FEASIBILITY STUDY OF LASPUR-MURIGRAM HYDROPOWER PROJECT

Executive Summary

Optimized maximum power station output of the Laspur Murigram Hydropower Project is 230 MW corresponding to a maximum design discharge of 30 m^3/sec at a maximum gross head of 924 meters achieved from a horizontal conduit length of 32,415 meters.

The optimized project will produce 874 GWh/year out of which 292 GWh will be available during 4 hours of daily peaking period. Firm capacity available during these four hours for the duration of the whole year is 127 MW.

Total project cost is 448.6 Million USD or 1950 USD / kW installed and construction time is 54 months. The site, after completion of Lowari tunnel, will be accessible around the year through the existing road system. Before completion of this tunnel, the site will only be accessible from mid-May till end of November.

Introduction

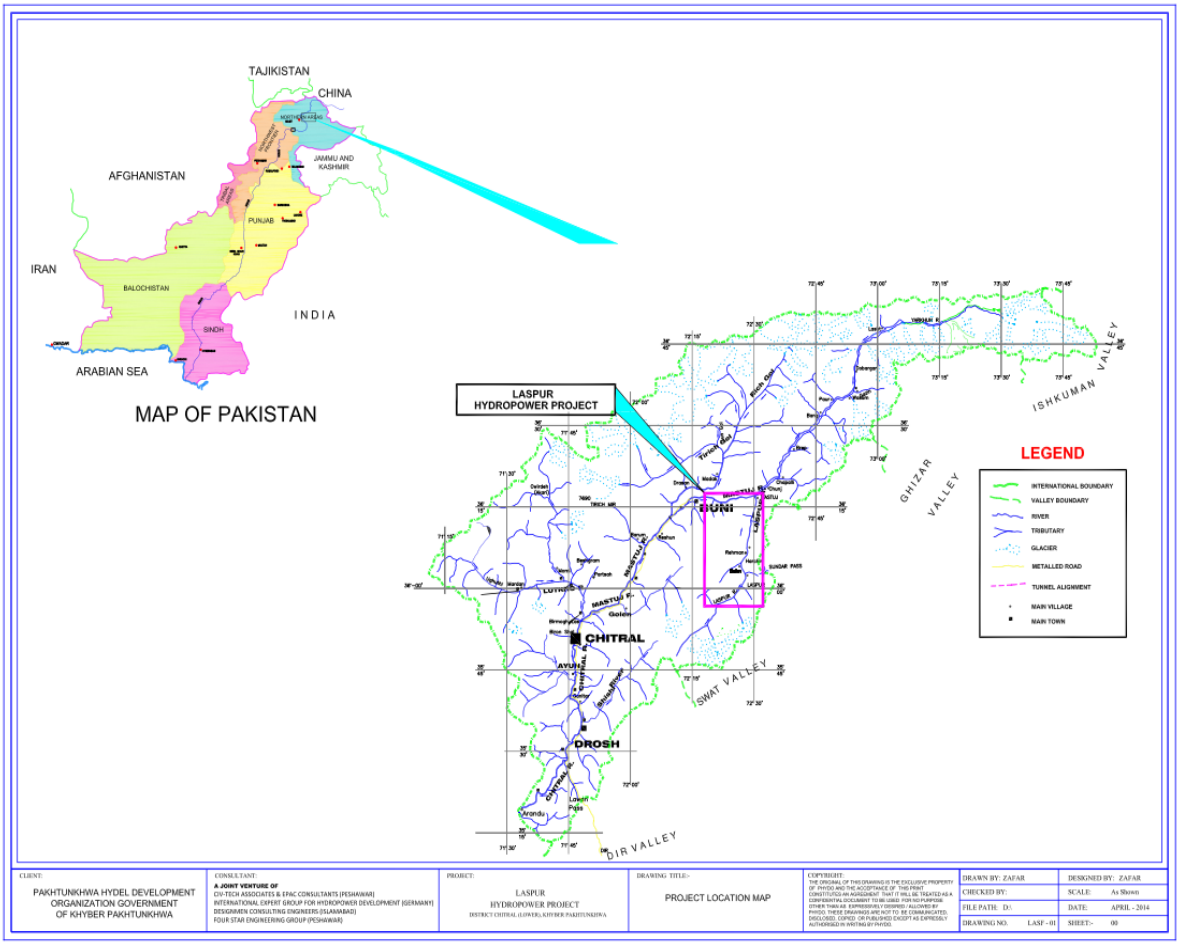
The project is located in Khyber Pakhtunkhwa (KP) province of Pakistan. The main intake of the power station is placed on Shaidali Gol, the glacier fed main source river of Laspur River, 8 km upstream of the village Sor Laspur and two additional intakes on smaller rivulets called Rizhun Gol and Phagram Gol contribute discharges from left side of Laspur River. The Laspur River is a left side tributary of Yarkhun River, and joins it downstream of Mastuj Town to form Mastuj River.

The powerhouse of the project will be constructed underground in a cavern within a massive rock formation on left bank of Mastuj River, approximately 8 km downstream of Mastuj Town.

The project area is accessible by road and is at a distance of 520 km from Islamabad, the capital of Pakistan, and 430 km from Peshawar, the capital of Khyber Pakhtunkhwa province.

Comprehensive inventory studies for identification of hydropower potential in the mountainous areas of KP have been carried out by the Government of KP, represented by Pakhtunkhwa Hydel Development Organization (PHYDO) for the Chitral Valley and supported by Ministry of Water and Power, Government of Pakistan, in due collaboration with the German Agency for Technical Cooperation (GTZ). Project site for the Laspur-Murigram Hydropower Project constitutes part of the inventory of hydropower projects identified during Identification Studies conducted by Ministry of Water and Power of the Government of Pakistan and GTZ on behalf of Ministry of Economic Co-operation and Development, Government of Germany in the years 1999 to 2001.

Location of the Laspur-Murigram Hydropower Project is presented in the project location map as follows:



Project Location Map

Within this Feasibility Study, extensive field-reconnaissance, including topographical surveys, hydrological and geological investigations and environmental assessments have been carried out. Subsequently, the size of the project was optimized and design criteria determined, followed by engineering studies and feasibility design.

Project Description

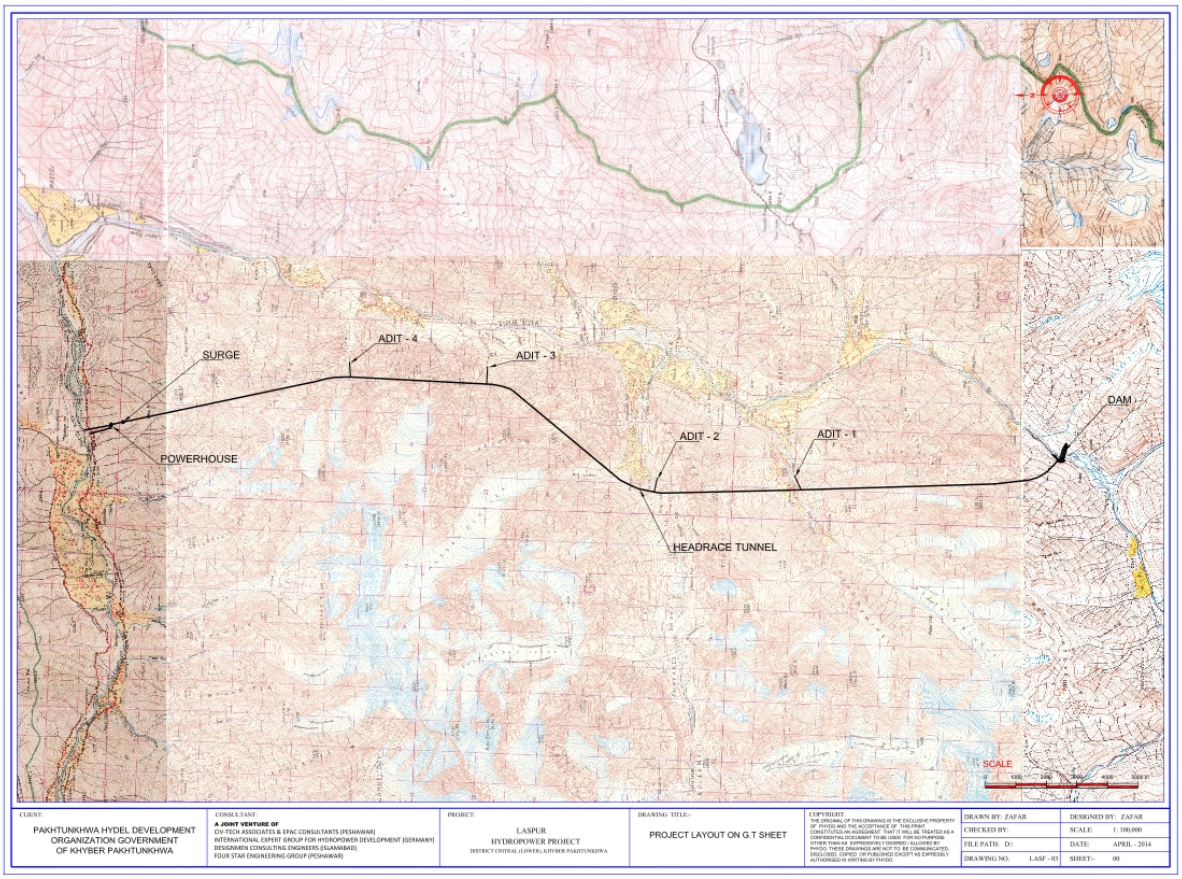
General Layout

From the project's main intake at the dam structure located on Shaidali Gol, the water is transferred through a desander basin, horizontal low pressure tunnel, surge chamber and a system of vertical pressure shafts with horizontal/inclined pressure tunnels to a cavern powerhouse situated in a massive rock formation on left bank of Mastuj River.

The 35 m high concrete faced rockfill dam creates a reservoir of about 0.92 million cubic meters to be used as live-storage for four-hour daily peak operation during dry season.

From the intake structure, a concrete lined 95 meter long open canal directs water to a desander basin of 120 m length connected to a 32,200 meter long headrace tunnel with a net diameter of 4.15 m, thereafter transferring the 30 m^3/sec design discharge to the surge tank. From there, a slightly inclined pressure shaft system of 767 m vertical and 780 m

horizontal projection will lead the water to the powerhouse cavern.



Layout Plan

The Maximum gross head is 924 m.

Water will be discharged through a 570 m long tailrace tunnel into Mastuj River.

The underground cavern powerhouse is 105.0 m long, 12.3 m wide and 29 m high, associated with a transformer cavern 123 m long, 24.2 m wide and 13.5m high.

The caverns will be accessed to outside world by means of a 560 m long access tunnel and served with fresh air through a 250 m long ventilation tunnel.

The powerhouse will accommodate 5 units of vertical shaft Pelton type turbine-generator sets of 46 MW, 11 kV each. The transformer cavern will house 5 power transformers 11/132 kV 63 MVA, each designated as block transformer to the relevant turbo generator set and interconnected to the same by 11 kV, 3000 A insulated copper bars through individual unit connection tunnels and gas insulated switch gear assemblies (GIS) 132 kV, 33 kV and 11 kV, internally interconnected by cables of relevant voltage levels.

Total annual production will be 874 GWh out of which 292GWh will be peak energy.

The project's firm capacity is 127 MW. Firm Capacity and peak energy refer to four hours daily at 90% discharge availability.

Power and energy will be evacuated to an external 132 kV transmission line gantry through 2 sites of three single phase 132 kV XLPE cables passing through a 600 meter long cable tunnel. The 132 kV transmission line gantry will then be connected to a 75 km double circuit 132 kV transmission line which will terminate in Central Chitral Grid Station of NTDC proposed to be established at Jut Lasht near Chitral Town.

Grid interconnection will be arranged according to the requirements of NTDC for systematic coordination of evacuation of power to the National Grid.

It is proposed to evacuate the entire energy of the District from the Central Grid Station in a step by step manner following the time scale in commissioning of individual power stations through a 220 kV and 500 kV transmission line corridor across Lowari Pass, Dir, Chakdara and beyond.

Environmental and Social Impact Assessment and Economic Analysis.

Demography, ethnic composition, socio-economic conditions, health and sanitation, land and water use, agriculture, irrigation, forestry, fisheries, flora and fauna, impact on land, water, air and socio economic activities have been thoroughly examined. Although the negative impact of the project on the ecology and the inhabitants will be negligible, yet a mitigation plan has been prepared to overcome problems of perceptible nature.

A significant positive effect is that emission of green-house gases will be avoided by replacement of fossil-fired plant capacity by environment friendly and renewable hydropower.

Cost Estimates, Implementation Schedule.

Detailed cost estimates and BOQ are available in Feasibility Report which may be used as a basis for development of tender documents.

The total construction cost works out to about US$ 448.6 million, with a specific capacity cost of 1950 US$/kW. Economic analysis establishes that the project forms part of the least cost generation expansion program of WAPDA and therefore will be economically feasible. The project has also been demonstrated to be technically feasible and financially viable.

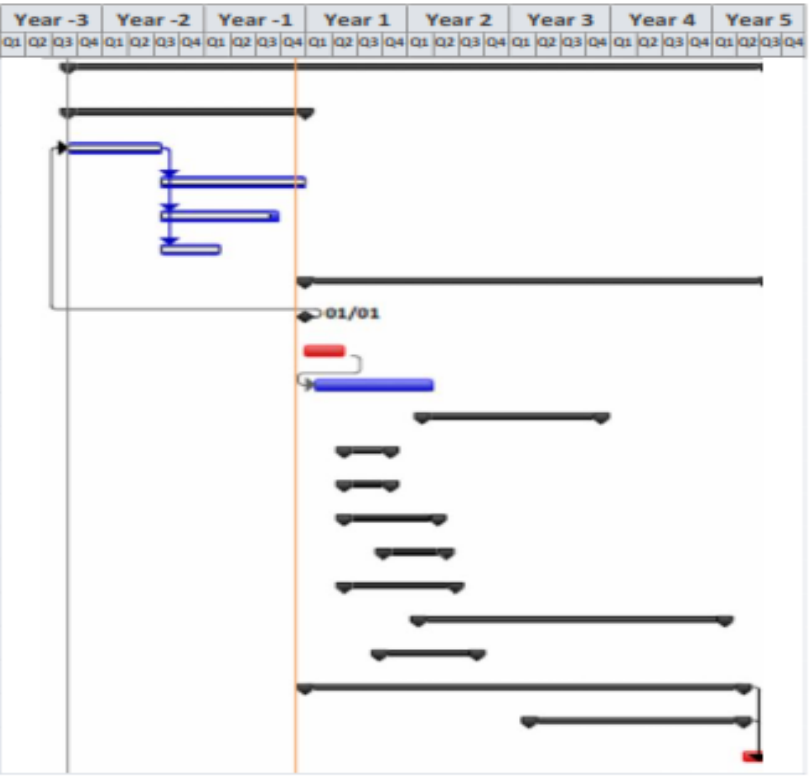
Economic analysis established the project to be attractive with NPV (at 12% discount rate) of about 606 million US$. The project EIRR works out to be 16.6%. The project is therefore economically attractive.

Project Cost Estimate

S. NO.	COST ITEM	COST US$
A.	**PRELIMINARY WORKS AND ENVIRONMENTS**	
A-1	Preparatory Works	1,033,333
A-2	Staff Residential Colony	6,736,851
A-3	Land Acquisition	2,906,977
A-4	Environmental Mitigation Cost	2,500,000
A-5	Mobilization/Demobilization (5% of B)	11,253,112
A-6	Access Road and Bridges	11,253,800
	Sub Total A	**35,684,073**
B.	**CIVIL WORKS**	
B-1	Coffer Dam	792,883
B-2	Weir (CFRD) with Spillways and Flushing Outlets	25,237,589
B-3	Intake Structure	808,649
B-4	Sand trap	3,486,367
B-5	Weir intake & Sand trap Phargam and RizhenGol	1,150,034
B-6	Adits Tunnel	7,293,995
B-7	Headrace Tunnel	122,348,855
B-8	Surge tank	1,527,043
B-9	Pressure Shaft and Penstock	30,515,718
B-10	Powerhouse Underground	28,567,210
B-11	Tailrace Tunnel	2,333,897
B-12	Protection and Miscellaneous Works	1,000,000
	Sub Total B	**225,062,239**
C.	**HYDRO MECHANICAL & ELECTRICAL EQUIPMENTS**	
C-1	Hydro Steel Structures	2,088,033
C-2	Power House Mechanical Equipment	21,010,056
C-3	Power House Electrical Equipment and Switch Yard	55,950,000
C-4	Transmission Line	9,867,500
	Sub total C	**88,915,589**
	Sub Total A, B & C	**349,661,901**
D	Erection, Commissioning & Testing Charges 15 % of C	17,783,118
E	Transportation and Shipment Charges 10% of C	8,891,559
F	Contingencies @ 5 % of (A to C)	17,483,095
G	Engineering Supervision 6% (A+B+C)	20,979,714
H	Engineering Design (1%)	3,139,778
I	Project Administration Charges 5% (A+B+C)	17,483,095
J	Import/Custom Duties, LC Charges & Taxes 5% of C	4,445,779
K	Risk and Uncertainties (2%)	6,993,238
	Project Construction Cost (A to K)	**446,861,277**
L	Financial Charges (0.5% of items A to C)	**1,748,310**
	TOTAL COST	**448,609,587**
	COST PER MW	**1,950,476**

Project Schedule

Tasks	Duration
LASPUR MURIGRAM HYDROPOWER PROJECT	**1793 days**
Pre Construction Activities	**608 days**
ICB Process	238 days
Financial Close	370 days
Detailed Design	300 days
Preparatory Works	150 days
Project Construction Works	**1185 days**
Start	0 days
Mobilization	100 days
Project Infrastructure Buildings	300 days
Dam and Intake	**460 days**
Intake Rizhun	**120 days**
Intake Phagram	**120 days**
Access Roads	**240 days**
Adits	**162 days**
Access Tunnels	**287 days**
Headrace Tunnel	**786 days**
Surge Tank and Pressure Tank	**250 days**
Power House and Electro Mechanical Equipment	**1125 days**
Switchyard and Transmission Line	**550 days**
Trial Run and Hand Over	60 days



Conclusions and Recommendations

It can be safely concluded from field investigations and engineering studies that the project is technically feasible financially sound, economically useful and environmentally safe. Laspur-Murigram hydropower project ranks as one of the most promising sites and should be undertaken as soon as possible, whether through public or private sector funding or a combination thereof for hydropower generation

PRINCIPAL DESIGN FEATURES

1. PROJECT LOCATION

MurigramVillage Pakistan, Chitral District (Upper)
Khyber Pakhtunkhwa (KP) Province, Pakistan

2. COORDINATES

Intake (Laspur/ Shaidali Gol):35° 59´ 05“ N / 72° 25´ 32“ / 3,109 m a.s.l
Powerhouse (Murigram): 36° 16´ 17“ N / 72° 26´10“ / 2,216 m a.s.l

3. ORGANIZATION

Pakhtunkhwa Energy Development Organization (PEDO)

4. RIVER SYSTEM

Tributaries Shaidali Gol, Rizhun Gol and Phagram Gol combine to form Laspur River / Mastuj River

Catchment Area at damsite on Shaidali Gol	557 km²
Mean Annual Discharge	21,43 m³/s
Average Annual Flow	676.3Mm³

5. COMPILATION OF MAIN STRUCTURES

Reservoir

Total Storage Capacity at 3140 m a.s.l	13.60 Mm³
Total Storage Capacityat 3139 m a.s.l	12.48 Mm³
Active Storage Capacity	0.92 Mm³
Buffer Volume	3.48 Mm³
Dead Volume	9.0 Mm³
Surface Area	1.0 km²
Length of Reservoir	1.4 km

Diversion WeirStructure (ShaidaliGol)

(Composite Concrete Weir/ Embankment Dam)

Height above Riverbed	35m
Crest Length	570m

Concrete Weir Structure on Left Side

Type: Concrete Gravity Dam

Height above River bed	35 m
Crest Length	110 m

UngatedSpillway

Number of Sections	2
Width of each section	20 m
Number of Under sluices	4
Size of Undersluice (each)	16 m²

Stilling Basin

Design Flood (1,000 year return period)	364 m³/s
Width	43 m
Length	38 m

Embankment Dam on Right Side

Type of Dam	Concrete Faced Rock fill Dam (CFRD)
Crest Elevation	3,144 m.a.s.l.
Crest Length	460 m

River Diversion at Shaidali Gol (during construction)

Diversion flood magnitude for 25 years return period 213 m³/s
River bed area upstream and downstream, each:

Width	50 m
Depth	25 to 30 m

Main Power Intake at Shaidali Gol

Nominal Discharge	33.6 m^3/s
Opening Width	7.0 m
Opening Height	6.1 m
Invert of Power Intake	3,135.0 m a.s.l
Maximum Operation Level	3,140.0 m a.s.l
Minimum Operation Level	3,139.0 m a.s.l
Connecting Channel size	5.0 m x 6.0 m

Stoplogs, Trashrack, Rack Cleaning Machine, Intake Gate Sand Trap

Number of Chambers	3
Total Length	120 m
Chambers SettlingBasins, each	
Length	90 m
Width	7 m
Depth	4.5 m

Diversion of flows from Rizhun Gol

Weir Type	Tyrolian Weir
Position on Headrace Tunnel (from main intake)	9.0 Km
Diverted flows	1.0 m³/s
Crest Elevation of over flow section	3,197 m a.s.l.
Design Flood (100 years return period)	63 m³/s
Total width of Nullah	15 m
Width of Weir	8 m

Diversion of flows from Phagram Gol

Weir Type	Tyrolian Weir
Position on Headrace Tunnel (from Main Intake)	13.3 km
Diverted flows	1.0 m³/s
Crest Elevation of over flow section	3187 m a.s.l.
Design Flood (100 years return period)	130 m³/s
Total width of Nullah	30 m
Width of Weir	18 m

Headrace Tunnel

Low Pressure Tunnel length from Intake to Surge Tank

Length	32,200 m
Internal Diameter	4.3 m
Lengths of Adit Tunnels:	
Adit Tunnel No. 1	460 m
Adit Tunnel No. 2	400 m
Adit Tunnel No. 3	585 m
Adit Tunnel No. 4	480 m

Surge Tank

Surge Shaft internal diameter	8.0 m
Height	118 m

Pressure Shafts

Upper Vertical Pressure Shaft	
Internal diameter	3.2 m
Length	380 m
Lower Vertical Pressure Shaft	
Internal diameter	3.2 m
Length	387 m

Pressure Tunnels

Upper in clined pressuret unnel from upper p ressures haft to lower pressure shaft	
Internal diameter	3.2 m
Length	200 m
Lower Inclined Pressure Tunnel from Lower Pressure Shaft to Powerhouse cavern	
Internal diameter	3.2 m
Length	580 m

Access Tunnels (length)

To Surge Chamber	155 m
To Upper Pressure Shaft/ HeadraceTunnel	300 m
To Lower PressureTunnel / Pressure Shaft	582 m
To Powerhouse Cavern	560 m
Cable and Ventilation Tunnel	365 m
Width	4 m
Heigth	3.5 m

Powerhouse

Sub soil Powerhouse cavern with Machine Hall	
Length	105 m
Width	12.3 m
Height	29.0 m

Transformers and Switchgear Cavern

Length	123 m
Width	24.2 m
Height	13.5 m
5 Connection Tunnels for block bus-connections, each	
Length	21m
Width	4.6 m
Heigth	3.5 m

Tailrace Tunnel

Length	570 m
Width	7 m
Height	4.5 m

6. HYDRO-MECHANICAL EQUIPMENT

Vertical shaft Pelton type turbines (No. of Units)	5
Speed	750 rpm
Discharge per Unit	6.0 m³/s
Total Discharge	30 m³/s

7. ELECTRICAL EQUIPMENT

Generators: Number of units	5
Speed	750 rpm
Capacity	56.62 MVA
Power Transformers: Number of Units	5
Capacity	63 MVA
Voltage	11/132 kV
Auxilliary Station Transformer	
Capacity	6.3 MVA
Voltage	132/33/11 kV
Batteries	110 V

8. POWER AND ENERGY

Design Discharge	30m³/s
Pelton Turbines (number of units)	5 (6 m³/s each)
Generator Sets (number of units)	5

Reservoir

Storage Volume	13.6 Mm³
For four hour daily peak operation	0.92Mm³
Buffer Storage Sedi mentation	9.0 Mm³

Head

Maximum Operation Level	3140 m a.s.l
Mean Operation Level	3140 m a.s.l
Normal Draw down Level	3139 m a.s.l
Minimum Tail water Level	2205 m a.s.l
Mean Tailwater Level	2207 m a.s.l
Maximum Tail water Level in operation	2210 m a.s.l
Maximum Tail water Level	2212 m a.s.l

Gross Head

Maximum GrossHead	924 m
Mean Gross Head	923.5 m
Minimum Gross Head	923 m

Losses

Head Losses for Q_{design} = 30m³/s	39.57 m

Net Head

Maximum Net Head (Q= 30m³/s)	885.0 m
Mean Net Head (Q= 30m³/s)	884.3 m
Minimum Net Head (Q=30m³/s)	884.2 m

Energy Output

Installed Capacity (5 Pelton)	230 MW
Firm Capacity	127 MW
Mean Annual Energy	874 GWh
Out of this Peak Energy	292 GWh
Plant Factor (Annual)	43.4 %