SJVN LIMITED.

(A Joint Venture of Govt. of India & Govt. of Himachal Pradesh)

Jakhol Sankri Hydro-Electric Project (2 x 22 MW)

Revised Pre- Feasibility Study Report (PFR)

SHIMLA **January, 2016**

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1.1 Introduction

The Jakhol Sankri Hydroelectric Project located in Uttarkashi district of Uttarakhand state envisages utilization of the water of river Supin for power generation on a run of the river type development harnessing a maximum gross head of about 445.80 m. The Supin River is the right bank tributary of the Tons River and Tons River is right bank tributary of Yamuna river located in Northern India. The diversion site is located at Latitude 31^{o}05'19"N-31^{o}07'06"N, Longitude 78^{o}11'10"E-78^{o}14'07"E, about 423 km north of New Delhi and 188 km north of Dehradun on the Supin River. The nearest railhead and airfield are located at Dehradun.

DPR of JSHEP (51 MW) was prepared & submitted to the GoUK in Decmber 2011, considering 10% of minimum flow during non-monsoon period as environmental releases. However considering the proposed revision in the environmental flows, the revised capacity of the project has been worked out as 44MW and the revised energy is 166.19 GWh in a 90% dependable year .This report presents the revised Pre-Feasibility Studies of the project.

1.2 Power Scenario

India's hydropower potential is estimated at around 1,50,000 MW, out of which only 42623.42 MW (28.42%) has been tapped so far. On the other hand, the gap between demand and supply of power has been increasing at a much faster rate especially during the last decade. The total power demand by 2030 is expected to cross 8,28,000 MW. Development of hydropower potential can significantly help bridge the gap between power demand and supply. In addition to meeting the power demand of the country, development of hydropower also helps in the development of water resources in general. Uttarakhand's hydropower potential is estimated at around 25,000 MW, out of which only 3164.75 MW (about 12.65%) has so far been harnessed. There are some major projects in various stages of implementation.

These are Bharon Ghati (I,II) 380 MW, Garba Tawaghat (630 MW), Tehri Stage – II (1000 MW), Kotli Bhel (850 MW).

The Jakhol Sankri Hydroelectric Project (JSHEP) forms a part of the cascade development planned along river Supin and river Tons (after its confluence with the river Tons) in Uttarkashi district of Uttarakhand State. There are several hydropower projects under different stages of development in this river basin. These are mainly Naitwar Mori HEP, Mori Hanol HEP and Hanol Tiuni HEP. In addition, River Tons has about 500 MW of identified hydropower projects under development. Jakhol Sankri HEP is one of the three hydropower projects awarded to SJVN Ltd. in the State of Uttarakhand. The other two projects are Naitwar Mori HEP on river Tons downstream of Jakhol Sankri HEP and Devasari HEP on river Pindar, a major tributary of river Alaknanda, in district Chamoli.

1.3 Justification

In India demand for electric energy is growing at an average annual compound growth rate of 7-8% per year. Per capita consumption of electricity has increased from 15 kWh in the year 1950 to 612.5 kWh in the year 2004-05, 717 kwh in 2007-2008, 779 kwh in 2009-2010 and 917.18 KWh in 2012-13. During the 12th five year Plan (2012-2017) 1,18,537 MW capacities shall have to be added. Out of this, hydropower is expected to account for almost 10,897 MW.

The total installed capacity as on 30 November 2015 was 2,82,023.39 MW, comprising thermal power at 1,96,204.44 MW accounting for 69.57% of the capacity, hydropower at 42623.42 MW accounting for 15.11 %, nuclear power at 5780 MW about 2.05% and the other Renewable energy source at 37415.53 MW including wind power accounting to about 13.27 %. For a balanced energy mix, the proportion of hydropower should be increased to 30 % in short term and 40 % in long term. As per the CEA report “Growth of Electricity sector in India from 1947-2013” the shortage in energy demand is 86905 GWh (8.71%) and Peak demand is 12159 MW (8.98%) for the year 2012-13.

The development of hydropower in Uttarakhand not only benefits the state but will meet the power requirements of the neighbouring states and northern region of the

country. Uttarakhand is currently a net importer of electric power, but generates a seasonal surplus and plans to become a net exporter of power by expanding its hydropower and high voltage transmission capacity. Total capacity expansion of 10,000 MW is planned by the year 2018. The development of Jakhol Sankri Hydroelectric Project (JSHEP) has been taken up in the direction of achieving the above targets.

1.4 Hydrology

The river Supin has a total catchment area of about 268.20 sq km at the proposed barrage site. The water availability for the project has been considered on the basis of 10 daily discharge data of river Supin at Tiuni gauge site after subtracting from it the discharge data of river Pabar at Tiuni gauge site, for the period 1977-78 to June-2012. The water availability at the barrage site has been derived from the above data on the basis of catchment area proportion. The computed inflow series worked out has been utilized for Power Potential Studies. The 1 in 100 year flood at the barrage location is 270 m^3/s.

1.5 Topography

Topographic survey data of the project location is available on scale of 1: 5000 & 1: 500. A reservoir level at 1959.40 MSL was defined as upper limit. This limit assures that permanent settlements, roads and the existing Reserved Forest areas as part of the Govind Wildlife Sanctuary will not be inundated.

1.6 Environmental Aspects

There is no displacement of population from the project site. The environmental flows requirements downstream of the diversion structure are given in Table No-1. The submergence area is 0.24 Ha. having no inundation due to project and does not have any adverse impact on hydrological regime or on the catchment area and the project is environmentally sustainable.

Table No-1

Season	Environmental Flow (cumecs)	% of Average Flow
June-Sept	3.51	30
Oct- Nov	1.61	25
Dec-March	0.63	20
April-May	1.61	25

1.7 Geology

Detailed geological investigations have been carried out for barrage and powerhouse locations (layout plan is enclosed). Geo-technical investigations have been carried out at the Barrage site. Necessary test and investigations have been carried out for all aspects of the project.

1.8 Alternative studies & Salient Features

The following alternatives were studied as part of feasibility study for the project.

• 1L Alternative: Barrage site is located upstream of Jakhol village, some 25m upstream of the suspension bridge and at immediate upstream of confluence of Bar Gad and Supin. Approximately 6 Kms long HRT runs along the left bank terminating in an underground powerhouse cavern through pressure shaft. FRL is in the order of 1886 MSL. Setting of turbines is taken as 1510 MSL, thus providing 376m of gross head.

• 2L-Alternative: Arch type Dam of 80.0m height located at 25m downstream of the suspension bridge had been considered with highest FRL at 1932 MSL keeping clear from wild life area boundary. A water conductor system slightly less than 6 kms was planned at left bank and ends in the same power house cavern as in case of alternative 1L thereby providing a maximum gross head of 422m.

• 3L-Alternative: This alternative comprises a Trench Weir at around 1600m upstream of 1L barrage location, an underground Desilting Chamber, some 6.5 kms long HRT on the left bank and an underground powerhouse. The steep river slope in this 1600m reach facilitated considerable increase in head. After careful examination

of the various investigation data obtained during preparation of DPR of 51 MW, two changes have been adopted in this alternative during detailed project study.

i) The diversion structure shall be a concrete gated Barrage structure by replacing the Trench Weir in light of its functional advantages over Trench weir. The design of the Barrage shall be in accordance with structure on permeable foundation prescribed by various IS codes and CBIP.

ii) There is provision of surface Penstock to cross the Purola thrust by a safe margin.

• 4L-Alternative: Powerhouse is to be located upstream of the Purola Thrust and consequently cross the Thrust with Tailrace Tunnel (TRT).

Selected Alternative-3L: Salient features of the scheme are given below:-

Salient Features

I)	**LOCATION**	
i)	State	Uttarakhand (formerly Uttaranchal)
ii)	District	Uttarkashi
iii)	Tehsil	Mori
iv)	Latitude	$31^{o}05'19''N$ - $31^{o}07'06''N$
v)	Longitude	$78^{o}11'10''E$ - $78^{o}14'07''E$
vi)	Nearest Rail head	Dehradun
vii)	Nearest Airport / Approach	Dehradun
viii)	Name of River / Tributary	Supin (Tributary of river Tons)
ix)	Name of River Basin	Yamuna River Basin
II)	**HYDROLOGY AND CLIMATE**	
i)	Catchment Area up to head works (km^2)	268.20
ii)	Snow Catchment area (km^2)	29.50 (11% of total)
iii)	Average annual Yield (Mm^3)	359.72
iv)	Maximum / Minimum Yield (Mm^3)	667.96 – Year 1990-91 / 214.07 – Year 2000-01
v)	Design Flood (m3/s)	270 (1 in 100 yr.)
vi)	Maximum temperature	$35^{o}C$

vii)	Minimum temperature	0^{o} C
viii)	Design Horizontal Seismic Coeff.	0.15
ix)	Design Vertical Seismic Coeff.	0.10
III)	**DIVERSION STRUCTURE**	
i)	Type	Barrage
ii)	Average River Bed Level at Barrage Axis	EL 1955.00 m
iii)	Deepest Foundation Level	EL 1945.20 m
iv)	Elevation at top of Barrage	EL 1962.20 m
v)	Length of Barrage at top (m)	33.00
vi)	Freeboard above MWL (m)	1.00
vii)	FRL	EL 1959.40 m
viii)	MWL	EL 1961.20 m
ix)	Maximum height above deepest foundation (m)	17.00
x)	No. & size of gates (Vertical gates)	4 Nos. – 5.00m (W) x 4.40m (H)
IV)	**RIVER DIVERSION ARRANGEMENT**	
i)	Diversion Pipes (Size, type and number)	1.65 m diameter Steel Pipes, 3 Nos.
ii)	Pipe Length	187.40 m
iii)	Construction Flood (m^3/s) (1 in 25yr)	
	U/s Coffer Dam	
iv)	Height (m)	4.00
v)	Bottom Width (m)	19.0
vi)	Length (m)	29.21
vii)	U/s Coffer Dam Top Elevation	EL 1962.50 m
viii)	Invert Elevation of Inlet Pipe (U/s)	EL 1960.00 m
	D/s Coffer Dam	
ix)	Height (m)	3.0
x)	Bottom Width (m)	15.0
xi)	Length (m)	38.15
xii)	D/s Coffer Dam Top Elevation	EL 1955.50 m

xiii)	Invert Elevation of Outlet Pipe (D/s)	EL 1953.00 m
V)	**DESILTING TANK**	
i)	Type	Underground, Twin Chamber
ii)	Number and size	Two,100.00m (L) x 12.00m (W) x 12.27m (H)
iii)	Particle size to be removed (mm)	0.2
iv)	Number of Adits	One
v)	Flow Through Velocity (m/sec)	0.167
VI)	**HEAD RACE TUNNEL**	
i)	Length and shape (m)	6624.48 , Modified Horse Shoe Shaped
ii)	Diameter (m)	3.0 m (finished)
iii)	Design discharge (m^3/s)	11.40
iv)	Bed Slope	1 in 375
v)	No. of Bends in HRT	4
vi)	Design Velocity (m/sec)	1.56
VII)	**ADITS**	
i)	Number of Adits	04
ii)	Length of Adit – 1 (m)	185.28
iii)	Length of Adit – 2 (m)	392.10
iv)	Length of Adit – 3 (m)	353.20
v)	Length of Adit – 4 (m)	208.13
vi)	Gated Plug	Adit No.-3
vii)	Type	Hinge Type
viii)	Size of Gate	2.5m x 2.5m
VIII)	**SURGE SHAFT**	
i)	Type	Underground Restricted Orifice
ii)	Shape	Circular
iii)	Diameter (m)	7.5 m
iv)	Height (m)	42.32
IX)	**PRESSURE SHAFT / PENSTOCK**	
i)	Type	Steel Lined Partly on surface & partly underground

ii)	Shape	Circular
iii)	Number	One
iv)	Internal Dia. of Pressure Shaft (m)	2.0
v)	Length of pressure shaft (m)	707.34
vi)	Length of Surface Penstock (m)	166.85
vii)	Design discharge through pressure shaft / penstock (m^3/s)	11.40
viii)	Maximum Velocity through Pressure Shaft/ Penstock (m/sec)	3.63
ix)	Internal Diameter of unit penstock –feeding each unit (m)	1.3
x)	Length of unit Penstock (m)	50.55
xi)	Steel type	ASTMA-537 Class-2
xii)	Penstock Gate at Surge Shaft	1 no.
xiii)	Valve House	2m dia. butterfly type valve.
xiv)	Main Inlet valve, (type & diameter)	2 Nos., 1.3 m dia Spherical type
X)	**UNDERGROUND POWERHOUSE**	
i)	Type	Underground
ii)	Location	Left Bank of River Supin, about 200 m upstream of confluence of Supin and Tons.
iii)	Number of Units	02
iv)	Installed Capacity Per Unit (MW)	22
v)	Installed capacity (MW)	2 X 22
vi)	Continuous Overloading	10%
vii)	Maximum Gross Head	445.80 m
viii)	Design Head	436.36
ix)	Type of turbine	Vertical Pelton
x)	Efficiency of Turbine	92%
xi)	Centre Line of Turbine	EL 1513.60 m
xii)	Maximum Tail Water Level	EL 1510.66 m
xiii)	Rated Discharge through each unit (m^3/s)	5.7

xvi)	Efficiency of Generator	98%
xvii)	Size of power house Cavern (including service bay)	58.425m (L) x 16.75m (W) x 34.75m (H)
xviii)	Size of Transformer Cavern	44.50 m(L) x 12.00 m(W) x 26.78 m(H)
xix)	No. of Transformers	02
xxi)	Transformer Floor Level	El 1523.0 m
xxii)	Bus Duct Gallery	4.0m (W) x 4.5 m (H)
xxiii)	Power House EOT Cranes	
	- Nos.	1
	- Capacity	80/20/5 MT
XI)	**TAILRACE TUNNEL / CHANNEL**	
i)	No. of tail Race Conduits	02
ii)	Size of Tail Race Conduits	4.9m (W) x 1.5m (H)
iii)	No. of Tail race Tunnel	01
iv)	Type & Size of Tailrace Tunnel	D-shaped, 3.5m (W) X 3.75m (H)
v)	Length of Tailrace Tunnel (m)	155.52
vi)	Nominal Discharge (m^3/s)	11.40
vii)	EL of the downstream crest	1508.36 m
XII)	**SUBSTATION**	
i)	Type of Substation	Gas Insulated Switchgear (Indoor)
ii)	Bus Arrangement	Single Bus with Sectionaliser.
iii)	Voltage	220 kV
XIII)	**POTHEAD YARD**	
i)	Type	Outdoor
ii)	Elevation	EL 1540.0 m
iii)	Size	71.5m (L) X 34.0m (W)
iv)	Voltage	220 kV
v)	No of outgoing feeder	2 nos. 220 kV lines
XIV)	**POWER BENEFITS**	
i)	Design Energy (GWh/annum)	166.19 MU
XV)	**TOTAL CONSTRUCTION PERIOD**	4 years (48 Months)

XVI)	COST ESTIMATES (Rs. in crore) @ November 2015 Price level	
	i) Civil & H-M	245.14
	ii) Electrical / Mechanical	144.40
	iii) Sub-Total (Generation)	389.54
	iv) IDC & Front end fee	52.77
	v) Total Cost with IDC & Front End Fee	442.31
XVII)	**LEVELISED TARRIF**	
i)	Levelised Tariff (Rs. / kWh) (with free power to home state	6.94
ii)	First Year Tariff (Rs. / kWh) (with free power to home state	7.10
iii)	Cost per MW with IDC & FC – in crore	10.05
iv)	Cost per MW without IDC, FC – in crore	8.85

1.9 Power Potential Studies

The computed inflow series for 35 years i.e., from 1977-78 to June-2012 have been considered in assessing the power benefits from the project. Based on energy generation estimates the year 1984-85 corresponds to 90% dependable year. Accordingly an installed capacity of 2 x 22 MW with two vertical Pelton Turbines has been provided. The entire water conductor system has been designed for a discharge of 11.40 m^3/s. The annual primary design energy availability in 90% dependable year is 166.19 GWh (or million units) in an average year.

1.10 Electro-mechanical Equipment

Jakhol Sankri H.E Project envisages installation of 2 units, each of 22 MW in underground powerhouse. Main equipment comprises of 2 nos. of Vertical Pelton Turbines & main inlet valve of spherical type complete with unit auxiliaries, two nos. Hydro Generators and 2 nos. three-phase generator step-up transformers. Design discharge and net design head are 11.40 m^3/sec and 436.36 m respectively.

1.11 Power Evacuation Aspects

For evacuating the 44 MW power of Jakhol Sankri HEP, the most suitable and economical system is 220 kV double circuit line system. The power plant shall be connected to proposed Mori Sub Station.

1.12 Estimates of the Cost

The estimate of cost has been prepared as per “Guidelines for Formulation of Detailed Project Reports for Hydro-electric Schemes” issued by Central Electricity Authority to arrive at the hard cost of the project at November 2015 price level.

The hard cost of civil & hydro-mechanical, electro-mechanical works have been estimated as Rs. 245.14 crore, and Rs. 144.40 crore respectively. Total hard cost comes out to be Rs. 389.54 crore which also includes cost of preliminary works, all civil, H-M & E-M works, Land, buildings, plantation, communication, special T & P, Environment & Ecology, miscellaneous & maintenance works.

The breakdown of the cost is given below in the following table:-

Table No-2

Breakdown of Cost

S.No.	Description of item	Amount in Rs Crore
1	Civil & HM Works cost	245.14
2	Electro Mechanical Works	144.40
3	Total Hard cost	389.54
4	Interest during construction	49.67
5	Front End Fee	3.10
6	Total Cost including IDC,Front end fee	442.31
7	Cost per MW	10.05

1.13 Financial Aspects

The levelized tariff has been worked out as per “Tariff Regulations for 2014 to 2019” issued by Central Electricity Regulatory Commission (CERC). Financial parameters like project life, return on equity, tax on return on equity, depreciation limit, average depreciation, repayment period, auxiliary consumption, transformation losses,

operation and maintenance charges, escalation in O & M charges, maintenance spares, receivables in terms of monthly billing and discount rate for tariff have been adopted as per CERC guidelines. The project is planned to be financed by 30% equity and 70% of commercial Rupee loan to be availed at an interest of 11.65% per annum. Interest on working capital is adopted as 12.80%.

All basic data and assumptions have been summarized in the following table:-

Table No-3 Basic data and assumption for economic evaluation

Sl.No.	**Item**	**Parameters adopted**
1	Life of the project	35 years
2	Planned construction period	4 years
3	Debt - equity ratio	2.33:1
4	Loan	70%
5	Equity	30%
6	Annual interest on loan	11.65%
7	Annual interest on working capital	12.80%
8	Return on equity	16.50%
9	Depreciation limit	90%
10	Receivables (in terms of monthly billing)	2 months
11	Auxiliary consumption	1.2%
12	Free power (i/c 1% for Local Area Development Fund)	13%

An auxiliary consumption of 1.2%, free power of 12% to the State and 1% of generated energy as free energy towards the Local Area Development Fund (LADF) has been considered in computation of tariff. The saleable energy will be the Design Energy minus the above consumption.

1.14 Tariff

The tariff worked out is summarized as below:

Considering total cost including IDC, Front end fee and, the tariff for first year and levelised tariff have been worked out as Rs. 7.10 per kWh and Rs. 6.94 per kWh respectively.

ALTERNATIVE LAYOUT PLAN

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ALL ELEVATIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSION SHALL BE SCALED OUT ONLY WRITTEN DIMENSIONS ARE TO BE TAKEN AS CORRECT.

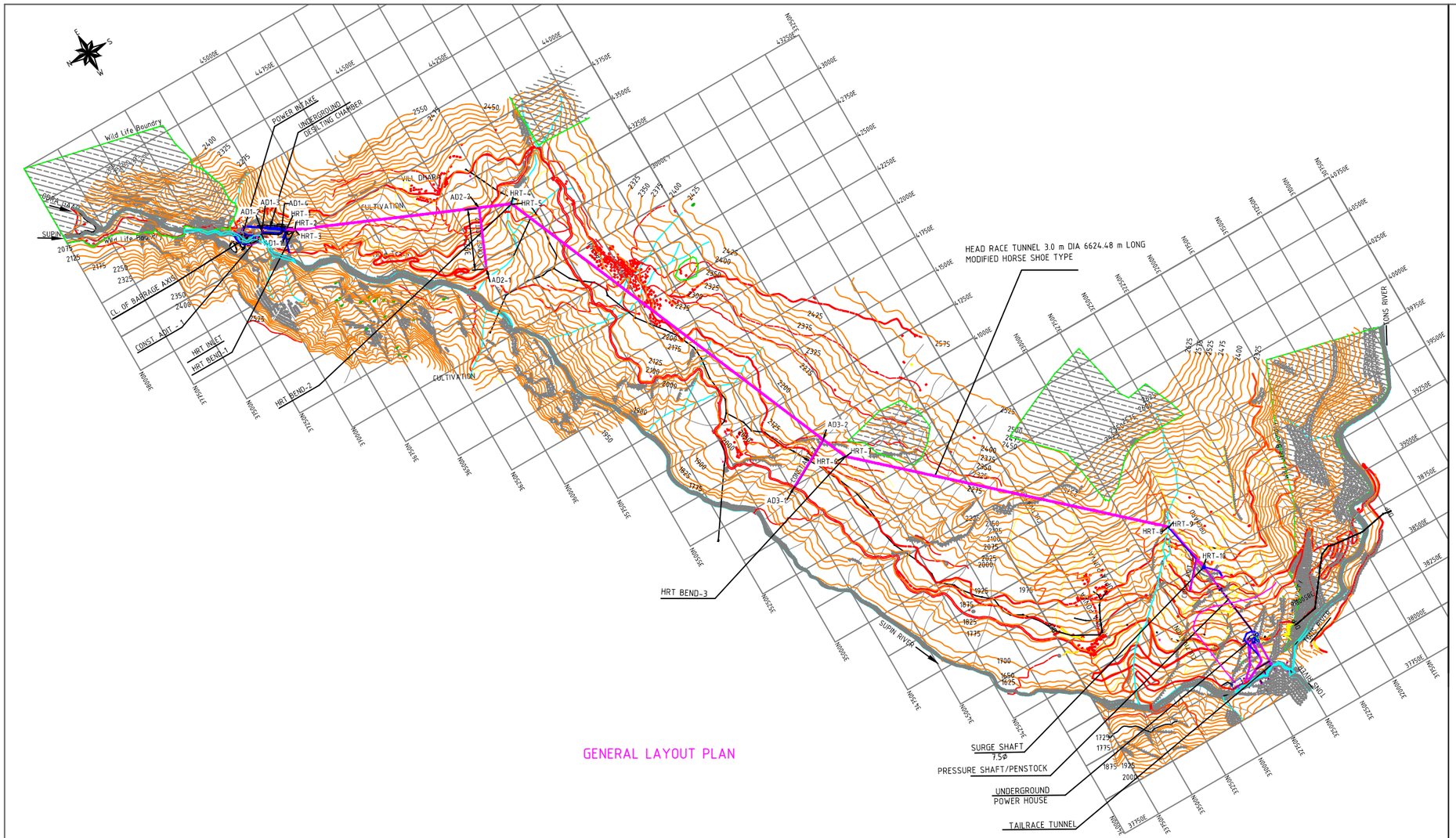
FOR PRE FEASIBILITY STUDY REPORT ONLY

एसजेवीएन लिमिटेड
SJVN LIMITED

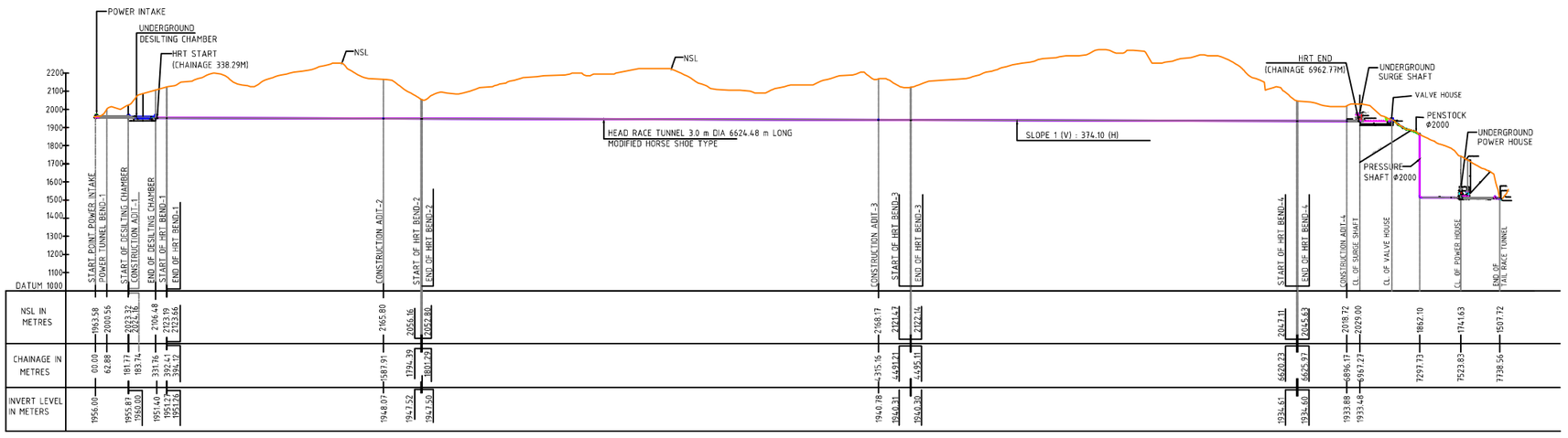
जखोल सांकरी जल विद्युत परियोजना उ0 ख0
JAKHOL SANKRI H. E. PROJECT (U. K.) 44MW

ALTERNATIVE LAYOUT -1L , 2L , 3L & 4L

DESIGN NM & JS HEP'S, SHIMLA



GENERAL LAYOUT PLAN



L-SECTION

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GENERAL LAYOUT PLAN & L- SECTION

DESIGN NM & JS HEP'S, SHIMLA