

PAKHTUNKHWA HYDEL DEVELOPMENT ORGANIZATION
GOVERNMENT OF KHYBER PAKHTUNKHWA



300 MW BALAKOT HYDROPOWER PROJECT



FEASIBILITY STUDY REPORT
EXECUTIVE SUMMARY

December, 2013

Balakot Hydropower Consultants:

MRES Mirza Associates Engineering Services (Pvt) Ltd.

ILF ILF Beratende Ingenieure ZT GmbH, Austria

BA Berkeley Associates

Sub-Consultants:

ILF Pakistan (Pvt) Ltd. ESUPAK, UET, Lahore NCEG, Peshawar HEC Peshawar

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EXECUTIVE SUMMARY

1 INTRODUCTION

Balakot Hydropower Project (HPP) is one of the series of hydropower development projects launched by PHYDO (Pakhtunkhwa Hydrel Development Organization), Government of Pakhtunkhwa (KP). The objective of the proposed hydropower scheme is to generate and add cheap energy to the system in order to meet the current shortfall and increasing demand of electricity in the region through economical and sustainable means.

Montreal Engineering Company (MONENCO), a Canadian Consulting Engineering Organization, identified three hydropower projects on Kunhar River, namely Naran, Suki Kinari and Patrind in 1984. Balakot HPP was identified in 1995, under the study "Identification of Hydropower Potential in Kaghan Valley" by Sarhad Hydrel Development Organization (SHYDO) with the technical collaboration of the German Agency for Technical Cooperation (GTZ) as a 190 MW HPP. The project envisaged a 140 m high dam with a 4.5 km long intake tunnel and an underground powerhouse. The dam axis was, identified 9 km upstream of Balakot town, headrace tunnel on the left bank and the powerhouse near the confluence of Sangarh nullah with Kunhar River.

PHYDO carried out ICB in 2011 for the selection of Consultant to carry out detailed Feasibility Study of the Project. As a result of competitive bidding, the Consortium of Consultants led by Mirza Associates Engineering Services (Pvt.) Ltd. (MAES) and consisting of ILF Beratende Ingenieure ZT GmbH, Innsbruck, Austria and Berkeley Associates, Pakistan, had been selected for implementation of the Feasibility Study of Balakot HPP. The Consultants carried out services for eighteen months and prepared this bankable Feasibility Study Report of the Project.

The Study has resulted in a project size of 300 MW with an excellent economic rate of return. **Table -1** presents the salient features of the Project. Balakot dam and powerhouse have been proposed on the 9 km stretch of the intermediate part of 20 km reach of Kunhar River from Paras to Sangarh Village. The dam site on Kunhar River is 03 kilometer downstream of Paras village, and 17 km upstream of Balakot town main bridge. The powerhouse is to be located on the left bank of Sangarh nullah confluence with Kunhar River, 1 km upstream of Dabrain village and 8 km upstream of Balakot main bridge. The whole project layout including the headrace tunnel is proposed on the left bank of Kunhar River. **(Drawing BLK-CS-GEN-DWG-001).**

Table - 1: Salient Features of the Project

HYDROLOGY (DESIGN FLOWS)	
Catchment area at dam site	1952 km ²
Mean annual flows	87.3 m ³ /s
Design discharge	154 m ³ /s
Design flood (10,000 Year Flood)	5312 m ³ /s
Probable maximum flood	5702 m ³ /s
Maximum flood level	1290 m.a.s.l

RESERVOIR	
Reservoir length	4,500 m
Reservoir area	0.555 km ²
Max. reservoir operating level	1288 m.a.s.l
Min. reservoir operating level	1283 m.a.s.l
Reservoir capacity at 1288 m.a.s.l	12.606 MCM
Reservoir capacity at 1283 m.a.s.l	10.040 MCM
DAM STRUCTURE	
Dam height above riverbed and Foundation level	78 m, 24 m
Dam crest level and length	1293 m.a.s.l, 250 m
Dam Type	Concrete gravity
DIVERSION TUNNEL	
Length of diversion tunnel	400 m
Size of tunnel (W x H)	10 x 12 m
SPILLWAY	
Gated surface spillway	
Number and type of gates	5 (Five), Radial gate
Gate Size	10.5 m x 12 m
Discharge capacity	5745 m ³ /s
Spillway crest / sill level	1276.0 m.a.s.l
LOW LEVEL OUTLETS/ FLUSHING SLUICES	
No. of outlets	3 (Three)
Gate type	Vertical lift gate
Gate size (W x H)	4 x 5 m
Discharge capacity	1721 m ³ /s
Sill level of flushing sluices	1217.0 m a s l
POWER WATERWAYS	
POWER INTAKE	
Type	Lateral intake
No. of gates	1 (one)
Gate size (W x H)	8 x 8 m
Deck elevation	1293.0 m.a.s.l
Sill level of intake racks	1264.0 m.a.s.l
LOW PRESSURE HEADRACE TUNNEL	
Diameter	8.0 m
Length	8420 m
SURGE SHAFT	
Diameter	12 m
Height	80 m

PRESSURE SHAFT (STEEL LINED)	
Diameter	5.6 m
Length	200 m
PENSTOCKS	
No. of penstocks	4 (Four)
Diameter	2.8 m
Total Length of 4 penstocks (20 m each)	80 m
POWER GENERATION	
Gross head	240.1 m
Installed plant capacity	300 MW
Mean annual energy (average 51 years.)	1187.2 GWh
Plant factor	45.2 % (Average year)
Turbine type	Francis, 333.33 rpm
No. of units	4 (Four)
No. of generators	4 (Four)
Powerhouse type	Underground cavern type
Powerhouse size (L x W x H)	(84 x 18 x 33.5) m
Transmission System	Indoor GIS
Transmission Voltage	500 kV
TAILRACE TUNNEL	
Diameter of tunnel	8.0 m
Length of tailrace tunnel	2075 m
COST ESTIMATES & ECONOMIC ANALYSIS	
Estimated cost	645.275 Million US \$
Discount rate	12 %
FIRR	6.44 %
Tariff	9.91 US Cents per kWh
B/C ratio	1.49

This Feasibility Study Report consists of a Main Report (Volume-1) and nine (9) supporting volumes. The Main Report consists of eighteen (18) sections completely covering all aspects of the Project at feasibility level, whereas the nine (9) volumes present details of the studies, field data, drawings and other required information related to different sections of the Main Report.

2 TOPOGRAPHIC AND HYDROGRAPHIC SURVEYS

For the preparation of a bankable Feasibility Study Report of international standard, a comprehensive topographic survey program was established and executed in the field by a qualified and experienced survey team of the Consultants.

The survey had been carried out in one uniform system of co-ordinates and elevations using S.O.P. Benchmark at Batrasi as datum. All survey work was then duly verified through GPS.

Following scales with contour interval of 2m have been adopted for the survey maps of the project:

I. Reservoir area, Headrace Tunnel / Channels, Access Roads	1:2000
II. Dam Site and Intake Area	1:500
III. Surge Tank, Pressure Tunnel/Penstock, Powerhouse and Tailrace	1:1000
IV. Project Layout	1:25,000

The terrestrial survey has been carried-out for the three (3) alternative project layouts conceived and selected for field work at the Inception Stage and covers all the above mentioned project components.

For the inaccessible areas of the tunnel alignments, topographic maps have been developed with the help of high resolution Digital Elevation Models (DEM), ortho-rectified with ground survey.

Hydrographic survey was carried out and longitudinal profiles of the relevant stretch of Kunhar River were prepared.

3 HYDROLOGY AND SEDIMENTATION STUDIES

The Project has a catchment area of 1952 Km² up to the dam site. Mean annual flows estimated for the Garhi Habibullah stream gauging station, dam site and powerhouse site are 102.3, 87.3 and 94.1 cumecs, respectively.

The recommended flood magnitudes corresponding to 10,000 year return period for the dam and powerhouse sites are computed as 5312 and 5745 cumecs, respectively. The computed PMF at the dam site is 5702 cumecs.

Average annual total sediment inflow to the dam site is 2.714 MCM (2201 AF). Average annual trapped sediment load at the dam site is 1.1 MCM (892 AF). Optimum discharge to carryout efficient flushing of the reservoir is computed as 150 to 350 cumecs, with flushing duration of 11.25 to 2.5 days, depending on the flow available and amount of deposited sediments. The life of the reservoir can be enhanced to about 40 years with appropriate flushing operations once a year during June or July, and annual monitoring of sediment delta. Construction of Suki Kinari reservoir would further extend the life of Balakot reservoir from 40 to 50 years. Further enhancement in life of reservoir can be achieved, by adopting appropriate watershed management measures.

Dam breach analyses for PMF shows that the generated flood peaks between the dam and powerhouse sites indicate no chances of flooding of the downstream settlements.

4 NEO-TECTONIC AND SEISMIC HAZARD ANALYSES

The region encompassing the Balakot HPP is highly complex in terms of its tectonic set up.

The estimated seismic hazards in terms of peak ground acceleration (PGA) with 10% probability of exceedance in 50 years i.e., 475 year return period as

computed by different workers for Kaghan, range between 0.09 and 0.7 with the recommended value as 0.38.

Kashmir Earthquake (2005) of M 7.6 was the major event in Kaghan valley. This earthquake generated very high isoseismal MMI intensities of XI at Balakot, while intensities as high as VII were recorded near Naran and VI at Batakundi.

Based on the standard MMI to PGA conversion models, the intensities generated by this earthquake yield PGAs of 0.8-0.9 for the project site.

4.1 Seismic Design Parameters Based on Deterministic Seismic Hazard Assessment (DSHA) Approach

According to ICOLD (2010), DSHA is used for assessment of Maximum Credible Earthquake (MCE), and PGA values for both 50-percentile (median) and 84-percentile (mean plus one standard deviation) are listed.

For the dam site, at GMPE with 84-percentile value, seven of 12 identified faults are capable of generating PGA >0.5g. The maximum PGA is expected from Panjal Fault (Segment 4) that passes close to the dam site with a value of 0.71g.

For the powerhouse site, at GMPE with 84-percentile value, 5 of 12 faults (Balakot-Bagh Fault, Panjal Fault VI, Kaghan Fault, Indus-Kohistan Seismic Zone, and Combined Balakot-Bagh-Indus Kohistan Seismic Zone) generate PGAs > 0.7g, which is close to PGA generated by the Balakot-Bagh Fault in the M 7.6 2005 Kashmir Earthquake. Therefore, for the Project, MCE is defined by a ground motion of 0.79g.

4.2 Seismic Design Parameters Based on Probabilistic Seismic Hazard Assessment (PSHA) Approach

Ground motion parameters for return periods from 200 to 10,000 years for appropriate selection as the MDE design parameters corresponding to PGAs of 0.24 to 0.74g for the dam and 0.24-0.73g for the powerhouse have been included. However, considering the seismic history of the Balakot area, it is recommended that the ground-motion parameters for the MDE may be selected for 1000 year return period as a minimum and 10,000 year as the maximum.

The OBE may be expected to occur during the lifetime of the structure. No damage or loss of service is allowed. It has a probability of occurrence of about 50% during the service life of 100 years. The return period is taken as 145 years (ICOLD 2010). The OBE ground motion parameters are estimated based on PSHA. For the Project 150 year return period has been recommended for selection of the OBE ground-motion parameters, which corresponds to 0.24g for the project.

5 GEOLOGICAL AND GEOTECHNICAL STUDIES

The field work for the Project comprised surface geological mapping including scan line surveys, geophysical survey using seismic refraction method, drilling of boreholes, coring and logging, performance of permeability and water pressure tests and excavation of test pits at potential construction material sources.

A total of 20 scan line surveys and 7 profiles of seismic refraction survey, were carried out at the dam/ intake area, headrace tunnel, powerhouse etc.

For collection of the soil/ rock samples and to perform in-situ tests, 22 boreholes were drilled at the proposed structure locations, with total drilling depth of 2768 m.

Test pits were also excavated at various structure locations for verification of the extent of overburden and physical inspection of its nature at the site. Some other pits were excavated in prospective borrow areas for evaluation of the construction materials i.e. coarse as well as fine aggregate, and cohesive material.

Suitability of the potential construction material sources has been examined through laboratory testing of representative samples.

The project area is located in rocks belonging to Murree Formation of early Miocene age, which consists of sandstone and siltstone, mudstone/shales and lenses of conglomerates. These rocks are exposed at the dam and powerhouse areas in alternate beds. Structurally, the formation shows a high degree of compression in the form of tight folding with repeated faulting and fracturing.

On the basis of observed RQD values, the bedrock can be classified as "Very Poor to Excellent" with a very wide range of core recovery from 0 % to 99 %.

In the light of data collected and analyses carried out, the rock mass design parameters were determined for various components of the project, and used for evaluating the stability as well as foundation design parameters for the various structures. For the underground structures i.e. headrace tunnel, surge shaft, powerhouse caverns and tailrace tunnel, stability analyses and design of support systems have been carried out.

6 DESIGN CRITERIA (CIVIL, ELECTRICAL AND MECHANICAL)

A design criteria is necessary for setting out the guidelines/ basis of all designs and field operations necessary for preparing the Feasibility Report. The design criteria document for Civil, Electrical and Mechanical works has been prepared, which covered all the aspects of design and field operations.

7 PROJECT LAYOUT STUDIES

The Consultants identified two alternative dam sites in addition to the previously identified site by PHYDO/GTZ (**Drawing BLK-GE-DWG-001**). Based on the parameters for screening viz: good topographical, hydrological and geological conditions and minimal environmental issue etc, the dam site selected is located 2 km upstream of Kewai nullah confluence. At the selected dam site, the valley sections are narrow at the upstream cofferdam, downstream cofferdam, diversion tunnel, main dam, plunge pool and power intake area.

Two powerhouse sites (P-1B, P-1C) in addition to and in close vicinity of the site identified by PHYDO/GTZ were investigated, which indicated poor geological structure along the depth, and were rejected as unsuitable for underground powerhouse. An alternative powerhouse site P-2 some 2.5 km upstream of Sangarh village was found to have better geological structure for the surge tank, pressure shaft and the underground powerhouse. Necessary investigations were conducted to confirm the location of the underground structure at the powerhouse.

The selected layout has relatively smaller dam, longer tunnel and a reservoir with adequate storage for daily peaking.

8 PROJECT SIZING AND POWER POTENTIAL STUDIES

For the selected Project layout, project sizing i.e., optimization of the type of plant and its capacity, fixing of maximum reservoir level and diameters of the headrace tunnel and shaft have been performed.

The sizing/optimization of the plant and reservoir level was done using design discharge values ranging from 90 to 194 cumecs at incremental intervals of 8cumecs. For each discharge, preliminary cost of the project was estimated and power/ energy calculations were performed. Corresponding net present value (NPV) calculations were also performed, and the highest NPV value was the deciding factor of the sizing/optimization process.

For optimization of the diameters of headrace tunnel and pressure shaft, different diameters were considered, and the construction cost for the total length of tunnel/shaft calculated. Further, the cost of loss of energy due to hydraulic losses was estimated. Then, both costs i.e. construction and energy losses costs were summed up, and the diameter having the lowest sum of costs was taken as the optimum.

The headrace tunnel and partially steel lined pressure shaft have been optimized as 8.0m and 5.6m respectively.

For optimization of plant capacity run-of-the river and peaking options were evaluated and sensitivity analysis performed. It was found that 4-hour peaking with design discharge of 154 cumecs and plant capacity of 300 MW will be the optimum. The maximum and minimum reservoir levels were optimized as 1288.0 and 1283.0 m.a.s.l.

With the above optimized reservoir levels, the power and energy estimations of the project have been performed with the following basic assumptions:

- a. The residual flows in the Kunhar River, during the low flow period, have been taken as 1.50 cumecs in winter and 3.0 cumecs in summer.
- b. For the design discharge available to the powerhouse, efficiencies of 91.0%, 97.0% and 99% have been used for the turbines, generators and transformers respectively.
- c. The head loss has been considered as 13.09 m to estimate net head at the turbines for the discharge of 154 cumecs
- d. Sediment flushing is to be carried out every year during the summer months, when discharge is above 154 cumecs.
- e. During the low flow periods, the live storage is used to store water during off peak hours to improve the flows for power generation in peak hours. It has been estimated that 2.566 million m³ storage would provide additional flows in 4 peak hours.
- f. Energy is calculated for the years 1960-2010 on 10-daily basis. The tailwater elevation varies from 1047.0 to 1055.0 m.a.s.l, and the net head varies between 225.1 to 234.0 m with an average value of 227.4m. For the design discharge of 154 cumecs and net head of 227.4 m, the optimum installed capacity would be 300 MW with average mean annual energy of 1187.18 GWH, at a plant factor of 45.2%. The calculated annual

energy, for years 1998 (average year), 1992 (wet year) and 2001 (dry year), is 1212.38, 1653.12 and 743.64 GWh respectively.

9 DAM AND OTHER HYDRAULIC STRUCTURES

Hydraulic analysis and sizing of the Project structures, has been carried out to the feasibility level for the following structures:

- a. Main Dam
- b. Power intake structure on the left bank of the river
- c. Low pressure headrace tunnel
- d. Surge tank
- e. Steel lined vertical pressure shaft
- f. High pressure tunnel/penstocks
- g. Underground powerhouse with transformer cavern.
- h. Free flow tailrace tunnel

9.1 Main Dam

A concrete gravity dam has been planned and designed to pass PMF flood of 5702 cumecs (**Drawing BLK-CS-GEN-DWG-012**). Five (5) overflow spillway bays, each having opening of 10.5 m height and 10 m width, equipped with hydraulically operated radial gates for flood discharge are set at the crest level of 1276 m.a.s.l. The dam crest (roadway/bridge deck) level is at El: 1293m.a.s.l. Three (3) circular bottom outlets of diameter 5.0 m will be provided near the riverbed with the bottom at El: 1217 m.a.s.l. for sediment flushing. The river bed level at dam axis is 1215 m.a.s.l. and the bedrock is encountered at EL. 1205 m.a.s.l. Height of the main dam from river bed is 78 m.

9.2 River Diversion Scheme

The river diversion works consist of the following components:

- a. Rock fill coffer dam with impervious core and crest level at 1230 m.a.s.l at the upstream side.
- b. Rock fill coffer dam with impervious core and crest level at 1227 m.a.s.l at the downstream side.
- c. A D-shaped diversion tunnel with arch section of 5 m radius and 393 m long.

9.3 Power Intake Structure

A 3-bay intake structure with trash racks has been proposed for passing the design discharge. A rectangular 8.0 m wide 8.0m high control gate equipped with upstream sealing has been provided.

9.4 Low Pressure Headrace Tunnel

Headrace tunnel has been optimized by considering different diameters for the design discharge with the following parameters:

- a. Manning- Stickler coefficient (shotcrete) 60
- b. Tunnel slope 0.11 %
- c. Shotcrete lining thickness 0.10–0.3 m (as per conditions)
- d. Concrete lining 0.3 m

The optimized dia. of low pressure headrace tunnel is 8.0 m and it is 8420 m long.

9.5 Vertical Shaft

Vertical shaft has been optimized with the following parameters:

Diameter	5.6m
Length	200 m

9.6 Pressure Tunnel

Pressure tunnel is partially steel lined and has the following dimensions.

Diameter	5.6m
Length	80 m

9.7 Tailrace Tunnel

The data of the main concrete lined tailrace tunnel is as follows:

Total Length	2075 m
Cross section type	'D' shaped
Width	8.0 m
Height	8.0 m

9.8 Head Losses in the Conduit System

The calculation results of the head loss of conduit system indicated that the total head loss in the conduit system is approx. 13.90 m.

9.9 Surge Tank

A circular surge tank having 12.0 m diameter has been provided at the end of low pressure headrace tunnel. The surge tank is 80.0 m deep starting from EL.1265 m.a.s.l. and rising up to EL.1345 m.a.s.l. at access opening. Surge tank diameter throttles to 6.0 m at the junction with headrace tunnel.

9.10 Power Complex

An underground powerhouse has been proposed comprising the following structures (**Drawing DGW-CS-GEN-DWG-013**):

- a. Underground Powerhouse Cavern
- b. GIS Transformer Cavern
- c. Main Access Tunnel
- d. Cable and Ventilation Tunnel
- e. Open Switchyard

The powerhouse cavern is 83.20 m long, 16.2 m wide and 25 m high from the main inlet valve floor to arch roof crown.

9.10.1 Multi Storied Transformer Cavern

The main features of the transformer hall cavern (L 83.2m x W 23.0m x H 12.8m) and the factors considered in the determination of the layout are:

- a. Single phase generator transformers (3 per unit, plus one spare) will be placed contained in separate fire-protected enclosure.
- b. Transformer transfer facility through rails starting from the unloading bay of powerhouse at El: 1054 m.a.s.l.
- c. Placement of GIS equipment,
- d. Facility for transfer of the power cable to cable tunnel.

9.10.2 Access Tunnel

The access tunnel is the main point of entry to the underground powerhouse complex. It is sized to accommodate two-way dump truck traffic during construction, and to provide the space needed to transport heavy equipment on low bay loaders or multi-wheeled transporters into the caverns. The largest items to be transported will be the generator transformers, the main inlet valves and the turbine spiral casing. A 'D' shaped access tunnel of 800 m length and size of 7.0 m width and 8.6 m height with a slope of 10 % is provided.

9.10.3 Cable and Ventilation Tunnel

The cables from transformer cavern are carried through a 4 m x 4 m cable tunnel up to the open switchyard (100 m x 50 m). This tunnel will also be used for ventilating transformer and powerhouse caverns. After construction of the powerhouse roof, the construction adit will be used to ventilate the powerhouse and connected with the cable tunnel.

10 POWER TRANSMISSION AND INTERCONNECTION STUDIES

The interconnection of the Project to evacuate power of 300 MW is envisaged and studied in detail as follows:

- a. According to National Power System Expansion Plan (NPSEP) of NTDC, a 500 kV double circuit (D/C) line will connect Suki Kinari HPP with Aliot S/S, a switching station located on the right bank of River Jhelum downstream of Neelum-Jhelum HPP, where Neelum-Jhelum HPP – Gujranwala S/S 500 kV D/C line will also be looped in-out.
- b. Balakot HPP will be connected by looping in-out one circuit of the D/C line of 500 kV from Suki Kinari HPP to Aliot that would be passing near the powerhouse of the project. The second circuit of 500 kV will connect Naran HPP to Aliot S/S.
- c. The proposed scheme for 500 kV switchyard has double bus-bars of 500 kV with 04 diameters of breaker-and-half scheme.

Detailed load flow, short circuit and transient stability studies have been conducted for the project peak load conditions of June 2020 for the interconnection scheme, as the plant is expected to be commissioned by the end of year 2019.

A load flow analysis reveals that the scheme is adequate to evacuate the maximum power of 300 MW under normal and N-1 contingency conditions.

The short circuit analysis shows that the short circuit levels of 500 kV are 19.57 kA and 15.88 kA for 3-phase and 1-phase faults respectively. Therefore, industry standard switchgear of the short circuit rating of 50 kA would be installed at 500 kV switchyard against sthughe fault current contribution from large future additions to be connected with the same 500 kV network such as Basha HPP.

The transient stability analysis of the proposed scheme of interconnection has been carried out. The stability check for the worst case of 3-phase fault right on the 500 kV bus bar of the substation followed by the final trip of 500 kV circuits emanating from this substation, has been performed for fault clearing of 5 cycles (100 ms), as understood to be the normal fault clearing time of 500 kV protection

system. The system has been found to be strong enough to stay stable and recovers with fast damping, and therefore passed the transient stability checks.

11 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT STUDIES

The broad objective of ESIA studies is to assess the beneficial and adverse impacts of the project implementation on the environment including physical, biological and socio-economic parameters and to mitigate the adverse impacts.

The Project area of the reservoir is under, agriculture, range land with a good number of forest and fruit trees, mixed shrubs and rough grasses.

There are no industries in and around the project area; therefore, noise pollution is generally below the EPA limit of 65 dB (A). The air quality in the area is also good.

The environmental and ecological water releases downstream of the dam will be 1.5 cumecs and 3.0 cumecs in winter and summer respectively. In addition to this, water ranging from 1.60 to 3.10 cumecs in winter and 5.3 to 18.5 cumecs in summer will also be added through the downstream streams and nullahs.

The flora existing in the Project as well as study areas falls under moist sub-tropical pine forests generally called Chir forests.

Fauna of the tract consists of mammals, reptiles, amphibians and birds. Some of the most colourful and beautiful fowls like Monal pheasants and Kaleej are found in the surrounding mountains.

Archaeological/ historical sites in the reservoir and powerhouse areas do not exist.

The population of the Project area is a mixture of Punjabi, Kashmiri and Pathan. The major language of project area is Hindko, while Urdu and English are also used by educated class of the area.

In the Project area, no proper medical facilities exist. Only one dispensary and some private medical stores are available in Paras village.

Majority (76%) of the female respondents do not take part in any activity except household chores and livelihood earning is the responsibility of males.

The reservoir of the Project will permanently occupy 127.5 acres of land. Out of this land, only 23 acre land is irrigated agricultural land whereas 31, 49.5 and 24 acres of land is grazing, barren and under infrastructure respectively. In addition, area of 10 acre will be occupied for residential colony near the powerhouse site.

In the reservoir area, 4663 trees (1642 forest and 3021 fruit) are being impacted. There will be no danger to large wildlife with the execution of the project as they live in forest areas, which are located at higher altitude.

There will be positive impact on the birds and the fowl communities as a suitable habitat will be formed for this community with the creation of the reservoir.

Construction of the project will result in the creation of job opportunities, better potential for business, transport and tourism development.

During construction, environmental monitoring will be done for air quality, noise and vibration, drinking water quality, sewage effluent, solid waste, explosive material used, hazardous/toxic materials and their proper disposal, flora/fauna, excavated material and traffic handling system etc.

Due to the construction of the project, 164 houses are being affected, which will require resettlement or compensation. In addition to this, 116 different types of commercial infrastructure is also being affected due to the reservoir.

All the owners of the land and land based assets will be resettled or compensated according to the D.C. rates or the rates assessed by the Committee constituted for this purpose by the D.C. The survey revealed that more than 71.4 % of the affectees favored cash compensation. A Grievance Redressal Committee (GRC) is proposed, which will look into all the grievance cases.

The project environmental and resettlement cost amounts to Rs.1100.8 million.

PHYDO will be responsible for the overall implementation of environmental mitigation measures and the RAP through its Project Director and field offices, with the collaboration of district government departments.

12 COST ESTIMATES

The cost estimates for the various works including Infrastructure Development and Site Installations, Civil, Hydro-Mechanical, Hydraulic Steel, Electrical & Substation have been prepared. These costs include estimates for Environmental Mitigation Program.

The unit and lump sum prices were adopted after doing the total cost rate analysis for various items, comparing and escalating the unit prices for certain items available from other on-going or recently completed similar projects. Table - 2 presents summary of cost estimates. These estimates do not include the financial Costs of US\$ 17.61 Million.

Table - 2: Summary of Cost Estimates

Sr. No	Description	Total CostM. US \$	Year 1	Year 2	Year 3	Year 4	Year 5
A	Infrastructure development, Mitigation and Preparatory works						
1	Mobilization and Demobilization	14.42	7.21	0	0	0	7.21
2	Infrastructure & Technical facilities including Access Roads, Water supply & Drainage and Power supply to Residential colonies at Dam and Powerhouse sites	7.21	7.21	0	0	0	0
3	Camps and Housing During Construction	9.38	9.38	0	0	0	0
4	Reservoir Slope Stabilization and Construction Difficulties costs	2.88	0.46	0.55	0.61	0.61	0.66
	Sub Total A	33.89	24.26	0.55	0.61	0.61	7.87
B	Civil Works						
1	Coffer Dams and Diversion Tunnel	11.17	6.7	4.02	0.44	0	0
2	Dam and Plunge pool Excavation	68.64	0	37.75	26.43	4.47	0
3	Power Intake	10.67	0	9.6	1.06	0	0
4	Low Pressure Headrace Tunnel	117.44	17.61	31.71	42.28	25.83	0
5	Surge Shaft	0.54	0	0.05	0.49	0	0

Sr. No	Description	Total CostM. US \$	Year 1	Year 2	Year 3	Year 4	Year 5
6	Pressure Shaft	1.32	0	0.13	1.19	0	0
7	High Pressure Tunnel	0.59	0	0	0	0.59	0
8	Penstocks	0.17	0	0	0	0.17	0
9	Powerhouse	25.16	0	16.35	8.81	0	0
10	Tailrace Tunnel	18.01	0	11.71	6.3	0	0
	Sub Total B	253.71	24.31	111.32	87	31.06	0
C	HSS, Mechanical and Electrical Works						
1	Hydraulic Steel Structures	23.76	0	4.75	10.69	8.32	0
2	Powerhouse Mechanical Works	45.54	0	0	11.38	34.15	0
3	Powerhouse Electrical Works	54.94	0	0	0	43.95	10.99
4	Switchyard Works	48.62	0	0	0	48.62	0
5	Transportation	10.89	0	3.81	4.03	2.5	0.54
	Sub Total C (FIT and E&C Costs included)	183.75	0	8.56	26.1	137.54	11.53
D	Environmental And Valley Development						
1	Valley Development And Uplift	28.94	6	6.94	6	5	5
2	Environmental Mitigation Measures	11	1.76	2.09	2.31	2.31	2.53
	Sub Total D	39.94	7.76	9.03	8.31	7.31	7.53
	Sub Total A+B+C+D	511.29	56.33	129.46	122.02	176.52	26.93
E	Management Consultants Engineering and Supervision	33.77	5.1	8.44	8.44	8.44	3.35
F	Contingencies	24.11	4.33	6.27	3.14	5.79	4.58
G	Miscellaneous (Insurance, Performance Bonds and workman Compensation etc.)	9.65	1.74	2.51	1.25	2.32	1.83
	Sub Total A to G	578.82	67.5	146.68	134.85	193.07	36.69
H	PHYDO Expenses, Administration, Counterpart Staff and Misc Costs	29.33	5.28	7.63	3.81	7.04	5.57
I	Allowance for greater risk and uncertainties	11.73	2.11	3.05	1.53	2.82	2.23
	Total Cost of the Project A to I	619.88	76.36	157.72	139.05	202.37	44.5
J	Duties	7.79					
	Grand Total	627.67					

1. Total Foreign Exchange Component (Including Financial Costs) (A+B+C+E+F+G+17.61M US\$) = US\$ 556.49 Million.
2. Total Local Component (D+H+I+J) = Pak Rs. 9,429,498,000.00.(9,429.5 million)
3. Total Project Cost in Equivalent Pak Rupees (@ US\$ 1.00=Pak Rs 106.20 as on October 15, 2013) is Pak Rs. 68,528,736,000.00. (68,529 Million)

13 PROJECT IMPLEMENTATION AND CONSTRUCTION PLANNING

Project implementation period is estimated to be 5 years including pre-construction activities (**Figure-5**) as summarized below:

14 ECONOMIC AND FINANCIAL ANALYSIS

Economic analysis, carried out on the basis of consumer surplus, indicates that the proposed investment is feasible as the NPV, at a discount rate of 12%, is 966 M-US\$ and the IRR is 25%.

The variation in costs and benefits is reflected in the sensitivity analysis. The Project is feasible on certain assumptions, and based on robust parameters, it is feasible on 10% and 20% reduction of benefits and 10% and 20% increase of costs; and the Project is feasible even if costs increase by 20% and the benefits reduce by 20%. The switching values at which the Project is feasible occurs when the gross consumer surplus at the generation level in 9.91c/kwh.

Economics of the Project was verified on the basis of benefits quantified on the long run marginal costs (LRMC) of capacity, peak energy and off peak energy at 500 KV level. The NPV at 12% discount rate is 797 M. US \$ whereas the IRR is about 23%.

The variation in costs and benefits is reflected in the sensitivity analysis. The proposed investment seems to be robust as it is economically viable even when benefits and costs are changed by 20%; even a combined sensitivity with benefits decreased by 20% and costs increased by 20% still results in a feasible project. The switching values at which the project is only marginally feasible are firm capacity 198 \$/kw, peak energy 7.61c/kWh and off-peak energy 4.76 c/kWh.

The financial analysis of the Project has been conducted in accordance with the procedure laid down by ADB Financial Management and Analysis of Projects. All financial costs and benefits have been expressed at early 2013 constant prices. Cost streams used for the purposes of FIRR determination (i.e. capital investment, operation and maintenance, insurance costs and taxes) reflect costs of delivering the estimated benefits. The NEPRA approved tariff for Suki Kinari, a high head hydroelectric project, was used to estimate the financial benefits.

The FIRR was calculated as 7.55% for the Project. The overall rate compares favorably with the estimated WACC of 6.35% substantiating the financial viability of the Project. The Project is financially feasible.

Risks have been quantified by the sensitivity analysis. The Project is financially feasible on certain assumptions, and based on robust parameters; it will be able to stand reasonable uncertainties. The tariff at which the Project becomes feasible is 9.91 c/kWh.

In conclusion, the Project is both economically and financially feasible. The Project is, however, sensitive to the cost overruns of reduction in tariff. It is recommended that the Project be implemented after tariff determination by NEPRA.