MASS – N – ERGY (PVT. LTD.) COMPANY

Detailed Project Report For

LASHPATHRI - I

2 X 4250 KW

Nodal Agency

JAKEDA

Executive Summary

Hydropower is one of the State's prime resources and J&K intends to accelerate harnessing this potential as an integral part of its economic development. Jammu and Kashmir Government for Speedy Development of Mini/Micro Hydro Electric Projects vide their Govt. Order No.177-PDD of 2009 dated 24.8.2009, has appointed Jammu & Kashmir Energy Development Agency (JAKEDA) with the mandate to implement all Micro / Mini Hydro projects up to installed capacity of 10 MW, who have planned to invite private entrepreneurs to undertake hydroelectric power generation with fetching incentives allowed by the Government of India and fully supported / reinforced by State Government . Jammu and Kashmir Energy Development Agency (JAKEDA) as nodal agency under Science and Technology Department shall be co-ordinating and promoting development of these Mini/Micro hydro power schemes and for this purpose and with an endeavour to promote Mini/Micro Hydel projects in the state, the Nodal agency through two tier tendering process has plan to award the Lashpathri - IMHP to private Developers for implementation/Development under policy referred hereafter. Mini Hydro Power (MHP) Program is one of the thrust areas of power generation from renewable sources in the Ministry of New and Renewable Energy. It has been recognized that small hydropower projects can play a critical role in improving the overall energy scenario of the country and especially in remote areas of the state. The Ministry is encouraging development of small hydro projects both in the public as well as in the private sector.The prime resource, Hydropower is one of the sectors where J&K intends to accelerate exploitationof this potential as avital part of its economic development. Jammu and Kashmir Government for Speedy Development of Mini/Micro Hydro Electric Projects vide their Govt. Order No.177-PDD of 2009 dated 24.8.2009, has appointed Jammu & Kashmir Energy Development Agency (JAKEDA) with the mandate to implement all Micro / Mini Hydro projects up to installed capacity of 10 MW, who have planned to invite private entrepreneurs to undertake hydroelectric power generation with fetching incentives allowed by the Government of India and fully supported /

reinforced by State Government . Jammu and Kashmir Energy Development Agency (JAKEDA) as nodal agency under Science and Technology Department shall be co-ordinating and promoting development of these Mini/Micro hydro power schemes and for this purpose, the job of topographical surveys, investigations and making of Project Reports thereof has been assigned to EnCon Group (JV) from Srinagar, with an endeavour to promote Mini/Micro Hydel projects in the state.

Topersuade upon the Private Developers participation in mini/micro hydropower projects JAKEDA has produced customary Policy for Development of Mini/Micro Hydro Power Projects. The said Policy provides various incentives to the developers of the Mini/Micro hydro projects. Key incentives under the policy are:

- *The Government land for Power Projects would be allotted on lease for 40 years at premium of Rs. 1 per sq. m. However, in case of non-availability of Government land, IPP will purchase land in the name of CEO, JAKEDA and will be leased out to IPP. JAKEDA will also help and facilitate in acquiring of the land.*
- *No entry tax would be levied by the State Government on import of Power generation/transmission equipment and building material used for MHPs. Exemption from court fee for registration of documents relating to lease of land would be granted to the IPPs.*
- *3% interest subsidy would be payable on the working capital facilities available from the commercial banks to IPPs for a period of 5 years initially from the date of allotment and this will be reviewed after 5 years.*
- *10% subsidy on capital investment subject to the ceiling of Rs.60.00 lacs would be given in addition to the central subsidy for the power projects from 1 MW to 10 MW after successful installation & commissioning of the project.*
- *Royalty @ 12% would be charged after the period of 10 years from the date of commissioning of the Hydel Projects up to 10 MW capacities.*
- *IPP would be eligible for central financial assistance as per the standing guide lines of MNRE, GOI.*

With these incentives, the economics of mini and micro hydro-electric schemes has substantially improved for public utility organisations and private entrepreneurs proposing to take up such schemes. The development of energy from renewable *resources is a very important step in the reduction of CO_2 emissions Furthermore a heavy demand of power in the country and in particular for Jammu and Kashmir has increased the need to utilize renewable energy sources at a top priority. Mini Hydropower Plants till date are the primary renewable energy source for generation of green energy within the state.*

It is proposed to develop a mini hydro power project (Lashpathri - IMHP a run-off-the-river scheme) on a sub tributary of River Sindhin District Ganderbal. The various essential steps that have been followed to evaluate the proposed scheme for its feasibility and successful completion does include Evaluation of the water resource and its generating potential, Site selection and basic layout, Type and selection of Hydraulic turbines and generators and their control, Environmental issues with mitigation measures, Economic evaluation of the project with financing potential, and the detailed discussions with civil contractors and Electro- mechanical equipment suppliers, Developers to obtain the necessary consents along with engineering of civil, electrical and mechanical aspects including proposal of optimal installed capacity, and finally to produce proposal in the form of Project report.

The Nallah water will be diverted by constructing a diversion structure across the river, to run 2 number turbines. The generated power can be evacuated from the powerhouse at 11/33 KV to the nearest existing receiving station atGagangeer, 9km away from proposed power house site. Energy of 36 million units have been estimated for the 75% dependable year as per guide lines, the financial feasibility of the Project has been based on the same.

Some of the important features included in the Project report are enumerated as under:-

- *All the minor issues relating to environment related with the project have been taken into consideration while conceiving the scheme including necessary release of sacrificial discharge for aquatic life/irrigation requirement beyond Diversion site.*
- *There is no. Submergence of any land at u/s of Head works even during floods.*

- *The scheme has been developed as "so called" penstock scheme with a Common structure of De-silting Tank and Forebay Tank very near to Diversion weir involving very short supply channel, wherein total length of penstock is quiet long and stands worked out as per appended report.*
- *JAKEDA has been in touch with Jammu and Kashmir Power Development Depart to facilitate the infrastructure facilities for evacuation of power from such projects, Though as per the requirement the proposed Transmission line has been placed at 11KV but due to the system voltage and availability of receiving stations concerns in Jammu & Kashmir, provisions in the project report relating cost of 33 KV line and other connected items as such, have been taken care while framing the Estimated cost of Project.*
    - *Available Gross Head 182.58m*
    - *Rated Discharge 6.38Cumecs*
    - *Net head corresponding to above discharge 174.45m*
    - *Total installed capacity 8.5 MW*
    - *Horizontal Axis Francis Turbines having synchronous generators directly coupled to the turbines are proposed.*
    - *Power shall be generated at 3.3 KV stepped –up to 11/33KV*

Cost parameters are as below:-

- *Capital cost (Civil and E & M) Rs.70.01 Cr*
- *Project Cost including IDC and interest*
  On loan and other soft costs complete Rs.86.09 Cr
- *Cost per KW Rs. 1.1lacs*
- *Internal Rate of Return 15.20%*
- *Average debt service coverage ratio 1.37*
- *Construction Period 48 months*

Check List

STATE	*Jammu and Kashmir*
NAME OF PROJECT	*Lashpathri - IMHP*
CATEGORY OF PROJECT	*MNRE Mini HYDRO-ELECTRIC PROJECT*

(i) General and Hydrological

1.	*Attach an index map (in the case of flood control scheme, the index map should show the flooded area for normal floods and the depth of flooding)*		*Not available*
2.	*Have hydrological, meteorological and other data been collected in respect of the following :*		
	a.	*Map showing Sub-Divisions of catchment by tributaries, water sheds rain gauge and temperature recording stations, gauge and discharge site, contour and isohyets.*	*Catchment area map showing tributaries, Diversion site and contours attached. No rain gauge and temperature recording station exists in the catchment.*
	b.	*Monthly and annual and rain fall and temperature data for the catchment.*	*Not available for the catchment.*
	c.	*Average, maximum and minimum rain fall and temperature*	*Mean monthly and annual rainfall at nearby rain gauge station collected.*
	d.	*Gauge and discharge data for tributaries and the main river.*	*Gauge and discharge data near diversion site collected for two lean seasons with some additional years available.*
	e.	*Hydrograph of the river*	*Flow duration curve given for limited period of discharge.*
	f.	*Maximum historical flood with hydrograph and designed*	*Maximum historical flood with hydrograph not available. Design*

		maximum flood and its frequency.	*maximum flood is given.*
	g.	*Maximum, minimum and average annual run-off.*	*Estimated 50%, 75% and 90% dependable monthly flow series given.*
	h.	*Hydrological studies to establish generally the availability to water for the benefits envisaged in the project*	*Given.*
	i.	*Suitability of water for irrigation, drinking etc. and treatment contemplated where required*	*Has been provided.*
	j.	*Silt discharge, showing maximum, minimum and average silt intensities*	*Silt samples collected for one season and sediment grain size and chemical analysis given.*
	k.	*The magnitude of the problem of soil erosion in the catchment area and the programme proposed for soil conversation measures*	*Not applicable.*
	l.	*Depth of sub soil water table in the command area and its seasonal variation*	*Not applicable.*
	m.	*Seismicity of the area.*	*The project area lies in zone IV of the seismic zoning map of India.*
3.	*Has basin wise development of the river been considered and the following information furnished?*		*Not applicable*
	a.	*A map showing the overall proposals for valley development*	*NA*
	b.	*Alternative proposals, discussing their merits and demerits.*	*Yes*
	c.	*Stages of development of the project and their salient features*	*Yes*
	d.	*Extent to which the existing project will be assigned or affected*	*Not applicable*

	e.	*Particulars of minor irrigation projects*	*Not applicable*
4.	*Have reservoir data been collected completely and the following information furnished?*		*Not applicable*
	a.	*Reservoir topography and area capacity curves.*	*Not applicable*
	b.	*Probable rate of silting in the reservoir in comprising with silting of any existing reservoir.*	*Not applicable*
	c.	*Live storage, the number of years in which the reservoir completely fills, average annual utilisation evaporation. Losses, extra storage provided for carry over from the year to year, if any.*	*Not applicable*
	d.	*Working tables for the reservoir*	*Not applicable*
	e.	*Flood absorption and flood routing*	*Not applicable*
	f.	*Back water (tail water curves with bank levels)*	*Not applicable*
	g.	*Fetch of reservoir direction and velocity of winds and free board*	*Not applicable*
	h.	*Malaria control*	*Not applicable*
	i.	*Area to be submerged and its classification, acquisition and compensation for land and properties.*	*Not applicable*
	j.	*Programme of resettlement of population displaced from the reservoir area.*	*No displacement is involved.*
5.	*Head Work (Dam or Weir)*		

	Have the following aspects been discussed and shown on map.		
	a.	*Dam site and considerations leading to its performance over other sites.*	*No dam contemplated. Considerations leading to the preference of the site in the vicinity discussed in the report.*
	b.	*Reservoir topography and area capacity curves.*	*No reservoir contemplated. Hence not applicable.*
	c.	*Borrow area and quarries.*	*Discussed in the report.*
	d.	*Road and Railways, existing and proposed*	*Yes.*
	e.	*Colonies, workshops and offices*	*Discussed in the report.*
6.	*Has a detailed survey map of the dam site been prepared (scale 1/5000 to 1/1000) showing the following :*		*2 metre contour interval map attached at scale 1H:1V.*
	a.	*All the natural features e.g. out-crops of rocks, aspiring etc.*	*Yes*
	b.	*Dam and appurtenant works*	*Yes.*
	c.	*Site for construction plant e.g. crushing and concreting plant, construction power plant, compressed air station etc.*	*Not applicable as it is a small project, however portable crusher site is available and may be explored.*
7.	*Has geological investigations been made and a report showing the following submitted.*		
	a.	*A brief account of regional geology, major rock types, effects of faulting etc. description of other structural features and their relation of water tightness and grouting proposals*	*Yes.*
	b.	*Laboratory tests of samples of foundation materials and their*	*Not applicable.*

		interpretation	
	c.	*Levels of ground water tables and discussions of percolation tests.*	*Not applicable.*
	d.	*Reference to any special conditions affecting the preliminary designs*	*Nil*
8.	*Have the following maps been included.*		
	a.	*Combined topographical and geological map*	*Yes.*
	b.	*Map showing bed rock contours*	*NA may be taken up at detailed designed stage.*
	c.	*Logs of drill holes, test pits, explanatory tunnel etc.*	*(Test pits 2 m deep)*
	d.	*Maps, profiles and station showing results of geophysical work or any other special methods.*	*Not applicable.*
	e.	*Ground and aerial photographs, if available*	*Ground photos provided.*
9.	*Have investigation of construction materials been made and report showing the following attached.*		
	a.	*Various types of embankment materials e.g. previous with quantities in various borrow areas.*	*Yes.*
	b.	*Stone for rip-rap and rock fill*	*Not applicable.*
	c.	*Materials for stone masonry and concrete, compressing rubble, fine and coarse aggregates, with quantities and physical properties*	*Yes.*
	d.	*Source of supply of cement.*	*Yes.*
	e.	*Laboratory test performed on item (a) to (d) above.*	*Not applicable.*

	f.	*Haul roads for transport of construction material.*	*Yes*
	g.	*Plans of borrow areas and quarries with bore of trial pit data.*	*Discussed in the report.*
10.	*Have the main structures and appurtenant works e.g. dam, spillway, outlets, coffer dam etc. been designed and the following appended.*		*Yes, to the extent necessary in a DPR.*
	a.	*General plan, upstream and downstream elevations showing natural ground levels, final excavation levels, etc.*	*Yes.*
	b.	*Foundation treatment and drainage.*	*Not required.*
	c.	*Spillway and outlet with energy dissipation arrangements*	*Yes.*
	d.	*Maximum section of overflow non-overflow and earth dams.*	*No dam contemplated.*
	e.	*Retaining and training walls*	*Yes.*
	f.	*Galleries and other openings.*	*Not required.*
	g.	*Gates, hoists and other control equipment's*	*Yes.*
	h.	*Diversion works during construction etc.*	*No design necessary for the small project.*
	i.	*Design calculations with list of assumptions made and factors of safety adopted, together with justification of the types of structures adopted.*	*Yes.*
(ii)	***Irrigation***		*Minor requirement of Irrigation flow kept reserved.*
(iii)	***Power development***		

11.	*Have investigations been made and the following furnished.*	
a.	*Present position of power sully in the region, system load factor etc.*	*Yes.*
b.	*Extent of firm power available from the scheme and also from the grid after commissioning of the plant (working tables and the basis of estimation of firm power should be supplied) and extent of.*	*Yes. Details of firm power generated from the scheme given. Firm power available from the grid after commissioning of the project is not necessary as it is a small hydro-electric project .*
c.	*Load survey giving details of major loads to be served, future peak and energy demands, and anticipated system load factor.*	*Discussed in the report power shall evacuated to Sate inter connection point.*
d.	*Proposed initial and ultimate installed capacities, number and size of generating units, number and capacity of turbines / boilers, power factor efficiency etc. transformer capacity added at power station and sub stations.*	*Yes, given in the report.*
e.	*Map showing the general layout of the schemes, including the dam, water conductor system, power house, step up substations and outgoing transmission lines.*	*Yes.*
f.	*General map showing the transmission system and the location of the present / future principal loads.*	*NA.*
g.	*Rout miles of trunk and main lines and distribution lines with voltages under the scheme.*	*NA.*
h.	*A note on the development of power in stages, if any.*	*Not applicable.*

	i.	*Proposed sources of coal, fuel etc. and technical characteristic of fuel, costs per tonne and distance from location of power station to source of fuel.*	*Not applicable.*
	j.	*Have the coal commissioner and railway been consulted in regard to supply of coal.*	*Not applicable.*
	k.	*Proposed sources of cooling water*	*Through penstock drain pipe.*
	l.	*Details of construction materials for hydro installations.*	*Discussed in the report.*
	m.	*In respect of distribution and rural electrification schemes, a list of small towns and villages (as per latest census) to be electrified.*	*Not applicable.*
(iv)	*Flood Control, Drainage, Anti Water Logging*		*Not applicable.*
(v)	*Navigation, Fish Culture etc.*		*Fish pass arrangement made. No Navigation...*
(vi)	*Construction Programme Equipment and Manpower*		
12.	*Has a construction programme been drawn up for execution of the various components of the project with the following details?*		*Yes.*
	a.	*Machinery and equipment available together with the proposed requirements.*	*Yes.*
	b.	*The quantities of material involved together with the daily out-turn proposed for major items like masonry, concrete or earth work.*	*Yes.*
	c.	*Yearly requirements of cement, steel, coal and other essential*	*Project requirements indicated in the*

		materials.	*report.*
	d.	*Synchronisation in the construction of head works, canal system including distributaries, minors and water courses, field channels (by the beneficiaries) and implementation activities to ensure phase realisation of maximum benefits.*	*Not applicable.*
	e.	*Synchronisation of generation facilities with completion of transmission system.*	*Yes.*
	f.	*Justification of the construction programme adopted.*	
		Have charts been furnished showing the construction programme and targets diagrammatically for the various components of the project.	*Yes.*

(vii) Estimate and Analysis of Rates.

13.	*Has project estimate of cost together with abstract of quantities and costs for various components of the project been made and the following details furnished.*		*Yes.*
	a.	*Estimated cost of the various stages of the project and the foreign exchange component thereof.*	*It is a single stage project.*
	b.	*The year to which the rates adopted in the estimate pertain.*	*As per prevailing market rates.*
	c.	*Allocated costs of irrigation, power, flood control, navigation and other purpose served by the project, as considered equitable by the State Govt.*	*Not applicable.*

14.	*Have analysis of rates been made and following details furnished.*		
	a.	*Labour out turns for various items.*	*Yes.*
	b.	*Materials required for unit quantities of items of work.*	*Yes.*
	c.	*The current schedule of rates in the area and rates proposed, comparison with rates obtaining on similar works.*	*The prevailing rates for labour, material and equipment have been adopted.*

(viii) Financial Returns And Benefits

15.	*Has the financial aspect of the project been discussed and the following details furnished.*		*Yes.*
	a.	*The phased or year wise programme of expenditure on the various units of the project, in foreign exchange and in rupees.*	*Yes.*
	b.	*The phased or year wise programme of development of irrigation, power, navigation etc.*	*Not applicable.*
	c.	*Present and proposed power tariff rates for different categories of consumers.*	*Not applicable.*
	d.	*Compulsory irrigation cess proposed.*	*Not applicable.*
	e.	*Scale of water rates proposed for the various crops, comparison with rates prevailing on existing projects in the region / States.*	*Not applicable.*
	f.	*Betterment levy proposed.*	*Not applicable.*
	g.	*Comparison of above rates with*	*Not applicable.*

		the rates proposed for other projects in the State.	
	h.	*Construction of the State Revenue Department in regard to the rates of betterment levy, water rates, compulsory irrigation cess, flood cess etc.*	*Not applicable.*
	i.	*Statement of gross revenue from the different functions of the project.*	*Not applicable.*
	a.	*The degree of public co-operation and participation expected for the project.*	*High degree of public co-operation and participation expected for the project.*
	b.	*View and attitude of the beneficiaries about the advantages from the project and in respect of water rates, betterment levy, irrigation costs etc.*	*Not applicable.*

(ix) Interstate Aspects

Are the inter-state aspects involved? If so, the details about the same may be mentioned together with the latest views of the state concerned.	*Not applicable.*

(x) Employment and Training.

18. a. Yearly employment during construction (approximately) by categories.

Year	*Professional and Technical*	*Clerical Services*	*Skilled workmen*	*Un-skilled workmen*
I yearly	*2*	*3*	*15*	*45*
II yearly	*2*	*3*	*15*	*45*

III yearly (half)	*2*	*3*	*15*	*45*

b.	*Personnel required to be retained under above categories after completion of the project (approximate).*	*1 Engineer* *2 Foreman* *3 Skilled Persons* *10 Un-Skilled Persons.*

SALIENT FEATURES OF MHP Lashpathri – I (2x1MW)

1	***Location***			
i	*State*	*Jammu & Kashmir*		
ii	*District*	*Ganderbal*		
iii	*Town/Tehsil*	*Kangan*		
iv	*Access Road*	*Jammu-Srinagar (NH-1A) Srinagar-Sonamarg Road.*		
v	*Village*	*Shitkari*		
2	***Geographical Coordinates***			
i	*Weir-Longitudes*	*75° 13'55.71"E*		
	Latitudes	*34°19'57.73"N*		
ii	*Basin-Longitudes*	*75°13'57.09"E*		
	Latitudes	*34°19'56.93"N*		
iii	*Forebay-Longitudes*	*75°13'57.09"E*		
	Latitudes	*34°19'56.93"N*		
iv	*Powerhouse-Longitudes*	*75°15'0.90"E*		
	Latitudes	*34°19'44.38"N*		
3	***River Catchment***			
i	*Catchment up to Headwork's*		*35*	*Sq-km*
ii	*Nallah/Stream*	*Lashpathri*		
iii	*Tributary*	*River Sindh*		
4	***Hydrology***			
i	*Catchment area of Nallah up to Diversion Weir site*		*35*	*Sq-km*
ii	*Climate Data*			
	a) Precipitation (Avg. Rainfall)		*1100*	*mm*
	b) Precipitation Max.		*1500*	*mm*

iii.	*Atmospheric Temp.*		
	a) Max.		*32^0C*
	b) Min.		*(-) 18^0C*
5	***Medium Head Scheme***		
5.1	*Diversion Structure (Head works)*		
5.1.1	*Weir*		
i.	*Type of Structure*	*RCC Trench Weir*	
ii.	*Discharge at Intake*	*8.12*	*Cumecs*
iii.	*Length*	*15*	*m*
iv.	*Width*	*2*	*m*
v.	*Average bed level of Nallah*	*3125*	*m*
vi.	*Longitudinal bed Grade in Trench, 1 in*	*8.90*	*m*
vii.	*Pond Level with 50% clogging*	*3123.6*	*m*
viii.	*Highest Flood Level*	*3128.58*	*m*
ix.	*Maximum Shingle Flushing Discharge*	*1.16*	*Cumecs*
x.	*Shingle Flushing Pipe Diameter*	*500*	*mm*
xi	*Sill Elevation of Flushing Pipe*	*3121.0*	*m*
xii	*Sill Elevation of Intake service Gate*	*3121.6*	*m*
xiii	*Sill Elevation of bulk head Gate*	*3128.8*	*m*
xiv	*Trash rack mesh openings*	*30.00*	*mm*
xv	*Length of Intake well*	*3.50*	*m*
xvi	*Width of Intake well*	*3.00*	*m*
xvii	*Number of Gates in well*	*3*	*no*
xviii	*Height of Intake well*	*7.78*	*m*

6 Water Conductor System Supply Channel

i.	Supply Channel- Length	42	m
ii.	Type of Structure	RCC Box Channel	
iii.	Design Discharge	7.54	Cumecs
iv.	Bed width	2.3	m
v.	Full Supply Flow depth	1.8	m
vi.	Free board	0.4	
vii.	Bed Grade 1 in	550	
viii.	Velocity of Flow	1.87	m/sec

7 De-silting Tank

i.	Type of Structure	RCC common structure with Forebay	
ii.	Design Discharge	7.54	Cumecs
iii.	Length (main tank)	38	m
iv.	Width	9	m
v.	Depth of water in main part of Tank (FSD)	4.26	m
vi.	Flushing discharge	1.16	Cumecs
vii.	Length (upstream transition)	11.1	m
viii.	Length (downstream transition)	0.00	m
ix.	Total Length including transitions		49.1m
x.	Particle size removal	0.2 mm and above	
xi.	Silt Flushing Pipe Length	20	m
xii.	Type of Flushing	Through M.S pipe 600mm diameter	
xiii.	Flushing Control arrangement	600 mm Dia. Sluice Valve	

9 Forebay

i.	Type	RCC Rectangular Tank combined with De-silting Basin	

	ii.	*Full supply Water Level*	*3122.58 m*
	iii.	*Minimum Draw Down Level (MDDL)*	*3120.58 m*
	iv.	*Size*	
		a) Length	*40 m*
		b) Width	*9.6 m*
		c) Overall Depth	*8.27 m*
	v.	*Design Discharge*	*6.38 Cumec*
	vi.	*Maximum Water Level*	*2945.5 m*
	vii.	*Spillway Crest Level*	*3122.58 m*
	viii.	*Storage Capacity Time*	*2 min*
	ix.	*Live Storage*	*766m^3*
10		***Penstocks***	
	i.	*Number*	*1 number*
	ii.	*Diameter*	*1600 mm*
	iii.	*Maximum Thickness*	*28 mm*
	iv.	*Each branch Diameter with Bifurcation at lower end*	*1132 mm*
	v.	*Length of main Penstock*	*1800 m*
	vi.	*Length of each branch penstock*	*15 m*
	vii.	*Design discharge in main Pipe*	*6.38 Cumecs*
	viii.	*Design Discharge in branch pipe*	*3.19 Cumecs*
	ix.	*Velocity of Flow*	*3.17 m/sec*
	x	*Maximum Pressure rise*	*84%*
11		***Power House***	
	i.	*Type*	*Surface- RCC framed structure*
	ii.	*Head*	
		a) Gross	*182.58 m*
		b) Net	*174.45 m*
	iii.	***Size of power house:***	

		a) Length	24	m
		b) Width	15	m
		c) Height (m)	13	m
		d) Machine Hall floor level	2938.75	m
	iv.	Installed capacity	8.5	MW
	v.	Turbines		
		a) Type	Horizontal Francis	
		b) Number	2	number
		c) Capacity each	4.25	MW
	vi.	Type of Generator:	Synchronous	
	vii.	Power house crane / lifting tackle capacity	30	ton
	viii.	Axis of turbine level	2940	m
12		**Tailrace**		
	i.	Type	RCC Rectangular Section	
	ii.	Bed width	5.5	m
	iii.	Max. Flow depth	0.7	m
	iv.	Design Discharge	6.38	Cumecs
	v.	Bed Grade 1 in	500	
	vi.	Free board	0.6	m
	vii.	Minimum Tail water Level	2940	m
	viii.	Maximum Tail water level	2940.45	m
13		**Power**		
	i.	Installed Capacity	8.5	MW
	ii.	Total Annual gross Energy Average Year @ 75% dependability	36.42	mu
14		**Switchyard**		
	i.	Voltage level/basic undulation level	3.3/11/33KV	

	ii.	*No. of Bays*	*One*	
	iii.	*Size :-*		
		(a) Length	*13*	*m*
		(b) Width	*10*	*m*
15		***Transmission Line***		
	i.	*Voltage Level*	*11/33.*	*KV*
	ii.	*Length*	*9*	*km*
	iii.	*Sub-station*	*Gagangeer*	
16		***Hard Cost of Project***	***86.09***	

Introduction

1.0 Introduction

1.0 Hydro power is a renewable, economic and non-polluting source of energy. Hydro power stations have inherent ability of quick starting, stopping and load variations offering operational flexibility and help in improving reliability of power system. Hydro stations are the best choice for meeting the peak demand. The generation cost is not only inflation free but reduces with time. Hydroelectric projects have long useful life extending over 50 years and help in conserving scarce fossil fuels. They also help in opening of avenues for development of remote and backward areas. Development of hydro power resources is important for energy security of the country. It is therefore necessary to prepare a long term plan of hydropower development.

Central Electricity Authority (CEA) has already covered planning of hydro power projects during 11th & 12th Plan period. This is one of the major sources of energy throughout the world and is considered to be a cheapest option. India is particularly interested in this source of power.

The first systematic and comprehensive study to assess the hydro-electric resources in the country was undertaken during the period 1953-1959 by the Power Wing of the erstwhile Central Water and Power Commission. This study placed the economical utilizable hydro power potential of the country at 42100 MW.The Reassessment study completed in 1987 revealed that the Hydro Electric Power Potential of the country was of the order of about 84,000 MW. In the 11th Plan of Hydro Development a capacity addition of 78,700 MW comprising of 59,693 MW from thermal projects, 15,627 MW from hydro projects and 3380 MW from nuclear projects was approved during the 11th Plan period. Out of 15,627 MW hydro projects, 8654 MW was proposed in Central Sector, 34810 MW in State Sector and 3491 MW in Private Sector.

Latest as per the studies carried out by CEA to assess the requirement of additional capacity during the 12th Plan (2012-2017), the requirement of installed capacity to meetthe all India peak demand and energy requirement at the end of 12th Plan would require a capacity addition of over 90,000 MW in the 5 years period of 2012-17. In pursuing low carbon growth strategy, it would be our endeavour to maximize exploitation of hydro power potential. This is also necessary for energy security of the country. Availability of Hydro Projects for benefits during 12th Plan

To meet the requirement of additional capacity during 12th Plan(2012-17), a shelf of 109 candidate hydro projects aggregating to30920 MW under Categories 'A' and 'B1' having higher level of confidence for realizing benefits during 12th Plan, based on their present status of preparedness, has been finalised. List of these schemes is given at Annexure 1.1. The status of these projects (sector-wise) State-wise (sector-wise) break up of identified H. E. Projects for benefits During 12th Plan is given below:

Annexure 1.1

S.no	*States*	*Central Sector*		*State Sector*		*Private Sector*		*Total*	
		No	*MW*	*No*	*MW*	*No*	*MW*	*No*	*MW*
1	*Himachal Pradesh*	*2*	*816*	*7*	*892*	*6*	*749*	*15*	*1782*
2	*Jammu & Kashmir*	*4*	*2450*	*4*	*1473*	*0*	*0*	*8*	*3923*
3	*Uttarakhand*	*12*	*4370*	*7*	*1655*	*5*	*829*	*24*	*6858*
4	*Punjab*	*0*	*0*	*1*	*168*	*1*	*75*	*2*	*243*
5	*Madhya Pradesh*	*3*	*166*	*0*	*0*	*0*	*0*	*3*	*166*
6	*Andhra Pradesh*	*0*	*0*	*3*	*1560*	*0*	*0*	*3*	*1560*
7	*Kerala*	*0*	*0*	*6*	*373*	*0*	*0*	*6*	*373*
8	*Karnataka*	*0*	*0*	*2*	*400*	*0*	*0*	*2*	*400*
9	*West Bengal*	*1*	*120*	*2*	*66*	*0*	*0*	*3*	*186*
10	*Sikkim*	*1*	*520*	*0*	*0*	*10*	*1935*	*11*	*2455*
11	*Arunachal Pradesh*	*3*	*1610*	*0*	*0*	*23*	*7969*	*26*	*9579*
12	*Assam*	*0*	*0*	*1*	*150*	*0*	*0*	*1*	*150*
13	*Manipur*	*2*	*1566*	*0*	*0*	*0*	*0*	*2*	*1566*
14	*Tamil Nadu*	*0*	*0*	*1*	*500*	*0*	*0*	*1*	*500*
15	*Meghalaya*	*0*	*0*	*1*	*54*	*1*	*450*	*2*	*504*
Total		*28*	*11622*	*35*	*7291*	*46*	*12007*	*109*	*30920*

Nature has gifted our state of Jammu and Kashmir with vast Hydro Power Potential in the form of snow fed rivers of Chenab, Chenab, Indus and other major tributaries thereof. Although, the *state is endowed with rich Hydroelectric resources, according to a recent review of the hydro-electric resources conducted by C.E.A. bulk of these resources still remain unharnessed. There are no two opinions about the fact, that power assumes high priority, for economic development of the state, which is suffering a major deficiency in this sector. This is not only hampering the development process, but also puts a common man to great inconvenience and hardship. As against the actual requirement during summer and winter, availability at the end till now has no nearby equation. Prosperity of an area is now measured in terms of per capita consumption of electrical energy. The per capita consumption of electricity in the state is relatively lower than the all India average standing at 650 Kwh, which itself is low in comparison to consumption obtaining in several other countries. Per capita consumption being an important indicator, the need for accelerated power development cannot be lost sight of. It is really disheartening to note that only about 8% of the available hydro-electric resources have been developed so far, and another 12% of the potential is under development. Thus even with the completion of the scheme under construction only about 20 % of the available identified potential would be harnessed. The demand for power in the state is far in excess of production and chronic shortage of power is being experienced. Our state still gropes in darkness and this has hindered the overall economic progress in the state. A beginning was made as early as in the year 1905 in the pre-independence era when 4 MW Mohra Hydro Electric Scheme was commissioned in the State. This was subsequently remodelled to 9 MW and Commissioning of Kishtwar, Chennai, Upper Sindh Stage- ii and a few small hydro-electric schemes followed thereafter. The first major hydro-electric project commissioned in the state sector was the lower Chenab Hydro-electric Scheme with an installed capacity of 105 MW. Vast hitherto untapped power resources to meet the ever increasing power demand of the state in particular & the Northern region, as a whole in general need to be picked up fast.*

1.2 Total Generation capacities in the state build so far.

Annexure 1.2.1

Name of Power House	*Size in MW*	*Total Capacity in MW*
STATE SECTOR		
Chenab River Basin		

Lower Chenab	3 x 35	105
Upper Chenab-I	2x11.3	22.6
Kishtawar	2x3+2x4.5	15
Upper Chenab-II	3x35	105
Pahalgam	3 x 1.5	4.5
Karnah	2x1	2
Chenab Basin		
Chennai-I	5x4.66	23.30
Chennai-II	2x1	2
Chenani-III	3x2.5	7.50
Bhaderwah	2 x 0.5	1
Baglihar	3x150	450
Ravi Basin		
Sewa-III	3x3	9
Indus Basin		
Iqbal	3x1.25	3.75
Hunder	2x0.20	0.40
Sumoor	2x0.05	0.10
Igo-Mercellong	2x1.50	3
Haftal	2x0.50	1
Marpachoo	3x0.25	0.75
Bazgo	2x0.15	0.30
Stakna	2x2	4
Total		759.2
CENTRAL SECTOR		
Salal HEP	6x115	690
Uri -I	4x120	480
Dul-Hasti	3x130	390
Total		1560.0

Annexure 1.2.2 Projects being taken up for the development in State/Central Sector.

S.No.	Name of the Project	Name of the Basin	Estimated Capacity (MW)
1.	Sawalkote I&II	Chenab	1200
2.	Baglihar-II	Chenab	450
3.	Parnai	Chenab	37.5
4.	New Kishtawar	Chenab	93
5.	Lower Kalnai	Chenab	50
6.	Kirthai-I	Chenab	240
7.	Kiru	Chenab	600
8.	Ratle	Chenab	690
9.	Kawar	Chenab	520
10.	Ujh Multipurpose Project	Ravi	280
11.	PakulDul (Central Sector)	Chenab	1000
12.	Bursar (Central Sector)	Chenab	1020
13.	Kishenganga (Central Sector)	Chenab	330

1.2.3 IPP Projects

S.No.	Name of the Project	District	Capacity
1.	Ratle	Kishtwar	850.00
2.	Athwathoo	Bandipora	10.00 (commissioned)
3.	Tangmarg	Baramulla	10.00 (Commissioned)
4.	Hirapora	Pulwama	12.00

5.	*Brenwar*	*Budgam*	*7.50 (Commissioned)*
6.	*Kahmil*	*Kupwara*	*4.00*
7.	*Boniyar*	*Baramulla*	*12.00*
8.	*Mandi*	*Poonch*	*12.50*
9.	*Ranjala Dunadi*	*Doda*	*15.00 (Commissioned)*
10.	*Drung*	*Kathua*	*5.00*
11.	*Hanswar Paddar*	*Kishtwar*	*6.00*
12.	*Shukhnag*	*Budgam*	*9.00*
13.	*Nihama*	*Kulgam*	*6.00*
14.	*Shaliganga*	*Budgam*	*4.50*
15.	*Bringi*	*Kishtawar*	*4.00*
16.	*Gulabgarh*	*Reasi*	*6.50*
17.	*Boniyar*	*Baramulla*	*6.00*
18.	*Mawar*	*Kupwara*	*10.00*
19.	*Erin*	*Bandipora*	*10.00*
20.	*Chenani IV*	*Udhampur*	*7.00*
21.	*Shranz*	*Baramulla*	*10.00*
22.	*Kutmarg*	*Kulgam*	*7.50*
23.	*Achura Gurez*	*Bandipora*	*7.00*
24.	*Pomai Aridajan*	*Kulgam*	*4.00*
25.	*Kutbal*	*Kulgam*	*3.05*
26.	*Sultanpathri*	*Poonch*	*3.00*
27.	*Upper Ans*	*Rajouri*	*3.00*
28.	*Chingus-I*	*Rajouri*	*3.00*

29.	*Chingus-II*	*Rajouri*	*3.00*
30.	*Rongdo*	*Leh*	*9.00*
31.	*Bairaas*	*Kargil*	*9.00*
32.	*Tamasha*	*Kargil*	*9.00*
33.	*Girjan Ki Gali*	*Poonch*	*12.00*

1.3 JAKEDA

Taking steps by J&K Government for Speedy Development of Small/Mini Hydro Electric Power, Government has invited private entrepreneurs to undertake hydroelectric power generation and has provided mandate to JAKEDA "Jammu and Kashmir Energy Development Agency" as nodal agency under Department of Science and Technology for co-ordinating and promoting development of mini hydro power schemes.

JAKEDA has invited various agencies to bid for identified projects for the development of this sector. These will be termed as Independent Power Producers (IPP). These would include any of the private sector entities, central power utilities, state governments or any other government entities and their joint ventures. The Projects have been reserved for execution by IPPs that are permanent residents of State of Jammu and Kashmir. This would include such IPPs in which permanent residents of J&K hold majority stake. This condition shall, however, be relaxed, in case the bidding process of the projects so reserved does not result in adequate & competitive response. The eligibility of the interested parties is being evaluated on the basis of pre-qualification criteria. Proposals of only those parties are being considered for bidding who qualify the pre-qualification criteria.

1.3.1 Private sector participation

With the incentives allowed by the Government of India and fully supported / reinforced by State Government, the private sector has been invited to participate in Mini hydro power development in the State. The State has decided for selective privatisation of its hydro-electric potential. The state, because of its mountainous topography, snow covered ranges, many major rivers with large numbers of tributary streams, possesses vast hydroelectric potential for schemes of all magnitudes, large and small.

MOU's are being signed by the JAKEDA with private entrepreneurs for development of more than 100 sites of Mini Hydel projects. Lashpathri - IMHP for which this Detailed Project Report has been prepared, is one of these. It is a scheme envisaging development of the hydroelectric potential available on the LashpathriNallah, a tributary of River Sindh, in Ganderbal district of J&K state. The project report as desired by JAKEDA has been prepared with all technical and financial viabilities as are in vogue and befitting the given situation.

1.3.2 *The Project will be developed by Mass-N-Ergy Pvt. Ltd, The findings along with the proposal for augmentation of the installed capacity was incorporated in form of a Project report and is being submitted to JAKEDA for approval.*

1.3.3 Location and Source

Lashpathri - IMHP scheme has been identified as a run of the river scheme onright side of the Nallah. Power house site is located at a distance of about 44Km from Tehsil Kangan and62 km from District headquarter Ganderbal. Lashpathri - Imini hydropower project is one of the mini hydro power sites identified for investigation by the Consultants for harnessing the vast mini/micro and small hydro potential of the Kashmir region. The location of the Lashpathri - IMHP and adjoining villages is shown in the site plan. The scheme proposes to generate gross energy of 36million units of power in a 75% dependable year. The installed capacity of the scheme is proposed to be 8500 KW from 6.38 Cumecs of discharge with 174.45m net head.

Lashpathriis primarily a snow melt based stream with some contribution from rain falls during some months of the year which improves seasonal flows. The duration curve of the assessed flows in a 75% dependability year is shown in figure 3.1.2 which gives the characteristics of the flow. Very lean monsoon flow and substantial summer flow is received over nearly 30% of the year followed by a 'knee zone' leading to much lower level of dry season flow over nearly 45% of the year.

A comparative examination has been made of the energy generation possible with different installed capacities and corresponding different values of installed capacities. Table 4.2 to 4.4 which give the details of energy generation possible in years of 50%, 75% and 90% dependability for utilisation with some selected design discharges and corresponding installed capacity.

A comparative examination has been further made of the energy generation with different installed capacities in Table 4.5. The stream discharge in a year of 75% dependability have been taken as representative of long term average discharge (in representative range of values) for carrying out the optimisation studies. The maximum available discharge as per this series is around 6.38Cumec and if all available discharges of 75% year up to this maximum value were to be utilised, the maximum restricted average generation will be 36MU. The energy generation corresponding to different installed capacities are summarised in the subsequent table.

1.3.4 Layout of theLashpathri - IMHP

The selection of the particular reach of the stream for hydro development has been made on the basis of topographical and geological considerations. taking into account detailed topographical surveys that were conducted, with updated recorded discharge series up to Aug 2014, it was seen that optimum advantage is obtained by location of the reach with diversion weir at El 3123.60m and power house at Ground Level El 2942m. chosen weir sites and power house locations have been found minimal affected due to floods which have occurred in Past one or two decades which is very important for such schemes.

Further as per the available topographical features it has been decided to provide Forebay and De-silting Basin as a common structureat a safe place very near to the Diversion weir. The scheme involves long Length of penstock with length/Head ratio more than 1/4,which isnot in line with norms preferably adopted, however the matter stands discussed with the Leading Turbine machine suppliers and it has already been confirmed that such technical issues shall be handled in the design of equipmentto be provided by them.

Water conductor system shall have no power channel as the alignment which needed to be adopted in such case would not have been safe due to rugged topography along the alignment with apprehensions of snow slides in certain patches along with falling of shooting stones in some of the reaches. Normal water conductor would involve bigger sections as compared to Penstock diameter adopted thereby involving some deep cutting into the hill making it more susceptible to landslides.

Therefore, the scheme proposal is preferred by making it a penstock scheme where in the penstock has been aligned at lower levels than WCS normal alignment all along the Right *bank of stream with due safety factors. Maximum part of Penstock is kept buried with sufficient cover of back filled soil which shall make it safe against Landslides etc.*

The severe floods have not washed away any nearby part of the alignment adopted.survey works were undertaken and established that to make the project viable, alignment was shifted to the right bank of Lashpathrias the Right Bankdoes not provide features suitable for Hydel project development. After detailed studies of the topography and the available alternatives the diversion structure comprising of a trench weir and an intake structure on the rightbank has been ideally located. The location is comparatively in straight reach. The banks of the stream provide suitable strata for proper anchorage of the weir. Comparatively a very flat terrain along the alignment of the water conductor close to the intake has been chosen for location of the Forebay cum de-silting tank. This location is 42.63 m away from intake. A suitable terrace at the end of the Supply channel has been chosen for these structures. The penstock has been aligned along a hill slope below the Forebay. The power house has been located at a suitable location on a solid shingle boulder bench, which is above the anticipated estimated flood level of the Nallah.The tailrace has been suitably aligned to lead the discharges from power house to the source Nallah.

1.4 Components of the Scheme

The scheme has following components:

1.4.1 Diversion Weir

Lashpathriis a hilly stream and trench weir has been considered as a diversion structure due to its several advantages. This structure does not pose much disturbance to the water way of the river even during flood flows and it may be considered safe from damage due to rolling boulders during maximum flood flows in this type of Stream. The trench weir has also the capability to arrest minimum flow effectively and efficiently. Several small and medium hydroelectric projects have been constructed during the last fifteen years with trench weir diversions in Himachal Pradesh and at other locations in the Himalayan Regions of our country. The conventional gravity type of weir which has been used in the past before the advent of trench weir had to be provided with a structure for spilling flood waters and for energy dissipation. This work was also subject to involve high cost and as such stands avoided for due consideration of Project viability. The repair works can be managed easily during such occurrence with simultaneous debris clearances. Conventional types of raised-crest weir were not found suited for this stream from cost benefit analysis. Considering it is a mini Hydel project. In addition if such a weir is *constructed across the stream, the rise in water level upstream of the weir may bring a remarkable change in the flow conditions upstream at present location. The sediments may get deposited upstream of the crest as a result the intake can get easily choked up under in particular stream having narrow widths. Since diversions are interference to natural flow regime of the river, the extraction of water changes the flow conditions downstream of the intake. Undesirable sediment deposition occurs downstream of weir when too much water is extracted. Conversely, severe erosion downstream of the diversion occurs when remaining river flow passing downstream is carrying less sediment than its transport capacity. Moreover, any structural component that protrudes out of the river-bed (like top of a weir) can get damaged easily by the force of large sediments rolling down with high velocities during floods due to Stream being narrow and steep.*

As such to overcome the above problems associated with raised-crest weir herein for this scheme, the most common type of weir adopted in such boulder streams for MHP was found trench weir. This is a weir by way of having a Reinforced Cement concrete Trench almost throughout width of stream. The top of the weir is covered with bottom rack bars, Water while flowing over it, passes through the bottom racks and enters into the trench and collected in an intake well located at bank to end of the weir. The top edge of the diversion weir has almost been flushed with the natural bed slope of the stream. The bottom racks shall be consisting of heavy flat steel bars laid on edge over structural steel Z piece members securely fixed in concrete side walls and placed parallel with the river flow on the bed level. The bottom rack bars have been proportioned to carry the weight of the heaviest boulders that are likely to flow down during the maximum probable flood.

This type of weir has the definite advantage as it does not affect the general bed level of the stream. Post-Flood clearance of the boulders and debris collected in the trench of the weir may be found obligatory. It needs to be mentioned here that in spite of the annual maintenance requirement, this type of weir has been widely adopted in the SHP/MHP schemes, built in Arunanchal Pradesh, Sikkim, Himachal Pradesh, and Uttaranchal and in few projects of J & K.

The estimated peak discharge using various methods and take the most reasonable of them as design discharge for trench weir for a conservative design. Flow in the stream at its different stages is analysed using the manning's equation with appropriate value of rugosity coefficient along with Flows over broad crested weir. Water while passing over the *bottom rack, enters into the trench due to gravity and remaining flow in the downstream of the trench in the streams beyond the required discharge max as designed flow. The flow in the stream with bottom rack is a case of spatially varied flow with decreasing discharge. The rack is made of parallel bars in panel form with Fixed to MS channels placed along the direction of flow. Main variables involved in computing the diverted discharge into the trench are flow characteristics of the stream, geometry and dimension of the rack, free and submerged flow conditions etc. The racks have been placed inclined with reference to the approach bed of the river. The inclination of the rack, which is normally of the order of 1 in 10, is provided at same slope to facilitate easy movement of bed load of stream moving over the rack.*

It has been assumed that the specific energy of flow shall be constant all over the longitudinal bottom rack, and from the structural consideration, flat bars have preferred over rounded bars as flat bars have more flexural rigidity. There is considerable effect of ratio of thickness of bars t and their clear spacing, i.e. t/s and inclination of bars, the value of Cd increases with increase of t/s ratio; however, it decreases with the increase of inclination of bars (SL) for constant value of t/s ratio.

1.4.1.2 Intake Structure/Intake well

Intake structure herein called as Intake Well with vertical lift gates has been proposed on the right bank to draw water from the pond created in the Trench weir. Intake structure will have 2 no gates as Bulk head and Intake Service gate. The Gates shall be operated through a lifting arrangement by Chain pulley mounted with Hoisting arrangement. During floods Gate operation has to be properly ensured for its adjustment in height of opening to avoid excess water entry to the water conductor system. The Intake well shall be made of RCC rectangular chambers having provision for flow control to the supply channel and Shingle flushing system. The height of the well has been fixed as per the worked out HFL at Diversion site.

Practical and economic considerations dictate that the Lashpathri - Iwater conductor system leading to powerhouse must be designed and constructed to accommodate combined flows for Intake well which shall include silt and shingle flushing discharges besides requirement of water for the overload generation requirements.The trash rack provided at the crest of the weir has 30 mm nominal size openings. The diverted water may therefore carry sediments up to 30 mm nominal size. It is advisable that majority of these *particles are eliminated before the water enters the inlet channel and further to the sedimentation chambers. To this end, a shingle excluder has been provided at the end of the trench weir in the Intake well on the right bank to arrest the entry of the shingles moving along the bed of the trench weir into the inlet channel. Near this end, the trench weir bed has been given a curved profile to facilitate rolling down of the bed load (shingles) into a pit. A1000 mm wide lip may be provided to prevent shingles and other particles collected in the pit to enter the Feeder Channel. From time to time, shingles accumulated in the pit will be flushed back into the stream through a shingle flushing MS Pipe of 500 mm diameter, provided at about right angle to the trench weir axis. The pit may be provided with a slope of 1:11 towards the flushing pipe.*

The flushing Pipe also has a slope of about 1 in 10 is considered to be adequate to generate non-settling velocity for particles up to 30 mm size. The flushing channel runs along therightbank of the Stream for a length of about 20m before it discharges back into the source stream, at above HFL.

To facilitate intermittent flushing, a- 1 m x 1.0 m (H) gate is provided in the shingle flushing channel. The gate will normally be kept closed and will be fully opened to flush the shingles. Following the shingle excluder is the water intake, with a 2.0m wide and 2.0m high gate, along with its control structure. The gate will be operated using a Chain pulley arrangement. A 0.6 m x 1.4 m opening in the hoist floor slab provides access to the intake bed. It may be noted that, the water conductor system is on surface; all the structures will be of cut-and-cover type in adjacent to Intake structure. The maximum flow which shall pass through the intake shall be 6.38Cumec.

1.4.2 Supply Channel

A short Feeder/approach/Supply channel in form of RCC Rectangular Box section leads the diverted water from intake to the de-silting tank carrying a discharge of 7.54 Cumecs with 20% silt flushing discharge and only 10% discharge on account of overload Generation. The section shall include the transition for smooth flow of water into Water conductor system from rectangular to rectangular. The Channel shall be of length 100 metres withBox of consistent section throughout. The bed grade of the channel is proposed to be 1 in 550. Additional Discharge of 10% required for overload running of plant at 20% shall be accommodated into free board which has been 0.4 m in depthin RCC Box. In view of the Geological and topographical features this part of water conductor system consists of same section through and through which is of RCC Box as strata is found suitable.

Open channel section stands avoided due to involvement of some huge excavation on hillside due tonon-availability rock underneath besides endanger from screed materials involving maintenance issues. The Alignment of water system has been opted on right bank of Stream as theRight Bankof does not provide a suitable terrain to generate the required head besides the fact that left bank of stream all along does involve Forest Trees. Now since the water conductor has been chosen on the right bank where most of the construction materials shall have to carried across the stream and it may not be affordable for such project to provide access road along the water conductor, But the length being too small RCC section was found to be most suitable conveyance system in place of other alternatives like MS Pipe Construction or Hume pipe arrangement etc . The Hume pipes are found very heavy in weight and handling of such pipes shall be difficult to handle along the selected corridor and it may not be possible to have the required diameters of needed quality as the system needs to be water proof in all respects in particular in view of the fact that available foundation may be susceptible to any saturated conditions.

The proposed RCC Box line shall be provided with Expansion joints (along with I number Manhole at appropriate location)with de-silting tank and Intake well, as per requirement. The RCC Box has been proposed to rest on solid foundation. The Supply channel shall have a length of 100 m and in the design roughness coefficient for flow has been adopted as 0.018;this is in line as per the Guidelines for Hydro Electric Projects. It has been proposed that there shall be no permanent road along this part of the water conductor, however a berm and proper drain shall be provided towards hills side, and the berm may be used for making any inspection during the plant operation. The hill slopes are stable as such 1:1 slope may be manageable with existing soil conditions. RCC Box construction for the reach shall help in having support to the hill slope and with more improvement if covered with earth fill ultimately.

1.4.3 De-silting Tank

Most of the Himalayan Rivers and rivulets carry a lot of sediment during Rainy seasons and some times during periods of heavy snow melt. For run-of-the-river plants located on such streams, it is essential that a de-silting arrangement be provided to trap and exclude sediment particles in excess of a selected size so as to minimize damage to underwater turbine components.

The maximum particle size that should be excluded before the diverted water is channelized into the water conductor system or to the Forebay directly as is in this case, leading to the turbine is directly linked to the potential wear of turbine parts due to sediment abrasion, which depends on the following factors:

- *Concentration of suspended sediment*
- *Hardness of particles*
- *Size of particles*
- *Shape of particles*
- *Abrasion Resistance of turbine parts*
- *Turbine head*

Since inter-relationship between these factors is complex, a universally accepted uniform criterion is not available for desander design. However, in India, the most commonly used criterion is to design the de-silting tank for such projects that would exclude particles greater than 0.2 mm with an efficiency of 90% or higher. This criterion could be relaxed somewhat for installations with Pelton turbines, however, at higher heads, , the criterion of excluding 90% particles greater than 0.2 mm should be, and is, retained.

Type of desanding arrangement

Three types of desanding basins are considered, namely

- *The Hopper type settling basin*
- *The DuFour type settling basin*
- *Basin with vortex tubes*
- *Bieri Type settling basin*

While the conventional settling basin has almost always been employed as preferred desander in hydroelectric projects, use of vortices for removing sediment load from water has largely been restricted to irrigation projects, with very limited application in *hydroelectric projects. In recent years, merits of using vortex tube type desanding arrangement at hydro project with small design discharges have been recognized and they have been employed at few hydroelectric projects in Himachal Pradesh and are also being considered at few other projects.*

Hopper type De-silting Basin

Between the two settling type basin arrangements, the DuFour type is not found suitable at places like Shatkari. Design calculations show that the length of Dufour type desanding basin is more than the single bay hopper type arrangement and does not suit the topography of head works area. The structure will extend into higher natural ground and would entail significantly higher quantity of excavation.

Design calculations for the conventional hopper type basin arrangement are presented hereafter. The system would have the following characteristics.

One settling basins is provided to improve reliability and enhance operating flexibility, basin in form of rectangular tank and provided with sectional area to reduce the velocity of flow comprising of bed raft laid at 45 degrees each , with a total length of 18 m on either side of the Tank inclined towards gutter at the centre of De-silting Basin , this bed raft has been considered below the water level of full supply depth adopted in tank design shall slip all silt contents into the gutter. The Gutter shall be provided with 2% bed slope which is found sufficient to carry the silt particles along with flushing discharge. Since the structure shall be constructed in combination to the Forebay as such a partition wall has been created at the end of De-silting Tank part with silt settlement assumed to be well before it and clean water to pass over the crest of this partition wall. The depth of flow as FSD in De-silting Tank has been adjusted to be the same as operating depth required in Forebay tank.

- *The flow through velocity in the tank has been taken as1.87m/sec.*
- *Basin is designed to settle all particles of size 0.2 mm and above.*
- *The settling velocity for 0.2mm size particle is taken as 2.5 cm/sec at 0º C (the water in the stream is mostly from snowmelt.)*
- *The flushing discharge is taken as 20% of the plant discharge. And mostly the operation shall be required during period when discharges are high in the stream as otherwise silt content in the stream is found to be in significant.*

• In order to dispense with the conventional 90º bend in flushing pipes (which makes it difficult to clean in case of choking of the pipes), a 0.8m wide and 1.0m high flushing gallery with a silt flushing channel (cunette) is proposed at the end of Gutter which will be laid underneath Forebay raft. The flushing flow will remain concentrated in the silt flushing channel.

As such the de-silting tank is single bay rectangular tank with flushing gutter type of RCC construction having 39.0m (length) x 9.00m (breadth) x 4.26m (water depth in main Tank) has been proposed at RD42.63m. It has been designed to remove 0.20mm and abovesize silt particles. MS Pipe 600mm diameter with min. slope 2% is proposed to be provided for flushing the silt and the flushing is controlled by 600 mm diameter sluice valve. The De-silting Basin has been provided with a free board of 600 mm. The Tank shall have upstream transition only as other end is directly merged with same width Forebay tank.

1.4.4 Forebay

TheForebay tank has been adopted as simple RCC Rectangular section having a common partition with de-silting tank. The tank will have an overall depth covering minimum water seal required to avoid any vortex formation in the Tank, this shall be located at the end of the de-silting tank part as discussed earlierbut the design discharge in case of Forebay has been taken to be 6.38Cumecs only. Further Tank is provided with sufficient bottom seal under the bell mouth in Forebay pool to take care any undue material that may go into Forebay including provisions for silt depositions. The tank has the basic purpose of absorbing the fluctuations in the water supplies providing cushion for sudden tripping of the machines. The Forebay is designed for a storage capacity time of 2 minutes with live storage full supply water level and minimum draw down water level. The design discharge for Forebay shall be 6.38 Cumecs which includes 20% additional discharge for overload power Generation, The Forebay is provided with an Intake gate arrangement to control flow into Penstock as per the size of Bell mouth, the hoisting arrangement will be of Double Rope drum electrically as well as manually operated, further provisions for removal of any silt accumulated have been kept by way of providing 300mm diameter MS pipe with control *arrangement of same diameter Sluice valve. The silt flushing pipe shall be dropped directly into source Nallah.*

. The average width available for the Forebay from the toe of the excavated slope on the hill side is limited to an excavated depth of 4 m to 8 m at an appropriate location on the valley side where ground level is not lower than the floor level of the Forebay. The sill level of the intake has been fixed on the basis of requirement of water cushion above the intake opening. Retaining walls forming the intake structure connect to the excavated slopes to form the Forebay. The retaining wall has a maximum height of 6.76 m. The Forebay is lined with Reinforced cement concrete. The Forebay intake is provided with a bell mouth opening for the penstock and would be of RCC construction. An earth fill cover has also been provided on the downstream of the retaining walls of the Forebay. LDPE film sheets may be used for the walls and sides of the Forebay structure to serve as a water proofing membrane. The excavated hill slope behind the Forebay is also proposed to be stabilized without causing any damages to an existing road passing nearby to Forebay site on hill side. Further these safeguards are done as an abundant measure of caution to minimize distress due to seepage and provide additional stability for the critical Forebay structure. The FSL of the Forebay is EL3122.58 m and the surplus escape located near the Forebay comes into operation to release the discharges during the sudden rejection of the load by the turbines.

A sharp crested Escape Bowl stands provided in Forebay for collection of any over flows during emergency shutdown or for other reasons. The collected water shall be taken to source Nallah nearby through proposed MS Pipe arrangement.Individual part of Forebay in combined structure with de-silting tank is proposed to be of size 40m x 9.6m, having an overall depth of 8.27 m.The Tank is provided with live storage for 2 minutes. And it has been assumed under draw down conditions there shall be no silt content flow from De-silting basin as both the structures have been designed independently for dimensioning of both structures.

1.4.6 Penstock

As discusses in above Para's the scheme has been developed as a "so called" penstock scheme wherein penstock length is found long for its "length verses head ratio". All care shall be taken in pressure rise due to such issue, proper care for pressure relive arrangement is recommended to be adopted at detailed design stage with due consultation with the Turbine manufactures/suppliers. However the penstock has been designed against the *actual pressure rise due long penstock which shall be provided even if PRV is kept in place. MainPenstock with 1600mm diameter and thickness varying from 28mm to 8 mm thick MS Plates with symmetrical bifurcation at the lower end of 1132 mm diameter with 28 mm thickness MS plates for each pipe for feeding two machines in the powerhouse has been adopted.*

The penstock has been aligned as per the topography available along the Nallah bank with sufficient safety margins from HFL in the Nallah point of view. Almost the entire length of penstock has been kept buried for its safety however suitable number of manholes at appropriate intervals for any inspection has been recommended through RCC well to be provided through back fill part. The penstock shall be having bituminous wrapping around it from outside to safeguard it from anycorrosion.For every change of alignment Anchor blocks of RCC shall be provided. The Penstock Liner shall be rested on saddle blocks.

1.4.7 Powerhouse

The proposed power house has been placed at relatively flat and stable terrace with turbine floor level --- m. The Power house shall be of RCC framed structure with brick work in form of panels in walls. The power house is surface type with Bed Raft/Floor of Reinforced cement concrete M20 grade. Walls of power shall be of RCC 0.6m above maximum tailrace water or backfill level. A single leaf gate shall be provided for 2 number draft tubes Gate openings with chain pulley arrangement for lifting. The power house shall have to be safe guarded by providing flood protection Bund. The power house building has been dimensioned in such a way so that full space is utilised for accommodating two number units of 4.25Mw each along with connected arrangements of Hydro mechanical and Electro mechanical equipment's and the structure has been divided into three parts i.e. service bay , Machine hall and Control room with HT/LT room. The battery bank has also been provided adjacent to Control room and further more office and on one number wash room has also been adjusted in the power house building.

The Layout of powerhouse building comprises of

- *A machine hall consisting of a separate turbine floor and a generator floor.*
- *A control room housing all the electrical panels required for the operation of the units including Ht and LT Panels.*
- *An unloading bay and service bay.*
- *Annexe space and auxiliary space for auxiliary equipment*

- *Draft tube and transformer deck.*
- *Outdoor switchyard.*
- *Option of providing standby third unit of 0.5 to 1 MW is kept open at this stage in case the Sale rate of power improves which likely may take place in future then the same can be a more viable proposal in overall interest.*

The centre of turbine is fixed taking into consideration of the hydraulic parameters of the horizontal Francis type turbine and the minimum/Maximum tailrace water level has been provided accordingly with respect to the bottom level of Turbine. The floor layout is so designed to accommodate the trenches to run the power cables from the generators to the control panels in the control bay. One number E.O.T. crane 30T capacity is provided in the power house with facility to operate in longitudinal and transverse directions, to handle the E and M equipment during construction as well as operation stages.

1.4.8 Tailrace Channel

This structure is used for sending the tailrace waters from power house to Source Nallah / stream. The tail race channel has been designed as RCC structure with discharge capacity of 40% of one unit discharge under minimum tail water condition and 120% of full design discharge of both the turbines under normal and maximum tail water level condition with free board of 0.6 m. The discharging capacity in each case is determined by Manning's formula. The channel has been designed as a rectangular RCC structure up to the bank of the stream and thereafter on crate construction in the stream bed making it flexible and repairable after flood seasons. The Tail pool shall as per the power house layout arrangement wherein the two individual draft tube exits shall deliver discharge into the pool, initial 4m in bed raft has been kept plain after which reverse grade in the bed raft has been provided to meet the bed level of Tailrace channel so as to maintain the minimum tailrace water level from Cavitations' stand point. The section of tailrace pool shall converge in accordance with Channel size. The tailrace channel shall be rectangular in shape.

1.5 Power Evacuation

The power generated from the scheme will be transmitted to PDD sub-station at Gagangeer at a distance of 9km from the powerhouse location. This will be done through 11/33 KV transmission line from switch yard to the receiving station. Though ideally 11 KV Transmission line would prove to be economical for such projects but due to the concerns of *system voltages in this provisions have been kept for 33 KV line while framing the estimated cost of the project. The transmission line shall be taken through the corridor initially along the Nallah bank with safety margins from Floods and then shall be made to cross area comprising hilly terrain.*

1.6 History and Background

Jammu and Kashmir Government for the last 5 years has been taking various steps for power generation with the objective of the economic development of the state. This includes the development of major power projects. Steps have been taken in the power sector for the development of mini and micro hydropower projects. A policy has been notified with Jammu and Kashmir Energy Development Agency having been assigned the charge of the mini-hydropower projects up to 10 MWs.The Lashpathri-Ihydropower project is one of the projects identified by EnCon Group for the development of hydropower scheme.

The scope of the report covers the following:

- *Review and analysis of hydraulic and other field data*
- *Formulation of the alternatives for the water conductor system and selection of optimum scheme from techno-economic consideration*
- *To carry out power studies in order to determine optimum installed capacity of the scheme, design parameters of the generating unit and annual generation possible.*
- *Selection of type, number and capacity of turbine generator units.*
- *Formulation of the project layout comprising of approach roads, head works on the river, water conductor system, power house, tail race, outdoor switch yard and power evacuation*
- *Details of hydro scheme covering civil, mechanical and electrical aspects.*
- *Project cost estimates, unit cost of generation and financial analysis.*
- *And Implementation schedule*

1.7.1 Location

The Proposed Project site can be approached through Srinagar-Ganderbal-SonamargRoad.The road lengthto becovered involves 21 Kmfrom Srinagarupto district HQ Ganderbal. Thereafter, the Project site is located at village Shatkari on Kangan-Sonamarg road, 44 km from Tehsil Kangan &62 km from District HeadquarterGanderbal.

1.7.2 Communications

The project site is connected through all-weather Road from National Highway NH-1A via Srinagar-Sonamarg.During the construction of the project existing kacha access road shall be upgradedand shall need to be taken right up to the Powerhouse site. Existing bridle path from Powerhouse to Forebay and to Headworks shall be strengthened for uninterrupted access to all components. The proposed headwork's is presently approachable from the main roadthrough a bridle path only. However an option shall be explored to have rope way arrangement for shifting materials to the location were road may not be made as the project in small. However option shall be taken up and decided upon as per space made available during the execution of Penstock and construction materials can be shifted along the plat form created after taking up excavation of penstock alignment as such the trench work and erection of penstock shall be managed in conjunction to the requirements of dumping materials for construction of Diversion weir, Common De-silting basin and Forebay to the nearby locations.

1.7.3 Population, Resources and Socio-economic conditions.

The project area is sparsely populated with the people mainly involved in small agriculture activities. The population of nearby villages including Shatkari is around 7000. The resources of the area are mainly green virgin forests clustered with Deodar, Kail and Fur trees in upper catchment area. Except for water resources, no other natural resources of any commercial significance are available in or near the project area. The forest resources are also very limited in project area.

The forest comprises mixed jungles, mainly of pine Trees. The economy of the hill areas of J&K is agriculture (Paddy) based. Some of the people from this area serve in bigger towns where infrastructure for industries and commerce exists. The remaining people work on small terraced fields. In general, the socio-economic condition of the people is poor. Development of tourist activities can be explored as the area has got tremendous Scenic beauties, the state tourist department is involved in various development activities of the area which can enable locals to get involved in some works.

1.7.4 Topography

The source Nallah viz.Lashpathri Nallah joined by other small sub-tributaries of the catchment forms one of the direct tributaries of River Sindh. It starts from Mountain peaks having Latitude 34º20'18.64" N and Longitude 75º8'44.23" E and elevation of 4550 m above MSL . The LashpathriNallah is perennial flow Nallah fed by glacial / snowmelts. The Nallah is flanked by steep mountain slopes on either side or traverses through Shatkari and other nearby villages negotiating a length of 9 km up to headwork's site. The bed gradient of the Nallah is fairly steep encountering a number of rapids in negotiating a fall of 1572 m up to Headworks Site.

The lower slopes are under dry crop cultivation. The portion above the winter snowline of elevation 3050m feeds the Nallah by snow and glacier melt. Minimum discharge in the Nallah occurs during November, December, January & February. Relatively high flows during summer months are contributed by snowmelt as well as rainfall in the catchment. The stream has got characteristics of its own with available rugged terrains in the catchment having very low discharges in winters starting from November and relatively high discharges in comparison to the other streams.

1.8 Climate

The climate of Jammu and Kashmir varies greatly owing to its rugged topography. In the south in the Jammu region the climate is typically monsoon very hot and can reach up to 45°C. Towards north in the Kashmir Valley across from the Pir Panjal range, South Asian monsoon is no longer a factor and most precipitation falls in the spring from southwest cloud bands. Because of its closeness to the Arabian Sea, Srinagar receives as much as average 1200 millimetres of rain from this source with March to May being the wettest months with around 100 millimetres per month. Winter precipitation falls in the form of snow depending upon altitude and other meteorological conditions. As the catchment is located in high altitudes the maximum temperature does not go beyond 32^{0}C, the winters being severe with minimum temperature of -5^{0}C.

1.7 River System

LashpathriNallah, asub tributary of River Sindh and is one of the small drainage line joined by a number of rivulets and smaller tributaries draining Middle Himalayas Pir Panjal range. The catchment is wooded in higher reaches and has steeper slopes with the forest line *meeting small hillocks and dunes of fertile land mostly barren of any vegetation. At the foot of these mountains rugged Karewa land cut by gullies with relatively moderate slopes.*

1.8 Hydrology

For correct estimation of hydrology and selection of proper site for the power plant, especially in case of a hill schemes, about 18 months' time are required for recording the discharge of two seasons. For the purpose of preparation of the Project Report and with a view to reduce the duration of project development, lean discharge is calculated by correlation of the discharge data having similar geographical and geological features based on the catchment area.

Lashpathriis a perennial Nallah starting from an altitude of 4550m of Glacier peaksabove MSL (Glacier) and is joined by a number of small tributaries. The precipitation in the area is seasonal/flashy rainfall during summer and spring: The run-off contributed by melting of snow starts increasing from March-April and gradually reaches its peak in the month of July and August. This gradual increase in the runoff from March to August coincides with the increasing trend of air temperature. In October the discharge starts diminishing and by the remaining months of the winter, the discharge fluctuates and shows a minimum discharge sometime in the month of Nov, Dec and Jan.

Due to low winter temperatures, the glacial sources of the Nallah freezes. However, the water continues to flow underneath. Total catchment area of the Nallah up to the proposed diversion site has already and previously has been established to be 35 Sq Km. This has been confirmed by satellite imagery and internet maps. An Ordinary Gauge and discharge station has been installed in 2012to measure the discharge in Lashpathritill August2014.

Nearly two and a half years discharge data has been used to formulate the project report. Firm discharge series from 2012 to 2014 has been used for dependability and optimization calculations. During the stage of execution, the hydro- logical data series will be updated further for computing the dependability of the discharge, the ten daily mean discharges have been tabulated and unrestricted energy has been calculated.

The 10 – daily discharges of the 75% dependable year have been used to arrive at the optimum and the best beneficial installed capacity of 8.5MW.

1.9 Site Selection

LashpathriNallah has a varying grade from the source up to Diversion site. In between there are some riparian demands even on downstream of the project site as such a total *resaved quantity of water i.e. 0.4 Cumecs has been take into account to result in selection of site at proposed location, wherein the diversion site has been proposed to downstream of irrigation canal take of point..*

The proposed headwork's has been selected based on the ideal site concept where the width of the stream is optimum i.e. not too wide to result in high costs and not too narrow to endanger the diversion and intake structures. The headwork's site has been fixed at appropriate location.The alignment of the water conductor and penstockin particular has been fixed on the available contour all along nearby to Nallah Bank, which involves minimum cut/ fill. The alignment has also been fixed keeping in view the minimum dislocation of residential houses and populated areas.In fact there is no involvement of any houses/ buildings along the alignment. Forebay and Power House have also been suitably located based on available space to minimise cost on account of heavy cut/ fill.

1.10 Discharge and Gauge observation

Being a small tributary historical discharge data is not available for this particular site. However the Consultant has been observing discharges at a nearby site of Headwork's for previous two and half years. The discharges have been updatedfor last three years (2012-2014) resulting in a firmed up data for the last two and half yearsnear the proposed headwork's.

1.11 Project Purpose

1.12.1 Needs

Inadequate power infrastructure has been the major factor for the underdevelopment of the State. The local area of Lashpathri is economically backward with no industrial development. Lashpathri - IMini-hydropower project if followed by appropriate policy of economic development will act as trigger for the economic development of the villages providing avenues for the villages.

1.12.2 Objectives of the Scheme

Envisaged by Government of Jammu and Kashmir such schemes will provide a platform for the villages of various kinds of economic opportunities including cottage industry and other economic areas with installation of such projects. The development of power potential will also facilitate better educational opportunities. This will also reduce *the local populations' dependence on firewood improving the environment and conserve the ecosystems of the area. In fact JAKEDA has been planning to develop the renewable energy from Mini Hydel Projects up to 10 MWS, as is being promoted by other potential states of the country. The need is to meet the electricity demands in our country through Environmental friendly means scheme will provide a platform for the villages for various kinds of economic opportunities including cottage industry and other economic areas. The development of power potential will also facilitate better educational opportunities. Business development will enhance over all business scenario in the state as such projects are being launched in every nook and corner of the state and will generate local employment and shall provide work and jobs to locals of the area. With un limited advantages from such projects will not explore the utilisation of energy which is otherwise going waste but shall also improve overall power set-up of the state which is bringing electricity from outside at rates which sometimes go un affordable for the state, in particular during winter when the demand is high in the state, These projects can got implemented in very quick time with very few environmental issues. It shall not help Government directly but shall also involve good number of Business class groups towards the development of state.*

Civil Engineering Structures

6.0 Civil Engineering Structures

6.1 Project Layout Planning

The location of the project has been carefully done after the study of the following parameters in view of the revision carried out:

- *a) Suitability analysis of the different components of the hydropower scheme*
- *b) Ecological and environmental sensitivities of the site*
- *c) Optimal civil cost of the works*
- *d) Geological & Geomorphology of the area.*

6.1.1 *All components of the project including the diversion weir, intake and approach channel, de-silting tank, forebay, penstock, switchyard, powerhouse and tail race have been located on the right bank of LashpathriNallah on the basis of topographical, geological, soil, ecological and environmental study. The layout has been fixed to maximize the exploitation of available discharge and head.*

6.1.2 *Diversion weir site has been proposed at appropriate location on the topographic survey sheet on a stable and relatively flat bed slope of the Nallah.*

6.1.3 *The location of Intake, Forebay and the alignment of , de-silting tank, and penstock are primarily based on the basis that power channel has been avoided due to reasons discussed in preceding Para's and topography of the area using the optimum hydraulic computation in adopting it as a penstock scheme.*

6.1.4 *Although many possibilities of the water conductor system alignment exist but the final alignment has been based on the most efficient and cost effective system after studying the geology, topography and hydraulic features in case of present proposal. RCC Box Contraction has been recommended for water conductor up to De-silting Tank. The Forebay and De-silting Tank shall be one Structure with design features for its purpose have been taken care independently as per the requirement as per general norms. The proposed alignment is based on the techno-economic comparisons of all the possibilities available at the site and to avoid certain UN avoidable encumbrances.*

6.1.5 Components of the Scheme

Following are the principal components of scheme.

- *a. Diversion weir*
- *b. Intake structure*
- *c. Approach channel*
- *d. De-silting tank*
- *e. Forebay*
- *f. Escape Bowl / Pipe*
- *g. Power house*
- *h. Tailrace Channel*
- *i. Switchyard*

These are discussed in below:

6.2 Diversion Weir

Alternatives considered

The width of the stream at this location at pond level elevation of 3122.8 m is 25.0 m. The abutments are of hard shingle boulder strata still necessary support at the ends has been provide. The intake structure is at the end of the trench weir adjacent to the right bank. The trench is below the bed level El 3120 with a top width of 2.0 m and bottom width 2.0 m as well and a depth uniformly varying from 1.0 m at the right abutment to 3.0 m at the right abutment where the intake structure is located. A trash rack grill has been provided on top of the trench opening sloped in the flow direction so that stones and pebbles do not settle but would roll away with the stream flow. The trench itself is provided with a bed slope of 1 in 12.5 in the flow direction of the diverted water so that sufficient velocity is generated to carry away heavy silt that may find entry into the trench through the trash opening. The intake structure is located on the right bank sufficiently away from the midstream so that the regime of the river is not affected during normal high flood level conditions. Two openings are provided in the intake structures, one of 2.0m x 1.80m for carrying the design discharge through to the de-silting tank and the other of size 1x1 m with shingle flushing pipe 500mm diameter *forcarrying directly the silt collected in the trench weir to a suitable location in the stream downstream. The intake opening is designed to carry 150% of the design discharge, which works out to be 6.38Cumecs to allow for the additional requirements for flushing silt at De-silting Tank and an overload discharge. Entry to these ducts is controlled by gates operated from the top of the intake structure. The intake structure permits the release of water to the desired extent. The top of the intake structure has been kept at El 3120 m. The 0.5m opening is continued as MS Pipe to terminate at a suitable location in the river at a level above the normal HFL. Such a location is met within length of pipe.*

The protection works in the river bed both upstream and downstream of the weir consist of wire boulder crates 1500 mm x 1500 mm x 1500 mm in size and PCC concrete M15 Blocks of size 1500mmx1500mmx900mm size. These are extended on the upstream and on the downstream. Concrete toe walls, one on the upstream and two on the downstream of the trench of different heights as per requirement serve as a safeguard against dislodging of the blocks and consequent erosion.

Lashpathri - Ialternatives of gated weir, trench type weir, boulder weir and RCC weir were considered. For steep rivers a feature of the Himalayan Rivers fully gated weirs are not suitable, as they are prone to damages due to rolling bed load and the flashy floods. Trench weirs herein has been adopted and it is envisaged that it should be able to perform optimally though may get filled-up with debris during storm flows, But will not be a matter of concern in the long run as may be simultaneously cleaned very easily. Further the abutment work has been adopted to be in crate work with concrete grouting on front face, the concrete as such will protect the wire mesh from tearing.

6.2.1Design

The height of Trench type weir is governed by the full supply depth of water in approach channel and elevation of bed at the start of this channel. The entry of rolling stones and boulders into approach channel is proposed to be restricted as it shall have tendency to roll over the Trench covered with reasonably strong Trash rack on it. Thus,

Invert level of intake at end of weir = Bed Level at start of Feeder channel +0.2m.

The water diverted by the weir is fed into a rectangular, gated intake structure. This intake structure is located on the right bank of the weir. The location of the intake structure has been selected ensuring that the regime of the stream is not disturbed. The intake structure performs the following functions.

i. *Regulation of the discharge for power generation irrespective of the discharge flowing in the river*

ii. *Acting as an abutment for the right bank of the weir.*

On the upstream side of the Nallah at right bank and just adjacent to the Trench weir a stone Masonry wall has been proposed which guide the flow and will safeguard the Intake well including the initial part of Feeder channel.

*6.2.2 **Design of Trenchweir***

Design Discharge	=	*8.12*	*Cumecs*
Pond Level	=	*3125.00*	*m*
Highest Flood Level	=	*3128.58*	*m*
Average bed level at Diversion site	=	*3125.00*	*m*
Width of stream	=	*15.00*	*m*

Calculations for size of Trench Weir

$B = (Q/(E_1 \times E_2 \times C_d \times L \times (2gE)^{1/2})$ **I**

$E = (Q/CL)^{2/3}$ **Ii**

Where,

Q is Diverted Discharge in Cumecs

L is Width of Stream

E_1 = ratio of opening/Total area of trash rack surface over trench = *0.5*

E_2 is area of opening in the trash rack likely to be clogged = *0.5*

L is length of weir across stream

E is specific Energy at any section of stream in the trench weir

B is width of Trash rack (width of Trech weir at top)
C is cofficient of Discharge for Broad crested weir = 1.53

C_d Cofficient of Discharge through opening = 0.46

E = Specific Energy , from Equation (ii)	=	0.5	
B= Width of Trash rack (Trench weir width at top) , from Eq. (i)	=	1.50	m
Provide, width of 2 m from practical consideration, then width per metre providing 0.4 m/sec			
Allowable velocity through Trash rack opening. (From, Q/0.4L)	=	1.353	m
Width required for 50% clogging criteria	=	2.707	m
Which is less than provided width , hence safe, Provided width	=	2	m
Level of Trench weir at top is fixed at E1	=	3125	

Check for discharge capacity of Trench weir

Design Discharge	=	8.12	Cumecs
Top width of Trench weir (T)	=	2	m
Let water depth along channel be = d			
Area =Txd	=	2	xd

Velocity head at the end of Trench h_σ is given as,

$$h\sigma = n/(n+1) \times A/2T$$

where n, is constant depending upon bottom profile of channel	=	0.5	
$h\sigma = n/(n+1) \times A/2T$	=	0.167	xd

The corresponding discharge is given as Q= Ax Sqrt(2gh)

where A	=	*2*	*xd*
g	=	*9.81*	
h	=	*0.167*	*xd*
Q is Diverted Discharge in Cumecs	=	*8.12*	*Cumecs*
Depth of flow at start (d)	=	*1.715*	
Provided (d)	=	*1.715*	*m*
Depth provided at Inatke end(TW)	=	*3.4*	*m*

Check for adequacy of waterway

Average Depth	=	*2.55731*	*m*
Area =Txd	=	*5.114621*	*sq m*
Wetted perimeter (P)	=	*7.11*	*m*
slope provided	=	*0.1124*	
which is	=	*1*	*8.9*
Using manings formula with value of n	=	*0.018*	

Mannings Formula is

$Q = A * R^{2/3} S^{1/2} / n$

Q	=	*76.434*	*Cumecs*
			Safe

Check for adequacy of capacity with 50% clogging

Average depth	=	*1.27*	*m*
Area	=	*2.55*	*sq m*
Wetted perimeter (P)	=	*4.55*	*m*
Therefore Discharge from Mannings formula	=	*32.40*	*Cumecs*
			OK

Calculations' of Levels at Intake for water conductor

Pond Level	=	*3125.00*	
Size of opening at entry of water conductor			
Width	=	*2.3*	*m*
Flow Depth	=	*1.8*	*m*
Velocity	=	*1.96*	*m/sec*
Invert of start of WCS	=	*3121.8*	*m*
Design Calculations			
Pond Level	=	*3125*	*m*
Level at Trench weir end	=	*3121.6*	*m*
Sill of Flushing Duct	=	*3121*	*m*
FSL at start of WCS	=	*3123*	*m*
Highest Flood Level	=	*3128.58*	*m*

6.3 Supply Channel

6.3.1 General

Since the de-silting basin has been proposed very near to The Diversion weir as such supply channel/approach shall found to be very short length. The total length involved is 42.6 m, this has been ended at allocation to suit the location of de-silting basin at RD 42.63m. The supply channel has been provided with Rectangular section of RCC Box with internal dimensions ofBox as 1.8x1.8 m.The Concrete section shall produce velocity of flow as 1.52 m/sec producing a full supply depth of 1.4m in the RCC Box. The bed grade of the channel is 1 in 550 m/m and the roughness coefficient of 0.018 has been adopted for Concrete section. Since the de-silting basin has been provided near Intake structure and due tosteep bed gradient in main stream, as such only a length of 42.6metres has got involved in supply channel. This has even facilitated the flushing of *de-silting basin into main stream above the HFL of source stream at its exit in nearby location. The RCC Box channel has been preferred as per site conditions to facilitate this type of construction and in addition due to the topography of the stretch along which alignment has been fixed.*

About 20% of the water shall be used for flushing the silt back to the source Nallah through the silt- flushing duct at De-silting Basin; thereby the supply channel shall a design discharge of 7.54Cumecs which also includes 10% over load requirement wherein it has already been adopted that 10% discharge shall also be absorbed in the free board of the channel which has been put at 0.4 metres.

The RCC Box shall be placed on firm ground over lean concrete 75 mm thick which will provide base for the placement of Reinforcement steel.

The alignment has been adopted as per contour alignment of channel reach to involve minimum cutting but at the same time stability of plat form by providing cushion to the RCC Box on hill downside has duly been taken care.

6.4 De-silting Tank

6.4.1 Generals

Formost part of the year silt content in LashpathriNallah water is almost insignificant with the silt factor of 6-6.5. Monsoons have very marginal effect on the flow in Nallah but in storms it carries boulders, small stones / pebbles and silt particles. . Since it is proposed to keep bed level of shingle flushing duct below the invert of water conductor system by 0.6m, boulders /pebbles and debris shall not enter the Supply channel and only the silt particles suspended in water shall enter the approach channel. These silt particles need to be removed from water before its entry into Forebay For this purpose considering project capacity a simple single bay de-silting tank has been proposed. Flushing of silt shall be done through 400 mm Diameter MS pipe and shall discharge back into main stream above HFL.

The location of de-silting basin has been adopted in a location wherein comparatively plain terrain is available and is placed very near tointake structure, the deepest level in de-silting ductas shown in drawing, wherefrom silt flushing pipe has been proposed to *carry away the silt to meet Nallah (above HFL) with sufficient grade in pipe line. The effort has been made to minimise the length of flushing pipe, as it has been observed that during the operation of projects the longer lengths of flushing pipes has the tendency to get choked making cleaning an uphill task and at times impossible particularly when the diameter is small. Therefore the basin has been fixed at location as shown in General Layout, starting at RD 42.6m, as discussed above the structure shall be constructed in direct connection to the Forebay with design parameters as per the requirement. The Basin will involve upstream transition only and flow shall pass over a partition wall having with of crest as 6.0 metres which is found sufficient to carry design discharge needed in to Forebay. The terrain wherein the common structure is proposed is in traces form as such though some deep cutting is involved for attaining the required levels is found manageable should not be of any difficulty for executing the same.*

It is recommended as per the guide lines to remove silt particles of size 0.2mm and above through the process in which flow through velocity and moderate settling velocities have been adopted as 0.197m/sec and 0.025m/sec respectively. The length of the main tank is worked out to be 25.0 m with de-silting basin width of 6.0 m, the depth of flow called as Full Supply depth of water is 4.26m.All these dimensions have been adopted in such a way so as to suit the site conditions besides requirements from Forebay stand point.

6.4.2 Design of De-silting Basin

Discharge for Desilting Tank	=	*7.54*	*Cumecs*
Smallest particle size to be removed =	=	*0.2*	*mm and above*
Max. Flow through velocity, V	=	$a \times d^{1/2}$	
Where,			
d, Particle size to be removed in mm			
a, Factor varying with particle size shall be	=	*44*	
Therefore Velocity, V shall be	=	*0.197*	*m/sec*

for the assessed silt load and particle size the settling velocity shall be, V_2	=	*2.7*	*cm/sec*
Let the width of Tank be	=	*9*	*M*
Depth required shall be	=	*4.26*	*M*
Moderate settling velocity shall be after making adjustment for turbulence in flow	=	*2.53*	*cm/sec*
	=	*0.0253*	*m/sec*
Therefore, Settling length of Tank shall be	=	*33.1*	*M*
Provided length of Tank	=	*38*	*M*
Length of upstream Transition with splay, 1:6	=	*11.1*	*M*
Length of downstream Transition	=	*0.00*	*M*
Total length of Desilting Tank	=	*49.1*	*M*

6.4.2.1 *The de-silting basin for this scheme is proposed at RD 100 with 12.6m upstream Transition..*

6.4.2.2 *No transition (contraction) has been provided as the flow is proposed to flow with same width of Forebay structure over a sharp crested weir which is of width found sufficient to carry maximum discharge...*

6.4.2.3 *Along the centreline of de-silting tank, a trench 0.60 m wide with its depth increasing from the beginning to the end has been provided for passing the silt which shall be flushed through MS pipe 500 mm diameter back to LashpathriNallah by opening the sluice Valve. Most likely regular operation of De-silting basin shall be in some of the summer months only.*

6.5 Forebay

Forebay has the basic purpose of providing water regulation in case of load rejection fulfilling the immediate water demand at the start of generating units. For Lashpathri - Imini-hydropower project it is proposed to provide a minimum storage volume above

Minimum Draw down Level (MDDL) for 120 seconds at the Maximum water demand of 6.38Cumecs including additional discharge of 20% needed for two machinesworking at 120% load. Required storage capacity is766m^3. The proposed Forebay Tank shall be rectangular in shape of Size 40 x 9.6 m size with an overall depth of 8.27m in Forebay pool. However bed of Forebay has been adopted in slope as per requirement. The FSL and MDDl in Forebay shall 3122.58m and 3120.58m respectively. The placement of Forebay has been considered in line with Geology of the location into terraces of land with created platform to limit internal width of Forebay to 9.0metres. The structure has been developed as a common structure with De-silting Basin and shall be provided with Intake arrangement having Forebay pool with provisions for silt flushing arrangement and Intake service gate to control flow into long penstock length of 1800m.

The Forebay Tank shall be of RCC grade M20 and shall have an Escape Bowl as well which could have been avoided in this case but has been included from environmental point of view along with laying of Escape arrangement kept in form of a short length of Escape Pipe and is constructed in monolithic to the structure with height equal to the Forebay pool height. In Forebay depressed part called as Forebay pool has been provided to accommodate height of bell mouth which in this case is1.36 m fixed in proportion to the penstock diameter of 0.85 m, further bottom sill of 0.44m and Water seal measuring from FSL to MDDL which will avoid any vortex formation in pool along with creation of live storage. The Forebay pool is also equipped with Trash rack arrangement for full height of Intake to avoid and Trash entry into penstock. An air vent pipe of 300 mm diameter will be fixed downstream of Intake service gate in the Intake wall. Design of Forebay has purely been made of section to suite site conditions and also to suit the De-silting Basin requirements as per the requirements of the scheme, which shall involve a overall cutting depth of 4 to 8 metres and with available soil condition should not of any major concern.

There shall not be an upstream Forebay Transition as discussed above that Water shall be directly taken from the de-silting Tank having same width as that of Forebay.

6.5.1 Design of Forebay

Discharge Q	=	*6.38*	*Cumec*
Design Discharge	=	*6.38*	*Cumec*
Diameter of Penstock	=	*1.60*	*m*
Full Supply Level at Entry	=	*3122.58*	*m*
Assuming MDDL	=	*3120.58*	*m*
Therefore operating depth	=	*2*	*m*
Provided operating depth	=	*2*	*m*
Bell Mouth Height H	=	*2.56*	*m*
Bottom Sill .2h+.25	=	*0.66*	*m*
Min. Water seal	=	*2.05*	*m*
Bed Level of Pool of Forebay	=	*3115.32*	*m*
Free Board	=	*1*	*m*
Overall depth of Pool	=	*8.27*	*m*
Allow Storage i.e Capacity of Forebay	=	*2*	*Minutes*
Allow Storage	=		
Discharge Q	=	*6.38*	
Required Storage Capacity	=	*766*	*Cum*
Take Water depth as	=	*2*	*m*
Min Draw down Level at Forebay	=	*3120.58*	*m*
Surface Area of Fore Bay	=	*383*	*m*
Let Length of Forebay be	=	*40*	*m*
then width of Forebay	=	*9.6*	*m*
Adopted width	=	*9.6*	*m*
Therefore Live storage of Forebay	=	*766*	*Cum*

Hence Overall Size of Fore Bay is ok

6.5.2 Design of escape pipe in the Forebay

In the scenario of load rejection all the incoming water shall be allowed to have free fall from the escape pipe and this water shall be diverted to LashpathriNallah near Forebay itself as the system is flowing under pressure beyond this point. MS escape pipe of 500mm, diameter will be sufficient to prevent damages that may occur to the Forebay tank in case the overflow is not properly guided. The pipe flow shall be directly dropped intoNallah over Big boulders available in the Nallah. Further it has been proposed to have Spillway Bowl at Forebay itself which shall collect and guide flow into the said Escape pipe. Free flow MS pipe has been proposed as the discharge is small besides being a mini Hydel project as proves to be very economical solution for such projects and has been the modern trend working on successfully in place of conventional Spillways for such projects.The MS pipe shall be made of 6mm thick MS plates and is proposed to be rested on RCCSaddle blocks.

6.5.3 Design of Escape at Forebay.

Design of Escape at Forebay.

Design Discharge Q	=	6.38	*Cumecs*
Provide Head Over Crest H	=	0.5	*M*
We know $Q = 1.7*L*H^{1.5}$	=		
Where L is length of Crest in m.	=		
Applying above equation Length of Crest L	=	10.6	*m*
Therefore Provide Sharp Crested spill over of Length	=	10.6	*m*
Full supply Level of Forebay	=	3122.58	*m*
Head over Crest	=	0.5	*m*
Max Level of Flow in Forebay	=	3123.08	*m*
Top of Forebay	=	3123.08	*m*

Freeboard for Escape = 0.5 m

Keeping in view the above parameters an Escape bowl of internal size 5.2x2.5 metre is proposed with height as per actual depending up built up section at its location adjacent to Forebay, however the overall height shall not be less than 4.0 metres. The above provided section is found to be safe for delivering the free-fall flow over crest into MS Escape pipe.

6.5.4Free Flow Escape Pipe Design.

Since the pipe alignment has been chosen along near Forebay to direct flow into Nallah as such the grade of pipe has been taken into account to work out the diameter of this free flow pipe. The gradient is found to be varying along the length of pipe line as such at this stage the mildest grade has been considered in determining the pipe diameter. The pipe line shall be rested on saddle blocks and shall be kept buried.

Design discharge =6.38 Cumec

Roughness coefficient =0.012

The mildest grade in pipe is 1:1.

With circular section properties from Manning's formula velocity V will be 13. m/Sec at peak load rejection. Depth of flow has been fixed at 80% full criteria having most efficient flow. Depth of water in free flow pipe shall be around 500 mm.

6.7 Tailrace

A very short Tailrace channel has been adopted in this project. This shall be in form of rectangular RCC channel beyond Common RCC Pool. The Bed width of channel adopted is 5.5m with a freeboard of 0.6m as per requirement, the channel shall meet to source Nallah above the HFL at its end. The design discharge for Tailrace has adopted as 6.38 Cumec which includes 20% additional overload discharge as well. The Full supply depth in channel will be 0.7 metres which shall produce a maximum tailrace water level of EL 3126m. The bed grade in *channel is proposed to be1 in 500 and minimum water depth with plant running at minimum possible generation shall be 0.25m in to provide minimum tail water level of EL 3127m. The channel shall be protected by providing Gabion wall protection in view floods protection measure near the stream.*

6.7.1 Hydraulic Design of Tailrace Channel.

Discharge Q	=	*6.38*	*Cumecs*
Coefficient of rugosity n	=	*0.018*	
Side slopes	=	*Vertical*	
Free board	=	*0.6*	*m*
Bed Grade	=	*1*	*500*
	=	*0.002000*	
Area =	$=BD+0.5d^2$		
Assumed Bed width of Canal = B	=	*5.5*	*m*
Assume depth of channel = D	=	*0.7*	*m*
Area	=	*3.85*	*sm*
Wetted Perimeter	=	*6.90*	*m*
Hydraulic mean Radius	=	*0.56*	*m*
velocity , V	=	$(R^{2/3} S^{1/2})/n$	
	=	*1.68 m/sec*	

Where,

$R^{2/3} =$ $=0.678m$

$S^{1/2} =$ $=0.045$

Calculation for passing of Discharge
= *3.85*

X1.68

=6.48cumec

Which is ok

6.8 Penstock

6.8.1 General

Penstock — a pipe used for the conveyance of water under pressure from forebay tank to the turbine – is proposed to be of MS Grade B. IS 2062, is proposed to be adopted for Lashpathri - Imini hydropower project. The penstock installation proposed is embedded with backfill of suitable earth got from excavation with well-designedconcrete support at bed to suit the buried penstock and on the bends anchor blocks have been proposed.

The radius of curvature in penstock profile is proposed to be three times the diameter of the penstock for efficient hydraulic flow and the bends are proposed to have successive segments of curved portion with optimum deflection angles avoiding sharp changes in the direction of flow. Air vent is proposed to be provided in the intake wall of Forebay avoiding the development of negative pressures also accelerating the draining. No surge shaft is used as pressure rise shall be taken care by thickness of penstock and pressure relief arrangements as Francis Turbine stands adopted in view of available circumstances. The speed rise in turbine shall be taken care as has already been discussed with leading manufacturer of Turbines in India who have proposed to adopt Francis Turbine in this case.

The main penstock shall be of 1.6 metre dia. to produce a economical velocity of 5.5m/sec, the penstock has been proposed to made of ferrules 2 metre in length or as worked as per availability of plate sizes with varying thickness from 28mm to 8mm . At this point the entire length of penstock is proposed kept underground by way of backfilling. The bifurcation diameter has been worked on identical velocity procedure and is worked out to be 1.132m. The length of branch for each pipe shall be 15 metres and this part of the penstock shall be embedded with proper treatment to *avoid any rusting. Max allowable water hammer pressure has been adopted to be 50%, against which the thickness of penstock has been worked out.*

The penstock will have a smooth entry of flow at forebay by providing well designed bell mouth.

6.8.3 Pressure Rise

The design of penstock is also dependent upon water hammer—a phenomenon of sudden pressure rise. In the operation of the hydropower plants the gradual change in flow cannot be guaranteed as the governing apparatus or plant operator rapidly opens or closes the inlet value with the change in velocity leading to the corresponding changes in the kinetic energy. The change in kinetic energy gives rise to the pressure surges in the penstock with the phenomenon being referred to as the 'water hammer.' The size of momentary pressure surges can be significant and in case these exceed the static pressure will lead to the burst of the pipes or leading to the reduction of pressure below the ambient pressure causing the pipes to collapse.

The parameter used to indicate the circumstances under which the water hammer should be considered is called the critical time.

6.8.4 Design of Penstock

Design Head of penstock = 182.58 m

Economical Dia. of penstock from empirical formula "D" =(P/H)$^{0.466}$

Where D = Penstock Dia. in feet.

P= Rated HP.

H= Rated Head in feet.

Therefore Diametre of penstock. =

P=	13211.2	HP
H=	599.02	Feet
P/H =	22.05	

D=	*4.23*	*Feet*
So, Diameter of penstock =	*1.29*	*m*

Also Dia. D= 5.821(P/H)$^{0.4043}$

Where, P= Installed capacity in MW.

H= Design Head in Metre

P/H =	*0.05*	
Therefore D =	*1.79*	*m*
Hence chosen Diameter between the two values as =	***1.6***	***m***
Sectional area =	*2.01*	*m^2*
Velocity in penstock =	*3.17*	*m/sec*

Pressure Rise in Penstock

Max. Water Level at Forebay =	*2945.5*	*M*
Design Discharge for main penstock =	*6.38*	*Cumecs*
Penstock Diameter =	*1.6*	*m*
Area pf Penstock =	*2.01*	*m^2*
Velocity in Penstock =	*3.17*	*m/sec*
Lowest Level of Penstock =	*2939.2*	*m*
Internal Steady Head =	*6.30*	*m*

Check for Pressure rise

Taking Thickness of Liner t =	*28*	*mm*
Diameter of penstock d =	*1600*	*mm*
Ratio of d/t =	*57.14285*	
Pipe line constant in ft. unit K = av/2gh =	*2.8*	
V= Velocity =	*3.17*	*m/sec*
h= steady head =		
Time line constant t=	*10*	*Sec*
	Gate closure	

Length of penstock L =	*1830*	*m*
Time constant factor =		
aT/2L =	***3.08***	
Where from manual constant ***a*** *(**for above d/t ratio**)=*	*3700*	
Ratio of pressure rise to initial steady head 2.K.P =	*26.044*	
reading from allievi chart P =	*0.45*	
where P is read from allievi chart.		
Hence pressure rise =	*84.5%*	
Max allowable pressure rise in penstock = 40%		
Hence Ok		
Calculation for Thickness of Penstock Pipe		
Gross Head =	*6.30*	*m*
Stress in steel =	*1050*	*kgs/cm^2*
Diameter of penstock =	*1600*	*mm*
Pressure rise due to water hummer =	*2604.4*	*.%*
Total Head =	*170.38*	*m*
Pressure =	*17.037*	*kgs/cm^2*
Thickness of steel liner =		
From Equation , PxD/2×σ =	*12.98*	*mm*
where P pressure, D ia Dia in cm =		
Add for corrosion and abrasion =	*1.5*	*mm*
Thickness of pipe for main penstock =	*14.48*	*mm*
Provide thickness of pipe =	*28*	*mm*
	Safe	

The penstock thickness is provided as 28mm and 8 mm thickness in two equal divisions for entire length from start of Power house to Forebay.

6.9 Economic Diameter of Penstock

Economic diameter of penstock has been calculated on the basis of empirical formulae derived on the basis of parametric study of the existing power projects in India.

Discharge in Penstock =	*6.38*	*Cumecs*	
Discharge in Cusecs =	*225.33*	*Cusecs*	
Gross Head available =	*182.58*	*m*	
Head with Water Hammer Pressure (30%) =	*333.95*	*m*	*1095.63*

velocity in Penstock , from Q=Av = Q/A

Area of Penstock = $Л/4 \times D^2$

Velocity in terms of Q and D = $4Q/ЛD^2$

Therefore, Velocity V = $\frac{286.85}{D^2}$

Using Scobey's formulae, Power losses for 1000 rfts. (Scobey's formulae)

$$V = \frac{D^{0.58} x h_f^{0.526}}{K_s^{0.526}}$$

$$h_f^{0.526} \quad \frac{K_s^{.526} X v}{D0.58}$$

Therefore $h_f =$ $K_s x V^{1.9} / D^{1.1} x (1/1000)$

$$0.34 \quad \frac{286.85}{D^2 x D1.1} \quad x \quad \frac{1}{1000}$$

$15.89 \div D^{4.9}$

(Per Rft.)

Penstock Length = *6004.23* *rft*

Total $h_f =$ **95383.61** $\div$ $\mathbf{D^{4.9}}$

Entrance Loss

$$\text{Entrance Loss} = \frac{0.2 x v_e^2}{2g}$$

Where, Ve is Entrance velocity = *1.67* *x* *Penstock velocity*

Entrance Area = *1.67* *x* $\frac{3.142}{4} D^2$

which is = *1.31* *x* D^2

$$V_e = Q/A = \frac{225.33}{1.31} x D^2$$

which is = *171.8* *x* D^2

Entrance loss , h_e *=* **91.7** $\div$ $\mathbf{D^4}$

Bend Loss

$$h_b = KV^2/2g$$

Taking value of k = *1.26*

Therefore from above $h_b =$ *0.0196* *x* *286.85* *sq*

$$\text{Cost of Power loss annually} = \frac{QH_L fR}{15} \times 8760$$

D^2

1610 ÷ D^4

Cost of Power loss annually $\frac{QH_LfR}{15} \times 8760$

..= **101327.3 x H_L**

	Diametre	D^4	Entrance Loss	Bend Loss	$D^{4.9}$	Friction Loss	Total Loss	Power Loss
	Feet		91.7 / D^4	1610 / D^4		95383.61 / $D^{4.9}$		101327.307
0.4	1.31	2.97	30.9	542.7	3.8	25173.8	25747.4	2608912618.1
0.5	1.64	7.24	12.7	222.3	11.3	8435.1	8670.0	878510366.1
0.6	1.97	15.02	6.1	107.2	27.6	3452.2	3565.5	361286855.3
0.7	2.30	27.82	3.3	57.9	58.8	1622.0	1683.2	170553919.7
0.8	2.62	47.47	1.9	33.9	113.1	843.1	879.0	89065887.0
0.9	2.95	76.03	1.2	21.2	201.5	473.4	495.8	50238902.1
1	3.28	115.88	0.8	13.9	337.6	282.5	297.2	30114375.0
1.1	3.61	169.67	0.5	9.5	538.6	177.1	187.1	18961259.3
1.2	3.94	240.30	0.4	6.7	824.9	115.6	122.7	12433546.3
1.3	4.27	330.98	0.3	4.9	1221.1	78.1	83.3	8435846.3
1.4	4.59	445.18	0.2	3.6	1755.7	54.3	58.1	5892090.9
1.5	4.92	586.66	0.2	2.7	2461.9	38.7	41.6	4219631.2
1.6	5.25	759.46	0.1	2.1	3377.7	28.2	30.5	3088438.2

Thickness of penstock t = WHD/2ns

P = Water pressure including water hammer is WH

s= stresses in steelPermmissible

D = Dia of pen stock

n= efficiency 0.9

s = 2400 kgs/cm2 or 34000 PSI

	Dia	Min. Thk.	Absolute Thk.	Corrosion	T.Thk. In
	Feet	.03D+.05	.04D	0.063	
0.4	1.3124	0.089372	0.052496	0.063	0.115496
0.5	1.6405	0.099215	0.06562	0.063	0.12862
0.6	1.9686	0.109058	0.078744	0.063	0.141744
0.7	2.2967	0.118901	0.091868	0.063	0.154868
0.8	2.6248	0.128744	0.104992	0.063	0.167992
0.9	2.9529	0.138587	0.118116	0.063	0.181116
1	3.281	0.14843	0.13124	0.063	0.19424

1.1	3.6091	0.158273	0.144364	0.063	0.207364
1.2	3.9372	0.168116	0.157488	0.063	0.220488
1.3	4.2653	0.177959	0.170612	0.063	0.233612
1.4	4.5934	0.187802	0.183736	0.063	0.246736
1.5	4.9215	0.197645	0.19686	0.063	0.25986
1.6	5.2496	0.207488	0.209984	0.063	0.272984

Dia	Thickness-In	Annual cost of Penstock-Lacs	Annual Cost of power loss-Lacs	Total cost per year-Lacs	
1.312	0.115	77.880	26089.126	26167.01	0.4
1.641	0.129	108.413	8785.104	8893.52	0.5
1.969	0.142	143.370	3612.869	3756.24	0.6
2.297	0.155	182.751	1705.539	1888.29	0.7
2.625	0.168	226.558	890.659	1117.22	0.8
2.953	**0.181**	**274.790**	**502.389**	**777.18**	**0.9**
3.281	0.194	327.446	301.144	628.59	1.0
3.609	**0.207**	**384.527**	**189.613**	**574.14**	1.1
3.937	0.220	446.033	124.335	570.37	1.2
4.265	0.234	511.964	84.358	596.32	1.3
4.593	0.247	582.320	58.921	641.24	1.4
4.922	0.260	657.101	42.196	699.30	1.5
5.250	0.273	736.306	30.884	767.19	1.6

Hence the economical diameter is provided in accordance with the requirements as per economical diameter worked out above which is 2.8 metres as the penstock length is quiet long.

6.9.1 Penstock bifurcations

Two turbines have been proposed with the single penstock of 1600 mm diameter bifurcated near the upstream end of the power house. The dia. of the bifurcated penstocks working out 1132mm based on the equal velocity criteria for least hydraulic disturbance.

Bifurcation of Penstock

Design discharge	*6.38*	*cumec*
Adopt Velocity in branch pipe =	*3.170*	*m/sec*
Discharge passing through each pipe =	*3.19*	*Cumecs*

Cross section Area.	*1.005*	*m^2*
So Diameter of each branch =	*1.132*	*m*
length of each branch	*15*	*m*

Adopted diameter of branch pipe shall be = 1132mm

6.9.2 Anchor Blocks and Saddle Piers

These support piers and thrust blocks have the function of providing necessary forces to a rigid pipe to check undesired movement.

6.9.2.1 Anchor Blocks

These are needed at every change of direction and at intermediate points and also if the distance between any two exceeds 150 m. As per IS: 5330-1984 the Anchor blocks are required to hold pipe at intervals along its length for:

- *Prevention of line sliding down the hill*
- *Control the direction of expansion*
- *Resist the unbalanced hydrostatic forces at the change of direction of the pipeline and*
- *Prevent pipe movement as a consequence of the water hammer*

The possible forces on the Anchor blocks include:

i. *Hydrostatic pressure on exposed end of the pipe*
ii. *Hydrodynamic forces acting along the axis of the pipe on each side of the bend*
iii. *Forces due to dead weight of the pipe and the weight of the water uphill and downhill*

The foundation of the Anchor blocks shall be designed so that the maximum pressure on the foundation shall not exceed the allowable bearing capacity of the soil determined as specified in IS 1904-1978. The permissible bearing capacity shall be increased in accordance with IS: 1893-1975 for seismic condition.

6.9.2.2 Saddle Piers

The force created by the weight of the portion of pipe and enclosed water supported by the pier is divided into two components:

Parallel to the pipe

Perpendicular to the pipe

Since the support pier is not designed to resist significant longitudinal forces and remains therefore unaffected by the component of this weight parallel to the pipe. IS 11639 Part-I have been followed for the design of saddle supports.

For Lashpathri - Iproject the spacing between any two saddles, structural stability and safety against sliding and overturning have been found in order in respect of the fact that maximum pipe line shall be laid underground by way of back filling .

6.10 Power House

6.10.1 General

The layout of the power house has been prepared as per relevant IS Codes including IS 12800 (Part 3); 1991.

The consultants propose to have a surface power house on a relatively plain terrain and are large enough to accommodate the electrical and mechanical equipment. The site for the power house is geologically stable on the right bank of the river. The power house is indoor type so that all erection and maintenance of the machines is done within the power house itself.

The size of the power house has been arrived at after the detailed layout plan of the units, control panels and service space and other requirements. The size and location of the power house also takes into consideration the surface drainage, ventilation, lighting etc. The location of the gantry columns has been based on the economy and the machine layout.

The location of power house site and the fixing of the machine hall floor level and the setting level of turbines is also determined by the HFL and minimum tail water level in the stream with the machine floor having been kept above the HFL ensuring that the power house is not flooded.

6.10.2 Design of Power House

Power house design has been divided into two units:

a. *Superstructure*

b. Substructure

The major components of superstructure are:

i. *Roof*
ii. *Roof support system*
iii. *Gantry Girder*
iv. *Gantry Columns*
v. *Cross Beams or Braces*
vi. *Panel Walls*
vii. *Floor*

Forces on the superstructure are:

Dead Loads: This includes the self load of the structure and permanent superimposed loads

Live Loads: For roof and floor as per IS:4247

Wind Loads: As per IS: 875

Crane loads: Weight of the fully loaded crane and longitudinal and lateral impact forces.

Seismic Forces: Using IS: 1893

Water Pressure and earth pressure wherever applicable.

6.10.3 Permissible Stresses

The permissible stresses for the design of the superstructure are taken as per IS: 456 for RCC and IS: 800 for structural steel. These have been increased for different combination of loads in accordance with IS: 4247.

S. No	***Load Combinations***	***Permissible increase in stresses***
1	*DL+LL+moving crane loaded to half of its capacity +normal TWL*	*8%*
2	*DL+LL+moving crane loaded to half of its capacity +temperature +normal TWL and wind load*	*25%*
3	*DL+LL+moving crane loaded to half of its capacity +temperature+ normal TWL*	*25%*

4	*DL+LL+un loaded standing Crane+temperature++earthquake+ maximum TWL (annual)*	*33.3%*
5	*DL+LL+moving crane loaded to half of its capacity+temperature+ TWL(maximum possible)*	*33.3%*
6	*DL+temporary construction load*	*25%*

The permissible stresses for rivets, bolts, etc are increased by 25% only in all the cases from serial 2 to 6.

In view of the site conditions, location, power house size and the economy in the construction truss of structural steel with CGI sheeting has been proposed. The thickness of the sheets has been determined on the spacing of the purlins. The CGI sheets shall conform to IS: 277. It is laid on purlins and is secured by hook bolts 8 to 10 mm diameter spaced at 400 mm Centre to centre. Joints along the length have an overlap of 150 mm and joints along the sides of the sheet overlap two corrugations and rivets /screws have been proposed at 300 mm c/c. The holes will be provided through the ridge and curved washers have been provided to prevent leakages.

6.10 .4 Roof Supports

The purlins rest on structural steel trusses with the spacing of the trusses being determined by the spacing of RCC columns in the layout of the power house.

6.10.5 Gantry Beams

The gantry beams of RCC have been proposed from the economy of construction. These beams have been designed for moments, shear forces and thrust transmitted to it by the longitudinal frame when the crane is positioned in the scenario of worst effect.

6.10.6 Columns

From the economy of construction and the speed of construction RCC columns are ideally suited to the site. Columns are subject to moments in longitudinal and transverse directions and direct thrusts and are designed for biaxial bending and direct thrust using the design procedure of IS: 4247-Part II and the reinforcement as per

IS:456. The columns are supported by RCC raft floor to ensure that the pressure below the base is limited to safe bearing capacity.

6. 10.7 Panel Walls

Panel walls have been proposed of brick masonry spanning between the columns and beams and the thickness being 225 mm.

6.10.8 Substructure

This is the part of the structure below the machine hall floor and is proposed to be rigid gravity structure. The stability analysis therefore considers the following:

a. *Overturning and bearing pressure*
b. *Shear friction factor*
c. *Floatation*

The analysis is done in both longitudinal and transverse directions and the loads for design are as:

a. *Dead load of structure including embedded parts*
b. *Main equipment loads such as turbines, generators, transformers etc.*
c. *Crane loads including horizontal thrust*
d. *Live loads*
e. *Wind loads as per IS: 875*
f. *Penstock thrust including water hammer*
g. *Weight of water acting on the substructure i.e. in scroll case, draft tube etc.*
h. *Back-fill pressure*
i. *Water pressure due to TWL*
j. *Uplift pressure*

k. *Pull of conductor if fixed on building*

l. *Seismic forces in accordance with IS: 1893.*

6.11 Generator Floor

The generator floor is designed to carry the load of machines, live load and any other thrust transferred through turbines, generators or any other machine. It has been designed as RCC raft with openings/pits as required for equipment and the cable trenches.

6.12 Tailrace Channel

Out flow from two numbers draft tube openings shall be flown into a common tailrace pool which shall finally be led to the stream through a tail channel. The channel shall be RCC structure or random rubble masonry structure. The channel is designed to have a discharging capacity of 40%% of one unit discharge under minimum tail water level condition and 120% of full design discharge of both the turbines under normal and maximum tail water level conditions. The discharging capacity in each case is determined by Manning's formula which shall be rectangular in shape with RCC bed raft laid in reverse slope in pool, to form the crest at its end. The crest level has been provided in conjunction to the flow depth in Tailrace Channel to maintain minimum tailrace water level during lowest power generation from the plant during lean flow condition to avoid cavitations' of turbines. Tail race channel shall be directly connected to the converged pool. This structure is used for sending the tailrace waters from power house to Source stream. The tail race channel has been designed as RCC structure with for required discharge capacities with free board of 0.6 m. The channel has been designed as a rectangular RCC structure up to the bank of the stream and thereafter on crate construction in the stream bed making it flexible and repairable after flood seasons. The size of the tail race is 3.6m wide with the full length made of RCC with Tailrace pool size as shown in Drawing. The FSD in the channel shall be 0.7 metres at a bed grade of 1 in 800.