parts of the area. The alluvium consist mostly loose eroded and weathered boulders/gravels with fine material of the surrounding hills.

Table 5.3 MATERIALS RESISTIVITY VALUES USED FOR THIS WORK

Rock type	Resistivity range (Ω-m)
Unconsolidated (surface materials) like, large size boulders/talus.	0-1000
Weathered, fractured bed rock	1000-2000
Moderately compacted bed rock	2000-3000
Massive fresh bed rock	> 3000

5.11 THE RELATIONSHIP BETWEEN GEOLOGY AND RESISTIVITY:

Before dealing with the more complex types of resistivity surveys, we will look briefly at the resistivity values of some common rocks, soils and other materials. Resistivity surveys will give a picture of the subsurface resistivity distribution. To convert the resistivity into a geological picture, knowledge of typical resistivity values for different types of subsurface materials, and the geology of the area surveyed, is important.

The resistivity values of common rocks, soils, chemicals and metals are given in below table. Metamorphic and igneous rocks typically have high resistivity values. The resistivity of these rocks is greatly dependent on the degree of fracturing and the percentage of the fractures filled with groundwater. Sedimentary rocks, which usually are more porous and have higher water content, normally have lower resistivity values. Wet soils and fresh groundwater have even lower resistivity values. Clayey soils normally have a lower resistivity value than sandy soil. The resistivity of groundwater varies from 10 to100 ohm.m depending on the concentration of dissolved salts.

Table 5.4 RESISTIVITIES OF SOME COMMON ROCKS

Material	Resistivity (Ω.m)	Conductivity (Ω.m)1
Limestone	5x103 - 106	10-6 – 2x10-4
Shale	8 – 4x103	2.5x10-4 - 0.125
Alluvium	10 - 800	1.25x10-3 - 0.1

5.12 RESULTS AND DISCUSSION AT INTAKE, POWER HOUSE:

(10) Vertical Electrical Soundings were recorded at these sites.

S-1 has been conducted at Intake site. At this point, overburden, which is comprises bedrock features such as bedrock pinnacles, bedrock ledges and large size boulders (float) suspended /exists in the overburden zones goes up to 8m and below this sandy gravels with cobbles and the boulders has been interpreted up to the depth of 8-22m and from 22m-30m weak to moderately weak shale bed has observed and from 30m-40m highly fractured outcrop of limestone with abundant vugs and the cavities has been interpreted.

S-2 has been conducted at Intake site. At this point overburden, which is comprises bedrock features such as bedrock pinnacles, bedrock ledges and gravels of coarse boulders (float) suspended /exists in the overburden zones goes up to 14m and below this highly fractured outcrop f limestone with abundant vugs and the cavities interpreted which is goes up to 25m and weak to moderately weak shale has been observed from the depth of 25m up to the 45m.

S-3 has been conducted at Intake site. At this point sandy gravels with cobbles and boulders goes up to 10m and below this moderately fractured outcrop f limestone goes up to 20m and weak to moderately weak shale has been interpreted from the depth of 20m up to the 35m,35-45m moderatly fractured limestone has been interpreted, 45-55m weak to moderatly weak shale has been interpreted.

S-4 has been conducted at Intake site. At this point medium dense to dense sandy gravels goes up to 15m and below this highly fractured outcrop f limestone with abundant vugs and the cavities goes up to 30m and weak to moderately weak shale has been interpreted from the depth of 30m up to the50m.

S-5 has been conducted at Intake site. At this point large boulders of igneous and metamorphic rocks with sandy gravels goes up to 5m and below this sandy gravels with cobbles and boulders goes up to 18m and weak to moderately weak shale has been interpreted from the depth of 18m up to the 23m, 23-60m highly fractured outcrop of limestone with abundant vugs and the cavities has been interpreted.

S-6 has been conducted at Intake site. At this point sandy gravels with cobbles and boulders of metamorphic and igneous goes up to 20m and below this weak to moderatly weak shale nad moderatly weathered goes up to 30m and highly fractured outcrop of limestone with extensive vugs and the cavities and highly saturated interpreted from the depth of 30m up to the 50m.

S-7 has been conducted at Intake site. At this point sandy gravels with cobbles and boulders of metamorphic and igneous goes up to 20m and below this highly fractured outcrop of limestone with extensive vugs and cavities and highly saturated goes up to 30m and highly fractured outcrop of limestone with extensive vugs and cavities and highly saturated interpreted from the depth of 30m.moderatly weathered, weak to moderatly weak shale interpreted from the depth of 30-40m.

S-8 has been conducted at power house. At this point angular to sub angular boulders and the cobbles with very dense to dense sand goes up to 10m and below this moderatly fractured limestone with vugs and cavities goes up to 30m and weak to moderatly weak shale interpreted from the depth of 30m to 50m.

S-9 has been conducted at power house. At this point loose sandy gravels with cobbles and boulders goes up to 10m and below this weak to very weak layer of shale bed goes up to 20m and highly fractured and jointed outcrop of limestone with saturated in nature interpreted from the depth of 20m to 60m.

RESISTIVITY LAYERS MODEL:

Table 5.5 S-1: Has been conducted on the Intake site

Layers	Depth in meters	Resistivity in Ohm-m	Interpretation
1	0-8	497.41	Gravels of coarse boulders
2	8-22	405.25	Sandy gravels.
3	22-30	308.25	Weak to moderately weak shale.
4	30-40	144.49	Highly fractured outcrop of limestone

Table 5.6 S-2: Has been conducted on the Intake site

Layers	Depth in meters	Resistivity in Ohm-m	Interpretation
1	0-14	449.8	Gravels of coarse boulders
2	14-25	127.56	Highly fractured outcrop of limestone with abundant vugs and cavities
3	25-45	137.0	Weak to moderately weak shale

Table 5.7 S-3: Has been conducted on the Intake site

Layers	Depth in meters	Resistivity in Ohm-m	Interpretation
1	0-10	271.69	Sandy gravels with cobbles and boulders,
2	10-20	173.97	Moderately fractured outcrop of limestone.
3	20-35	114.57	Weak to moderately weak shale.
4	35-45	96.44	Moderately fractured limestone
5	45-55	80.36	Weak to moderately weak shale

Table 5.8 S-4: Has been conducted on the Intake site

Layers	Depth in meters	Resistivity in Ohm-m	Interpretation
1	0-15	756.21	Medium dense to dense sandy gravels
2	15-30	162.54	Highly fractured outcrop of limestone with abundant vugs and cavities.
3	30-50	78.0	Weak to moderately weak shale

Table 5.9 S-5: Has been conducted on the Intake site

Layers	Depth in meters	Resistivity in Ohm-m	Interpretation
1	0-5	176.9	Large boulders of igneous and metamorphic rocks with sandy gravels.
2	5-18	436.6	Sandy gravels with cobbles and the boulders..
3	18-23	87.76	Weak to moderately weak shale
4	23-60	32.6	Highly fractured outcrop of limestone with abundant vugs and the cavities

Table 5.10 S-6: Has been conducted on the Intake site

Layers	Depth in meters	Resistivity in Ohm-m	Interpretation
1	0-20	341.16	Sandy gravels with cobbles and boulders.
2	20-30	81.5	Weak to moderately weak shale and moderately weathered.
3	30-50	102.4	Highly fractured outcrop of limestone with extensive cavities and highly saturated.

Table 5.11 S-7: Has been conducted on the Intake site

Layers	Depth in meters	Resistivity in Ohm-m	Interpretation
1	0-20	725.2	Sandy gravels with cobbles and boulders,the cobbles and boulders are of igneous and metamorphic origin.
2	20-30	183.13	Highly fractured outcrop of limestone with extensive vugs and cavities and highly saturated.
3	30-40	237.65	Moderately weathered weak to moderately weak shale.

Table 5.12 S-8: Has been conducted on the Powerhouse

Layers	Depth in meters	Resistivity in Ohm-m	Interpretation
1	0-10	182.0	Angular to sub angular boulders and the cobles with v.dense to dense sand.
2	10-30	793.62	Moderately fractured limestone with vugs and cavities.
3	30-50	161.83	Weak to moderately weak shale.

Table 5.13 S-9: Has been conducted on the Powerhouse

Layers	Depth In meters	Resistivity in Ohm-m	Interpretation
1	0-10	182.0	Loose sandy gravels with boulders
2	10-20	463.3	Weak to very weak layer of shale bed.
3	20-60		Highly fractured and jointed limestone outcrop and saturated in nature.

6 HYDROLOGY AND SEDIMENTATION

Power potential of any river or nullah system is dictated by its hydrological regime. This provides quantum of flow of water during various days and months of a year as it varies according to rain fall and snow melt in the catchment areas of the system. Since the snow fall and rain fall is a natural phenomenon and it varies in various years therefore it essential that this could be studied in detail. In addition with water flowing in the rivers streams and nullahs also carry particles of varying size with it. This is detrimental for life of various equipments. In addition trash also flows with water which is also harmful for machines and equipment. Accordingly it also needs to be studied. In this section of the report these two aspects are discussed.

6.1 Hydrology

The Jabri Bedar Hydro Power Project is proposed on Haro River at a distance of approximately 45 kilometer from Murree, about 45 kilometers from Hassan Abdal to Lora Chowk (about 10 kilometers from Haripur city on Karakoram Highway) and then 26 Kilometer to proposed project site.

The Project has been planned on Haro river in the upper reach of Haro River (about 15 to 20 kilometer upstream of khanpur Dam) starting just downstream of Jabri Bridge on Lora-Murree Link

Haro River a tributary of river Indus originates from the high altitudes of galliyats, draining the area of Siribang and Dubran and flows through a length of about 140 kilmeters before its confluence with River Indus downstream of tail race of Ghazi Barotha Hydropower Project in District Attock.

Haro River is fed by four major tributaries:

1. The Lora Haro, rising in the Murree Hills around Lora
2. The Stora Haro, rising in the Nathia Gali Hills
3. The Neelan, rising in the Nara Hills
4. The Kunhad, draining the area of Siribang and Dubran.

Minor tributaries include the following rivulets.

- Jab
- Pakshahi, Narota, Baghpur Dheri, Muslimabad and Halli
- Najafpur.

The project area consists of a reach of 8 – 10 km of Haro River. This part of the Haro River is running through the hilly portion of high elevation and no water is drawn from the river flows for the purpose of irrigation. The hydrological data shows that through out the year sufficient discharge is available to produce hydropower upto 4-5 MW.

The reach of Haro River where the project is proposed has a steep bed slope of 0.8 % to 1.2% is reaches which is very favorable for construction of proposed power house.

6.2 Gauging

The hydrological data collected from WAPDA in respect of Haro River during the period 1997 to 2010. The mean annual runoff for the Haro River at Jabri Gauging station has been estimated as 9.86 cumecs. The mean monthly discharge confirms an availability of 10 cumecs during 6 months of year which has been taken basis for power generation.

Therefore it is envisaged that the maximum optimized installed capacity could be in the range of around 4-5 MW for 6 months in a year.

6.3 Climate

The climate of the area varies during the year. It is hot in summer and temperature shots up as high as 40 degree centigrade whereas in winter it cold and the goes down as low as 4 degree centigrade mean. Precipitation in the area is not very high as mean rainfall is between 7.7 mm in June whereas it is maximum (76 mm) in March. **Table 6.1** shows Temperature and Rainfall data for Peshawer observatory.

Figure 6.1 & 6.2 depict the mean monthly data for Temperature and Rainfall for Haripur Hazara.

Table 6-2: Temperature & Rainfall Data, Peshawer

Month	Mean Temperature C°		Mean total Rainfall (mm)
	Daily Minimum	Daily Maximum	
Jan	4.0	18.3	26.0
Feb	6.3	19.5	42.7
Mar	11.2	23.7	78.4
Apr	16.4	30.0	48.9
May	21.3	35.9	27.0
Jun	25.7	40.4	7.7
Jul	26.6	37.7	42.3
Aug	25.8	35.7	67.7
Sep	22.7	35.0	17.9
Oct	16.1	31.2	9.7
Nov	9.6	25.6	12.3
Dec	4.9	20.1	23.3

Figure 6-6: AVERAGE MONTHLY TEMPERATURES HAZARA (^{0} C)

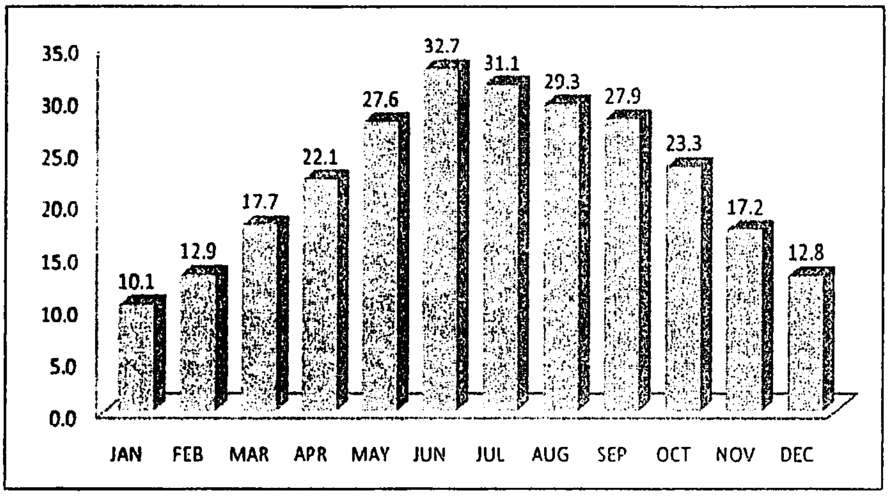
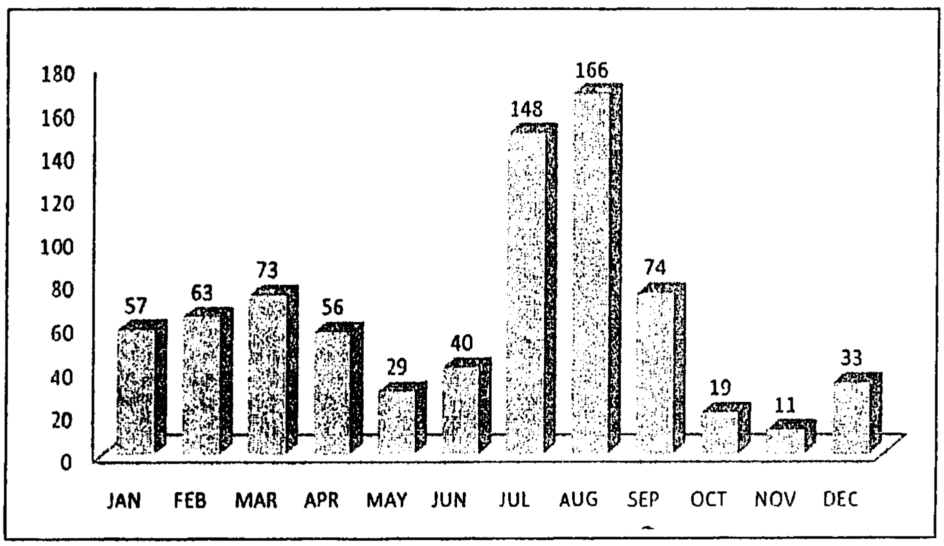


Figure 6-7: AVERAGE MONTHLY RAINFALL HAZARA (MM)



6.4 Discharge Data

The hydrological flow data of Haro River was obtained from WAPDA for the period 1997-2010. This data has been used to calculate average annual flow, average monthly flow and the flow duration curve. The average flows are presented in **Figures 6.3 to 6.4** shows the average monthly and yearly flow under various conditions and **6.5** shows the flow duration curve.

The average annual flow for the 14 years of record has been calculated as 9.86m^3/s for the project site.

The maximum annual flow of around 21.53 m^3/s occurred in the year 1997 and the minimum of 5.61 m^3/s occurred in the year 1999 as can be seen from the graphical presentation. This shows that annual discharge of Haro River is very variable.

The average monthly flows are presented in **Figure 6.3**. The flow is in the range from 4.44m^3/s (157.08ft^3/s) to 21.15m^3/s (747.12ft^3/s).

It is observed that for about for about Six (6) months of the year i.e Febraruy, March, April, July, August, September a flow more than 10 m^3/s will be available that would be able to generate a full output for four months and at part load for remaining of the year.

Year 1999 was the driest year. The mean monthly discharge in the driest year varies from 1.88m^3/s to 14.8m^3/s.

Table 6-2: Monthly Average Discharge Data (Cumecs)

AVERGAE MONTHLY & ANNUAL FLOW OF JABRI BEDAR(CUMECS)

MONTH	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	AVERAGE MONTHLY
JAN	2.09	6.90	6.30	6.04	3.96	9.47	7.70	1.72	1.51	12.24	0.00	3.06	4.10	3.44	4.90
FEB	5.65	9.82	6.86	6.76	3.40	47.06	8.83	43.10	1.84	7.32	9.02	3.86	20.52	2.52	12.61
MAR	6.46	10.13	5.76	48.84	3.35	22.61	4.71	32.51	3.08	7.72	8.36	9.91	38.39	4.12	14.71
APR	2.71	26.76	5.86	13.10	2.95	11.53	4.94	12.70	2.05	8.44	4.77	5.56	20.72	32.47	11.04
MAY	1.83	9.33	4.62	8.04	2.09	5.56	8.17	6.89	1.03	4.61	3.21	2.82	15.22	19.69	6.65
JUN	1.37	4.96	6.44	4.18	2.12	3.23	4.41	5.16	13.17	14.34	1.52	1.88	6.09	9.97	5.63
JUL	27.39	5.46	8.97	11.98	14.08	13.18	4.40	7.97	15.84	18.45	7.99	4.06	13.99	48.67	14.46
AUG	33.82	6.83	13.74	9.51	32.19	10.28	11.92	11.13	24.92	16.88	22.45	14.83	12.76	74.93	21.16
SEP	12.57	5.65	7.21	6.74	8.58	3.81	5.41	13.39	15.35	15.85	14.21	8.34	7.46	33.94	11.32
OCT	6.36	4.07	6.13	5.39	3.79	5.46	6.42	8.29	5.25	4.51	13.84	4.77	4.22	15.32	6.70
NOV	3.61	2.94	3.93	2.83	2.87	3.69	4.60	4.76	2.55	1.99	12.52	4.63	2.49	8.87	4.45
DEC	3.69	2.38	5.61	3.59	8.52	2.73	6.50	7.16	2.00	1.29	13.76	3.62	1.96	4.42	4.80
AVG ANNUAL	8.96	7.94	6.78	10.58	7.33	11.55	6.50	12.90	7.38	9.47	9.30	5.61	12.33	21.53	10.32

Figure 6-3: Average Annual Flows 1997 to 2010 at Haro River

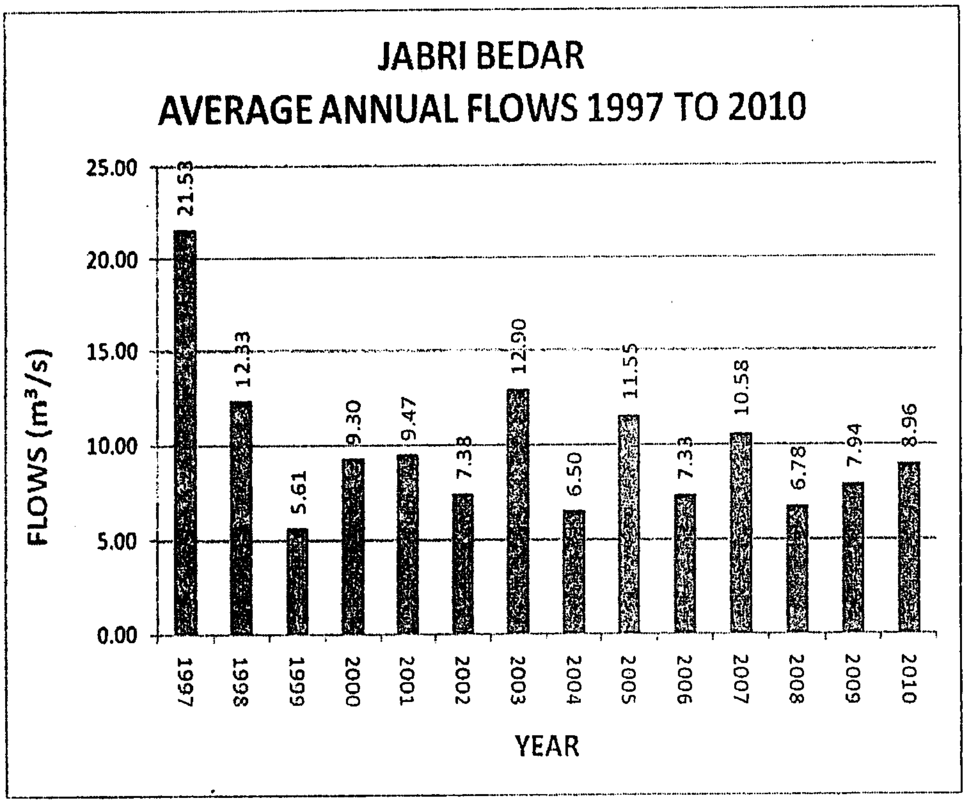
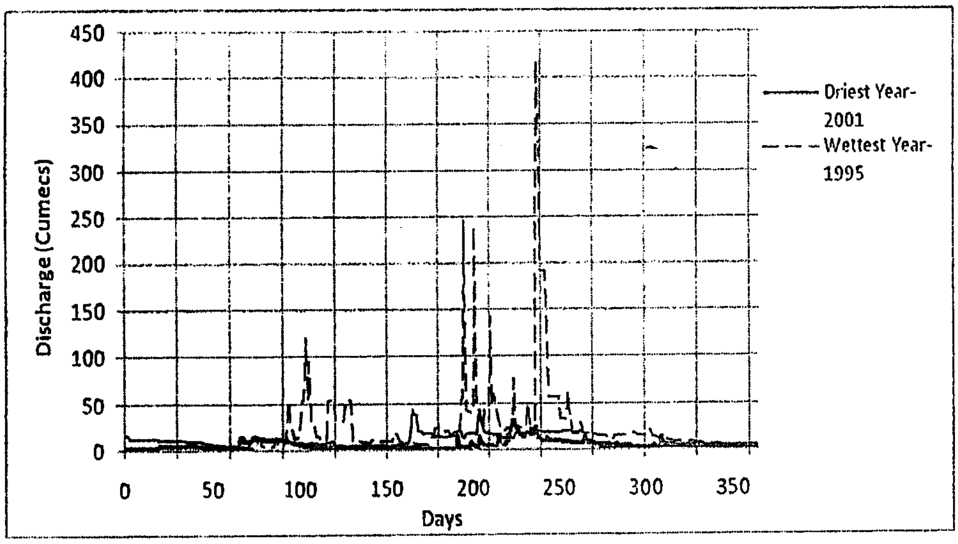


Figure 6-4: Typical Hydrographs of Daily Flows in Haro River



It is observed that for about for four (4) months of the year i.e during March, April, July & August a flow more than 10m³/s would be available to generate an optimum output for four months and partial output for remaining of the year.

Year 1999 was the driest year. The mean monthly discharge during the driest year varied from 3.44m³/s to 4.42 m³/s.

Figure 6.5: Average Monthly Flows 1997 to 2010

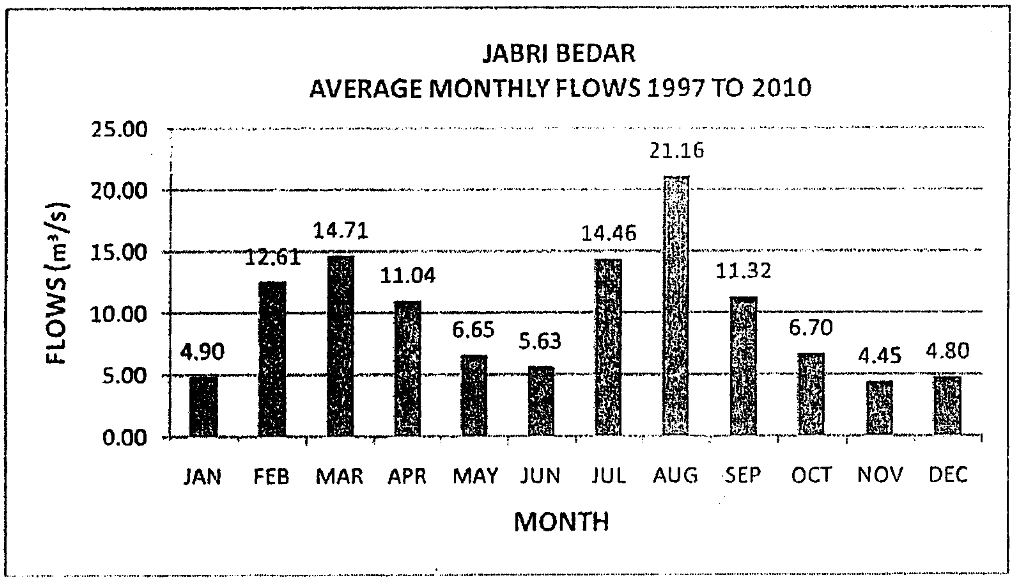


Figure 6.6: Average Monthly Flows for driest year 1999

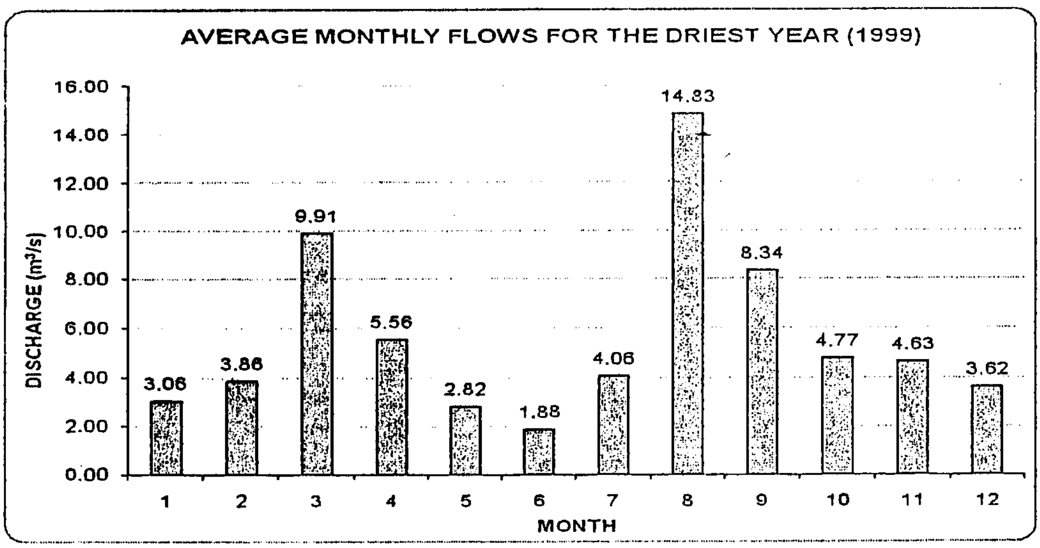


Figure 6.7: Average Monthly Flows for 2001

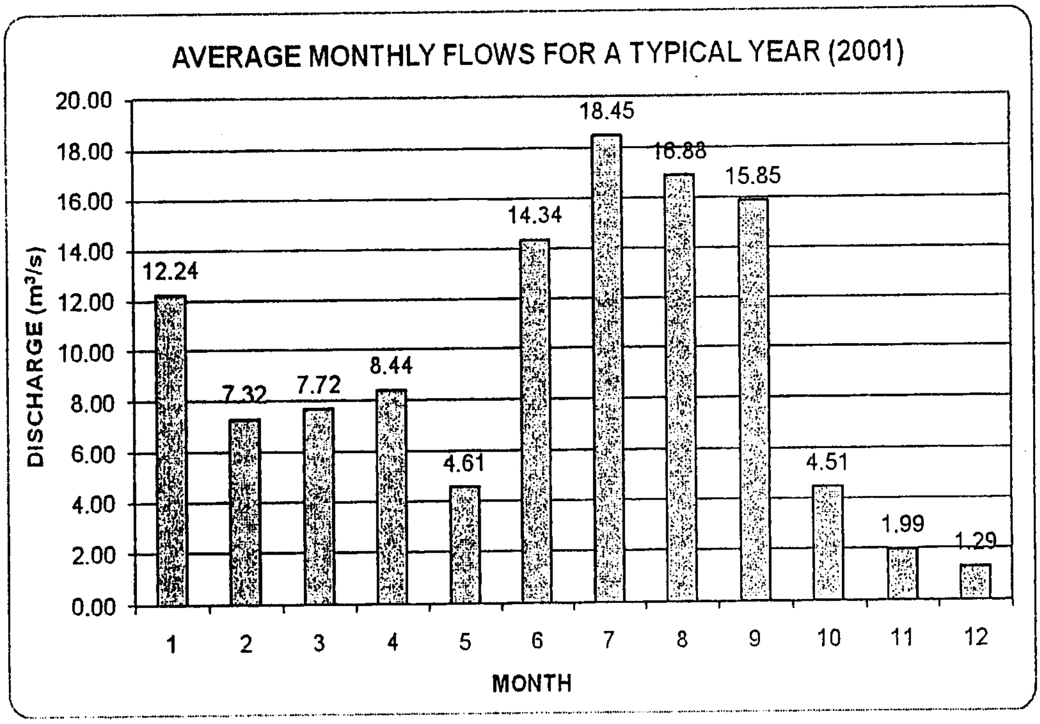


Figure 6.8: Average Monthly Flows 1997

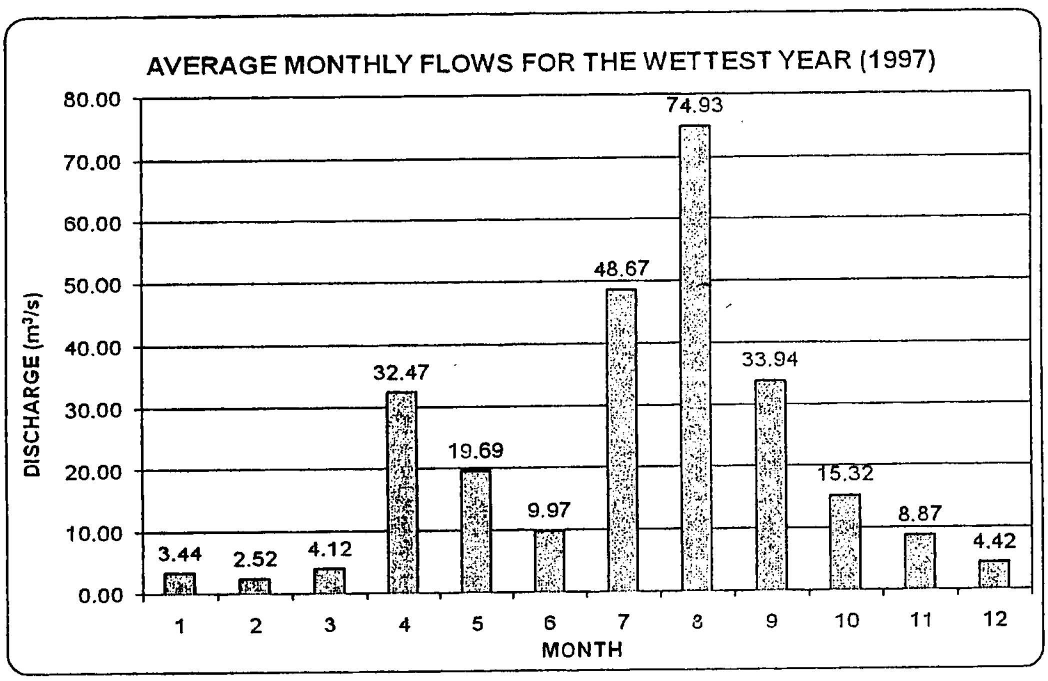


Figure 6.9: Flow Duration Curve (1997-2010)

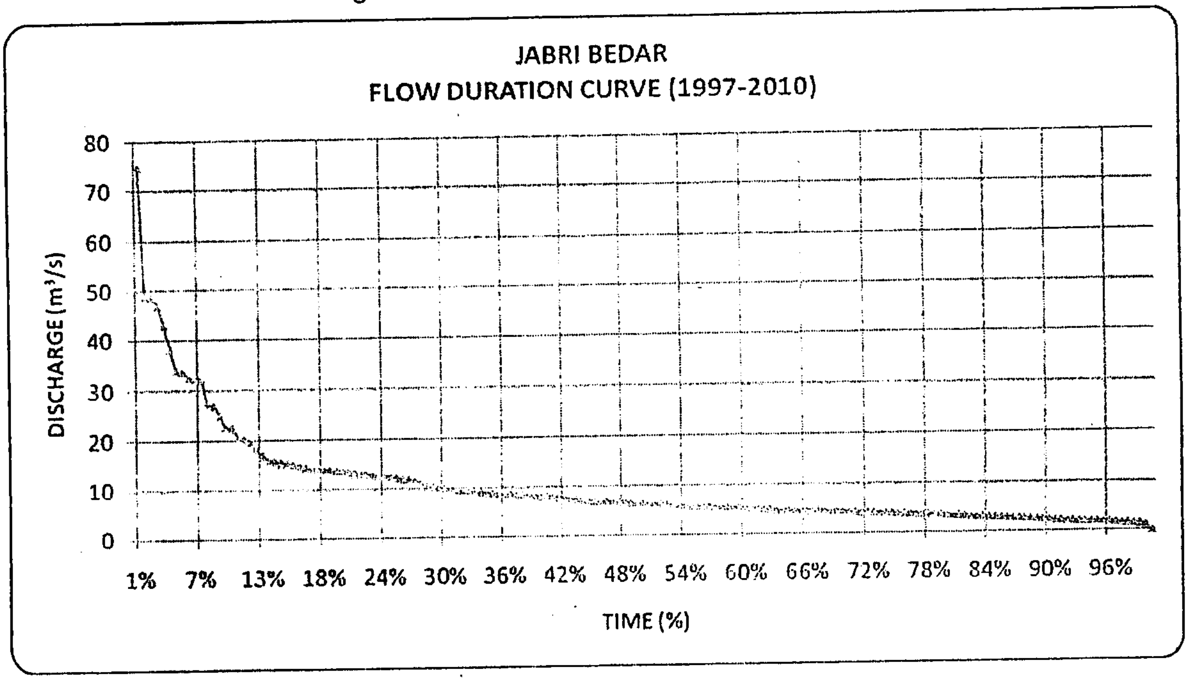
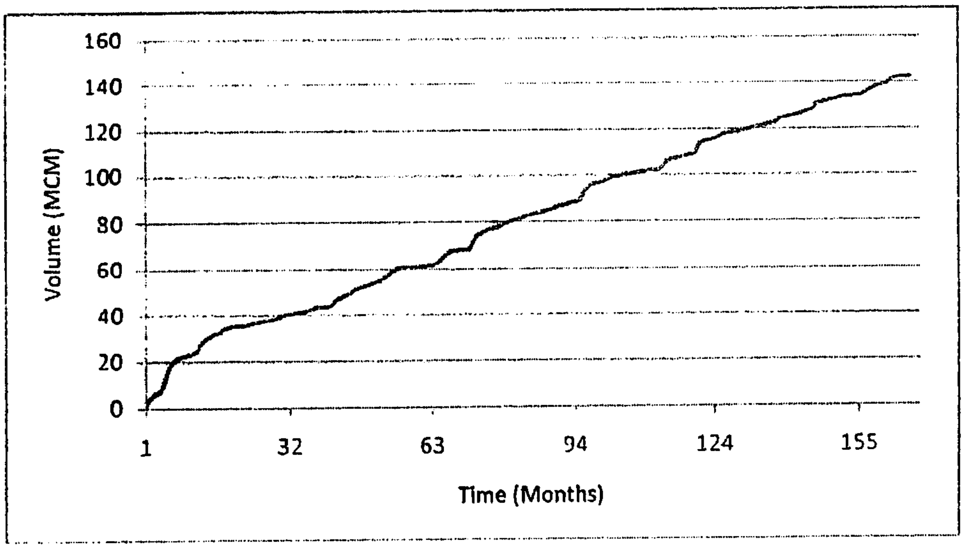


Table 6.3 Flow Avialability versus Time

	Discharge
%	m^3/s
100	0.01
90	2.38
80	3.4
70	4.22
60	5.41
50	6.44
40	7.99
30	9.91
20	13.74
10	22.45

To check the consistency of the data, a double mass curve was developed as presented in **Figure 6.10** below.

Figure 6.10: Double Mass Curve



6.5 ESTIMATION OF FLOODS

Estimation of floods is required to prevent damage to the components and structures of power station during operation. The maximum flood in a stream is usually assessed by analyzing the available peak flows in the catchment.

In August, 1997, an event of flood was observed with flow values of 74.93m^3/s at Haro River.

6.5.1 Estimation of Floods by Long Term Mean Specific Flood

Estimation of Floods for Haro River through frequency analysis of historic records of River is not accurate because the floods in smaller catchments usually show larger specific discharges as compared to the larger catchments. Therefore, empirical relationships, developed to calculate specific maximum discharge have been used for accurate estimation of floods for Haro River.

1) Design flood at the site of the intake.

As for design flood at the site of the intake, the long term mean specific flood of the catchment area was decided first, than the long term mean flood was calculated, and the flood based on the design flood criterion was calculated.

As for calculation formulas and methods, the empirical formulas and methods were provided and applied by analyzing the flood data measure by the hydrological observations stations in the Haro River catchment area at Jabri Bedar.

i) Long term mean specific flood

Empirical formula:

$\bar{M}max = 19.4 \times 10^{6} \times e^{-1.145} \times F^{-0.27}$ (l/s.km²)

where,

$\bar{M}max$: Long Term mean specific flood (l/s.km²)

e: Mean Elevation of catchment above sea level (m)= 1695 masl

F: Catchment Area (km²)= 393 km²

The result of the calculation is:

$\bar{M}max = 776.1$ (l/s/km²)

ii) Long term mean flood

$$\bar{Q}max = \bar{M}max * F/1000 \quad (m^3/s)$$

The result of the calculation is:

$\bar{Q}max = 305.01\ m^3/s$

The flood value of 100 years' period was obtained from the flood rate frequency curve (figure 4.2) and was calculated by the following formula.

$Qp=1\%=\bar{Q}max \times Kp \quad (m^3/s)$

Kp: flood rate in case of p = 1%

The design flood when Kp = 2.356 is:

Qp = 1% = 718.6 (m^3/s)

2) Design Flood at the site of Power House

The flood of 100 years period at the site of the tailrace has been taken as 858.07(m^3/s).

6.5.2 ESTIMATION OF FLOODS BY REGIONAL METHOD

A regional investigation method has been derived by German Agency for Technical Cooperation (GTZ) for estimation of floods in the Northern regions of Pakistan. Empirical relationships with morph metric parameters of the watershed have been established for determining the maximum floods. The morph metric parameters include catchment areas and mean elevation. To establish the empirical relationships, the maximum floods for various periods of return were estimated from the available series of maximum floods at the established gauging stations in the Northern areas.

The method for estimation of floods was developed as follows:

- Flood frequency analysis was performed for all available stations in the area.
- Specific Discharge of estimated 5, 10, 100, 1000 and 10000 years floods were calculated.
- Enveloping curves were drawn to each set of specific discharges (5.10.100, 1000 and 10000 years floods) and a mathematical function was fitted to the curve.
- Estimation of floods for Haro River at the proposed intake was undertaken.

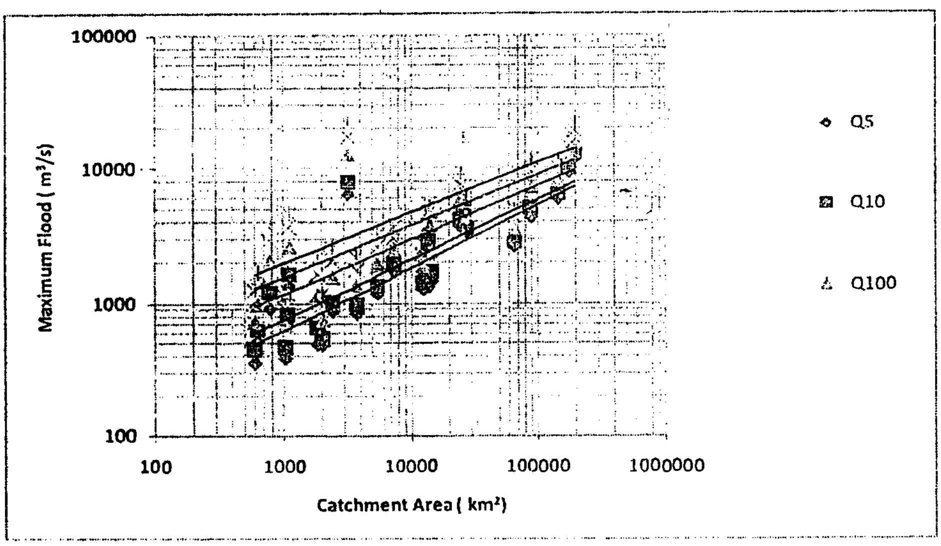
Stations for which flood frequency analysis were performed are given in Table 6.4 alongwith estimated 5,10,100,1000, 10000 years floods and the Specific Discharges have been plotted in Figure 6.4

Table 6.4 Estimated 5, 10, 100, 1000 & 10,000 years Floods (Gumbel)

River	Station	Period	Catchment Area (Km2)	Q_5	Q_{10}	Q_{100}	Q_{1000}	Q_{10000}
Shyok	Yugo	1978-83	65025	2622	2851	3570	4275	4979
Indus – I	Kachura	1973-83	146100	5869	6437	8215	9961	11704
Hunza	Danyore	1974-83	13925	2520	2817	3749	4663	5576
Gilgit-I	Gilgit	1980-85	12800	1354	1476	1857	2232	2606
Gilgit-II	Alam bridge	1973-83	27525	3305	3561	4360	5145	5929
Indus-II	Partab	1973-83	176775	9179	9942	12331	14677	17018
Astore	Doyian	1974-87	3750	839	967	1368	1762	2155
Gorband	Karora	1975-84	625	515	627	978	1322	1666
Indus-III	Besham	1973-83	196425	11990	12947	15942	18883	21819
Brandu	Daggar	1973-86	598	356	444	718	988	1257

Siran	Phulra	1973-83	1057	696	811	1170	1522	1873
Chitral	Chitral	1973-84	12425	1286	1430	1878	2319	2759
Swat-I	Kalam	1973-85	2024	481	547	754	957	1160
Swat-II	Chakdara	1973-85	5400	1171	1365	1973	2570	3166
Bara	Jhansi	1973-83	1846	490	651	1156	1652	2148
Kabul	Nowshera	1973-88	88540	4308	5003	7179	9316	11449
Haro	Khanpur	1973-83	777	918	1191	2044	2883	3719
Jhelum-I	Chinari	1970-90	13735	1330	1573	2332	3078	3823
Jhelum-II	Domel	1980-90	14490	1462	1691	2408	3111	3813
Neelum	Muzaffarabad	1963-90	7275	1737	1918	2486	3043	3600
Kunhar-I	Naran	1960-90	1036	386	457	680	899	1117
Kunhar-II	G. habibullah	1970-88	2382	873	1040	1562	2075	2587
Jhelum-III	Kohala	1965-90	24769	3651	4188	5869	7520	9168
Jhelum-IV	Azad pattan	1979-90	26289	3808	4296	5822	7320	
Kasni	Palote	1979-90	1111	1340	1653	2633	3595	4556
Punch	Kotli	1961-90	3177	6405	7920	12662	17319	21967

Fig 6.11 Max Flood Vs Catchment Area



The mathematical functions fitted to the enveloping curves are of the following form:

$Q_{max} = C \times A^{n}$

Where;

Q_{max} = Maximum instantaneous discharge for the return period in m^3/s

C, n = Coefficients

A = catchment Area in Km^2

The mathematical functions so fitted to the enveloping curves are as under:

$Q_5 = 11.97 \times A^{0.59}$

$Q_{10} = 15.60 \times A^{0.57}$

$Q_{100} = 40.45 \times A^{0.50}$

$Q_{1000} = 64.05 \times A^{0.47}$

$Q_{10000} = 84.85 \times A^{0.46}$

Where, Q is maximum instantaneous discharge for return periods of 5, 10, 100, 1000, 10000 years in m^3/s and A is catchment area in Km^2.

The coefficients of the equations presented above, are in good agreement with the values obtained by other authors in previous studies. **Creager** in his remarkable work on floods found with data available in 1926a value of 0.5 for the exponent "n" of equation. The values obtained for the same exponent through the regional analysis presented in this document are 0.59, 0.57, 0.50, 0.47 0.46 for 5, 10,100, 1000 and 10000 years floods equations respectively. . **Creager** further remarks that the value of exponent" in these equations range between 0.3 and 0.8.

The values of coefficients of above equations are also comparable with coefficients of formulas obtained in EUROPE. The **Illwerke** formula assigns a value of 0.83 to the exponent "N" and a value of 5.5 to the coefficient "C" for estimates of 100 years floods. The value of "n" in the **Illwerke** formula is larger than the value presented in the corresponding formula, while the value of "C" is smaller in the same formula. However, estimated floods from both equations are comparable for catchments with areas upto 700 km^2.

The **Hofbauer formula** developed in Europe is remarkably similar to the 100 years floods obtained in this study report. The values of the coefficients "n" and "C" given by **Hofbauer** are 0.5 and o.42 respectively. . The exponent "n" being the same as presented in equation for 100 years floods and the value of "C" is very close to the value given in the same equation. Similar relationships have been used in Pakistan in the past to estimate floods. Direct estimation of floods from the records by statistical method has been considered to be inadequate because the records may not include floods caused by extremely severe Monsoon events that could penetrate the upper valleys including Swat valley. These extreme events have been considered in this study report by including stations in areas where maximum floods are produced by Monsoon rains. Stations in areas moderately affected by the Monsoon are Swat River at Chakdara, Gorband River at Karora, Siran River at Phulra, Brandu River at Daggar and Bara River at Jhansi Post.

Floods affected by extreme Monsoon rains cannot be calculated with the equations developed above. Stations on rivers recording such floods are Punch River at Kotli, Kansi River at Palote in the Jhelum catchment and Haro River at Khanpur in the Indus catchment. The estimated 5, 10, 100,, 1000, and 10000 floods estimated for those stations fall above the enveloping curves . Consequently floods caused by extreme Monsoon rains are higher than the values estimated with these equations.

The watershed of Haro River is affected by Monsoon rains. The results obtained for Haro River obtained with the help of developed equations are towards higher side. However, the regional method of flood estimation is equally applicable to floods originated by rains and snowmelt. This method may, therefore, be used for the estimation of floods as a comparison with flood frequency analysis. The estimated 5, 10, 100, 1000 and 10000 years floods of Haro River at proposed weir site are given in Table 6.5.

Table 6.5 Estimation of Floods by regional Method for Haro River

Return Period (years)	Volume of Floods (m^3/s)
5	406.24
10	469.82
100	801.89
1000	1061.41
10000	1324.56

6.7 CONCLUSION

The peak flood discharge of 801.89m^3/s with a return period of 100 years may be adopted at the proposed intake site.

7 HYDRAULIC DESIGN

7.1 Project Design Parameters

Design parameters selected after detailed site investigations are as under:

Installed Capacity	3.6 MW
Normal water level at intake	809.30 m
Normal water level of fore bay	800.15 m
Length of Channel	6455 m
Diameter of penstock	1.75 m
Design Flood level at Tailrace	755.0 m

7.2 Determination of Effective Head

In order to determine the effective head for the powerhouse, following formula has been employed:

$Hs = Z_f(Z_{la}+Ah_m)$ Where as:

Hs	=	Stands for Static Head
Zf	=	Water level of Fore bay
Z_{ta}	=	Water level at tailrace
Ah_m	=	Turbine Axis height above flood level
Hs	=	800.15-(752.84-3.38) = 50.69 m

The effective head is obtained by subtracting the head losses.

$H_e = H_s - H_l$

Where:

H_e	=	Effective Head
H_s	=	Static Head
H_l	=	Loss of head in Penstock

The loss of head in the penstock varies with the available discharge. However, the maximum loss of head is determined by the expression.

Effective head is thus worked out to be: 50.69– 6.58 = 44.11

The design discharge for a run - off river scheme is governed by the following expression.

QD = Installed Capacity / (9.81 x H_e x E_{tu} x E_g)

Where

H_e = Effective Head

E tu = Efficiency of the turbine

Eg = Efficiency of the generator

Inserting the values of effective head and turbine / generator efficiencies in the expression, the design discharge is worked out to be:

Q_D = 3622/ (9.81x44.11x0.88x0.96) = 9.9 m^3/s

The minimum discharge reported at Q_{95} in the flow duration curve is 1.84 m^3 / s.

8 POWER POTENTIAL AND OPERATION

This section presents the methodology and results of the energy production simulations for the Project.

8.1 General description

Energy production simulations were conducted based on the historical flow conditions (inflows) of Haro River for the period 1997-2010 and the physical parameters of the project to estimate annual average energy production that would be expected from the completed project.

8.2 Methodology

The project has no appreciable upstream storage reservoir capacity and is operated as a run-of-river scheme.

The main constraints and assumptions included in the model are:

- The upstream water level is assumed to be equal to rated water level 809.30 m, at all times.
- A maximum capacity of $9.91m^3/s$ is used for four turbines (four units at $2.477m^3/s$ each), for the estimated rated head and being operated to provide maximum energy production at all times. When the inflow is greater than the sum of the maximum capacity of the turbines and the ecological flow, the remainder is evacuated through weir with the help of overflow spillway. For adequate operation of the turbine units, the minimum allowable flow for each is set equal to 40% of their respective design flow, i.e. $0.99m^3/s$.
- The head losses (frictional and singular) along the entire conveyance system are included in the energy simulations;
- Estimated efficiencies of the Turbine (88.0%), Generator (96%) Powerhouse service requirements are assumed to represent 1% of the electrical generation and a 2% loss for stoppage time is included.
- In our case for this Project. flows of $9.91m^3/sec$ have been selected for estimation of economic energy and power production which are available for 30% of time.

8.3 Valuation of Head Losses

Head losses are evaluated using up-to-date plans of the project for a Power Channel 4 m x 1.45 m and a penstock diameter of 1.75 m. The evaluation included all frictional and singular losses from the intake entrance (including the trash rack) to the tailrace outlet. A Manning's n value equal to 0.013 is used for all concrete sections of power channel, while a Manning's n value equal to 0.011 is used for steel lined sections. With this information, global head loss coefficients (K values) which are related to the velocity head are estimated.

The head losses estimated for a discharge of 9.91m^3/s are as given below summing upto a total head loss of 6.58 m.

Head Losses In Penstock

Q	9.91	m^3/s
n	0.011	
d	1.75	m
Total head loss will constitute of following losses		
i) Friction loss in pipe for velocity	4.5	m/sec
Using Formula V=1/n R^2/3 S^1/2		
S	0.0074	
Length of penstock	175	m
Loss of head	1.30	m
ii) Loss through trashrack		
iii) Entry loss at Bell-mouth for each these the loss may be taken as 0.1 times the velocity head.		
D	3	m
A	0.60	m^2
Velocity at entry to bell mouth	16.52	m/sec
Loss due to (ii) & (iii)	2.781	m
iv) Losses in bends		
There would be about 5 bends in horizontal plane or vertical plane.The deflection angles will be moderate & R/D ratio of about 5. We can therefore assume loss in each moderate bend with "K" VALUE AT 0.25.		
No of bends	4	
K	0.25	
Losses in bends	0.26	m
Loss in 24 moderate bends	1.03	m
Two sharp bends will have a K value of	0.6	
No of sharp bends	1	
Loss	0.62	m
Loss through sharp bends	0.62	m
Total loss in bends	1.65	m
v) Loss in trashrack may be taken	0.1	m
vi) Total losses in valves and fittings may be taken	0.75	m
Total losses	6.58	**m**

8.4 Turbine operation

As previously stated, the computational model is setup in order to compute the maximum energy production at all times with the given turbine configuration.

8.5 Power and energy production estimates

The estimated average annual energy production is calculated as being as 18.129 GWh, which gives a Plant Factor of 58.73 %.

Because of its simplicity in applications for run of river / nullah projects, flow duration curve method of estimating power and energy has been used for evaluating the generation and energy of Jabri Bedar Hydropower Project,

The flow duration curve constructed/developed for the years, 1997-2010, based on Haro River flows, the flow duration curve reveals that the discharge from the Haro River varies from 22.45m^3/sec. to 0.01m^3/sec from 10% to 100% of time exceedence respectively. Usually, projects having discharge available for 50% of lime exceedence are evaluated as viable schemes provided the economic analysis which the other project parameters, also favourably recommended the selected plant capacity. In our case for this Project, flows of 9.91m^3/sec have been selected for estimation of economic energy and power production which are available for 30% of time.

Table 8.1 Flow Availability versus Time

Time	Discharge
%	m^3/s
100	0.01
90	2.38
80	3.4
70	4.22
60	5.41
50	6.44
40	7.99
30	9.91
20	13.74
10	22.45

Assuming the considerable head loss for this range of power plant, a net head of 44.11 m has been worked out from site topography data. Therefore, the installed capacity will be as under:

P (kW) = 9.81 x Q x H x ηt x ηg

Where,

P = Power output in kW

Q = Design discharge in m^3/sec.

= Q_{30} = 9.91 m^3/sec

Net Discharge

Q = 9.91 m^3/sec

H = Design net head = 44.11 m

ηt = efficiency of turbine = 88%

ηg = efficiency of generator = 96%

P(kW) = 9.81 x 9.91x 44.11 x O.88 x O.96

3622 KW = 3.62 MW

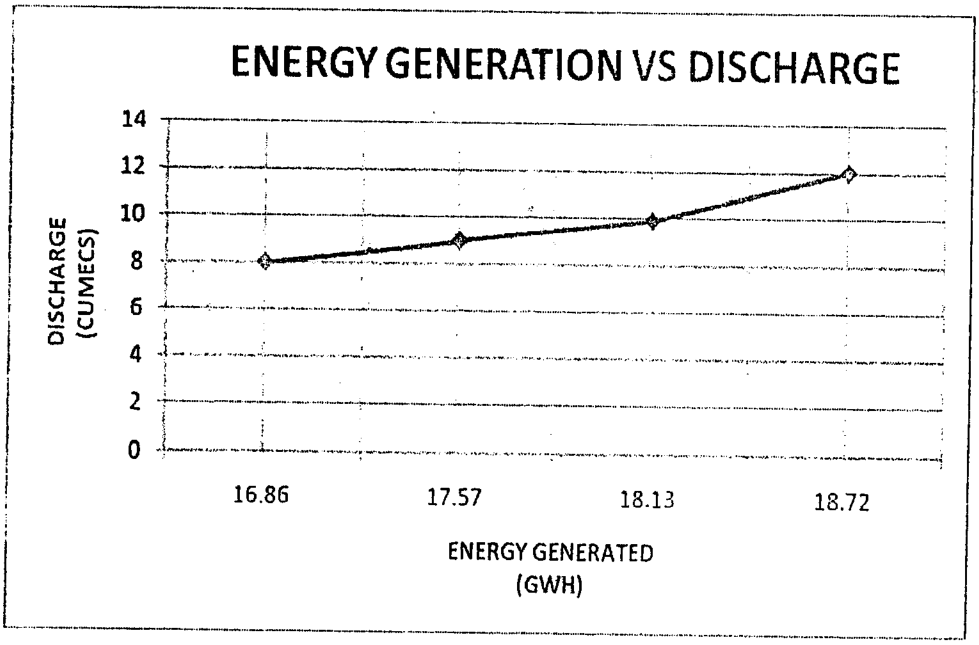
i.e. Four turbines of 0.9 MW each

The table given below shows the energy generation, plant factor and installed capacity for different flow.

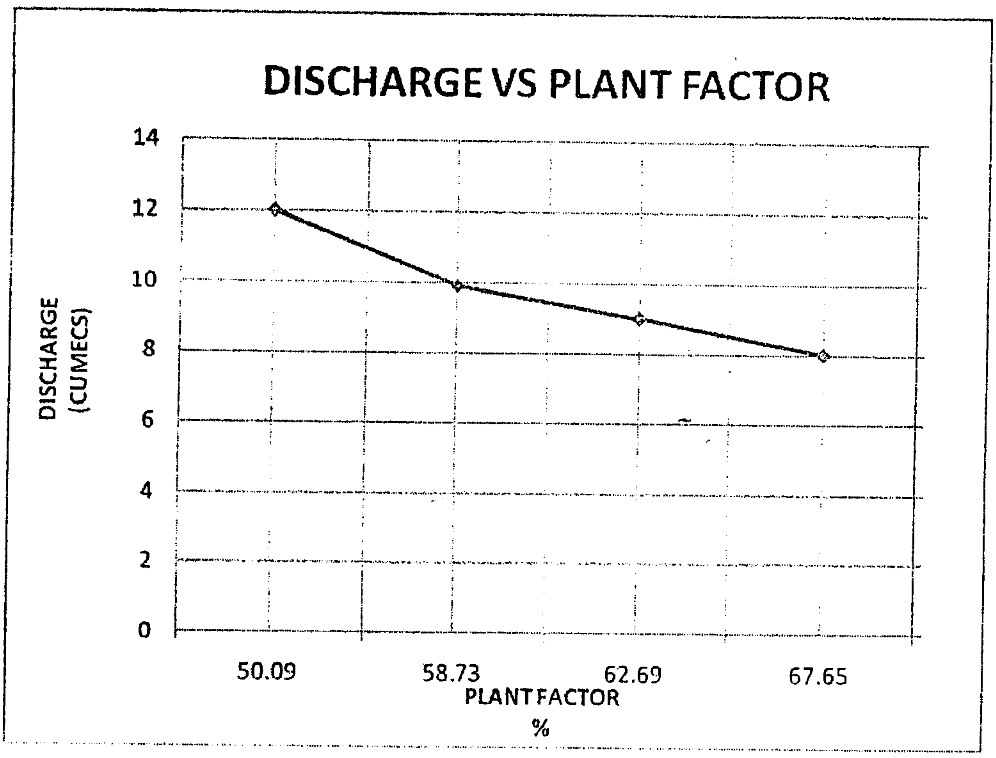
Table 8.2 Discharge versus Energy generation

Rated Discharge (Cumec)	Energy Generated	Plant Factor	Installed Capacity
	E (GWH)	%	MW
8	16.86	67.65	2.92
9	17.57	62.69	3.29
9.91	18.13	58.73	3.62
12	18.72	50.09	4.39

Graph 8.1 Discharge versus Energy Generation



Graph 8.1 Discharge versus Plant Factor



JABRI BEDAR HYDROPOWER PROJECT
POWER AND ENERGY ESTIMATION
4 UNITS - 9.91 CUMECS

Rated Discharge = 9.91 m^3/s
Rated Discharge/unit = 2.48 m^3/s
Environmental Flows = 0.6 m^3/s

MONTH	Head (m)		Power			ENERGY GENERATED												Energy Generated Yearly
	Gross	Net	Total Installed	Units Installed	Unit Capacity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	E (GWH)
1997	58.75	44.1	3.6	4	0.9	0.77	0.00	0.96	2.87	2.96	2.47	2.96	2.96	2.87	2.96	2.18	1.04	25.01
1998	58.75	44.1	3.6	4	0.9	0.95	2.68	2.96	2.87	2.96	1.44	2.96	2.96	1.80	0.96	0.00	0.00	22.53
1999	58.75	44.1	3.6	4	0.9	0.67	0.80	2.53	1.31	0.60	0.00	0.94	2.96	2.04	1.13	1.05	0.82	14.87
2000	58.75	44.1	3.6	4	0.9	0.00	2.07	2.11	1.10	0.71	0.00	2.01	2.96	2.87	2.96	2.87	2.96	22.63
2001	58.75	44.1	3.6	4	0.9	2.96	1.65	1.54	2.08	1.09	2.87	2.96	2.96	2.87	1.06	0.00	0.00	22.44
2002	58.75	44.1	3.6	4	0.9	0.00	0.00	0.58	0.00	0.00	2.87	2.96	2.96	2.87	1.26	0.00	0.00	13.81
2003	58.75	44.1	3.6	4	0.9	0.00	2.68	2.96	2.87	1.71	1.20	2.00	2.96	2.87	2.09	1.09	1.79	24.23
2004	58.75	44.1	3.6	4	0.9	1.93	2.02	1.12	1.14	2.06	1.00	1.03	2.96	1.27	1.58	1.05	1.61	18.78
2005	58.75	44.1	3.6	4	0.9	2.41	2.68	2.96	2.87	1.36	0.69	2.96	2.83	0.84	1.32	0.81	0.56	22.12
2006	58.75	44.1	3.6	4	0.9	0.92	0.69	0.75	0.62	0.00	0.00	2.96	2.96	2.10	0.87	0.60	2.15	14.62
2007	58.75	44.1	3.6	4	0.9	1.48	1.51	2.96	2.87	2.02	0.84	2.96	2.42	1.62	1.30	0.59	0.81	21.50
2008	58.75	44.1	3.6	4	0.9	1.55	1.54	1.40	1.36	1.09	1.54	2.28	2.96	1.74	1.50	0.88	1.36	19.22
2009	58.75	44.1	3.6	4	0.9	1.71	2.26	2.59	2.96	2.37	1.15	1.32	1.70	1.33	0.94	0.62	0.00	18.95
2010	58.75	44.1	3.6	4	0.9	0.00	1.24	1.60	0.57	0.00	0.00	2.96	2.96	2.87	1.57	0.79	0.84	15.41
Min	58.75	44.1	3.6	4.00	0.91	0.00	0.69	0.75	0.57	0.00	0.00	1.32	1.70	0.84	0.87	0.59	0.00	14.620
Average	58.75	44.1	3.6	4.00	0.91	2.41	2.68	2.96	2.96	2.37	1.54	2.96	2.96	2.87	1.57	0.88	2.15	22.119
Max	58.75	44.1	3.6	4.00	0.91	1.35	1.65	2.04	1.88	1.14	0.72	2.68	2.61	1.75	1.28	0.71	0.96	18.639

Plant Factor 59.73
Outages 10 days annually
Net Generation [illegible]

9 ALTERNATES AND SELECTED PROJECT LAYOUT

9.1 General

The purpose of having layout alternatives in the early stage of project feasibility studies is to demonstrate that all factors influencing project cost and benefits have been thoroughly executed leading logically to the adoption of an optimum development

9.2 Design issues

The main factors affecting project cost and technical feasibility in the comparison of alternatives and the eventual choice of recommended project are summarized as follows:

- Definition of the concession limits.
- Choice of left versus right bank development scheme.
- Determination of a project design head and flow.
- Reservoir sediment management, method of handling sediment, desander capacity.
- Choice of powerhouse site and surface.
- Power tunnel alignment and length, tunnel size, construction access and muck disposal schemes.
- Choice of seismic coefficients.
- Site conditions, geology, construction infrastructure requirements.
- Environmental and resettlement requirements.

9.3 Concession Limits

The concession of the project starts just downstream of Jabri Bridge and covers a stretch of about 8 to 10 kilometres.

9.4 Left versus Right Bank Development

Comparison of left and right bank for the general arrangement of project component was done considering topography, geology and environmental aspect along with financial implication.

The right bank of the river has not been selected because of the following reasons:

- Longer length of power channel is required and more cross drainage structures are required.
- More resettlement issues.

- The above two increase the cost for right bank alternative also implementation of the same will be difficult.

9.5 Project Design Head and Flow

The gross head for the project will be 60 m while the design flow selected for the project was 9.91 m^3/s, a flow volume which was determined to be available approximately 30 % of the time.

For the present report, a maximum reservoir level, including backwater effects has been assumed at elevation 815 m.a.s.l., and with a tail water elevation of 755 m.a.s.l., the gross development head available is thus 60 m.After comparison of energy generation potential and construction costs for a range of plant capacities, the design flow has been fixed as 9.91 m^3/s.

9.6 Powerhouse Location and Type

The selection exercise was concentrated in the area of Jabri Bedar Project, which offers the greatest head for the concession. Thereafter, the location of powerhouse sites was mainly based on available head, topography, favourable geology, access and impact of powerhouse construction on existing Sari Baang village structures and activities. Security issues in terms of protection against landslides and powerhouse flooding were also taken into account.

9.6.1 Alternatives

In order to present a comprehensive comparison of cost and technical factors influencing feasibility, Designmen have considered and compared different intake and Power house alternatives.

9.6.2 Power Channel Alignment and Layout Considerations

While comparing weir/ powerhouse alternatives it is necessary to take into account the varying lengths of headrace channel and construction access and cross drainage structures. Therefore, an open channel along left bank has been proposed considering the above mentioned constraints. Rectangular headrace channel takes off immediately after the outlet gate of the sediment trap along the left bank of the River except for a stretch of about 600 m where RCC cover has been considered in the design to take care of social issues of local population.

9.6.3 Seismicity

The Project area lies in the Hazara Thrust fault System. The Margala hill ranges are traversed by a system of nearly parallel northeast/southwest trending faults. These faults join the

Himalayan thrust along a syntexial bend towards northeast and Kirthar, Suleiman fault zone, towards southwest. Preliminary designs prepared for the comparison of alternative diversion sites and structures have used a seismic acceleration coefficient of 0.25 g.

9.6.4 Site Conditions

This heading covers issues associated with site geological conditions and construction infrastructure requirements (Owner and contractor colonies, shops and storage facilities, worker camps, construction access roads and disposal areas for excavation spoil from weir foundations and underground works). It also includes requirements for temporary and new roads required for project alternatives.

For purposes of this report the following assumptions have been made regarding the location of owner and contractor colonies, labour camps, shops and storage areas and disposal areas for excavation spoil.

The access to the weir site during construction is quite easy as only an existing track branching from Jabri-Kohala Road just before Jabri Bridge has to be improved for transporting construction material and equipment to the site. Access to the Power Channel route is through Jabri-Nala Road and then through a four kilometre long jeepable tracks leading upto Village Pina. The route of Power Channel from Village Pina onwards does not pass near any existing road or track therefore a project road alongside the Power Channel has to be constructed through a length of about two and a half kilometres which will also provide access to Forebay and powerhouse sites for construction activities.

9.6.5 Environment & Resettlement

Environmental and resettlement scoping surveys and studies for the powerhouse and the intake alternatives have been concluded and .apparently there are no major resettlement issues at intake (head works) however there will be limited resettlement and compensation required along power channel and power house area.

10 TRANSMISSION INTERCONNECTION

10.1 Introduction

Hydro electric generating plants are generally located away from load centers. Accordingly power generation voltage is stepped up to a suitable high voltage in step up substation at generating end and transmission lines laid for interconnection with the grid at a suitable point. The basic purpose of transmission interconnection study is to provide a safe and reliable interconnection facility for any new power plant that is being connected to the existing system. The incoming power plant should be connected to a system in a manner that it not only provides reliability but also it provides maximum security to the existing system because Pakistan National grid system integrate southern part and northern part of the country through a reliable transmission network therefore any mishap or fault occurred at any line or power plant can be travel fast to other segment of transmission lines or power plant thus causing detrimental affect to other areas. These mishaps or fault can lead to a cascading affect thereby plunging the entire country in to darkness. However this need to be done with due regard to its economics.

In case other power plants are planned in the near vicinity and in near feature, then a regional planning for transmission network has to be carried out so that all the incoming power plants are accommodated in the system. In order to understand the regional scenario it is important that at the out set existing system is discussed followed by all other power plants expected to come on line in near future and vicinity and various technically and financially viable options. Finally an appropriate recommendation will be made.

10.2 Existing Network of the Proposed Area

The proposed power plant is located at the village Peena on the tributary of Haro river in the Hazra Division of Khyber Pakhtunkhwa. The surrounding area of the proposed power plant is under the administrative jurisdiction of Peshawar Electricity Supply Company (PESCO).

Present power requirement of the proposed project area is fulfilled by PESCO through 132 kV Haripur grid station located at about 40 km from the proposed site. This grid station is connected with National Grid system through 132 kV transmission lines at 220/132 kV grid station Burhan directly through 132kV dual transmission lines. Mostly the conductors used in these transmission lines are Lynix which have maximum current carrying capacity of about 550 Ampere. An existing and proposed power transmission network diagram of area under jurisdiction of PESCO presented as **Figure 10-1.**

The 132kV Haripur grid station is equipped with two 132/11 kV power transformers having capacity of 20/26 MVA. A total of fourteen circuits (feeders) of 11 kV are going out to feed various localities/ villages in the area. One of the feeder i.e Baldher feeder is passing close to the proposed power plant site. This feeder is very long and using "Dog" conductor. Discussion with the grid staff revealed that the radial length of the feeder is approximately about 100 km excluding its branches, having about heavy technical losses. The existing power transformers at the grid station are not sufficient to cater the load of the area throughout the day; therefore they have to resort with load shedding. A single line diagram of 132 kV grid station Haripur is presented at **Figure 10-2.**

The Power requirement of Haripur city is partially fulfilled by 66 kV grid station Haripur, which is very old and situated in the city area. The 66 kV Haripur, 66 kV Havaillian and 66 kV Abbottabad grid stations all are connected with the bus bar of 132/66 kV Wah grid station through 66 kV circuit. The transmission network and the transformation capabilities of 132/66 kV systems are shown in the **Figure 10-3.**

Information gathered by the Consultant (during the visit of the site of the proposed power house) from 132kV Haripur grid station, the sub division office of Lora Chock as well as from the general public of surrounding area at Jabri are summarized in the **Table 10.1** given below:

Table 10-1: Information provided by Sub Division Lora Chowk

Peshawar Electric Supply Corporation	
Division	**City Division Abbottabad**
Sub Division	**Lora Chowk**
Consumers on 11 kV Baldher feeder	**9000**

Consumers on 11 kV Industrial feeder	**8400**
Total Industrial Consumers,	**60**
Total Commercial Consumers	**540**
Total Residential Consumers	**17200**
All above figures are approximated	

	Transmission	
Feeders under PESCO	Name of 11kV Feeder originating from Haripur Grid Station	Maximum Load during Summer 2011 in "Amps"
Feeders connected with 132/11 kV 20/26 MVA Power Transformer, T-1	Khanpur	200
	Town-I	410
	Baldher	190
	T&T	100
	Sarai Nimat Khan	360
	Kalabat	380
	Chamba project	15
Feeders connected with 132/33/11kV 15/5/10 MVA Power Transformer, T-2	Hazara Phosphate	60
	Panian	320
	Swabi Mera	280
	Town-II	300
	Kot Najeebullah	260
	PIDC	5
	Zeb Pharmacutical	15

During visit of 132kV Haripur grid, it was noted that two feeders out of fourteen feeders are emanating from the grid station having substantial technical losses and both transformers of 20/26 MVA are heavily overloaded, therefore intensive load shedding carried out throughout the day However bifurcation of the feeder is being planned. . In addition 66kV Havaillian grid station is also planned for upgrade and connected with 132 kV transmission systems in near future. Thereafter 11kV Baldher feeder will be connected with the 132 kV Havailian grid station.

In 132 kV Haripur grid yard, ample space is available to accommodate additional 132kV circuit and 132/11 kV power transformer. However no space is available in the 11kV switch room.

10.3 TRANSMISSION INTERCONNECTION

Hydroelectric generating plants are generally located away from load centers. Accordingly power generated is stepped up to a suitable high voltage in step up sub-station at generating end and transmission lines laid for interconnection with the grid at a suitable point. In order to provide a reliable interconnection to the proposed power plant with the national grid system a team of experts visited the area to study various options of the transmission interconnection arrangement with the following consideration:

i) Safety and reliability

ii) Simplicity of operation

iii) Good technical performance

iv) Readily maintainable (e.g., critical components can be removed from service without shutting down the balance of plant).

v) Flexibility to deal with contingencies.

vi) Ability to accommodate system changes

Keeping in view of the existing network and after studying the capacity and location of proposed power project site and to provide flexible transmission interconnection, the team of experts studied various possible interconnection arrangements / options to connect the power plant with the bus bar of 132kV Haripur grid station. The arrangement should be fit in the planning criteria used to design the connected transmission system.

10.4 Possible options

Following possible options have been looked in to:

- **Option -I**

  In this option, the proposed power house Jabri Bedar will be directly connected with 132 kV Haripur grid station through 132 kV independent circuit emerging from Jabri Bedar hydropower project, as shown in the **Figure 10-4 & 10-5.**

- **Option – II**

In this option, the proposed powerhouse will be directly connected with 66 kV Havailian grid station through 66 kV inter link emerging from Jabri Bedar hydro power project, as shown in the **Figure 10-6 & 10-7.**

- **Option - III**

In this arrangement two 11 kV transmission links (feeders) will be directly connected with the 66 kV Havailian grid Bus Bar. These feeders would follow independent path, stringing over separate pole/structure, as shown in **Figure** 10-8 & 10-9.

10.5 Analysis of Arrangements

The above options are analyzed in the subsequent paragraphs.

- **Option I**

In this option the losses of the system will be reduced although the cost of construction of transmission system will be more as compared to other options. In addition the security of the system will not be improved because the tripping of 132 kV Jabri Bedar Haripur circuit will isolate the proposed power project from the national grid system. However the technical losses of the system will be less as compared to other options. This option has advantage that other power plants being developed in the surrounding could be connected to this circuit to connect with national grid system.

- **Option II**

The distance from the proposed power project to 66 kV Havailian grid station is about 8 km less as compared to its distance from 132 kV Haripur grid station. Although the merits in option-I are same as in option-II but the cost and length of transmission circuit will be less as compared with option-I.

- **Option III**

This option is economical as compared to other options. It will improve both reliability and security of the system, although the technical losses will be increased which could be compensated by using capacitors at both ends of the circuit. In this option, the feeders are connected with 66 kV Havalian grid station the length of which is less, but if the feeders is connected with 11 kV bus bar at 66 kV Haripur grid station the length of the feeders will be increased.

10.6 Investment required in each option

The project is to be implemented by private sector investment therefore investment becomes as important as other factor.

Under the private power policy as in vogue presently, requires that sponsor will sell power to the utility at grid/sub-station bus of plant and all power evacuation is the responsibility of power buying utility. However it also provides that the investor/ sponsor could also be asked to build power evacuation line but it will be operated by concerned DISCO and investment will be a pass through item in the tariff. Alternatively the evacuation arrangement will also be operated by the power plant investor. Cost of development of power evacuation arrangement along with its operation and maintenance cost will be a pass through item in tariff. In addition the power purchasing utility may also not agree with such cost as the investor will also claim adequate return on his investment thereby increasing the tariff that could not be acceptable.

Total investment[1] required for development of power evacuation facility has been worked out for each option and is provided in **Table 10.2**

Table 10.2: Estimated Cost of Power Evacuation Facility

Options	Description	Length (Km)/ Capacity(MVA)	Cost per Km Approx Rs. in Million	Total cost Approx Rs. in Million
I	132 kV transmission Line	36	9.120	328.320
	Grid Equipments, Transformers, C.T, P.T, etc	11/132 kV 3*2 MVA		100.000
	Grid Equipments, Step-Up Transformers, C.T, P.T ,etc	3.3/11 kV 4*1.0 MVA		50.000
			Total	478.32
II	66 kV transmission Line	28	6.84	191.520
	Grid Equipments, Transformers, C.T, P.T, etc	11/66 kV 3*20 MVA		85.000
	Grid Equipments, Step-Up Transformers, C.T, P.T ,etc	3.3/11 kV 4*1.0 MVA		50.000
			Total	326.52

[1] The estimated cost is based on the cost provided by WAPDA in their PC-1 for various similar projects in 2005-2006 and escalated appropriately. Therefore it is only indicative cost to provide some idea for comparison will need to be updated based on the actual EPC cost. Cost of 11kV line is however is based on 2010 price as implemented by MEPCO, IESCO.

10.9 INTERCONNECTION STUDIES

Before connecting a new generating facility to the existing system, normally following studies are conducted:

- Load flow studies
- Stability and
- Short circuit studies

Primary purpose of such studies is to look in to the fact that incoming generating facility is not having a negative impact on the existing transmission lines and transformation system.

If it decided to connect the proposed power plant at 11 kV therefore the proposed interconnection not being connected to any existing transmission lines as such there is no possibility of overloading the existing line.

In view of the above the Consultant is of the opinion that a load flow studies is needed for the project on the basis of above said arrangements.

As for as stability and short circuit studies are concerned, it needs to be conducted before the power plant is connected with the grid. However for conducting stability studies characteristics of the machines to be installed will be required, which will only be available when EPC contract is finalized.

The stability study of such a small power plant is also essentially needed for the project as this will provide reliability in operation of the power plant.

10.10 Recommendation

Considering reliability and security of power dispersal, the consultant recommends Option - III.

Since the project is at EPC stage therefore load flow study will need to be conducted along with system stability short circuit study as soon as possible but before starting construction of the project.

Figure 10-1: PESCO System

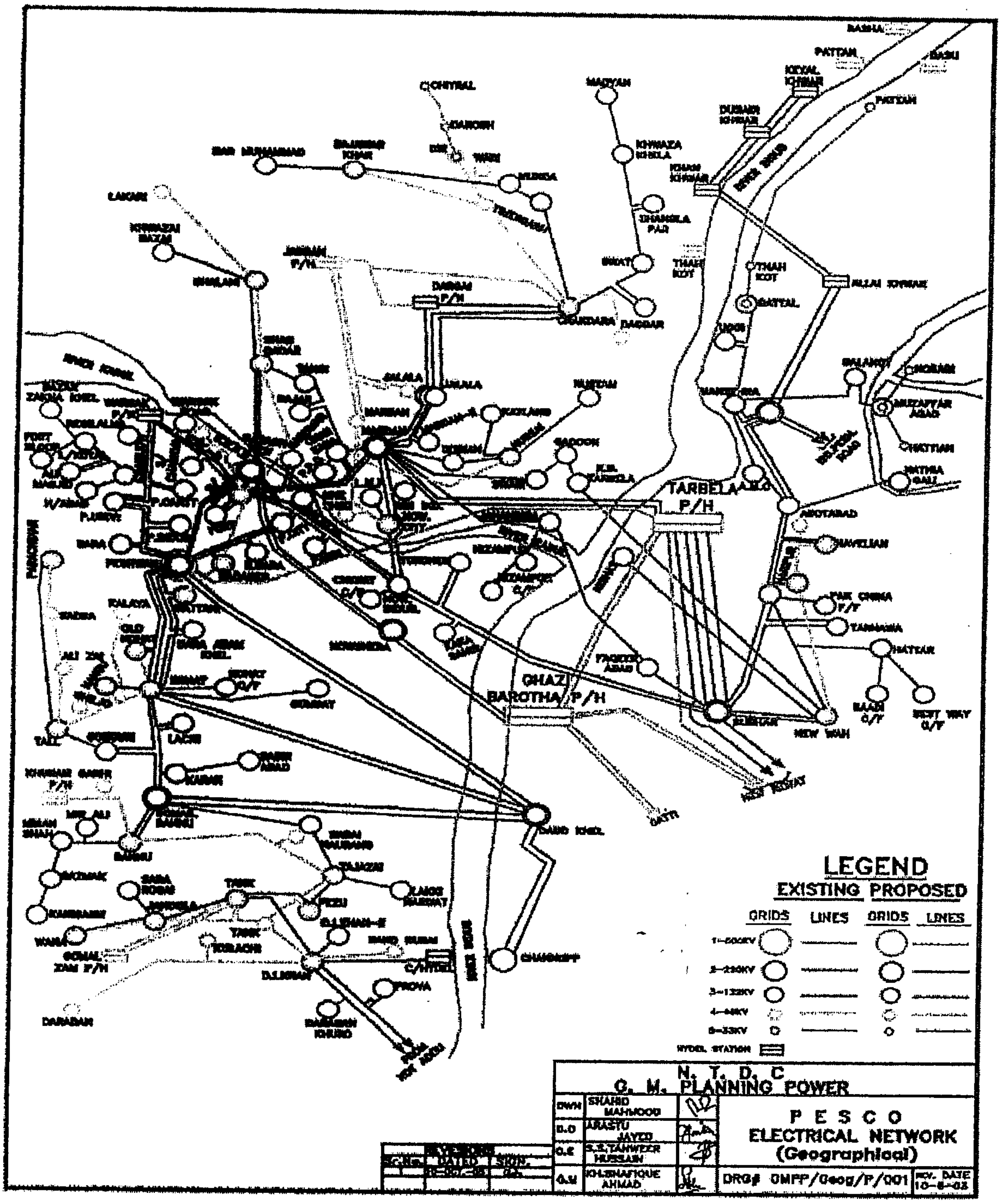


Figure 10.2: Single line diagram of Haripur Grid Station

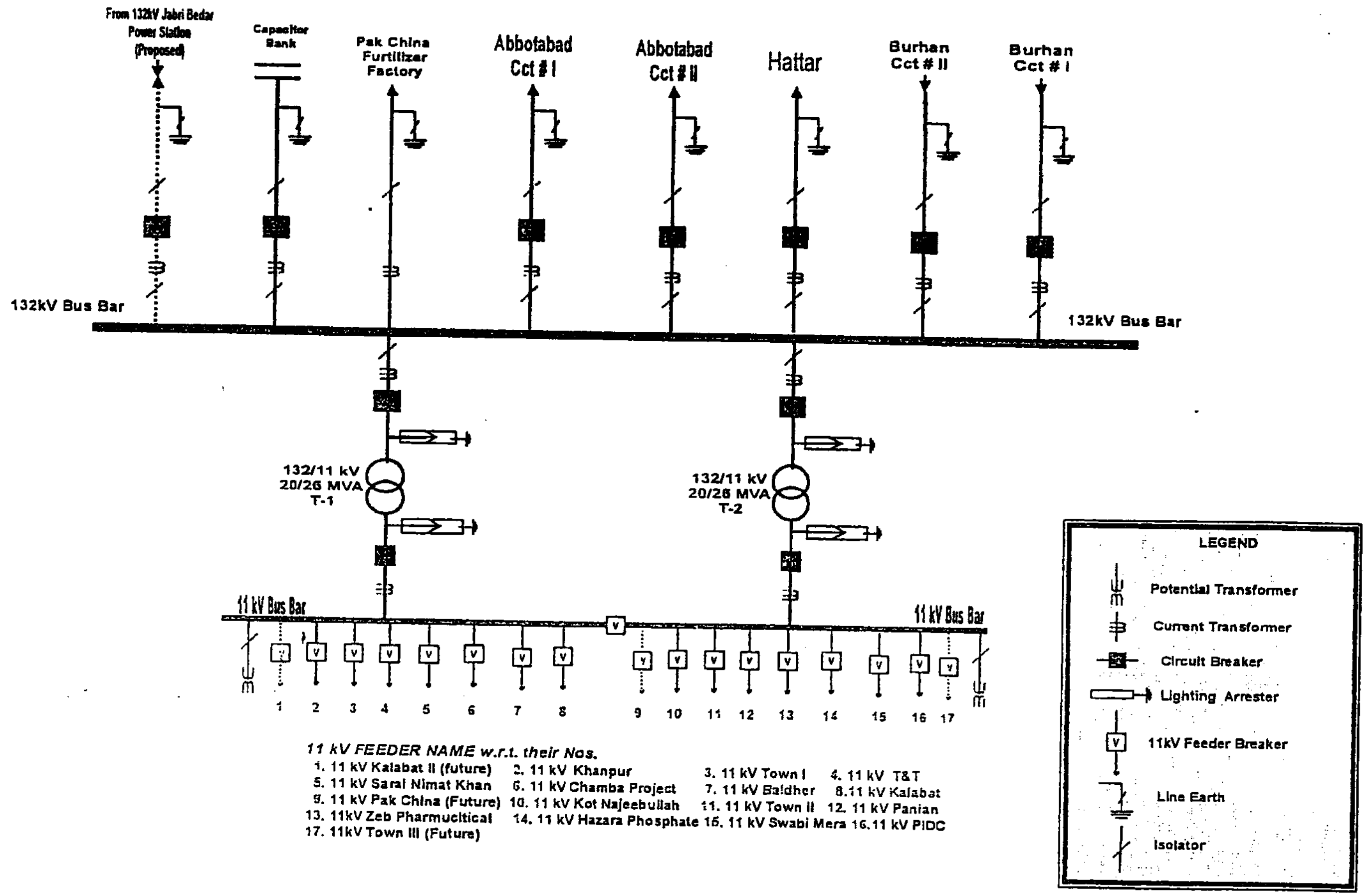


Figure 10.3: Single line diagram of existing 132/66 kV Network

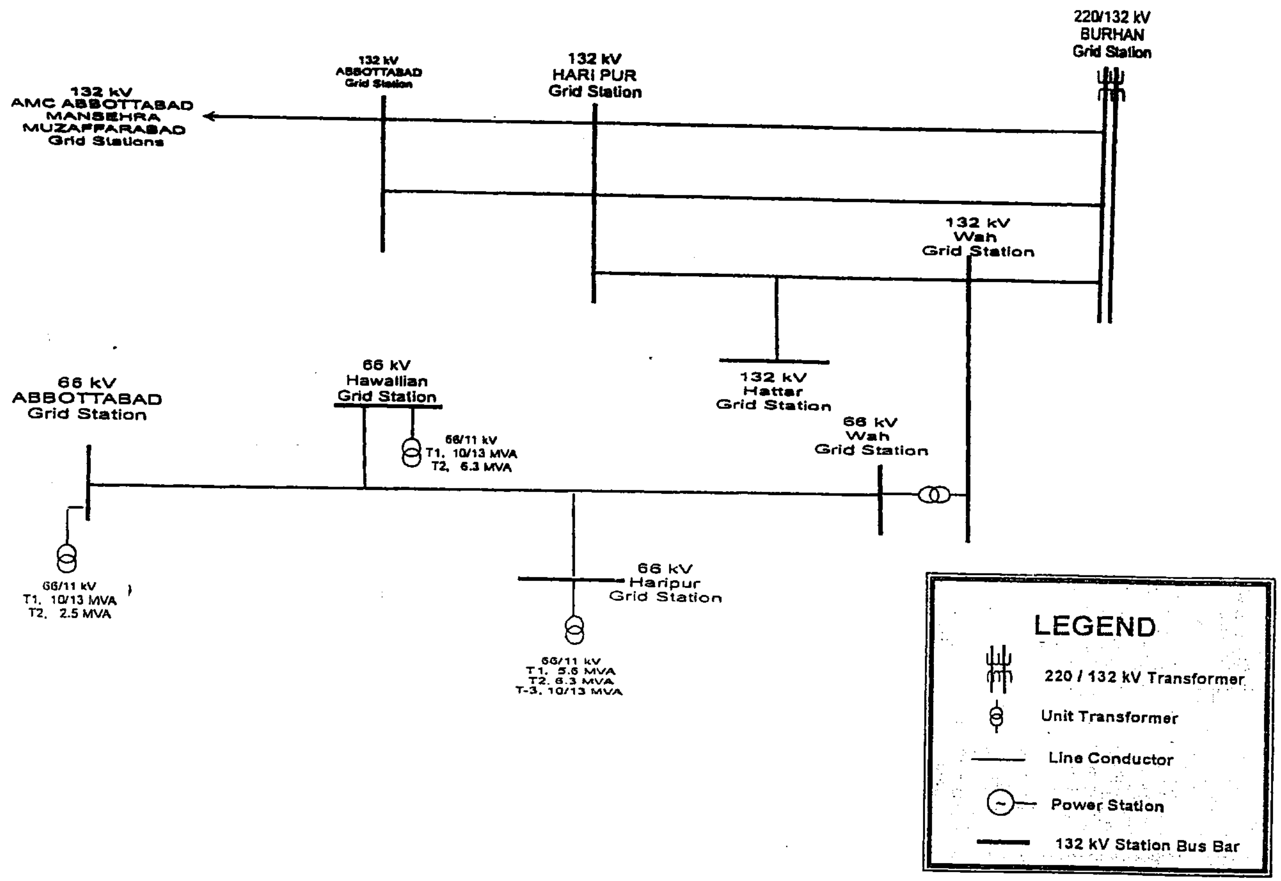


Figure 10.4: Single line diagram of Proposed 132/66 kV Network for Option - I

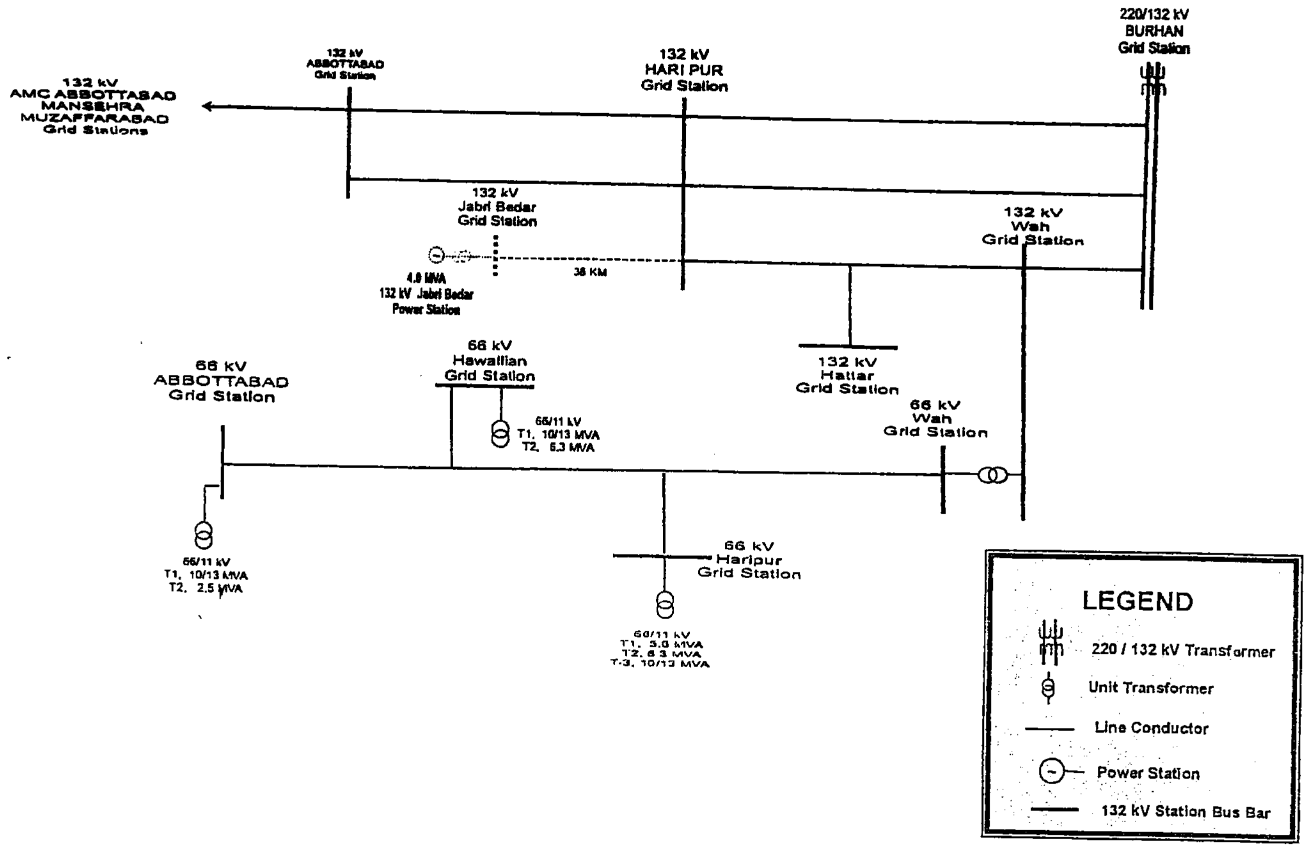


Figure 10-5: Single line diagram of Proposed Power Plant Jabri Bedar, for Option - I

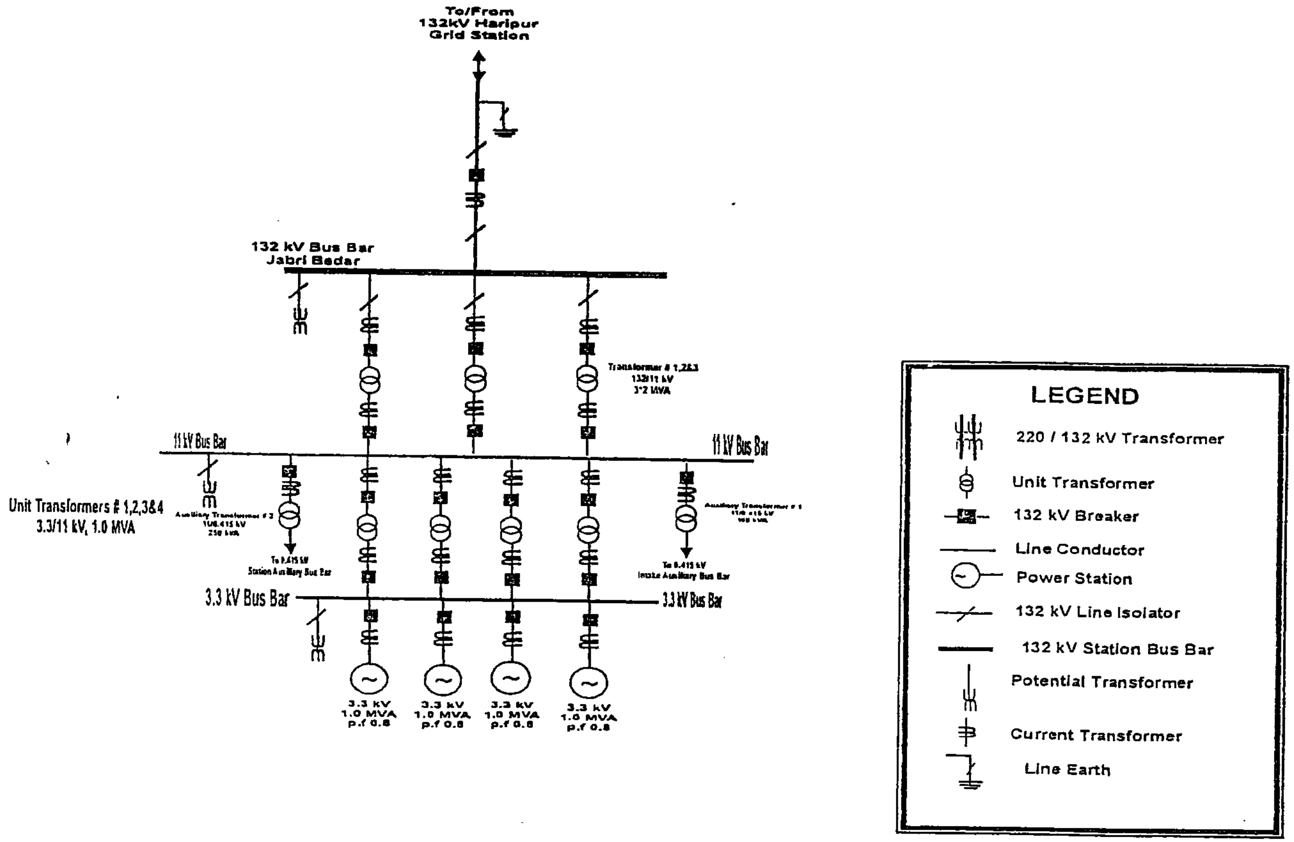


Figure10-6: Single line diagram of Proposed 132/66 kV Network for Option – II

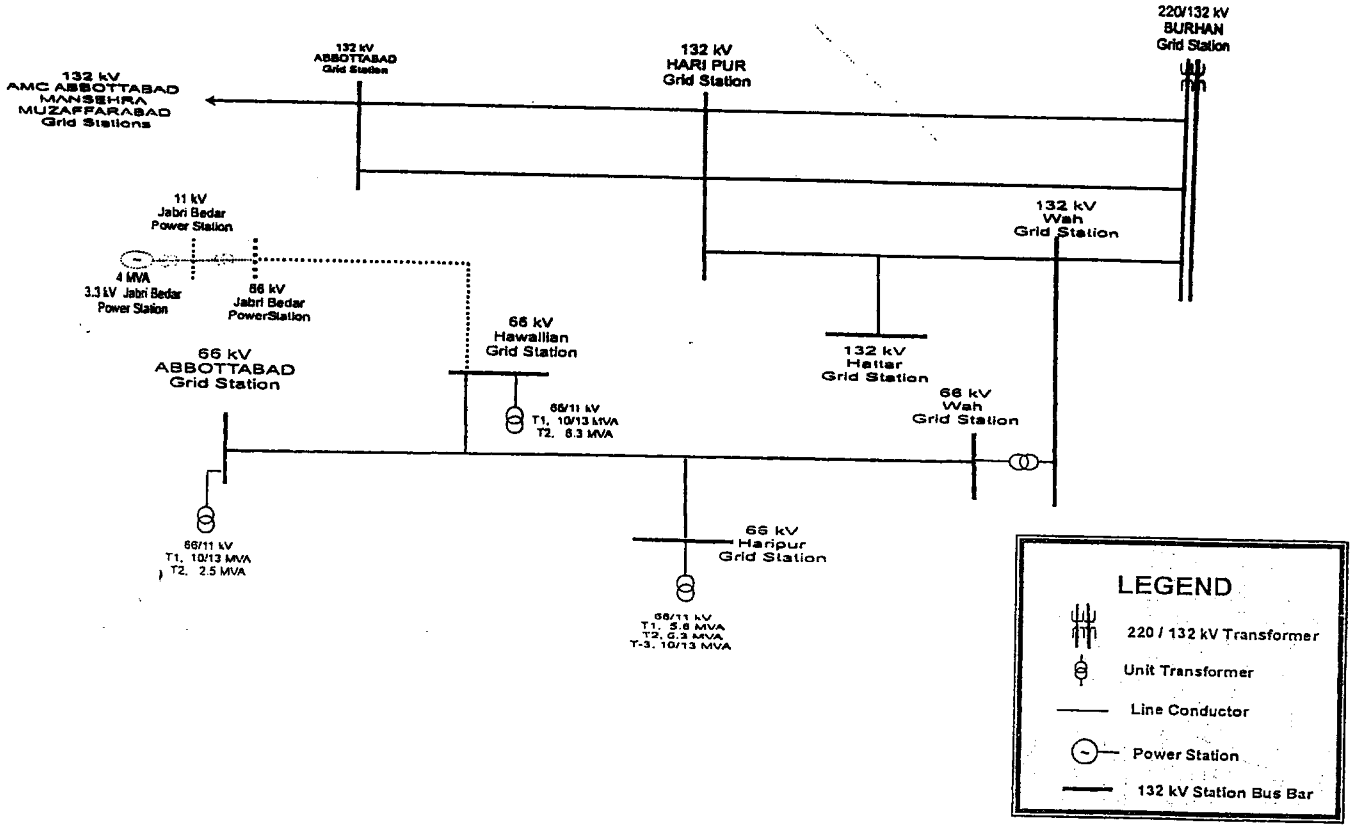


Figure 10-7: Single line diagram of Proposed Power Plant Jabri Bedar, for Option - II

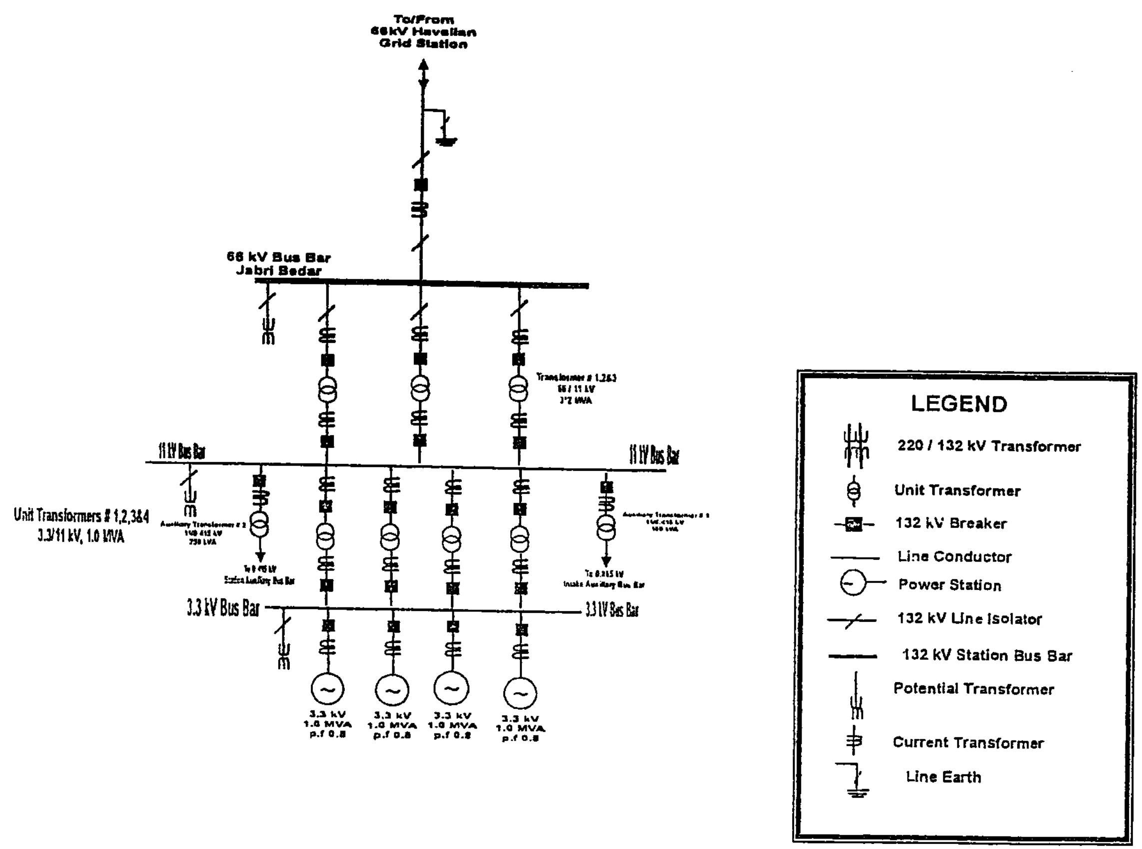


Figure 10-8: Single line diagram of Proposed 132/66 kV Network for Option - III

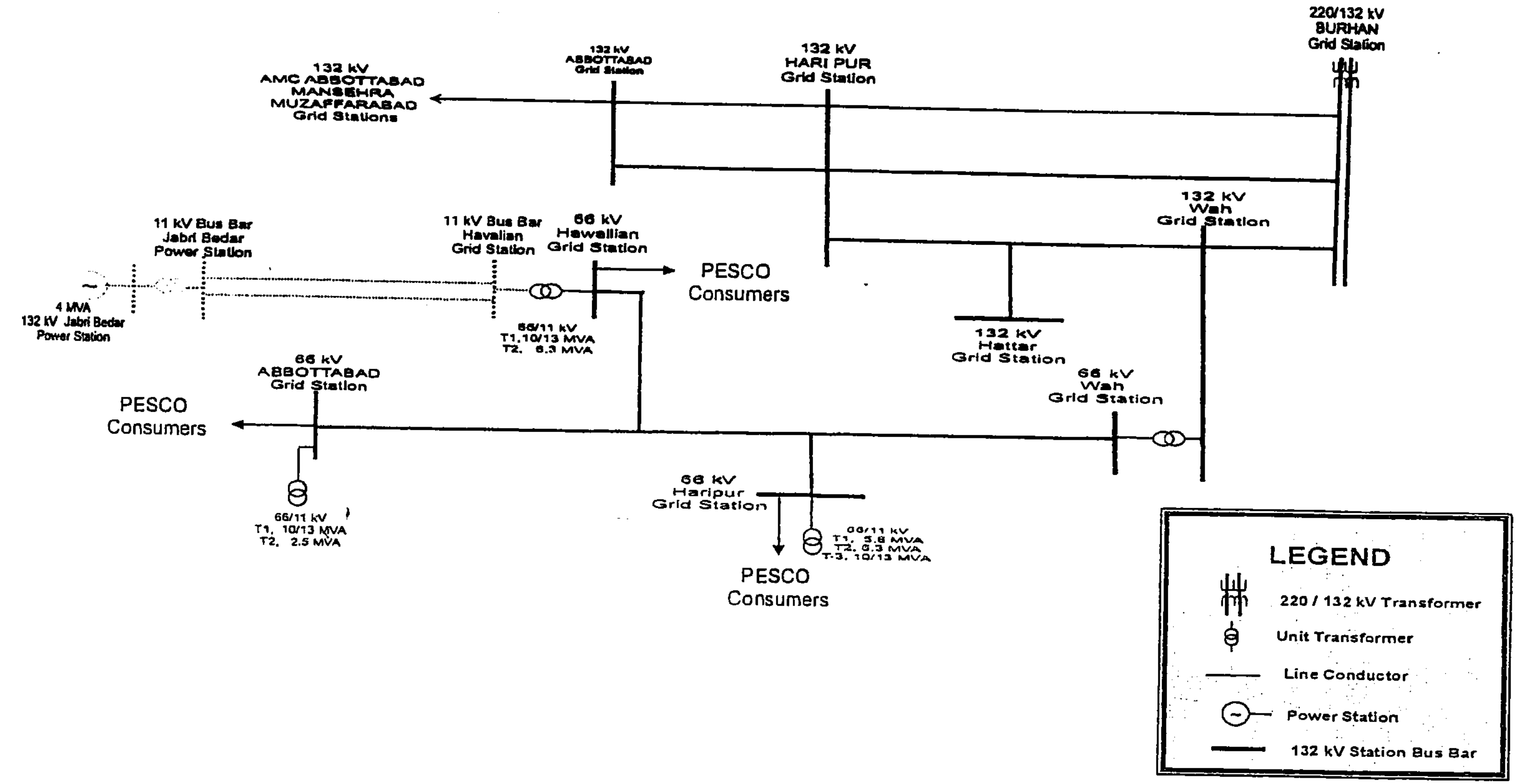
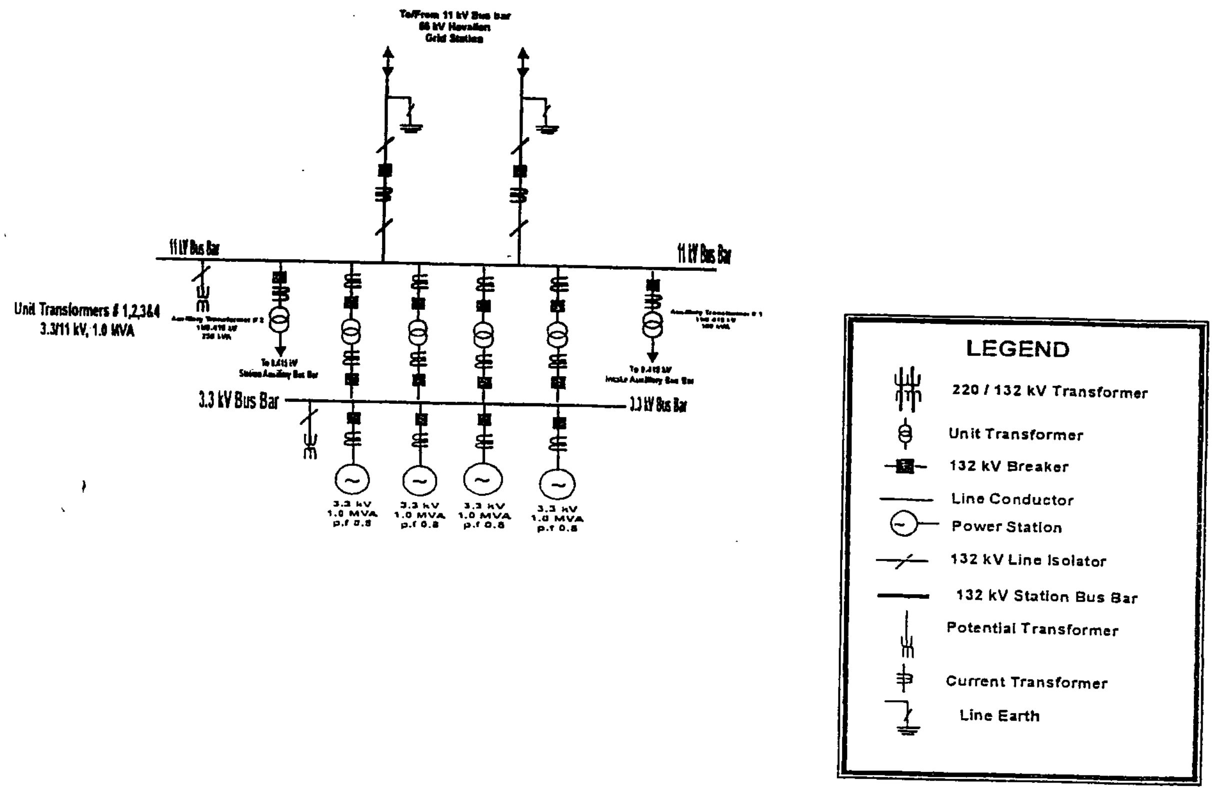


Figure 10-9: Single line diagram of Proposed Power Plant Jabri Bedar, for Option - III



11 ENVIRONMENTAL IMPACT ASSESSMENT

11.1 INTRODUCTION

Environmental Studies of Jabri Bedar Hydropower Plant are the part of feasibility study of the project. The Initial Environmental Examination (IEE) report will highlight the potential environmental and social impacts associated with the project activities and their mitigation measures so as to minimize the adverse impacts as much as possible. Impact assessment and screening would help decision makers to assess the environmental and social implications of the proposed development and to decide about the requirement for detailed environmental assessment.

11.2 Scope of Environmental Studies

The purpose of this Initial Environmental Examination (IEE) study is to evaluate the proposed project activities, which include the construction of a run of river hydropower plant of capacity 3.6 MW against Pakistan Environmental Protection Agency (Pak-EPA) standards and other applicable national environmental laws and regulations (refer to section-2 of the IEE report). Aim of the IEE study is to ensure that proposed development is to be carried out in sustainable manner with minimum adverse impacts on natural environment as well as on humans of the project area.

The specific objectives of this IEE were to:

Assess the existing environmental and socioeconomic conditions at and around the project site, particularly identify any environmental and social sensitivity areas;

Identify the likely impacts of the proposed project on the natural and socioeconomic environment, predict and evaluate them quantitatively wherever possible and determine their significance in the light of technical and regulatory concerns, as well as those related to public perceptions;

Propose appropriate mitigation and monitoring measures that can be incorporated into the design of the proposed activities to minimize any damaging effects or lasting negative consequences identified by the assessment;

Help to decide whether detailed environmental assessment of the proposed hydropower plant is required as well as to identify the scale of environmental assessment if required;

To develop an Environmental Management and Monitoring Plan (EMMP) so as to minimize pollution, environmental disturbance and nuisance during site evaluation, construction, operation and decommissioning phases of the proposed development;

Prepare an IEE report for submittal to the KP Environmental Protection Agency.

This IEE covers assessment and screening of physical, biological and socioeconomic impacts of site evaluation, construction and post development phases of the project and suggests the applicable remedial measures to minimize the damage to any environmental component.

11.3 Approach and Methodology

The IEE was performed in five main phases, which are described below.

Baseline Studies

The project area was surveyed to collect primary data. During the field visits, information was collected on ecologically important areas, ambient air quality, surface and groundwater resources, existing and proposed roads, local communities, public services, and sites of archaeological, religious or cultural importance:-

Public Consultation

Consultation was held with the local communities and other key stakeholders as part of the assessment process.

Impact Assessment

The environmental, socioeconomic, and project information collected in previous phases was used to assess the potential impacts of the proposed activities. The issues studied included potential project impacts on:

Geomorphology;

Groundwater and surface water quality;

Ambient air quality;

Ecology of the area, including flora and fauna;

Local communities;

Workers health and safety

Impact assessment discussion covers the following aspects:

The present baseline conditions;

The change in environmental parameters likely to be effected by project related activities;

Identification and prediction of potential impacts;

Likelihood and significance of potential impacts;

Evaluation of the importance or significance of impacts;

Identification of cumulative environmental impacts due to other existing or on-going developmental activities in the area;

Mitigation measures to reduce impacts to as low as possible;

Implementation of mitigation measures (i.e. environmental Management and Monitoring Plan)

Documentation

At the end of the assessment, a report was prepared according to the relevant guidelines of the Pakistan Environmental Protection Agency. This report includes the findings of the assessment, project impacts, and mitigation measures to be implemented during the site evaluation, construction and execution of the proposed activities.

11.4 LEGISLATIVE, REGULATORY, AND INSTITUTIONAL FRAMEWORK

This topic provides a brief description of the national/provincial legislative, regulatory, and institutional frameworks relevant to the environmental and social aspects of the Jabri Bedar Hydropower Project.

National Legislative and Regulatory Framework

Pakistan's statute books contain a number of laws concerned with the regulations and control of the environmental and social aspects. However, the enactment of comprehensive legislation on the environment, in the form of an act of parliament, is relatively a new phenomenon. Most of the existing laws on environmental and social issues have been enforced over an extended period of time, and are context-specific. The laws relevant to the developmental projects are briefly reviewed below;

Pakistan Environmental Protection Act, 1997

Pakistan Environmental Protection Act, 1997 (the Act)2 is the basic legislative instrument empowering the government to frame regulations for the protection of environment (the 'environment' has been defined in the Act as: (a) air, water and land; (b) all layers of the atmosphere; (c) all organic and inorganic matter and living organisms; (d) the ecosystem and ecological relationships; (e) buildings, structures, roads, facilities and works; (f) all social and economic conditions affecting community life; and (g) the inter-relationships between any of the factors specified in sub-clauses 'a' to 'f'). The Act is applicable to a broad range of issues and extends to socioeconomic aspects, land acquisition, air, water, soil, marine

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2 GoP 1997. *Act No. xxxiv OF 1997; the Pakistan Environmental Protection Act, 1997.* Government of Pakistan. December, 1997

and noise pollution, as well as the handling of hazardous waste. The discharge or emission of any effluent, waste, air pollutant or noise in an amount, concentration or level in excess of the National Environmental Quality Standards (NEQS) specified by the Pakistan Environmental Protection Agency (Pak-EPA) has been prohibited under the Act, and penalties have been prescribed for those contravening the provisions of the Act. The powers of the federal and provincial Environmental Protection Agencies (EPA's), established under the Pakistan Environmental Protection Ordinance 1983,3 have also been considerably enhanced under this legislation and they have been given the power to conduct inquiries into possible breaches of environmental law either of their own accord, or upon the registration of a complaint.

The requirement for environmental assessment is laid out in Section 12 (1) of the Act. Under this section, no project involving construction activities or any change in the physical environment can be undertaken unless an Initial Environmental Examination (IEE) or an Environmental Impact Assessment (EIA) is conducted, and approval is received from the federal or relevant provincial EPA. Section 12 (6) of the Act states that this provision is applicable only to such categories of the projects as may be prescribed. The categories are defined in the Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 2000.

Pakistan environmental protection agency review of IEE and EIA regulations, 2000

The Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 20004 (the 'Regulations'), developed by the Pak-EPA under the powers conferred upon it by the Act 1997, provide the necessary details on preparation, submission and review of the IEE and the EIA. Categorization of projects for IEE and EIA is one of the main components of the Regulations. Projects have been classified on the basis of expected degree of potential adverse environmental impacts. Project types listed in Schedule I are designated as potentially less damaging to the environment, and those listed in Schedule II as having potentially serious adverse effects. Schedule I projects require an IEE to be conducted, provided they are not located in environmentally sensitive areas. For the Schedule II projects, conducting an EIA is mandatory.

According to these Regulations, JBHPP falls in schedule-I of the guidelines. According to category B (1) of schedule-I, hydroelectric power generation with capacity of less than 50

[3] Superseded by the Pakistan Environmental Protection Act, 1997.
[4] S.R.O. 339 (1)/2001. *Pakistan Environmental Protection Agency, Islamabad. 2000.*

MW requires an Initial Environmental Examination (IEE). Hence an IEE had to be carried out for the Project.

National Environmental Quality Standards 2000

National Standards

The National Environmental Quality Standards (NEQS) have been promulgated under the PEPA 1997. The ones relevant to the Project are listed below.

Maximum permissible limits for motor vehicle exhaust and noise,

Maximum allowable concentration of pollutants (32 parameters) in municipal and liquid industrial effluents discharged to inland waters, sewage treatment and sea (three separate set of numbers).

Selected NEQS for liquid effluents discharged to inland waters and emissions from motor vehicles are provided in **Tables 11-1** and **11-2**, respectively. These standards are applicable to the gaseous emissions and liquid effluents discharged to the environment from the Project.

The Pak-EPA has also issued standards for drinking water quality. These are listed in **Table 11-3**.

International Standards

The NEQS do not cover the ambient air quality or water quality standards. The international standards for ambient air quality are presented in **Table 11-4**. Recently, the Pak-EPA has drafted the national ambient air quality standards, which are provided in **Table 11-5**. However, these standards are yet to be approved.

Table 11-3: Selected NEQS for Waste Effluents [5]

Parameter	Unit	Standards (Maximum Allowable Limit)
Temperature increase	°C	< 3
pH value (acidity/basicity)	pH	6-9
5-day biochemical oxygen demand (BOD) at 20 °C	mg/l	80
Chemical oxygen demand (COD)	mg/l	150
Total suspended solids	mg/l	200
Total dissolved solids	mg/l	3,500
Grease and oil	mg/l	10
Phenolic compounds (as phenol)	mg/l	0.1
Chloride (as Cl)	mg/l	1,000
Fluoride (as F)	mg/l	10
Sulfate (SO_4)	mg/l	600
Sulfide (S)	mg/l	1.0
Ammonia (NH_3)	mg/l	40
Cadmium	mg/l	0.1
Chromium (trivalent and hexavalent)	mg/l	1.0
Copper	mg/l	1.0
Lead	mg/l	0.5
Mercury	mg/l	0.01
Selenium	mg/l	0.5
Nickel	mg/l	1.0
Silver	mg/l	1.0
Total toxic metals	mg/l	2.0
Zinc	mg/l	5
Arsenic	mg/l	1.0
Barium	mg/l	1.5
Iron	mg/l	8.0
Manganese	mg/l	1.5
Boron	mg/l	6.0
Chlorine	mg/l	1.0

Source: Government of Pakistan (2000).

Notes:

1. The standard assumes that dilution of 1:10 on discharge is available. That is, for each cubic meter of treated effluent, the recipient water body should have 10 m^3 of water for dilution of this effluent.
2. Toxic metals include cadmium, chromium, copper, lead, mercury, selenium, nickel and silver. The effluent should meet the individual standards for these metals as well as the standard for total toxic metal concentration.

[5] The full text of the NEQS is available at the Pak-EPA website: (http://www.environment.gov.pk/info.htm).

Table 11-4: NEQS for Motor Vehicles Exhaust and Noise [6]

(i) For In-use Vehicles

	Parameter	Standard (Maximum Permissible Limit)	Measuring Method	Applicability
1	Smoke	40% or 2 on the Ringlemann Scale during engine acceleration mode.	To be compared with Ringlemann Chart at a distance 6 or more. r	Immediate effect
2	Carbon Monoxide	6%	Under idling conditions: Non-dispersive infrared detection through gas analyzer.	
3	Noise	85 db (A).	Sound meter at 7.5 meters from the source.	

(ii) For new Vehicles

Emission Standards For Diesel Vehicles

(a) For Passenger Cars and Light Commercial Vehicles (g/Km)

Type of Vehicle	Category/Class	Tiers	CO	HC+ NOx	PM	Measuring Method	Applicability
Passenger Cars	M 1: with reference mass (RW) up to 2500 kg. Cars with RW over 2500 kg to meet NI category standards.	Pak-II IDI	1.00	0.70	0.08	NEDC (ECE 15+ EUDCL)	i. All imported and local manufactured diesel vehicles with effect from 01-07-2012
		Pak-II DI	1.00	0.90	0.10		
Light Commercial Vehicles	NI-I (RW<1250 kg)	Pak-II IDI	1.00	0.70	0.08		
		Pak-II DI	1.00	0.90	0.10		
	NI-II (1250 kg< RW <1700 kg0	Pak-II IDI	1.25	1.00	0.12		
		Pak-II DI	1.25	1.30	0.14		
	NI-III (RW>1700 kg)	Pak-II IDI	1.50	1.20	0.17		
		Pak-II DI	1.50	1.60	0.20		

Parameter	Standard (maximum permissible limit)	Measuring Method
Noise	85 db (A)	Sound meter at 7.5 meters from the source.

[6] Full text of the NEQS is available at the Pak-EPA website: (http://www.environment.gov.pk/info.htm).

(b) For Heavy Duty Diesel Engines and Large Goods Vehicles (g/Kwh)

Type of Vehicle	Category / Class	Tiers	CO	HC	NOx	PM	Measuring Method	Applicability
Heavy Duty Diesel Engines	Trucks and Buses	Pak-II	4.0	1.1	7.0	0.15	ECE-R-49	All Imported and local manufactured diesel vehicles with the effect 1-7-2012
Large goods Vehicles	N2 (2000 and up	Pak-II	4.0	7.0	1.10	0.15	EDC	

Parameter	Standard (maximum permissible limit)	Measuring Method
Noise	85 db (A)	Sound meter at 7.5 meters from the source.

Emission Standards for Petrol Vehicles (g/km)

Type of Vehicle	Category / Class	Tiers	CO	HC+ NOx	Measuring Method	Applicability
Passenger	M 1: With reference mass (RW) up to 2500 kg. Cars with RW over 2500 kg. to meet N1 category standards	Pak-II	2.20	0.50	NEDC (ECE 15 + EUDCL)	All imported and new models* locally manufactured petrol vehicles with effect from 1st July, 2009**
Light Commercial Vehicles	N1-I (RW<1250 kg)	Pak-II	2.20	0.50		
	N1-II (1250 kg>RW <1700 kg)	Pak-II	4.00	0.65		
	N1-III (RW>1700 kg)	Pak-II	5.00	0.80		
Motor Rickshaws & motor Cycles	2.4 strokes <150 cc	Pak-II	5.50	1.50	ECER 40	
	2.4 strokes>150 cc	Pak-II	5.50	1.30		

Parameters	Standard (maximum permissible limit)	Measuring Method
Noise	85 db (A)	Sound meter at 7.5 meters from the source

Explanations:	
DI:	Direct Injection
IDI:	Indirect Injection
EUDCL:	Extra Urban Driving Cycle
NEDC:	New Urban Driving Cycle
M:	Vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat
N:	Motor vehicles with at least four wheels designed and constructed for the carriage of goods.
*	New model means both model and engine type change
**	The existing models of petrol driven vehicles locally manufactured will immediately switch ever to Pak-II emission standards but not later than 30th June, 2012

Table 11-5: National Drinking Water Quality Standards (Draft) [7]

Properties/Parameters	Standard Values for Pakistan
Bacterial	
All water intended for drinking (e.Coli or Thermotolerant Coliform bacteria)	Must not be detectable in any 100 ml samples
Treated water entering the distribution system (E.Coli or thermotolerant coliform and total coliform bacteria)	Must not be detectable in any 100 ml samples
Treated water in the distribution system (E.Coli or thermo tolerant coliform and total coliform bacteria)	Must not be detectable in any 100 ml samples In case of large supplies, where sufficient samples are examined, must not be present in 95% of the samples taken throughout any 12- month period.
Physical	
Color	≤15 TCU
Taste	Non objectionable/Accept able
Odor	Non objectionable/Accept able
Turbidity	< 5 NTU
Total hardness as $CaCO_3$	< 500 mg/l
TDS	< 1000
pH	6.5 – 8.5
Chemical	
Essential Inorganic	***mg/Liter***
Aluminum (Al)	≤0.2
Antimony (Sb)	≤0.005 (P)
Arsenic (As)	≤ 0.05 (P)
Barium (Ba)	0.7
Boron (B)	0.3
Cadmium (Cd)	0.01
Chloride (Cl)	<250
Chromium (Cr)	≤0.05
Copper (Cu)	2
Toxic Inorganic	***mg/liter***
Cyanide (CN)	≤0.05
Fluoride (F)*	≤1.5
Lead (Pb)	≤0.05
Manganese (Mn)	≤ 0.5
Mercury (Hg)	≤0.001
Nickel (Ni)	≤0.02
Nitrate (NO_3)*	≤50

7 Full text of the Standards is available at the Pak-EPA website: (http://www.environment.gov.pk/info.htm).

Properties/Parameters	Standard Values for Pakistan
Nitrite (NO_2)*	≤3 (P)
Selenium (Se)	0.01 (P)
Residual chlorine	0.2-0.5 at consumer end; 0.5-1.5 at source
Zinc (Zn)	5.0
Organic	
Pesticides mg/l	PSQCA No. 4639-2004, Page No. 4 Table No. 3 Serial No. 20- 58 may be consulted.**
Phenolic compound (as phenols) mg/l	
Polynuclear Aromatic hydrocarbon (as PAH) g/L	
Radioactive	
Alpha Emitters bq/L or pCi	0.1
Beta Emitters	1

* indicates priority health related inorganic constituents which need regular monitoring.

** PSQCA: Pakistan Standards Quality Control Authority.

Table 11-6: WHO Ambient Air Quality Standards

Pollutant	Maximum Allowable Limit	Units	Averaging Time
CO	35	ppm	1 hour
NO_X	106	ppb	1 hour
SO_2	134	ppb	1 hour
PM_{10}	70	$\mu g/m^3$	24 hours

Source: World Health Organization.

Table 11-7: National Ambient Air Quality Standards (Draft) [8]

Pollutants	Time-weighted Average	Concentration in Ambient Air		Method of Measurement
		Effective from 1st January 2009	Effective from 1st January 2012	
Sulfur Dioxide (SO_2)	Annual Average*	80 μg/m³	80 μg/m³	Ultraviolet Fluorescence Method
	24 hours**	120 μg/m³	120 μg/m³	
Oxides of Nitrogen as (NO)	Annual Average*	40 μg/m³	40 μg/m³	Gas Phase Chemiluminescence
	24 hours**	40 μg/m³	40 μg/m³	
Oxides of Nitrogen as (NO_2)	Annual Average*	40 μg/m³	40 μg/m³	Gas Phase Chemiluminescence
	24 hours**	80 μg/m³	80 μg/m³	
O_3	1 hour	180 μg/m³	130 μg/m³	Non dispersive UV absorption method
Suspended Particulate Matter (SPM)	Annual Average*	400 μg/m³	360 μg/m³	High Volume Sampling, (Average flow rate not less than1.1 m³/minute).
	24 hours**	550 μg/m³	500 μg/m³	
Respirable Particulate Matter. PM_{10}	Annual Average*	200 μg/m³	120 μg/m³	β Ray absorption method
	24 hours**	250 μg/m³	150 μg/m³	
Respirable Particulate Matter. $PM_{2.5}$	Annual Average*	25 μg/m³	15 μg/m³	β Ray absorption Method
	24 hours**	40 μg/m³	35 μg/m³	
	1 hour	25 μg/m³	15 μg/m³	
Lead (Pb)	Annual Average* 24 hours**	2 μg/m³	1.5 μg/m³	ASS Method after sampling using EPM 2000 or equivalent Filter paper
Carbon Monoxide (CO)	8 hours**	5 mg/m³	5 mg/m³	Non Dispersive Infra Red (NDIR) method
	1 hour	10 mg/m³	10 mg/m³	

*Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly /8 hourly values should be met 98% of the in a year. 2% of the time, it may exceed bu not on two consecutive days.

For noise, the NEQS are limited to the vehicular noise. For noise generated by other sources, the WB standards are usually applied.[9] According to these standards, the allowable noise limits for the residential/institutional/educational receptors are 55 dB (A) for daytime and 45

[8] Full text of the Standards is available at the Pak-EPA website: (http://www.environment.gov.pk/info.htm).

[9] World Bank, UNIDO, and UNEP. 1999. *Pollution Prevention and Abatement Handbook*: Towards Cleaner Production. Environment Department, The World Bank, UNIDO, UNEP.

dB (A) for nighttime, or a net increase in the background noise level by 3 dB. The noise from the proposed project has been analyzed against these standards.

Land Acquisition Act, 1894

The Land Acquisition Act (LAA) of 1894 amended from time to time has been the de-facto policy governing land acquisition and compensation in the country. The LAA is the most commonly used law for acquisition of land and other properties for development projects. It comprises of 55 sections pertaining to area notifications and surveys, acquisition, compensation and apportionment awards and disputes resolution, penalties and exemptions.

Any land acquisition for the Project will follow the procedures defined in the Act; certain additional procedures as defined by the international best practice (eg, WB Operational Policy on Resettlement – OP 4.12) will also be followed.

Canal and drainage ordinance, 1873

The Canal and Drainage Act, 1873 entitles the provincial government to use and control for public purposes the water of all rivers and streams flowing in natural channels, all of lake, sub-soil and other natural collection of still water.

Wildlife (protection, reservation, conservation and management) act, ordinances and rules

This law has been enacted to protect the province's wildlife resources directly and other natural resources indirectly. It classifies wildlife by degree of protection, i.e., animals that may be hunted on a permit or special license, and species that are protected and cannot be hunted under any circumstances. The Act specifies restrictions on hunting and trade in animals, trophies, or meat. The Act also defines various categories of wildlife protected areas, i.e. National Parks, Wildlife Sanctuaries and Game Reserve.

This Act will be applicable to the construction as well as operation and maintenance (O&M) activities of the JBHPP

Forest Act, 1927

The Act deals with the matters related with protection and conservation of natural vegetation / habitats. The Act empowers the concerned agency to declare protected and reserved forest areas and maintain these forests. In spite of the fact that Act recognizes the right of people for access to the natural resources for their household use, it prohibits unlawful cutting of trees and other vegetation. Therefore, for cutting trees for the construction purposes or otherwise, prior permission is required from the Forest Department.

Antiquities Act, 1975

The Antiquities Act of 1975 ensures the protection of cultural resources in Pakistan. The Act is designed to protect 'antiquities' from destruction, theft, negligence, unlawful excavation, trade and export. Antiquities have been defined in the Act as ancient products of human activity, historical sites, or sites of anthropological or cultural interest, national monuments, etc. The law prohibits new construction in the proximity of a protected antiquity and empowers the Government of Pakistan to prohibit excavation in any area that may contain articles of archeological significance.

Under this Act, the project proponents are obligated to:

- Ensure that no activity is undertaken in the proximity of a protected antiquity, and
- If during the course of the project an archeological discovery is made, it should be protected and reported to the Department of Archeology, Government of Pakistan, for further action.

This Act will be applicable to the construction as well as O&M activities of the JBHPP.

Factories Act, 1934

The clauses relevant to the Project are those that address the health, safety and welfare of the workers, disposal of solid waste and effluents, and damage to private and public property. The Act also provides regulations for handling and disposing toxic and hazardous substances. The Pakistan Environmental Protection Act of 1997 (discussed above), supersedes parts of this Act pertaining to environment and environmental degradation.

Explosives act, 1884

Under the Explosives Act, the project contractors are bound by regulations on handling, transportation and using explosives during quarrying, blasting, and other purposes.

Employment of Child Act, 1991

Article 11(3) of the Constitution of Pakistan prohibits employment of children below the age of 14 years in any factory, mines or any other hazardous employment. In accordance with this Article, the Employment of Child Act (ECA) 1991 disallows the child labor in the country. The ECA defines a child to mean a person who has not completed his/her fourteenth

11.7 ENVIRONMENTAL BASELINE-PHYSICAL ENVIRONMENT

Physical environment of an area generally constitute the air, land and water resources. The baseline data on physical environment has been collected from both primary as well as secondary data sources. Physical environmental baseline of the project area has been developed which covers the description of geography, physical features, and climatic conditions of the area.

Such description of physical baseline of the area will help to interpret and identify the potential impacts of proposed hydropower plant on the ambient physical environment as well as the impacts of existing physical environment on the project may also be assessed which in turn would be helpful to develop the efficient design of the power plant and best construction and operation practices can be adopted in line with existing conditions of physical environment.

Methodology

Description of physical environment presented in this section has been derived from secondary literature related to the physical features of the area Local knowledge had also been utilized to describe the geography, physical features, water resources and climatic conditions of the area.

A site visit to the project area had been carried out by environmental experts in order to gather information on physical environmental resources of the area. The data obtained from primary and secondary literature review had been analyzed and interpreted to be incorporated in the IEE report. On the basis of physical profile of the area, potential project impacts have been identified and mitigation measures have been proposed.

Geography

Haripur is a city and a district in the Hazara region of the Khyber Pakhtunkhwa province of Pakistan.Haripur District is situated At latitude 33° 44' to 34° 22' and longitude 72° 35' to 73° 15' and about 610 meters above the mean sea level.

Boundaries of Haripur district touch Mardan District, in the North West. Abbottabad District in the North East, Mansehra District in the North, Margallah hills of Islamabad in the South East, Swat valley in the North-West, Buner and Swabi districts are in the West. Besides Swabi, Mansehra and Abbottabad districts of Khyber Pakhtunkhwa, two districts of Punjab province i.e. Attock and Rawalpindi lie on the South-West and South-East respectively of Haripur district. The Federal Capital Islamabad is also adjacent to the district in the South.

Geology

From geological point of view the project area falls under the Hazara Group. The Age of Hazara group is Precambrian. The weathered color of splintery shale is blackish brown to light dark brown while the fresh color is yellowish brown and other place the weathered color is yellowish brown and fresh color is radish brown. The beds are thick to thin beds. Beds thickness is about 11/2 to 3 feet on out crop. The upper contact of Hazara has tanaki conglomerate while lower contact will not exposed. Texture of shale is fine grained and become thick to thin bedded about 1 cm to 1 foot. The thickness of bed on different places is different like 95cm and 18cm The Sedimentary structure is Parallel lamination. The project area does not fall under the seismically active zone.

Soils

Soil texture of the project area is mostly silty clay loam and silt loam non-saline in nature, slightly alkaline in reaction, moderately calcareous, deficient in organic matter and available potassium and adequate in sulphate-S and soluble chlorine-Cl

Climate

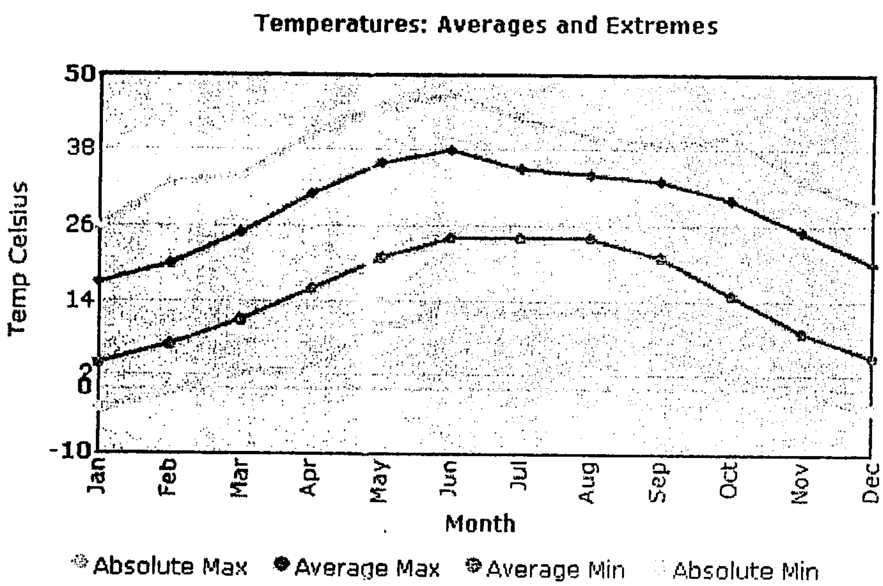
The information presented below give the detailed historical yearly average weather conditions of the area along with exceptional weather occurrences. To maintain relevance to current weather trends the displayed information has been calculated using data collected over the past two decades. The climate profile is taken from closest available data source to Haripur.

Yearly Trends: Weather Averages & Extremes

The following charts show yearly weather trends with information on monthly weather averages and extremes.

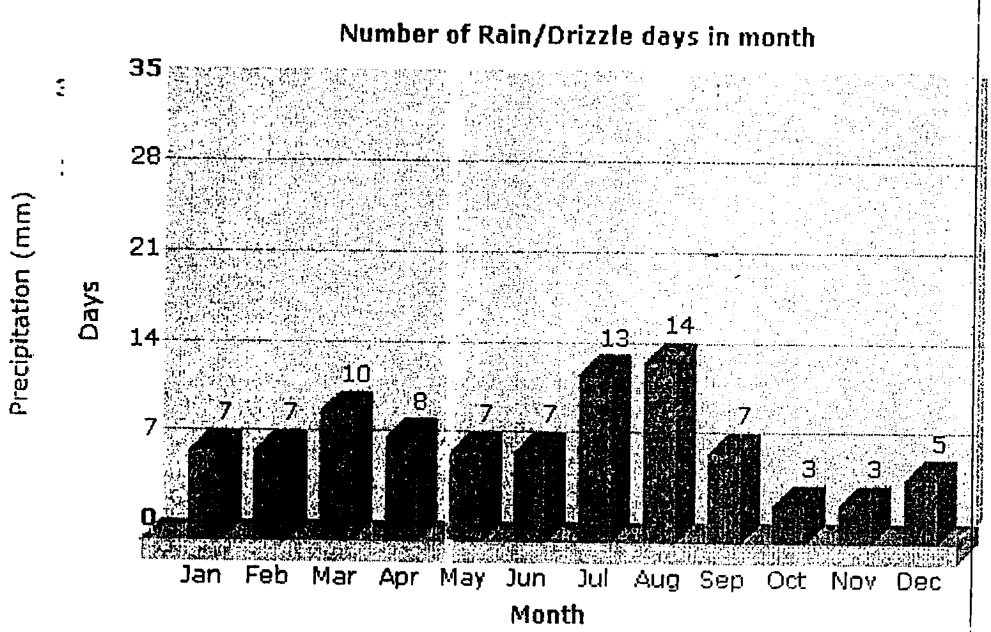
Temperature

The chart below plots the average high and low temperature for each month of the year. It also shows the maximum and minimum recorded temperatures.



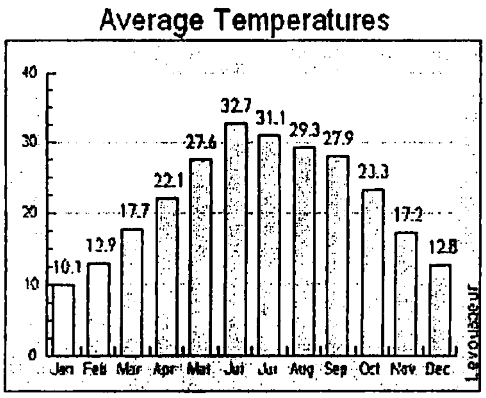
Precipitation Amount

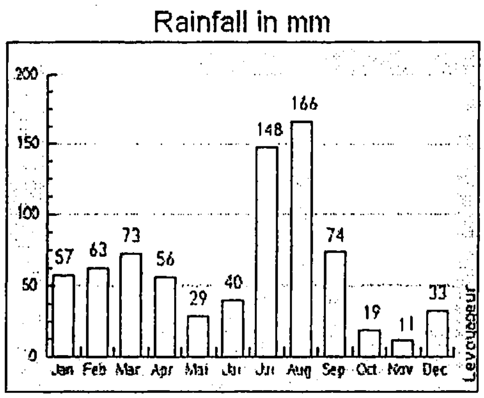
The chart below plots the average monthly precipitation amount which is highest during the months July and August



Rain days

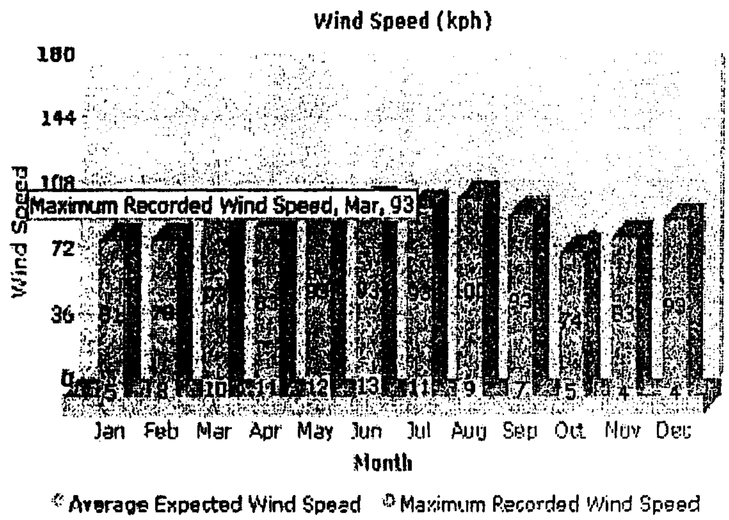
The chart below plots the average number of days in any month when rainfall can be expected





Wind Speed

The chart below plots the average daily wind speed for any month. It also shows the maximum recorded sustained wind speed for each month



Water Resources

Surface Water

The Harro River originating from Murree hills (foothills of Himalayas) flow meandering down hills and reaches Khanpur some 12kms from Haripur where the water has been blocked by damming giving rise to Khanpur dam.

At the Jabri Bridge, due to reasonable sloping water flows with relatively higher speed. Within the 10 Kilometers patch of project area no irrigation network was found. Moreover no fishing activities were found in the project area related to Harro River.

Ground Water

The ground water of the area is clear in appearance and seems to be fit for human consumption as it was also told by the local people of the area during the site visit. Water table is not very deep and ground water is generally available at the depths of 100-150 feet. In project surrounding areas, ground water is quite fit for drinking purposes. Especially at village Peena, ground water quality is very good.

Ambient Air Quality

Air quality of the project area is quite fair and fresh air is unpolluted as there is no prominent industrial unit located in the nearby areas of the project and also the enormous vegetation enhances the freshness in air. Major sources of air emissions in the area may include neighboring domestic sources of air pollution, such as emissions from wood and kerosene burning stoves in households.

Ambient Noise and Vibration

Over all quality of ambient noise and vibration in the project area is fairly good. In the project specific area no significant source of ambient noise was observed during the field surveys of the project area. The major road passing through the area is Lora-Jabri. Traffic density on this road is very small least contributing to the ambient noise in the area.

Socio-economic baseline

A brief baseline of socio-economic conditions of the project area is illustrated below:

Education

oThere is no education facility in the project area except a primary school located in village Peena. The other nearest school is in village Nala at 2km distance away from the Village Peena. This is also a Middle school only for girls. In Jabri village there exists a secondary school for boys. The nearest educational hub is in Haripur city which is around 30 km away from the project site. Due to hilly area and unavailability of proper road network and transport facilities, it is quite difficult for the students to travel for higher education.(See Photgraph D-9)

Health

No proper clinic/basic health unit available in the village Peena nad Tayal. The nearby clinic/BHU found in Jabri Village, 10km away from the area, there are couple of clinics run by commoners. There is no government hospital or dispensary or maternity home and other indoor treatment facilities in the village Peena. The people of Peena have to travel either Abbotabad or Haripur for better medical facilities.

Demography

According to the analysis of the survey of the area it was reported that the Peena Village has 150 houses, each constituting of 8-9 members. Hindko language is preferred to speak.

Languages

According to the 1998 District Census Report, Hindko, Urdu is the predominant languages in the district, representing >70% of the total population. Other languages spoken are Gojri, Potohari, Pashto and Pahaari.

11.8 Physical infrastructure

Electricity

The grid electricity is available to the area but its supply similar to other rural areas of the Pakistan is uncertain and unreliable due to load-shedding for long durations.

Drinking water

The groundwater in the area is clean and clear and fit for drinking purposes. People get drinking water from ground water by using the boring process, and also from direct river water, stream. The running water is also used for washing and bathing purposes. Usually adult women fatch water for their homes.

Natural gas

There is no piped gas supply or any outlet for LPG. The people use dung cakes/wood for cooking and other agriculture waste like wheat straw for heating purposes.

Sewerage system

There is no sewerage system in the area. Domestic waste water is generally discharged in open areas.

11.9 Physical and Cultural Heritage

Shrines

There is a no shrine in the nearby areas of project site.

Mosques

There is a small mosque located in Peena village. This mosque is out of the project boundary and will have no impacts from the project

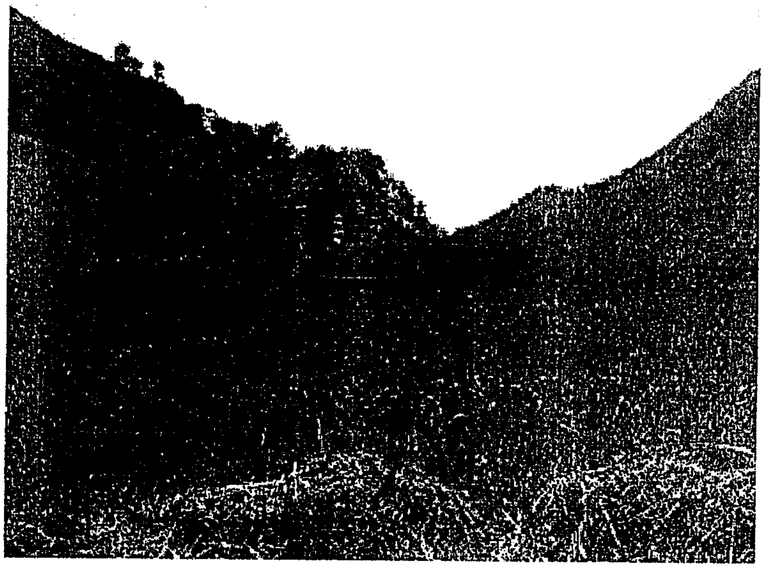
Graveyards

There is a small graveyard belonging to residents of village Peena. The boundary of graveyard is touching the channel route, so there must be some alternate for the channel route. Keeping in view the cultural and religious significance of the graveyard, all the construction and project operational activities are proposed to be careful by minimal disturbances to local communities and their cultural and religious assets.

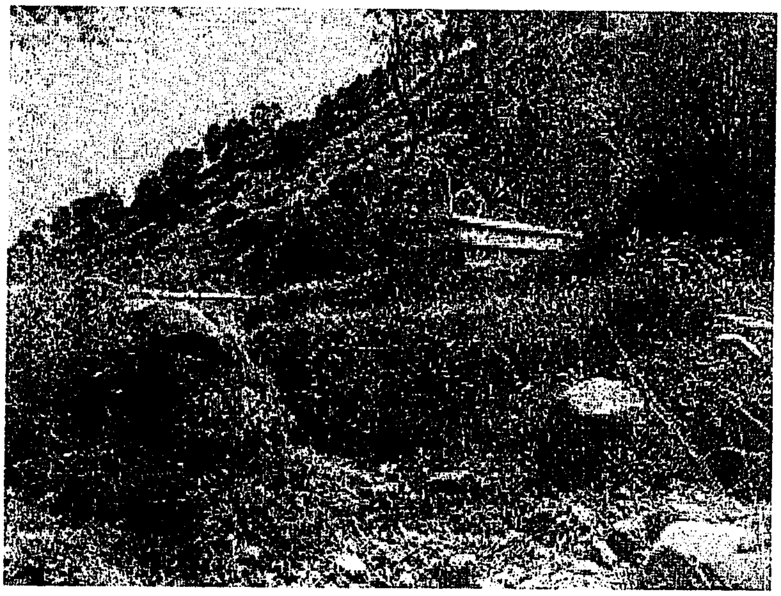
Recreational Sites

There is no recreational site in or around the project influenced areas.

Photograph: Mosque at Village Peena



Photograph: Graveyard at Peena village



11.10 SCREENING OF POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS MITIGATIONS

This section details the potential environmental and social impacts of the proposed project activities, predicts the magnitude of the impact, assesses significance, recommends mitigation measures to minimize adverse impacts, and identifies the residual impacts of the project. The discussion starts with a description of the methodology used for the impact assessment. Discussion of the environmental and socioeconomic impact is then organized in the following manner:

Impacts associated with site evaluation/design;

Impacts associated with pre construction and construction activities;

Impacts associated with operation and maintenance phase;

Impacts associated with decommissioning phase.

Impact Assessment Methodology

During the present assignment, the potentially significant environmental and social impacts of the Project were characterized according to the aspects described below.

Categories	Characteristics
Nature	**Direct:** The environmental parameter is directly changed by the project. **Indirect:** The environmental parameter changes as a result of change in another parameter
Duration of impact	**Short-term**: lasting only for the duration of the project such as noise from the construction activities. **Medium-term**: lasting for a period of few months to a year after the project before naturally reverting to the original condition such as loss of vegetation due to clearing of campsite, contamination of soil or water by fuels or oil. **Long-term**: lasting for a period much greater than medium term impact before naturally reverting to the original condition such as loss of soil due to soil erosion.
Geographical extent	**Local, regional (spatial dimension)**
Timing	**Construction** and **Operation**
Magnitude	**Large scale** or **small scale**.
Reversibility of impact	**Reversible**: when a receptor resumes its pre-project condition **Irreversible**: when a receptor does not or cannot resume its pre-project condition
Likelihood of the impact	**Almost Certain:** Impact expected to occur under most circumstances **Likely:** Impact will probably occur under most circumstances **Possibly:** Impact may possibly occur at some time **Unlikely:** Impact could occur at some time **Rare:** Impact may occur but only under exceptional circumstances
Impact consequence severity	**Major**: When an activity causes irreversible damage to a unique environmental feature; causes a decline in abundance or change in distribution over more than one generation of an entire population of species of flora or fauna; has long-term effects (period of years) on socioeconomic activities of significance on regional level. **Moderate**: When an activity causes long-term (period of years), reversible damage to a unique environmental feature; causes

Categories	Characteristics
	reversible damage or change in abundance or distribution over one generation of a population of flora or fauna; has short-term effects (period of months) on socioeconomic activities of significance on regional level. **Minor**: When an activity causes short-term (period of a few months) reversible damage to an environmental feature; slight reversible damage to a few species of flora or fauna within a population over a short period; has short term (period of months) effects on socioeconomic activities of local significance. **Negligible**: When no measurable damage to physical, socioeconomic, or biological environment above the existing level of impact occurs.
Significance of impact	Categorized as **High, Medium**, or Low Based on the consequence, likelihood, reversibility, geographical extent, and duration; level of public concern; and conformance with legislative of statutory requirements.

11.10.1 Impacts Associated with Site Evaluation /Design Land Use

Altered river flow volume

The Project may alter the current water flow regime in the Haro River, immediately downstream of diversion weir. Water flow in the Haro River has seasonal variations and there is minimum supply of water during the lean seasons. Once the diversion weir is constructed, it is expected that regular water flow will be maintained throughout the year. Moreover the proposed hydropower weir does not entail any water storage instead weir has been designed in order to divert the water without altering the existing river flow. Moreover there is no significant vegetation at the river bed due to its stony nature which might be impacted due to altered river flow and also no irrigation network exists immediately downstream of weir. Therefore this impact may be considered as positive impact in terms of water flow in the river

Disruption of Fish Migration

The project may have adverse or beneficial effects on the fish fauna, depending upon the fish fauna inhabiting the Haro River. Similarly it may have varying impacts on the people, the livelihoods if they are dependent on fish. The regulation of a river flow leads to the fragmentation of habitat and may have adverse effects on indigenous and migratory fish.

During the site visit of environmental experts it was observed that no specific fish species are present in the Haro River within the proposed hydropower plant area as well as upstream of the diversion weir. It was told by the local people of the area that there are rare chances of finding any fish species in the river. Therefore local people were not found to involve in any fishing activities in the area.

Water Availability in Haro River

As discussed in section-3, Haro River originates from the high altitudes of Galliyats and runs through Khyber Pakhtunkhwa and Punjab provinces. It flows through a length of about 140 kilometers before joining River Indus downstream of Ghazi Barotha Hydropower Project in District Attock. Haro River is fed by four major tributaries and three minor tributaries. Any water resource development works on the river upstream of the diversion weir can adversely affect the water availability in the river and hence the generation capacity of the Project may be affected.

Eutrophication of river

Eutrophication of river can be caused by the presence of excessive vegetation and inflow of nutrients from natural and/or anthropogenic sources upstream the diversion weir and it can adversely affect the water quality especially during the low flow seasons, since the upstream area of the river is sparsely populated and cultivation activities are occurring in the low lying areas of river, the nutrients flow from the anthropogenic source would be nominal. Owing to the main vegetation growing on the river bank is pine with some trees having their canopy reasonably away from the river water; the natural nutrients inflow is also likely to be nominal.

Air Emissions

Impacts to air quality during site evaluation activities would be limited to temporary and local generation of vehicle and equipment emissions and fugitive dust from vehicle traffic and ground disturbances. These impacts are unlikely to cause an exceedance of air quality standards, or impact due to reasonably small scale site evaluation and design phase activities. Dust emissions are rare because of the hilly nature of the area.

Ecological Resources

Impacts to ecological resources (vegetation, wildlife, aquatic biota, special status species, and their habitats) would be minimal during site evaluation because of the limited nature of the activities. The introduction and spread of invasive vegetation could occur as a result of vehicular traffic. Soil borings would destroy vegetation and disturb wildlife.

Community Health and Safety

Occupational and public health and safety risks normally associated with construction and outdoor activities (working in potential weather extremes and possible contact with natural hazards, such as uneven terrain and dangerous plants, animals, or insects) exist. Moreover site evaluation activities such as drilling and movement of equipments and vehicles may pose safety hazards to the nearby communities but are very limited because of the limited range of activities and small number of machinery and workforce.

Acoustics (Noise)

Activities associated with site evaluation would generate low levels of temporary and intermittent noise. Drilling activities, if required, and the use of larger equipment associated with drilling activities, would generate the most noise during this phase, but impacts would be much lower than those that could occur during construction.

11.10.2 Impacts associated with construction activities

The potential impacts relating to construction of proposed structures such as diversion weir, powerhouse, transmission line, have been discussed in this section. Most of these impacts are temporary in nature and can easily be addressed through adopting appropriate

Mitigation/control measures.

Impact on Topography

During construction, the topography will change due to excavation and construction of powerhouse, fore bay, and penstock. The most prominent impact on the surface topography will be setting up of powerhouse and the power evacuation line in the hilly region. The impact will be local but irreversible due to the presence of the power line, and powerhouse. However the proposed JBHP project does not require significant amount of construction material due to small scale construction activities.

Impact on Surface Water Quality

Contamination of river water may result due to spilling of construction materials and surface runoff from the construction site. Contamination of water levels may increase where the surface runoff during construction enters the river. Even during repair of the trench weir, water conductor/pipe, turbidity, total suspended solids, and some other parameters are likely to increase.

Soil Erosion and Degradation

Soil erosion is likely to be caused by the vehicular traffic on unpaved roads, land clearing for construction camps and other site facilities (for transmission line works), construction of roads and excavation for transmission line tower foundations.

Soil Contamination

Soil may be contaminated as a result of fuel/oils/chemicals spillage and leakage, and inappropriate waste (solid as well as liquid) disposal.

Air Quality Deterioration

Construction machinery, diesel generators and project vehicles will release exhaust emissions, containing carbon monoxide (CO), sulfur dioxide (SO_2), oxides of nitrogen (NO_X), and particulate matter (PM). These emissions can deteriorate the ambient air quality in the immediate vicinity of the project site and along the road leading to it. Furthermore, construction activities such as excavation, leveling, filling and vehicular movement on unpaved tracks may also cause fugitive dust emissions

Loss of Natural Vegetation/Threat to Wildlife

Land may need to be cleared of natural vegetation for constructing the permanent facilities at the Project site (Offices, residential facilities for operation and maintenance staff, power house, diversion weir and head channel etc). These activities may result in lass of natural vegetation and terrestrial fauna including reptiles and small mammals as well as soil biodiversity of the area.

Aquatic flora and fauna

There may be temporary significant impacts on aquatic life due to water quality impacts from construction activities. However as mentioned earlier no specific aquatic flora and fauna exist at the river bed except small number of seasonal fish species and sparsely grown shrubs.

Damage to agricultural land and crops

Agricultural land and crops may be affected during the construction of head channel, forebay and power house. Moreover agricultural crops may also be affected during the movement of construction vehicles and machinery.

Traffic and transport

Project vehicles and machinery as well as the construction activities may cause temporary disturbances to the nearby communities. However there is no high traffic density because of the small scale of the project.

Public health

The pools of stagnant water can serve as habitats for proliferation of mosquitoes, which can lead to increased incidence of vector-borne diseases. Diversion of water into trench weir would convert riverine ecosystem into a lacustrine ecosystem. But since, this is a run-of stream project in a hilly region, increase in water spread area will be marginal and it would remain mostly confined in the gorge of the river stream, the increase in the incidence of water borne disease is not expected.

Human Interference

The construction activities and washing and bathing nearby the Harro River in the hilly terrain will impact to the downstream habitats and water users – such as increase in salinity and turbidity. These impacts will be significant for the dwellers and their lives.

Resettlement and compensation

As discussed in section 3 of the report, best feasible option is to construct the power house and other structures such as forebay and power channel at the left bank of Haro River which encompass the relocation of few houses encountered by the construction of proposed forebay. Moreover land may need to be acquired or leased for the construction of permanent facilities such as offices. However the construction of power channel and power house at left bank of the river does not encounter any human settlement. The land under the transmission line is generally not purchased, and the right of way along the transmission line is only temporarily acquired during the construction works. Furthermore, the transmission line route will be finalized in a manner to avoid the cultivation fields as much as possible.

Damage to infrastructure

The road leading to the Project site is currently in a poor condition. Public infrastructure may also be damaged during the transmission line works.

Blocked Access

The construction activities and Project-related vehicular traffic may cause hindrance to the traffic on Lora-Jabri road. Similarly, the transmission line works may also block the local roads, routes and accesses. However the existing traffic load on the Lora-Jabri road is very small.

Noise and Vibration

The noise generated by the construction machinery/vehicles/generators may affect the nearby communities, animals as well as the project personals. Moreover the transmission line works near the communities may generate noise, affecting the nearby population

Safety Hazard

The construction activities involve operation of heavy construction machinery, vehicular traffic, excavation, filling operations, high voltage (in powerhouse, switchyard, and on transmission line). In addition, the project traffic on the local roads leading to the site poses safety risks to the nearby communities. The transmission line works near the communities may also pose safety risk to the population

Gender and Social Issues

The vehicular traffic on the local roads and construction activities can potentially pose low level of adverse impact on the women of the area.

Impacts on Archeological, Cultural, Historical or Religious Significance

No archeological or cultural heritage sites have been reported at the project site and its vicinity except a small graveyard at the left bank of river.

Child Labor

Although the use of child labor is not prevalent in the construction works such as those involved in the JBHP, however, it will be explicitly prohibited at the site, and the provisions of the Child Labor Act (see Section 2.1.11) will be made part of the construction contracts, in order to ensure that no child labor is employed at the project sites or campsites.

11.10.3 Impacts Related to Operation and Maintenance Activities

The activities related to the operation and maintenance (O&M) of proposed, powerhouse, and transmission line are mostly environmentally benign. The proposed project is a Run of River hydropower plant which needs no damming or storage reservoirs. Moreover the installed capacity of proposed project is 3.6 MW ranking the project in small hydropower plants. Therefore no significant Environmental impacts are anticipated due to operation and maintenance of power plant. Few impacts which are expected can readily be addressed with the help of appropriate mitigation measures. These impacts and associated mitigation actions are discussed below.

Soil and Water Contamination

The O&M activities of the Project facilities (powerhouse, offices, and residences) may generate several types of wastes, which can cause soil as well as water contamination. These include domestic solid waste from the offices and residences at the powerhouse, sewage from the offices and residences, and wastes from the repair and maintenance activities, workshop, and warehouse (discarded equipment and parts, packing materials, cardboards, used oils and chemicals, cotton rags and the likes). In addition, leakage and spillage of transformer oil can contaminate soil and water.

Water Supply in Haro River

The reduction in flow or drying of the river in the intervening stretch is not likely to have any adverse impact on the downstream population as they do not use water for irrigation purposes. On the whole, no significant impact is anticipated as a result of modification in hydraulic regime.

Impact on Climate

The proposed project is very small, and the project construction will not involve any significant tree removal and no significant impact on climate of the area is anticipated.

Impact on Hydrology

The headwork for the hydropower unit consists of a trench weir for diversion purposes and hence the operation will not have a significant impact on water table in the area. Some erosion may take place mainly on the terraces and slopes covered with soil.

Safety Hazard

The powerhouse and transmission line operation and maintenance activities pose a low level of safety hazards to the nearby population. Moreover the project traffic on the local roads leading to the site poses safety risks to the nearby communities.

Mitigation Measures: The Standard Operating Procedures (SOPs) for power plant O&M will be prepared and strictly implemented. The standard EHS Guidelines will be made part of the SOPs mentioned above, and will be strictly followed.

The O&M staff will be provided essential protective gears and equipment. The O&M staff will be provided safety training. The Project sites will have protective fencing to avoid any unauthorized entry.

The project drivers will be trained for defensive driving skills. Vehicular speeds near/within communities will be kept low to minimize safety hazards.

Firefighting equipment will be made available at the site; fire extinguishers will be provided in the project vehicles. All safety precautions will be taken to transport, handle and store hazardous substances, such as fuel.

Liaison with the community will be maintained for the transmission line maintenance works, where necessary. The trees under the transmission lines will be regularly trimmed.

Loss of Agriculture

During the repair and maintenance activities on the transmission lines, the nearby crops can potentially be damaged. Impacts Related To Decommissioning/Site Reclamation

Decommissioning and site reclamation activities include facility removal and re vegetation. Important environmental aspects have been given in the table below;

Soil erosion and degradation

Only a small portion of the site would be impacted by decommissioning and deconstruction activities. Transmission lines would remain in place as part of the transmission grid.

Mitigation: Decommissioning activities should be restricted to the site without affecting the surrounding areas

Air emissions

Decommissioning and reclamation activities would produce small amount of fugitive dust emissions caused by vehicle traffic and breaking up of concrete foundations, vehicular and equipment emissions, and volatile organic compounds from storage and use of fuels for equipment.

Mitigation: Water spraying should be practiced at decommissioning sites to avoid the dust emissions. Fuel spillage should be avoided and decommissioning vehicles and machinery should be in good working conditions

Waste generation

Wastes generated would include solid and industrial wastes similar to those from construction, broken concrete, pipelines, plant components, electronic equipment, and transformers.

Mitigation: Waste generated through decommissioning activities should be segregated to identify the recyclable and reusable waste. Hazardous waste should be disposed of carefully to avoid soil and water contamination as well to ensure the community health and safety.

11.11 Beneficial Environmental and Social Impacts

Environmental Benefits

The beneficial environmental impacts associated with the Project include i) reduction in green house gas (GHG) production associated with the hydropower generation (more than 57,000 tons of CO2 annually, based upon 91 GWh of electricity generation per year from the powerhouse); ii) implementation of proper water resource management;

Social Benefits

The social benefits of the Project are numerous and far reaching. Salient among them are i) reduced losses caused by the floods; ii) increased commercial activities in the area, resulting in improved economic conditions of the people and poverty reduction; iii) increased electricity supply in the area thus reduction in the use of fuels such as cow dung, natural gas and wood/biomass; iv) employment opportunities for the local population; v) At present there is no industry in the region, but with the availability of assured electricity, there is significant potential for the development of agro, horticulture and forest based industries. In the view of the foregoing, the proposed scheme will go a long way in meeting the demands of the surrounding area and give relief to the grid system and; vi) the development induced by all these factors. All these benefits, coupled with the likely development of physical and social infrastructure in the area being recommended in this report, can have a major impact on the socioeconomic landscape of the Project area of influence, and can also become role model for other such areas needing developmental interventions

11.12 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

A Comprehensive Environmental Management and Monitoring plan (EMMP) is required enlisting the potentially significant effects of each activity associated with the project and their associated mitigation and monitoring measures as well the monitoring responsibilities of the project developers and contractor.

Purpose and Objectives of EMP

This EMMP provides the delivery mechanism to address the adverse environmental and social impacts of the proposed project during its execution, to enhance project benefits, and to introduce standards of good practice to be adopted for all project works.

The primary objectives of the EMP are to:

Facilitate the implementation of the mitigation measures identified in IEE report

Define the responsibilities of the project proponents, contractor, and environmental monitors, and provide a means of effectively communicating environmental issues among them,

Define a monitoring mechanism and identify monitoring parameters in order to:

- Ensure the complete implementation of all mitigation measures, and
- Ensure the effectiveness of the mitigation measures.

Provide a mechanism for taking timely action in the face of unanticipated environmental or social situations,

Identify environmental training requirements at various levels.

Environmental management and monitoring plan for various activities of the project has been provided in **Table 11.3**

Components of the EMMP

The EMMP consists of the following:

- Organizational structure; roles and responsibilities
- Mitigation plan
- Monitoring plan
- Communication and documentation
- Environmental training.

These shall be discussed in the relevant sections of the final IEE report to be included as a separate volume of Feasibility Study Report.

11.13 CONCLUSIONS

Proposed JBHP project will prove a fabulous input in existing power sector of Pakistan generally and that of Khyber Phakhtunkhwa particularly. Such small hydropower schemes are an urgent need of Pakistan to share the worse power shortages through private sector investment. Moreover the economy of Pakistan is not in a condition to afford heavy investment in large scale hydropower plants.

Similar to other small hydropower schemes, JBHP project has least environmental and social impacts. Present report on Initial Environmental Examination of the project reveals that proposed development poses minor environmental and social impacts which can easily be mitigated through careful environmental management.

For the present IEE study a comprehensive baseline survey has been conducted by environmental and social experts. On the basis of existing baseline environmental and social conditions and comparing with project scale and activities, potential positive and negative impacts of the proposed project have been screened as well as the significance of impacts have also been evaluated. **Table 11-1** below presents the environmental and social impact matrix for the proposed hydropower plant. This matrix indicates the potential project impacts during various project phases and their significance so as to facilitate the evaluation of overall significance of the project in terms of environmental and social impacts which would help to appraise the need of further environmental assessment of the project.

Table 11-8: Environmental and social impact matrix of JBHP

S.No	Environmental and Social impacts	Impact Significance		
		Low	*Medium*	*High*
A: Impacts associated with Site evaluation and design phase activities				
	Land Use	■		
	Diversion weir structure collapse	■		
	Altered river flow volume		■	
	Disruption of Fish Migration	■		
	Water Availability in Harro River	■		
	Eutrophication of river	■		
	Air emissions		■	
	Ecological resources	■		
	Community Health and Safety	■		
	Acoustics (Noise)			
B: Impacts associated with Pre construction and construction phase activities				
	Impact on Topography		■	
	Impact on Surface Water Quality	■		
	Soil Erosion and Degradation	■		
	Soil Contamination	■		
	Air Quality Deterioration	■		
	Loss of Natural Vegetation/Threat to Wildlife		■	
	Aquatic flora and fauna	■		
	Damage to agricultural land and crops	■		
	Traffic and transport	■		
	Public health	■		
	Human Interference	■		
	Resettlement and compensation		■	
	Damage to infrastructure	■		
	Blocked Access	■		
	Noise and Vibration	■		
	Safety Hazard	■		
	Gender and Social Issues	■		
	Impacts on Archeological, Cultural, Historical or Religious Significance	■		

C: Impacts Related to Operation and Maintenance Activities				
	Soil and Water Contamination	■		
	Water Supply in Harro River	■		
	Impact on Climate	■		
	Impact on Hydrology	■		
	Safety Hazard	■		
	Loss of Agriculture	■		
D: Impacts Related To Decommissioning/Site Reclamation				
	Soil erosion and degradation	■		
	Air emissions	■		
	Waste generation	■		

As evident from the environmental and social impact matrix, most of the impacts of the proposed power plant have low significance which can easily be managed by adopting the mitigation measures proposed in the IEE report. Environmental Management and Monitoring Plan have also been proposed in the IEE report in order to manage the environmental impacts identified in the IEE and to enhance the overall environmental and social performance of the project.

Therefore present IEE concludes that an EIA will not be required for the proposed hydropower plant based on the findings that the Project will not cause significant environmental problems and the potential minor impacts are manageable through proper policy, planning, public relations, and good construction and supervision practices and implementation of management and monitoring measures proposed in EMMP

12 PROJECT COST ESTIMATES

12.1 Basis of Cost Estimates

The project cost estimates consists of the following main components:

- Preparatory works
- Civil works
- Electrical & Mechanical Equipment
- Project Development & Other Works

12.2 Preparatory Works

The cost under this head comprises of camps and temporary facilities with all utilities access road, clearing and grubbing, stripping, mobilization and demobilization.

12.3 Civil Works

The costs of civil works include construction of intake, sediment trap, headrace, forebay and spillway, penstock anchors, powerhouse and tailrace structures. The cost estimate provides for some margin for the specific site conditions. The cost of entire civil works has been estimated to be 5.068 million US $.

12.4 Electrical& Mechanical Equipment

The cost component of power plant includes inlet valve, turbine, draft tube, gates, generator, control and protection equipment and substation for transformation of power to the transmission line.

12.5 Project Development & Other Works

Project development & other works cost comprises of land and resettlement cost, project development cost, detailed project engineering design and project construction management, insurance during construction and financial fees and charges.

SUMMARY OF COST ESTIMATES

S. NO.	COST HEADS	COST (US $)
A.	**PREPARATORY WORKS**	1,430,000
B.	**CIVIL WORKS**	
i	Intake Structure &Diversion Works	423,917
ii	Cofferdams	18,082
iii	Approach Channel	77,515
iv	Desanders	304,471
v	Power Channel	2,686,243
vi	Aqueducts	82,213
vii	Forebay	88,297
viii	Spillway	23,238
ix	Penstock	271,954
x	Power House	476,950
xi	Tail Race	12,133
xii	Switch Yard	10,000
xiii	External Works (Roads+Culvert)	490,465
xiv	Protection &Miscalleneous	100,000
C.	**E & M**	
	Complete E & M	1,953,000
D.	**TRANSPORT & PORT CLEARENCES**	97,650
E.	**PROJECT DEVELOPMENT & OTHER WORKS**	
	Custom Duty & Fed	136,710
	O&M Mobilization	136,000
	Engineering & Supervision-Owner Engineers	272,800
	Engineering & Supervision-Owner Advisor	272,800
	Engineering & Supervision-Lender Advisor & Agents	272,800
	Owner Administration & Overhead	681,000
	Insurance During Construction	205,168
	Legal Fee & Charges & Taxes	568,881
	Land Acquisition &Resettlement	267,388
	Environment & Ecology	218,000
	TOTAL PROJECT INVESTMENT COST	**11,580,437**
	FINANCIAL CHARGES	**277,925**
	INTEREST DURING CONSTRUCTION (IDC)	**529,685**
	TOTAL PROJECT COST	**12,388,047**

BREAKUP OF CIVIL COSTS

INTAKE STRUCTURE & DIVERSION WORKS

ENGINEER'S ESTIMATE by Designmen Consulting Engineers(Pvt.) Ltd.

Sr. No.	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 92 Rs	U.S $ (Million)
1	Excavation in overburden	M^3	1141.21	260	296,715	3225.16	0.003
2	Excavation in Common Material	M^3	7417.87	390	2,892,969	31445.30	0.031
3	Excavation in Rock	M^3	2853.03	1,075	3,067,007	33336.98	0.033
4	Dewatering	Per day	30.00	8,850	265,500	2885.87	0.003
5	Reinforced cement concrete (21 Mpa)	M^3	777.24	9,375	7,286,625	79202.45	0.079
6	P.C.C (15 Mpa)	M^3	1176.00	6,600	7,761,600	84365.22	0.084
7	P.C.C (10 Mpa)	M^3	150.60	5,650	850,890	9248.80	0.009
8	Stone Masonry	M^3	459.00	3,030	1,390,770	15117.07	0.015
9	Reinforcement (40 Grade)	Ton	49.743	99,810	4,964,885	53966.14	0.054
10	Stone Gabion	Cum	2565.00	1,735	4,450,275	48372.55	0.048
11	Wire For Gabion	Kg	1282.50	174	223,155	2425.60	0.002
12	Supply of trash rack	Ton	1.81	173,600	313,522	3407.84	0.003
13	Installation of trash rack	Ton	1.81	86,800	156,761	1703.92	0.002
14	Supply of Vertical Steel Gates	Ton	3.24	173,500	562,140	6110.22	0.006
15	Installation of Vertical Steel Gates	Ton	3.24	86,750	281,070	3055.11	0.003
16	Supply of Radial Steel Gates	Ton	13.11	216,500	2,839,309	30862.05	0.031
17	Installation of Radial Steel Gates	Ton	13.11	86,750	1,137,691	12366.20	0.012
18	Installation of anchors including drilling & grouting	M	30.00	8,650	259,500	2820.65	0.003
	Total				**39,000,375**	**423,917**	**0.424**

COFFER DAM (SUPERS)

ENGINEER'S ESTIMATE by Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty.	Rate (Rs)	Total (Rs)	1 US $= 92 Rs	U.S $ (Million)
1	Dewatering	Per day	14.75	8,850	130,500	1418.48	0.001
2	Excavation in Common Material	M^3	324.00	390	126,360	1373.48	0.001
3	Back Filling	M^3	960.00	435	417,600	4539.13	0.005
4	P.C.C (10 Mpa)	M^3	20.74	5,650	117,169	1273.57	0.001
5	P.C.C (15 Mpa)	M^3	3.21	6,600	21,173	230.14	0.000
6	Stone Masonry	M^3	133.07	3,030	403,200	4382.61	0.004
7	Rock Filling in Gabbions	M^3	225.00	1,600	360,000	3913.04	0.0039
8	Wire Mesh for Gabbions	Kg	502.87	174	87,500	951.09	0.0010
	Total				1,663,502	18,082	0.018

APPROACH CHANNEL

ENGINEER'S ESTIMATE by
Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 92 Rs	U.S $ (Million)
1	Excavation in overburden	M^3	1732.50	260	450,450	4896.20	0.005
2	Excavation in Common Material	M^3	390.69	390	152,368	1656.17	0.002
3	Excavation in Rock	M^3	184.28	1,075	198,106	2153.32	0.002
4	Sand Filling	M^3	27.56	915	25,220	274.13	0.0003
5	P.C.C (10 Mpa)	M^3	132.31	5,650	747,539	8125.43	0.008
6	Back Filling	M^3	230.47	435	100,254	1089.72	0.001
7	Reinforced cement concrete (21 Mpa)	M^3	10.50	9,375	98,417	1069.74	0.001
8	P.C.C (21 Mpa)	M^3	265.32	8,225	2,182,257	23720.18	0.024
9	P.C.C (15 Mpa)	M^3	273.40	6,600	1,804,433	19613.41	0.020
10	Reinforcement (40 Grade)	Ton	0.67	99,810	67,200	730.43	0.001
11	Stone Masonry	M^3	372.04	3,030	1,127,280	12253.04	0.012
12	Cement Plaster	M^2	462.00	325	150,150	1632.07	0.002
13	R.C.C Pipe (0.15m dia)	R.m	49.00	565	27,685	300.92	0.0003
Total					**7,131,358**	**77,515**	**0.078**

FOREBAY

ENGINEER'S ESTIMATE by
Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 92 Rs	U.S $ (Million)
1	Excavation in overburden	M^3	331.29	260	86,235	937.34	0.001
2	Excavation in Common Material	M^3	887.86	390	346,267	3763.77	0.004
3	Excavation in Rock	M^3	106.51	1,075	114,495	1244.51	0.001
4	P.C.C (10 Mpa)	M^3	45.58	5,650	257,520	2799.13	0.003
5	Back Filling (Around the structure)	M^3	132.21	435	57,512	625.13	0.001
6	Reinforced cement concrete (21 Mpa)	M^3	351.52	9,375	3,295,546	35821.15	0.036
7	Reinforcement (40 Grade)	Ton	33.72	99,810	3,365,664	36583.30	0.037
8	Supply of Steel Gate	Ton	1.15	173,500	200,100	2175.00	0.002
9	Installation of Steel Gate	Ton	1.15	86,750	99,820	1085.00	0.001
10	Supply of trash rack	Ton	1.15	173,600	200,100	2175.00	0.002
11	Installation of trash rack	Ton	1.15	86,800	100,050	1087.50	0.001
Total					**8,123,309**	**88,297**	**0.088**

DESANDER

ENGINEER'S ESTIMATE by
Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 92Rs	U.S $ (Million)
1	Excavation in overburden	M^3	8532.90	260	2,218,554	24114.72	0.024
2	Excavation in Common Material	M^3	1706.58	390	665,566	7234.42	0.007
3	Excavation in Rock	M^3	1137.72	1,075	1,223,049	13294.01	0.013
4	P.C.C (10 Mpa)	M^3	104.00	5,650	587,600	6386.96	0.006
5	Back Filling (Around Structure)	M^3	1124.64	435	489,220	5317.60	0.005
6	Reinforced cement concrete (21 Mpa)	M^3	906.13	9,375	8,494,999	92336.94	0.092
7	Reinforcement (40 Grade)	Ton	50.61	99,800	5,050,729	54899.22	0.055
8	Stone Masonry	M^3	2789.08	3,030	8,450,898	91857.59	0.092
9	Cement Plaster	M^2	966.00	325	313,950	3412.50	0.003
10	Steel Pipe 10" dia	Ton	0.75	174,000	130,500	1418.48	0.0014
11	Supply of Steel Gates	Ton	1.47	173,500	255,750	2779.89	0.0028
12	Installation of Steel Gate	Ton	1.50	86,750	130,500	1418.48	0.0014
Total					**28,011,314**	**304,471**	**0.304**

POWER CHANNEL

ENGINEER'S ESTIMATE by
Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 92 Rs	U.S $ (Million)
1	Excavation in overburden	M^3	56481.25	260	14,685,125	159620.92	0.160
2	Excavation in Common Material	M^3	44605.71	390	17,396,225	189089.40	0.189
3	Excavation in Rock	M^3	11033.55	1,075	11,861,063	128924.59	0.129
4	Sand Filling	M^3	1271.81	915	1,163,708	12649.00	0.0126
5	P.C.C (10 Mpa)	M^3	6487.28	5,650	36,653,104	398403.30	0.398
6	Back Filling	M^3	13298.36	435	5,784,786	62878.11	0.063
7	Reinforced cement concrete (21 Mpa)	M^3	483.21	9,375	4,530,075	49239.95	0.049
9	P.C.C (15 Mpa)	M^3	13265.03	6,600	87,549,165	951621.36	0.952
10	Reinforcement (40 Grade)	Ton	23.30	99,810	2,325,600	25278.26	0.025
11	Stone Masonry	M^3	17895.05	3,030	54,222,000	589369.57	0.589
12	Cement Plaster	M^2	22314.44	325	7,252,193	78828.18	0.079
13	R.C.C Pipe (0.15m dia)	R.m	2422.50	565	1,368,713	14877.31	0.0149
14	Water Stopper (300 mm Thick)	R.m	1560.95	1,400	2,185,3330	23753.54	0.024
15	Stop Logs	Sq.m	8.50	18,500	157,250	1709.24	0.002
	Total				**247,134,336**	**2,686,243**	**2.686**

AQUEDUCTS

ENGINEER'S ESTIMATE by
Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 92Rs	U.S $ (Million)
1	Excavation in overburden	M^3	70.24	260	18,262	198.50	0.000
2	Excavation in Common Material	M^3	23.88	390	9,314	101.23	0.000
3	Excavation in Rock	M^3	11.29	1,075	12,137	131.92	0.000
4	Back Filling (Around Structure)	M^3	35.12	435	15,277	166.05	0.000
5	P.C.C (10 Mpa)	M^3	16.59	5,650	93,725	1018.75	0.001
6	Reinforced cement concrete (21 Mpa)	M^3	392.76	9,375	3,682,125	40023.10	0.040
7	Reinforcement (40 Grade)	Ton	37.40	99,810	3,732,791	40573.82	0.041
Total					**7,563,630**	**82,213**	**0.082**

SPILLWAY

ENGINEER'S ESTIMATE by
Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 92 Rs	U.S $ (Million)
1	Excavation in overburden	M^3	4.27	260	1,110	12.07	0.00001
2	Excavation in Common Material	M^3	8.72	390	3,400	36.96	0.00004
3	Back Filling Around the Structure	M^3	2.115	435	920	10.00	0.00001
4	P.C.C (10 Mpa)	M^3	14.603	5,650	82,505	896.74	0.00090
5	P.C.C (21 Mpa)	M^3	249.241	8,225	2,050,005	22282.61	0.0223
Total					**2,137,940**	**23,238**	**0.023**

STEEL PENSTOCK & ANCHORS

ENGINEER'S ESTIMATE by
Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 92 Rs	U.S $ (Million)
1	Excavation in overburden	M^3	407.23	260	105,881	1150.88	0.001
2	Excavation in Common Material	M^3	109.09	390	42,545	462.44	0.000
3	Excavation in Rock	M^3	51.10	1,075	54,930	597.06	0.001
4	Back Filling (Around Structure)	M^3	1058.05	435	460,253	5002.75	0.005
5	P.C.C (21 Mpa)	M^3	734.44	8,225	6,040,733	65660.14	0.066
6	P.C.C (10 Mpa)	M^3	31.79	5,650	179,637	1952.57	0.002
7	Reinforced cement concrete (21 Mpa)	M^3	38.47	9,375	360,642	3920.03	0.004
8	Reinforcement (40 Grade)	Ton	2.49	99,810	248,184	2697.65	0.003
9	Supply, fabrication, transportation of Steel pipe and erection at site.	Ton	65.25	265,000	17,291,956	187956.04	0.188
10	By Pass Valve	No	1.00	235,000	235,000	2554.35	0.003
	Total				**25,019,759**	**271,954**	**0.272**

POWER HOUSE

ENGINEER'S ESTIMATE by Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 92 Rs	U.S $ (Million)
1	Excavation in overburden	M^3	1113.75	260	289,575	3147.55	0.003
2	Excavation in Common Material	M^3	1559.25	390	608,108	6609.86	0.007
3	Excavation in Rock	M^3	1108.57	1,075	1,191,713	12953.40	0.013
4	Dewatering	Per day	24.29	8,850	215,000	2336.96	0.002
5	P.C.C (10 Mpa)	M^3	344.38	5,650	1,945,728	21149.22	0.021
6	Back Filling (Around Structure)	M^3	668.25	435	290,689	3159.66	0.003
7	Reinforced cement concrete (21 Mpa)	M^3	1055.00	9,375	9,890,624	107506.78	0.108
8	Reinforced cement concrete (28 Mpa)	M^3	632.21	11,250	7,112,359	77308.25	0.077
9	Reinforced cement concrete (15 Mpa)	M^3	83.67	9,400	786,536	8549.30	0.009
10	P.C.C (15 Mpa)	M^3	150.00	6,600	990,000	10760.87	0.011
11	Reinforcement (40 Grade)	Ton	127.87	99,810	12,762,977	138728.01	0.139
12	Block Masonry	M^3	258.52	5,650	1,460,638	15876.50	0.016
13	Cement Plaster	M^2	2284.31	325	742,400	8069.57	0.008
14	Flooring	M^2	61.20	1,880	115,056	1250.61	0.001
15	Aluminum Doors and Windows &Ventilator	M^2	16.75	8,000	134,004	1456.57	0.001
16	Main Gate	M^2	40.00	3,480	139,200	1513.04	0.002
17	Miscellanieous Works	L.s	1.00	440,000	440,000	4782.61	0.005
18	Supply of Structure Steel for Roof Truss	Ton	20.64	126000	2600640	28267.83	0.028
19	Erection of Structure Steel	Ton	20.64	56500	1166160	12675.65	0.013
20	Supply & Installation Corrugated GI sheets roof	Sqm	516.00	1870	964920	10488.26	0.010
Total					**43,846,325**	**476,590**	**0.477**

TAIL RACE

ENGINEER'S ESTIMATE by
Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 92 Rs	U.S $ (Million)
1	Excavation in overburden	M^3	60.18	260	15,647	170	0.0002
2	Excavation in Common Material	M^3	48.33	390	18,849	205	0.0002
3	Excavation in Rock	M^3	11.97	1,075	12,868	140	0.0001
4	Back Filling	M^3	332.82	435	144,778	1,574	0.0016
5	P.C.C (10 Mpa)	M^3	18.25	5,650	103,118	1,121	0.0011
6	P.C.C (21 Mpa)	M^3	5.89	9,375	55,242	600	0.0006
7	Stone Masonry	M^3	205.58	3,030	622,895	6,771	0.0068
8	Cement Plaster	M^2	439.53	325	142,848	1,553	0.0016
Total					**1,116,247**	**12,133**	**0.012**

ROAD & CULVERTS

ENGINEER'S ESTIMATE by Designmen Consulting Engineers(Pvt) Ltd.

Item	Description	Unit	Qty	Rate (Rs)	Total (Rs)	1 US $= 106 Rs	U.S $ (Million)
1	Structural Excavation	M^3	550.00	391	215,050	2337.50	0.002
2	Excavation In Road	M^3	16209.00	182	2,953,280	32100.87	0.032
3	Road in Embankment	M^3	16209.00	261	4,230,549	45984.23	0.046
4	P.C.C (10 Mpa)	M^3	86.25	5,650	487,313	5296.88	0.005
5	Reinforced cement concrete (21 Mpa)	M^3	213.39	9,375	2,000,495	21744.51	0.022
6	Reinforcement (40 Grade)	Ton	20.32	99,810	2,028,250	22046.20	0.022
7	Stone Masonry	M^3	719.20	3,030	2,179,185	23686.79	0.024
8	Sub Base	M^3	8788.88	920	8,085,770	87888.80	0.0879
9	Base	M^3	6593.86	1,842	12,145,883	132020.46	0.1320
10	T.S.T	M^2	12200.00	885	10,797,000	117358.70	0.1174
	Total				**45,122,773**	**490,465**	**0.490**

13 PROJECT CONSTRUCTION PLANNING AND SCHEDULE

13.1 Introduction

This chapter documents the assumptions made in the preparation of the implementation schedule for the Jabri Bedar Hydropower Project.

13.2 Contract Packaging

The project is being developed as an independent power generation project. It is anticipated that the financing plan will require construction and equipment procurement to be carried out under a classic Engineering-Procurement-Construction (EPC) contract in which the Client manages all engineering design and supervision activities together with a series of civil construction and permanent equipment supply and installation packages.

It is expected that contracts will be awarded to civil contractors with capabilities to undertake the construction of the civil works.

Additional contracts can also be awarded to provide support services during construction such as construction power, site security, etc.

The electrical and mechanical components of the project will include the supply, installation and testing of:

- Turbines and generators and all associated auxiliary mechanical and electrical equipment;
- Gates, hoists, powerhouse overhead crane, trash racks and the penstock steel liners;
- Medium and high voltage equipment such as main power transformers, bus work and switchgear;

The client will also award contracts for any additional topographic and geotechnical surveys and investigations required for the final design and construction of the project. The Client's engineer will be responsible for all aspects of the final design, including the preparation of construction and as-constructed drawings and operation and maintenance manuals.

13.3 Construction Planning

A construction plan has been prepared and serves as the basis for developing the Project and the project cost estimate. As described below, the plan addresses the following components required to complete the project:

- Site Facilities
- Construction Methods
- Construction Materials

13.4 Site Facilities

The proposed project site is upstream of khanpur Dam and is approximately 45 kilometer from Murree, about 45 kilometers from Hassan Abdal to Lora Chowk (about 10 kilometers from Haripur city on Karakoram Highway) and then 26 Kilometer to proposed project site

Land acquisition for the project construction and permanent structures (including the eventual transmission line) is an important activity for which surveys should be started well before the Notice to Proceed has been issued. The extent of land required for owner and contractor camps, offices, shops and storage facilities is significant and any delay in acquiring lands required for construction will impact the entire project schedule.

13.5 Construction Materials

Other than the steel needed for structure reinforcement and cement for concrete production, the principal construction materials required for the project are the fine and coarse aggregates needed for intake concrete structure,desanders,Power Channel,Forebay, Penstock and powerhouse infrastructure.

It appears that the nearest sources of materials suitable for fine aggregates is Lawrancepur, located 105 km from the project site while for coarse aggregates the nearest source is Margalla, 110 km distant from the project. These indications represent a major logistical challenge for project construction, particularly the Weir for which Reinforced cement concrete requirements may exceed 13332 m^3.

Further investigation of closer sources is required.

13.6 Transportation to Project site

The access to the weir site is quite easy as only an existing track branching from Jabri-Kohala Road just before Jabri. Access to the Power Channel route is through Jabri-Nala Road and then through a four kilometre long jeepable tracks leading upto Village Pina.

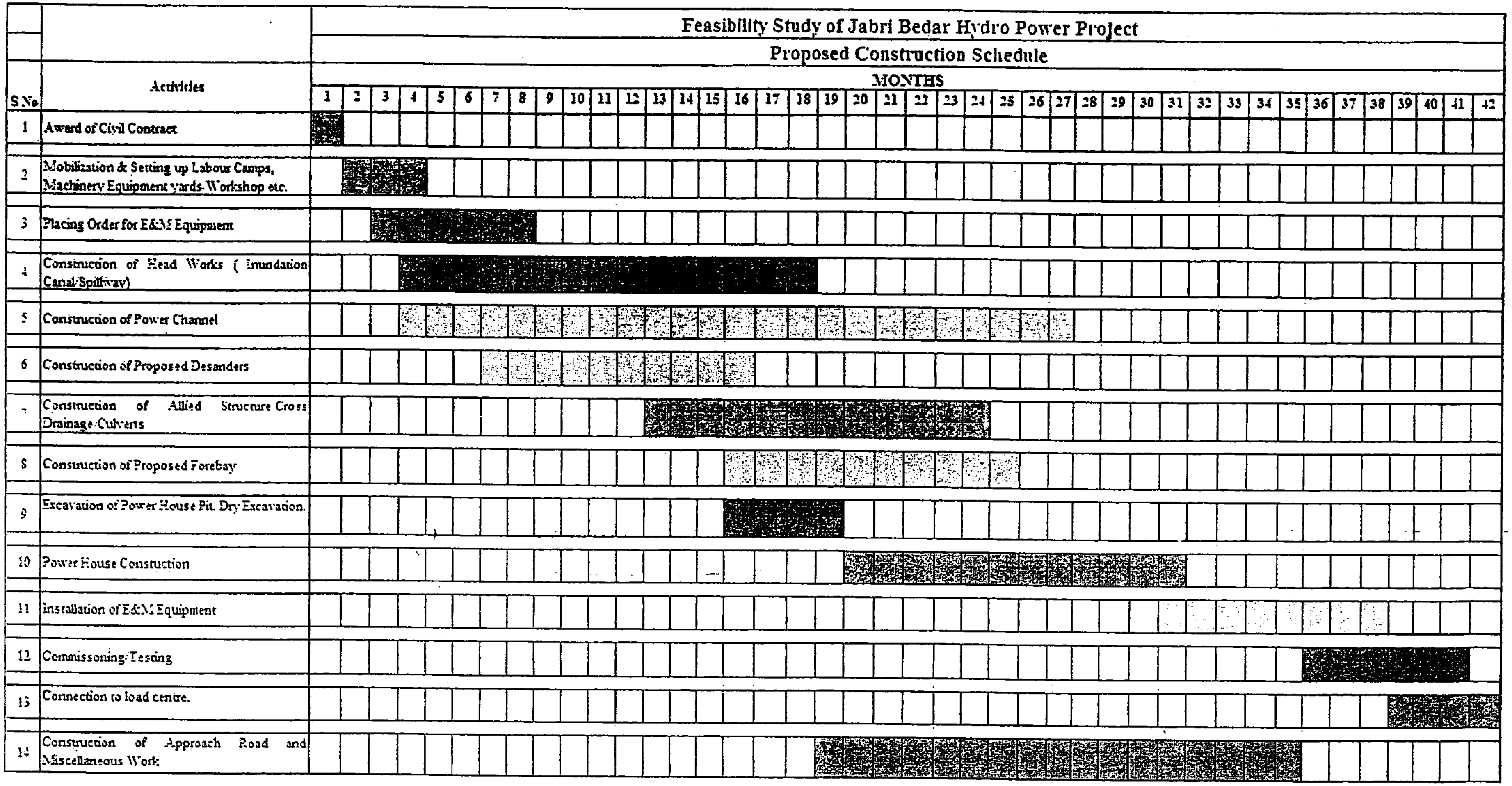
13.7 Project Schedule

As shown in Figure 13.1, the schedule includes a pre-construction period and the construction period. The pre-construction or project development schedule includes the major activities leading up to the award of contracts. Key activities include completion of additional studies and investigations, as required, financing negotiations and environmental approvals. Preparation and tendering of contracts is included with this project development schedule. It is foreseen that the Project financing process will be completed by March, 2013.

The project construction schedule is broken down into the major work packages that are grouped according to structure, such as the dam and river diversion, the power tunnels, the surge tanks and penstocks and the powerhouse complex civil works. The schedule was developed by estimating the sequence of the detailed activities for each work package and the duration of tasks using average production rates based on the scope of the work.

The overall construction period from Notice to Proceed to commercial operation of the first unit is expected to be approximately 42 months. The start-up and duration of testing and commissioning is estimated to be about Two months for each unit. Testing can begin once the Weir is finished and the hydraulic circuit is complete. The start of commercial operation is estimated to be around 42nd month of construction, following commissioning of the first unit. It is expected that the entire power plant will be fully operational by 42nd month.

Figure 13-8 : Project Schedule



14 FINANCIAL ANALYSIS

14.1 FINANCIAL STRUCTURE AND ANALYSIS

A financial analysis is usually undertaken in order to evaluate the cost and benefit brought about by a project to all the stakeholders. This section of the report covers the financial analysis of the project. The detail of financial structure and analysis of approx. 3.6 MW Jabri Bedar Hydropower project is given in the subsequent sections.

14.2 Cost Estimate

The estimated investment of the plant is presented in **Table 14-1**. PKR/USD exchange rate of 92 has been assumed.

The EPC contract covers the supply and transportation of all electrical and mechanical components of the power plant together with all the necessary auxiliary machinery, equipment and systems including the erection, testing and commissioning of these equipment and Civil works. The EPC price of the power plant is based on a budgetary turn-key proposal.

Table 14-1: Project Cost Estimâtes

Item	USD Million (1 USD = 92 PKR)
EPC Cost	
Civil Works	5.068
Hydro & Electro Mechanical Works	1.953
General & Preparatory Works	1.430
Transportation & Port Clearances	0.098
Sub-Total	8.549
Project Development & Other Cost	
O&M Mobilization	0.136
Engineering & Supervision-Owner Engineers	0.273
Engineering & Supervision-Owner Advisors	0.273
Engineering & Supervision-Lenders Advisor & Agents	0.273
Owner Administration & Overhead	0.681

Insurance during construction	0.205
Legal Fee and Charges & Taxes	0.569
Land Acquisition and Resettlement	0.267
Custom Duty and FED	0.137
Withholding tax on local EPC Works	0.000
Environment & Ecology	0.218
Contingency (Civil & E&M)	0.000
Sub-Total	**3.032**
Project Investment Cost	11.580
Financial Charges	0.278
Base Project Cost	11.858
Interest During Construction	0.530
Total Project Cost	**12.388**

14.3 Break Up of Project Cost

Following are the breakup of Project cost estimates

- **EPC COST**

i) Budgetary EPC cost has been obtained from various EPC contractors. ***However, the EPC cost may need to be adjusted after final negotiations with EPC contractor and award of contract.***

ii) The cost covers the following:

- **Civil Works:** Consists of cost of diversion weir, approach channel, spillway, desander, head race, tail race, and power house building etc. the cost of civil work is estimated as 5.07 million US$ which will be finalized upon selection of EPC contractor.
- **Hydro & Electro Mechanical Equipment:** US$1.953 million cost have been estimated for E & M, the cost component of power plant includes inlet valve, turbine, draft tube, gates, generator, control and protection equipment and substation for transformation of power to the transmission line.
- **General &Preparatory** Work comprises of camps and temporary facilities with all utilities access road, clearing and grubbing, stripping, mobilization and demobilization costs. The detail of the estimation is provided in the below **Table 14.2.**

Table 14-2

Sr. No.	Items	Amount (PKR Million)	Amount (US$ Million)
I.	General & Preparatory Works	131.65	1.43
	Temporary Works & Facilities	13.16	0.143
	Permanent Works & Facilities	73.14	0.795
	EPC Engineering& Design Cost	12.97	0.141
	Contractor Establishment Cost	32.38	0.352

- **Transportation & Port Clearances:** All of the electro-mechanical equipment including turbines and generators are to be imported. These materials are to be shipped from the country of its manufacturer and special arrangements for its inland transportation are to be made. The cost of freight, shipment and insurance etc. from the country of manufacturer has been taken as 5% of E&M equipment, which is estimated as US$ 0.10 million.

■ **PROJECT DEVELOPMENT COST:**

- **O & M Mobilization** It is planned that for operation and maintenance a contractor will be hired and this is a normal practice for any IPP. The O&M contractor is to be mobilized during construction of the plant so that they are familiarized with the plant. It is understood that plant's O&M will have to be paid a mobilization advance. It is estimated that they will charged about 0.14 US$ million as an advance.

- **Project Engineering &Supervision.** The cost of Engineering & Supervision includes cost of Owner's Engineer, Owner's Advisor and Lenders' advisors and agents and was reasonably estimated about 0.818 US$ million. The Sponsor also understand that Engineering design cost component is essential and will be borne by the Project whether it is borne directly by the Sponsor or it is made part of the EPC Cost.

- **Owner Administration & Overhead** The Owner's administration cost includes salaries, wages, utilities, vehicles, travel and conveyance, office supplies, rent and rates, medical, insurance, depreciation, Auditor's remunerations, amortization, lease rentals, inventory, computer software, site office expenses for the owner as well as lenders. The estimate cost worked out is about 0.681 US$ million.

- **Insurance DuringConstruction**The cost of insurance during construction has been accounted for keep in view the construction period, geographical situation including but not limited to seismicity and law & order situation in Pakistan. The cost is taken at 2.4 % of the EPC cost which is the estimation made on the allowed percentage to the other hydropower projects. The hydropower projects are exposed to higher construction risks because of long construction period compared with solar or thermal projects.
- **Legal Fee, Charges & Taxes** This estimated cost is 0.569 million US$ which includes the government licensing fee for the Tariff approval and generation license as per NEPRA standards, procedures, and EPA fee for the approval of IEE and lawyer fee for Implementation agreement (IA), Power Purchase Agreement (PPA), EPC &OM contracts.
- **Interest during Construction (IDC)** The IDC is an integral part of the project cost. This is calculated based on the anticipated interest rates, equity injections, and construction payment schedule. This is also capitalized.
- **Land Acquisition & Resettlement** Land purchase cost covers the payment of the cost of land to the owner of the land/property along with stamp duty and registration fees, the fees of the lawyers, as well as the cost of fill to level the site for construction purposes. It also includes cost of boundary walls and access roads etc. The cost under this head is estimated about 0.267 million US$.
- **Custom Duty and FED** Import duties inclusive of custom duties have been calculated based on energy policy 2002. This includes custom duties for each imported equipment and material. The total duties at a rate of 7% of the imported equipment and material have been added to the estimates, which is US$ 0.14 million.
- **Environment & Ecology** Major bases of environment mitigation cost are for the measures taken at pre-construction and construction stages. The main components covered under this head are temporary

relocation cost and compensation paid to the private land owners, compensation for the loss to forest trees, water supply provision costs, costs or disposal of excavated material, channel lining cost and afforestation cost, etc. the cost worked out under the head is US$ 0.22 million.

- **Financing Charges and Fees** This includes the up-front fee, commitment fee, lenders' consultant's fee, L/C charges etc. It is assumed that local funding would be available for the project, in case of foreign funding additional financing cost will be considered. The financing charges and fee is taken 3% of total debt.

14.4 Financial Assumptions

As per standards, debt forms 80% of the total project cost. Interest rate for debt is based on annual average of LIBOR/ KIBOR, with some premium, which is normally 3% over and above the interbank rates. The same has been assumed in the tariff model. However, the actual interest rate shall be adjusted at the time of financial close. The IRR on equity has been assumed as 20% which is normally allowed by the regulator. Discount rate for the purpose of computation of levelized tariff as provided by NEPRA and has been applied. Details are given in **Table 14-3.**

14.5 Technical Assumptions

The plant operation is guaranteed round the clock for 335 days a year and the remaining 30 days cater for routine and emergency plant shutdowns. Annual energy output is computed based on these figures.

14.6 Components of Tariff

Under the policy two parts tariff are to be proposed by project proponent. These includes capacity purchase price (CPP) and energy purchase price (EPP). Whereas the EPP includes variable O&M cost; the CPP includes all capital expenditure, Fixed O&M cost, ROE, ROEDC, interest charges etc. However such cost cannot be finalized till the finalization of EPC cost. Therefore these numbers of cost components are subject to change on finalization of different activities.

Table 14-3: Data for Tarrif Computation

Plant Price EPC US$ Million	8.55
Financial Assumptions	
Debt	80%
Equity	20%
Six Month KIBOR	10.45%
Spread	3.00%
LIBOR	0.50%
Spread	3.00%
Equity IRR	20%
Discount Rate	10%
Financing Fee	3.00%
Insurance	2.45%
Variable O & M US$ M/year	0.012
Fixed O & M US$ M/year	0.225
Plant Capacity MW (net)	3.4
Hours Run	24
Days Guaranteed	365
Exchange Rate	
Rs/US$	92

14.7 Variable O & M rate

Variable O& M component caters the cost of the services of the O&M operator, contractors' and replacement of spare parts on completion of their service life as well as replacement on account of premature failure of the parts. It also Includes cost of maintenance for unscheduled/unforeseen outages and consumption of lubricants, chemicals etc

- **Fixed O & M**

iii) Fixed O&M consists primarily of plant operating labor, number of employees working on the plant and their monthly salaries and all other fixed cost. Detail is provided at

14.8 Capital Structure

The debt and equity component is computed as 80:20 in the tariff model (**Table 14-4**) as provided in the policy.

Table 14-4: Capital Structure

CAPITAL STRUCURE		
Equity	US$ (M)	2.48
Debt	US $ (M)	9.91
Total Project Cost	**US $ (M)**	**12.39**

14.9 CAPEX Disbursement

The CAPEX disbursement is based on the assumption of 30 months COD period. The percentage disbursement of different components of CAPEX will change as per EPC contracts.

Initial expenditure is met through equity disbursement. The ROE during construction is computed on each disbursement and becomes the equity contribution at the end of COD. Interest during construction is also computed on each disbursement and capitalized. The financing fee for the purpose of this model is assumed to be applicable on every loan disbursement.

14.10 Debt Servicing Schedule

Debt service schedule is spread over a perlod of 12 years with equal installments computed on quarterly basis. Mark-up is computed as per financial assumptions using annuity method. The interest charges are also computed per kWh to be used as a fixed charge for tariff computation. The Debt Servicing Schedule is provided in **Table 14-5.**

14.11 Equity Repayment

Return on equity is computed in two parts A) Return on equity during construction, which becomes the part of equity contribution at the end of construction and B) Return on equity during tariff period. Return on equity and ROE during construction are also worked out per kWh for the purpose of fixed cost in tariff computation.

Table 14-5: Debt Servicing Schedule

Year	Foreign Bank		Local Bank		Total	
	Principal	Interest	Principal	Interest	Principal	Interest
1	0.603	0.301	0.039	0.143	0.64239	0.44455
2	0.625	0.280	0.045	0.138	0.669	0.418
3	0.647	0.258	0.051	0.131	0.698	0.389
4	0.670	0.235	0.058	0.124	0.728	0.359
5	0.693	0.211	0.067	0.116	0.760	0.327
6	0.718	0.186	0.076	0.107	0.794	0.293
7	0.743	0.161	0.087	0.096	0.830	0.257
8	0.770	0.135	0.099	0.084	0.869	0.218
9	0.797	0.107	0.113	0.069	0.910	0.177
10	0.825	0.079	0.129	0.053	0.954	0.133
11	0.855	0.050	0.147	0.035	1.002	0.085
12	0.885	0.019	0.168	0.014	1.053	0.034
Total	8.830	2.022	1.080	1.111	9.91062	3.133

14.12 Operating Costs

Operating costs include fixed and variable cost and are calculated based on financial and technical assumptions. The fixed costs include Operating Insurance, Fixed O&M and Cost of Working Capital. Variable costs include only Variable O&M. Per unit costs (Rs/kWh) have been computed based on dependable capacity – the maximum possible energy the plant can deliver per annum.**Table 14.6**

Table 14.6 Operating Cost

Item	Unit	Value
Plant Capacity net	MW	3.4
Plant Factor	%	58.73%
Hours/Day		24
Days		365
Electrical out put at 100% plant factor	MWh	29,784
Net Electrical Output 58.73% plant factor	MWh	17,492
Variable O&M Cost	Rs/kWh	0.062
Fixed O&M Cost	Rs/kWh	1.184
Operating Insurance 1.35%	%	1.35%
Annual Insurance Cost	$	0.1154
	Rs	10.616
	Rs/kWh	0.607

14.13 Tariff

Tariff is computed as a two part-variable (Energy Purchase Price; EPP) and fixed charge (Capacity Purchase Price; CPP) (**Table 14-9**). Variable O&M which is a very small part of overall tariffs has been made the part of variable portion (Energy Purchase Price). The capacity charge (Capacity Purchase Price) includes:

- Fixed O&M
- Operating Insurance
- Return on Equity during Construction
- Return on Equity
- Withholding Tax on Dividends
- Loan repayment
- Interest Charges

- Water Use Charges
- Tariff is calculated based on net capacity of 3.4 MW

iv)

Gross Capacity	Auxiliary Consumption	Net Capacity
3.6 MW	0.2 MW	3.4 MW

v) Auxiliary Consumption

The plant will consume some power generated in house that includes power house own consumption in lighting and other facilities that includes various pumps, overhead crane etc. Out of this load in power house, major load will be of crane. Though the crane will not be operated in normal case but it will be counted in connected load. In addition the residential colony which is supposed to be part of the plant will have free electricity. It is estimated that about 200 KW will be consumed in the plant and residential colony. Details are as under:

vi)

Auxilary Consumption 200 KW	
Housing Consumption	150 KW
Power House Consumption	50 KW

Table 14-7 Breakup of Housing Consumption

Designation	No.	Consumption Per house	Total
Resident Engineer	1	25 KW	25 KW
Shift Supervisor	4	25 KW	60 KW
Technician (elect)	4	8 KW	32 KW
Technician (mech)	4	8 KW	32 KW
Total Consumption			150 KW

Fixed charges reflected in the tariff table are computed based on installed capacity as calculated in the respective tables discussed above. The total fixed charge is adjusted for 58.73 % plant factor to calculate the applicable tariff at calculated plant factor.

Tariff computed based on the assumptions indicated above shows that the tariff will be high in the first ten years after COD thereafter it reduces substantially. Initial high tariff allows enough cash for debt repayment during the first 10 years of the tariff period. The leveled tariff is computed using the discount rate as per financial assumptions. Average and levelized tariffs are also calculated separately for EPP and CPP at different periods i.e. 1-10 years, 11-20 years and 21-30 years for ready reference. Summarized position is at **Table 14-8**.

Table 14-8: Summary of Tariff

Tariff	**3.6 MW**	
	Rs/ kWh	**¢/kWh**
Average tariff (1-10) years	11.245	12.223
Average tariff for (11-20) years	6.759	7.347
Average tariff for (21-30) years	5.638	6.128
Levelized Tariff	**9.691**	**10.534**

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	Rs/ kWh	**¢/kWh**
Average tariff (1-10) years	11.245	12.223
Average tariff for (11-20) years	6.759	7.347
Average tariff for (21-30) years	5.638	6.128
Levelized Tariff	**9.691**	**10.534**

Table 14-9: Detailed Tariff

Reference Tariff Table

Period	Energy Purchase Price - (PKR/kWh)				Capacity Purchase Price (PKR/kW/Month)									Capacity Charge	Total Tariff	
	Water Use Charges	Variable O&M (Foreign)	Variable O&M (Local)	Total	Fixed O&M (Foreign)	Fixed O&M (Local)	Insurance	ROE	ROE DC	Withholding Tax	Loan Re-payment	Interest Charges	Total	PKR/kWh	PKR/ kWh	US ¢ per kWh
1	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,055.259	326.497	103.632	1,368.045	946.735	4,525.757	11.178	11.245	12.223
2	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,055.259	326.497	103.632	1,425.419	889.361	4,525.757	11.176	11.245	12.223
3	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,055.259	326.497	103.632	1,486.082	828.698	4,525.757	11.176	11.245	12.223
4	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,055.259	326.497	103.632	1,550.326	764.454	4,525.757	11.178	11.245	12.223
5	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,055.259	326.497	103.632	1,618.481	696.299	4,525.757	11.178	11.245	12.223
6	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,055.259	326.497	103.632	1,690.917	623.863	4,525.757	11.178	11.245	12.223
7	0.005	0.006	0.056	0.068	383.852	95.963	246.774	1,055.259	326.497	103.632	1,766.050	546.731	4,525.757	11.178	11.245	12.223
8	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,055.259	326.497	103.632	1,850.346	464.435	4,525.757	11.178	11.245	12.223
9	0.006	0.006	0.056	0.068	383.652	95.963	245.774	1,055.259	326.497	103.632	1,938.331	376.449	4,525.757	11.178	11.245	12.223
10	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,055.259	326.497	103.632	2,032.601	282.179	4,525.757	11.178	11.245	12.223
11	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,055.259	326.497	103.632	2,133.825	180.955	4,525.757	11.176	11.245	12.223
12	0.005	0.006	0.058	0.068	383.652	95.963	245.774	1,055.259	326.497	103.632	2,242.761	72.020	4,525.757	11.176	11.245	12.223
13	0.005	0.006	0.058	0.068	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
14	0.005	0.006	0.056	0.068	363.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
15	0.005	0.006	0.056	0.068	363.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.126
16	0.005	0.006	0.058	0.066	383.652	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.126
17	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.636	6.128
18	0.005	0.006	0.056	0.068	383.652	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
19	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
20	0.005	0.006	0.056	0.066	383.652	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
21	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
22	0.005	0.006	0.056	0.088	383.852	95.983	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
23	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
24	0.005	0.006	0.056	0.066	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
25	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.636	6.126
28	0.005	0.006	0.056	0.068	363.852	95.963	245.774	1,096.443	328.497	106.720	-	-	2,255.249	5.570	5.638	6.128
27	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
26	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.636	6.128
29	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.126
30	0.005	0.006	0.056	0.066	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.636	6.126
Average & Levelized Tariff																
	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,055.259	326.497	103.632	1,672.860	641.920	4,525.757	11.176	11.245	12.223
	0.005	0.006	0.056	0.066	363.852	95.963	245.774	1,086.206	326.497	106.103	437.659	25.297	2,709.351	6.892	6.759	7.347
	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,096.443	326.497	106.720	-	-	2,255.249	5.570	5.638	6.128
	0.005	0.006	0.056	0.068	383.852	95.963	245.774	1,066.676	326.497	104.486	1,208.798	464.305	3,696.353	9.623	9.691	10.534

14.14 Financial Analysis

Financial analysis is done to evaluate the internal financial rate of return, benefit cost ratio and net present value at different discount rates on an overall basis. Following assumptions has been for financial analysis:

- The project cost portion includes all fixed costs (CPP) that comprises of WUC, fixed O&M cost, insurance, taxes etc. The Capacity Purchase Price (CPP) has been adjusted for 58.73% plant factor. Variable costs (EPP) associated with the dispatch is also included in cost portion.
- The project benefit portion includes CPP revenue fixed at 58.73% plant factor and EPP revenue linked with dispatch.
- The net benefit is the difference of CPP and EPP benefits.
- Discount rate of 10% has been assumed as stipulated in the policy
- NPV of total cost, benefits and net benefits has been calculated at 10% discount rate.

Results of financial analysis shows that the project carries **IFRR** of 10.61%. Detailed calculation is presented at **Table 14-10.**

The proposed project is first of its kind in the country as till now no such project has been implemented in the country, therefore the project is expected to yield **benefits of carbon credit**. The sponsor is committed to process the project for carbon credit. However its processing time is more than a year and revenue from CERs are not confirmed; therefore we have not included this in benefits of the project at this stage of time

Table 14-10: IFRR

FINANCIAL ANALYSIS 3.6 MW JABRI BEDAR HPP

Year	Project Cost	WUC	O&M	Insurance	Total Cost	Energy (GWh)	Total Benefits	Net Benefits
-3	227.976		-		227.976	-	-	(227.976)
-2	341.964		-		341.964	-	-	(341.964)
-1	569.940		-		569.940	-	-	(569.940)
1	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
2	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
3	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
4	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
5	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
6	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
7	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
8	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
9	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
10	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
11	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
12	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
13	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
14	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
15	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
16	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
17	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
18	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
19	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
20	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
21	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
22	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
23	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
24	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
25	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
26	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
27	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
28	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
29	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
30	-	0.091	21.822	10.610	32.523	17.492	169.393	136.869
Total	1,139.880	2.730	654.672	318.300	2,115.582	524.760	5,081.776	2,966.194

Present Work of Benefits @10% million PKR	1513.83
Present Work of Costs @10% million PKR	1247.36
Net Present Worth	266.47
Benefit Cost Ratio	1.21
EIRR	10.61%

14.15 Income Statement

The project income statement is prepared for the whole tariff period of 30 years. The net revenue is the sum of the net EPP and CPP revenues from the gross sales in the income statement. The variable (EPP) costs are treated as costs of sales and fixed costs (CPP) are taken as operating expenses. The financial charges include the interest on long term debt and short term borrowings fixed as working capital. The income statement confirms that the net income after tax is equal to 20% equity of IRR as guaranteed by the project.

14.16 Balance Sheet

The balance sheet is projected for the tariff period of 30 years. The fixed assets are reflected in the cost and net of accumulated depreciation.

It is assumed that all short term liabilities including current maturities of long term debt, financial charges on debt and short term borrowings, insurance, fixed O&M, tax and dividends are paid as and when they are due. The principal short term debt held as working capital is the only short term liability reflected in the balance sheet. The long term liability is the balance portion of debt for each year until it is completely retired in the tenth year. Equity is reflected after incorporating the ROEDC in the first and subsequent year of operation. As the total working capital is financed, the net working capital reflected in the balance sheet is zero and the difference of current assets and current liabilities is the reported cash.

14.17 Cash Flow Statement

Projected cash flows statement is prepared for the tariff period using a direct method composed of sources and application of funds. The cash received from the customers is the gross income reflected in the income statement minus the receivables. The funds from the financing activities include the debt and equity disbursement during construction. ROEDC is taken as source of funds and reflected as change in equity in the first year of operation. Short term borrowing to be used as working capital is also a source of fund.

Application of funds include cash outflows to meet all current liabilities like debt installment, interest charges on long and short term debt, dividends, fixed O&M, insurance and tax. The payment for fuel inventory and advance for fuel is also treated as funds application. The difference of sources and application of funds give cash surplus/deficit, which is added to the cash value at the end of proceeding to compute the net cash at the end of each year and resulting value is reflected in the balance sheet.

14.18 Ratios

The ratios have been computed to gauge the liquidity and leverage position during the tariff period of 30 years. The profitability ratios are not relevant as the net profit is fixed and guaranteed in the model.

- **Current Ratio:** The current ratio is less than unity during ninth to twelfth year of operation primarily because of cash utilized in debt retirement. However, it consistently remains above unity before and after this period showing strong liquidity position.
- **Quick Ratio:** This reflects conservative liquidity position and shows that the current liabilities cannot be met through cash and accounts receivables up to the sixteenth year of operation. This is also primarily because of cash used up in debt retirement in the initial periods.
- **Cash Ratio:** It is the most conservative liquidity test and indicates that cash alone will be enough to meet the current liabilities from the nineteenth year of operation and onwards.
- **Debt to Total Asset Ratio:** It is an indicator of how the assets cover debt in the long run. The lower the value of the ratio, the better is the coverage. The ratio starts high, increases further until the fourth year and then drops and becomes constant after the debt retirement period. However, the ratio is consistently less than one meaning that the assets give fairly good coverage to the debt.
- **Long Term Debt to Equity Ratio:** This is the indicator of long term debt paying ability and how well the creditors are protected in case of bankruptcy. The lower this ratio, the better is the debt position. The ratio is higher in the initial years of operation but decreases as the debt is retired. It is zero after debt retirement indicating no debt paying crisis.
- **Times Interest Earned Ratio:** It is also an indicator of long term debt paying ability from the income statement view. It indicates how well the firm can meet its interest obligations. The higher the value, the better is the interest coverage through income. The ratio always remains more than unity and increase in the later operation years, which indicates that interest is covered satisfactorily.

15 CONCLUSIONS AND RECOMMENDATIONS

15.1 Conclusions

- The Sponsor has proposed Jabri Bedar Hydroelectric Project on the Haro River in District Haripur KPK, Pakistan that would have an installed capacity of 3.6 MW and would generate 18.129 GWh annually.
- The concession of the project starts just downstream of Jabri Bridge on Lora-Kohala Link also called Murree-Haripur Link and covers a stretch of about 10 kilometers of River reach upto Village Sari Baang
- The intake is an inundation canal for diversion of flow to the power channel. Construction of a large weir structure is not feasible considering the size of the project and the type of intake selected is quite successful for such projects already in operation in the region. The intake sill level is 809.35 m.
- The Project area lies in the Hazara Thrust fault System. The Margala hill ranges are traversed by a system of nearly parallel northeast/southwest trending faults. These faults join the Himalayan thrust along a syntexial bend towards northeast and Kirthar, Suleiman fault zone, towards southwest. Preliminary designs prepared for the comparison of alternative diversion sites and structures have used a seismic acceleration coefficient of 0.25 g.
- Environment Impact assessment studies show that the project is expected to have an overall beneficial effect on the economy, infrastructure, and public health in the area. The potential construction impacts would be temporary in nature
- The project implementation period, from notice to proceed to commercial operations, should not exceed five years. Excluding the interest during construction, the total project cost including environmental monitoring and resettlement is estimated to be 10.12 Million PKR (May-2012).

15.2 Recommendations

Preparatory activities for project implementation should be taken up as soon as this report has been approved by the concerned authorities. These activities should include:

- Supplementary topographic surveys covering all project elements (i.e. main project structures plus reservoir, highway bypass tunnel, required construction camp and spoil disposal areas) for purposes of detailed planning and land acquisition;
- Supplementary geological and geotechnical investigations;
- Supplementary Environmental Surveys, as required;
- Construction Permit and Approval Applications for the project and associated transmission line from all concerned authorities;
- Preparation of tender documents for all main civil and M&E packages in support of capital cost estimates and determination of project financing requirements.