PRE-FEASIBILITY REPORT

OF

Rongnichu Hydroelectric Project (115MW)
EAST SIKKIM DISTRICT
SIKKIM.

Project Proponent
M/s Madhya Bharat Power Corporation Limited
Raipur

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1.0 EXECUTIVE SUMMARY

Rongnichu Hydroelectric Project (96 MW) on Rongnichu stream in East Sikkim district of Sikkim, being developed by M/s. Madhya Bharat Power Corporation Ltd. (MBPCL), is a run-of-river hydro development project.

The Barrage complex is located about 2km downstream of Namli village and 16km south of Gangtok city along NH-31A. The project envisages construction of a 120m long x 35m wide x 14m high Barrage across Rongni Chu. A surface Desilting Basin is located on the left bank of the river, just upstream of the Barrage axis. The Desilting complex has 2 chambers of which one will be in service and the other will be stand by. The Desilting basin has a collection chamber at its end for collection of desilted water. A Power Intake Structure located near the left end of this chamber feed a 12.581 km long Head Race Tunnel (HRT) leading to a Surge Shaft at its tail end and a Pressure Shaft, which will terminate at the valve house. The water from Penstock shall feed 2 units of 48 MW (Pelton Turbines), installed in a surface Powerhouse proposed on the right bank of Rongpo river 2.5 km from Rongpo town by the side of Rongpo- Rongli State Highway. The proposed scheme will provide a gross head of 423 m and a net head of 405m for power generation and is intended to operate as a run-of-river scheme providing a daily maximum of 6 hours of firm peak energy during the non-monsoon season and during the monsoon season the generating units will operate continuously for several weeks. The present project having an installed capacity of 96 MW will generate approximately 384 GWh of electricity (gross) per annum in a 90 % dependable year with 95 % machine availability. Techno-Economic Clearance of 96MW Rongnichu HEP DPR was granted by Government of Sikkim vide letter dated 01.10.2008 to expedite the implementation of the project

The EC was accorded on 4.4.2007 for a period of 10 years as per the provisions of EIA Notification, 2006. After obtaining the EC in April 2007, there has been an initial delay of more than 3 years to start the actual construction. The geological difficulties of lower Himalayan region resulted in slower pace of excavation of underground works. Viewing the delays being encountered, M/s. Madhya Bharat Power Corporation Ltd., had applied for extension of validity of EC for 3 years. The Ministry vide letter dated 16.6.2017 granted extension of validity of EC initially for six months and vide letter No J-12011/56/2006-IA-I dated 9.11.2017 accorded extension of validity for two and half year i.e. up to 3.4.2020.

The civil work of head works, desilting complex, power intake, head race tunnel, surge shaft, pressure shaft, power house are either completed or near completion. The balance works at barrage complex are erection of hydro-mechanical component like gates, counter weights, stop- log gates, Stanchion, gate lifting mechanism and top deck of barrage. Balance work of water conductor system involves excavation of HRT in 13.39 m length, lining in 4383.38m length and steel lining of LHPS in 881.324 m length. Balance work under power house complex is 671cum excavation and 6005 cum concreting work besides erection of Electro-mechanical equipment/plant and TRC.

For completion of E&M works of Powerhouse two separate contracts have been awarded for (a) Turbines & Turbine Auxiliaries and (b) Generator & Generator Auxiliaries with due consideration of delivery period and design of the equipment matching the already constructed civil foundation with higher continuous overload capacity of 30%.

Meanwhile M/s. Madhya Bharat Power Corporation Ltd. (MBPCL) intends to enhance the installed capacity of power house from 96 MW to 115MW.

1.1. Statutory Requirement of Environmental Clearance for the Project

The validity of original EC accorded for project (96 MW) on 4.4.2007 for a period of 10 years has ended on 3.4.2017 and further extension of validity of EC has been granted for a total period of three years i.e. up to 3.4.2020. The balance work under project is not likely to be completed by 3.4.2020. Within present frame work of EIA Notifications validity of EC beyond 3.4.2020 is not available to the project developer.

Apart from this M/s. Madhya Bharat Power Corporation Ltd. intends to enhance the installed capacity of power house from 96 MW to 115MW owing to higher inflows available during 5 10-daily blocks in monsoon period and in the light of enabling provision of running machines at 20% overload as stipulated in power potential studies carried earlier. Even if the amendment to the capacity enhancement of earlier EC granted for 96 MW to 115 MW is accorded, the main issue of working beyond the extended EC period shall remain un-resolved. In the wake of this application for seeking prior EC for Rongnichu Hydroelectric Project (115 MW) is furnished *de novo* such that the balance works may legitimately carried beyond 3.4.2020 and no violation of notification is made.

1.2. Reasons for Capacity Enhancements

The original DPR was approved by Government of Sikkim as the cost of project was less than Rs 500 crores. The provision under section 7 pertaining to power potential studies, sub section 7.10 Is reproduced hereunder:
"There are 9 (nine) 10-daily blocks in monsoon period in which river flows are higher and power more than 96 MW can be generated during these 10-daily blocks. In order to utilize their high inflows during monsoon period it is proposed to provide 10% and 20% overload capacity in each of the two units resulting in 2x (48+10%) =105.6 say 106 MW and 2x (48+20%) = 115.2MW."
It is evident that at DPR stage itself 115.2 MW maximum continuous capacity of generation was found technically feasible with regards to the inflows available. However, at that stage, considering capital cost considerations station capacity of 96 MW (2x48 MW) was found more viable.

1.3. Re-assessment of Hydrological data

The hydrological data (inflows/river discharge) as provided in the approved DPR was reassessed with respect to the prevailing e-flow norms i.e. a discharge of 15% of the average of concerned period/season as Environmental Discharge and following was observed:

Table 1.1 : 10-daily blocks where inflow is available for higher power generation

Dependability	Dependable Year	No of 10-daily blocks where inflow is available for higher power generation
		At 115.2 MW
50%	1979-80	5
75%	2006-07	7
90%	1996-97	3

Based on the available inflows (as per the original DPR), Generation capacity of 115 MW and above is found sustainable and technically feasible. The power potential study calculation is enclosed as **Annexure-1.**

Thus, it is imperative that the project capacity is amended to 115 MW (already found feasible in the original DPR) to derive advantage of obtaining higher generation which will benefit both the developer and Govt. of Sikkim (beneficiary of Higher royalty i.e. free power @12% of the deliverable energy). Considering the present circumstances, equipment capable of generation 124 MW on a continuous basis has been already installed.

1.4. Changes Implemented

In the implementation stage of the project, following changes in certain components became inevitable considering the technical, environmental and socio-political ground realities.

- In lieu of horse shaped concrete lined HRT with a finished diameter of 4.0 m was changed from horse shoe to D-shaped, keeping the diameter 4.5 m.
- An additional Adit (Adit-2B) has been introduced between Adit -2 and Adit-3 at RD 7572.00m of the HRT culminating into increase in length from 1304.76m to 1866 m.
- The surface penstock followed by 80m deep Vertical Shaft and 138m long Horizontal Shaft was changed to a 318m deep Vertical Pressure Shaft followed by 924m long "Horizontal Pressure Shaft". This change was necessitated by geological conditions.
- Change in HRT alignment following an incident of cavity formation in Face – 5. The total length of HRT up to Surge Shaft is now 12.581 K.M. as against the 12.302 K.M in DPR.

All the above changes have already been informed to the EAC and the EAC observed in its meeting dated 3rd March 2017 that the minor deviations encountered while taking-up the project may not be treated as violation.

1.5. Salient Features of The Project

The salient features of project are provided in **Table-1.1**

Table 1.1 : Salient Features of Project

S. N.	Particular	Details
1	**NAME OF PROJECT**	Rongnichu Hydroelectric Project (96MW)
2	**STATE/DIST./TEHSIL**	Sikkim/ East Sikkim /Gangtok
3	**RIVER**	Rongni Chu / Rangpo River
4	**Barrage/Powerhouse SITE**	Near Namli village/ Rangpo village
5	**GEOGRAPHICAL CO- ORDINATES**	
(i)	Barrage Latitude/ Longitude	27° 16' 6.859" N/88° 35'20.058" E
(ii)	Powerhouse Latitude/ Longitude	27° 10' 42.339" N/88° 32'21.577" E
6	**HYDROLOGY**	
(i)	Total Catchment Area at Barrage Site	190.00sq km
(ii)	Average Annual Rainfall	3581mm
(iii)	Average Annual Runoff	3166mm
(iv)	Flood Discharge for River Diversion (Dry Season)	100 cumec
(v)	Probable Maximum Flood (PMF)	1195 cumec
(vi)	Standard Project Flood	920 cumec
7	**Reservoir**	

(i)	Full Reservoir level (FRL)	El – 740 masl
(ii)	Minimum Draw Down Level (MDDL)	El – 734.5masl
(iii)	Maximum Reservoir Level	El – 741 masl
(iv)	Gross Storage at FRL	0.33 MCM
(v)	Active Storage at MDDL	0.24 MCM
(vi)	Active Storage at MDDL	0.013 MCM
(vi)	Dead Storage at FRL	56.25 MCM
(vii)	Reservoir Area at FRL	10.70 ha
(viii)	Reservoir Area at MFL	11.70 ha
8	**BARRAGE and APPURTENANT WORKS**	
8.1	Barrage	
(i)	Type	Barrage
(ii)	Top of Barrage Elevation	El-742.00 masl
(iii)	Streambed Elevation	El-728.00 masl
(iv)	Maximum Barrage Height	14.0m
(v)	Length of Barrage	120.00 m
8.2	Spillway (incl. Sluice)	
(i)	Type	Free flow
(ii)	Sill Crest Level	El-728.00 masl
(iii)	Gate Type	Fixed Wheel Gate & Stoplog
(iv)	Gate Size (H x W)/ Numbers	12.2m x 6.5 m/2+1
(v)	Maximum Head	13.2m
(vi)	Discharge Capacity at EL 740.0	1200 cumec
(vii)	Dissipater Invert Level	El-727.00 masl
(viii)	Dissipater Basin Length	76.50 m
9	**DESILTING BASIN**	
9.1	Basin	Surface
(i)	Number of Troughs/Size (L x W x H)	2/59m x 35.9m x 9.5m
(ii)	Nominal Discharge through Chamber	38.16 cumec
(iii)	Size of Particles to be removed	>0.2 mm
(iv)	Trash rack size/Number of Panels	31.2m x 9.5m/24
9.2	Flushing System	
(i)	Type/Diameter	Sluice Pipe/1000mm
(ii)	Number of Sluice Pipes/Discharge through pipe	2/7.6 cumec
10	**INTAKE STRUCUTRE**	
(i)	Location/Number of openings	Left Abutment/1
(ii)	Top of Structure	El-742.50 masl
(iii)	Nominal Discharge Capacity (Design Discharge + 15% flushing + 10% over load)	38.16 cumec
(iv)	Gate Type/Number of Gates	Fixed Wheel Gate/1
(v)	Dimensions/Sill Elevation	4.0 x 4.0/ El-725.70 masl
11	**HEAD RACE TUNNEL & ADITS**	
11.1	Tunnel	
(i)	Shape/ Length	D Shape /12.581km
(ii)	Excavation Diameter/ Finished Diameter	4.5m/4.0m
(iii)	Slope/ Nominal Discharge	1: 400/30.5 cumec
(iv)	Lining Type/ Lining Thickness	Plain Cement Concrete/250mm
11.2	Adits	

(i)	Number of intermediate Adits/ Total Length	5/1866m
(ii)	Shape /Size	D-shape/6m x 5m to 6m x 5.25m
12	**SURGE SHAFT**	
(i)	Type	Vertical with Restricted Orifice
(ii)	Top Elevation / Bottom Elevation	El-782.50 masl / El-697.50 masl
(iii)	Total Height / Finished Diameter / Av. Lining	88m/10m/750mm
(iv)	Orifice Diameter/ Guard Gate	1.7m/2.5m x 4.0m
13	**VALVE HOUSE**	
(i)	Type	Butterfly
(ii)	Number of Valves/ Internal Diameter	1/3.0m
(iii)	Water Head	90m
14	**PENSTOCKS (UHPS, VPS, & LHPS)**	
14.1	Upper Horizontal Pressure Shaft (steel lined)	
(i)	Length / Diameter / Thickness	160.8m/3.0m/25-32mm
14.2	Vertical Pressure Shaft (steel lined)	
(i)	Length / Diameter / Thickness	318m/3.0m/16-32mm
14.3	Lower Horizontal Pressure Shaft (steel lined)	
(i)	Length / Diameter / Thickness	924m/3.0m/16-32mm
14.4	Bifurcation (Y-section)	29.5m/2.2m
(i)	Length / Diameter	
15	**POWERHOUSE**	
15.1	Structure	
	Type / Size (L x W x H)	Surface Station /61.5mx 45.75mx 38.0m
15.2	Turbines	
(i)	Type/ Number of Units	Pelton, Vertical Shaft/2
(ii)	Turbine Setting Elevation	El-312.50 masl
(iii)	Rated Discharge per Unit	13.35 cumec
(iv)	Gross head/ Rated Head	425.5m/404.1m
(v)	Installed Capacity	48MWx2+30% overload
15.3	Inlet Valve	
(i)	Number of Valves	2
15.4	**Generator**	
(i)	Number of Generators/ Type	2/ Suspended
(ii)	Nominal Speed	300rpm
(iii)	Voltage, Frequency	11 kV, 50 Hz
16	**TRANSFORMERS**	
(i)	Transformer Type/ Dimensions (L x W)/ Number	Three Phase, OFWP/5m x 3.5m/2
(ii)	Unit Capacity	60MVA
17	**SWITCHYARD**	
(i)	Type	Conventional
18	**ESTIMATED COST(Rs.)**	
(i)	Civil Works	61328.00 Lakh
(ii)	E&M Works	17956.00 Lakh
(iii)	Total basic cost	79284.00 Lakh
(iv)	Escalated cost for Civil and E&M works	8057.00 Lakh
(v)	Interest during construction & Financing Charge	314.07 Lakh
(vi)	Total (Generation Works)	118748.00 Lakh

(vii)	Cost per MW Installed	1236.95 Lakh

2.0 INTRODUCTION OF THE PROJECT/ BACKGROUND INFORMATION

2.1. Identification of Project and Project Proponent

M/s Madhya Bharat Power Corporation Limited, E-585, Greater Kailash-II, Ground Floor, New Delhi-110048is the project Proponent.

2.2. Brief Information about the Project

The project envisaged construction of the following project components:

- 120 m long and 14m high barrage with 3 bays of free flow spillway with sill crest level at 728.00 masl, with 3 gates (12.2mx 6.5m).
- Surface desilting basin, fitted with trash rack of 24 panels, with 2 troughs (59m x 35.9m x 9.5m) to exclude sediments >0.2 mm m through 1000m flushing pipe.
- 1 gated power intake for passing 38.16 cumec
- 12.581 km long D-shape lined HRT of finished diameter of 4.0m
- 88m high and 10 m diameter vertical surge shaft with 1.7m diameter meter orifice
- Underground steel lined Pressure shaft comprising of UHPS (160.8m/3.0m), VPS (318m/3.0m) and LHPS (924m/3.0m)
- Surface powerhouse (61.5mx 45.75mx 38.0m) for housing 2 vertical shaft Pelton turbine

The General Lay Out Plan of project and the Satellite image of project area are shown in **Figure -1 and Figure-2** respectively**.** The site photograph of work under progress are shown in **Figure-3** through **Figure 10.**

2.3. Current Status of works

Component wise detail of works carried out is as under:

Barrage:

1. Entire excavation in barrage has been completed
2. Excavation of Upstream and downstream flexible apron has been completed.
3. The u/s right-side protection works beyond BRG-1 has been completed up to El.742.50m.
4. Cladding wall and cable anchoring works have been completed.
5. The casting of concrete blocks at u/s & d/s flexible apron is completed.
6. Barrage concreting works is under progress. Barrage raft concreting has been completed. Concreting in barrage piers is under progress and structure levels are as follows:
   - Deck slab over bay and approach road of bridge construction over bay of BRG II is complete.
   - Bridge pier no. 5 raised upto EL 737.8 final level EL 742.5
7. Rim treatment at right bank of river is underway. Block 1 (L=25m) reached upto EL 742.0, Block 2 (L=22m) erection reached upto EL 742.0, Block 3 (L=20m) erection

reached up to EL 742.0, Block 4 (L=23m) erection reached up to EL 739.5 & Block 5 (L=10m) erection reached up to EL 731.5

8. Gate groove concreting in progress. HPC M55 fed at bottom sills. BRG II service & stop log gate groove in-between pier no. 3 & 4 reached upto El 742.5 and 2 & 3 reached upto El 742.5.
9. Desilting basin d/s adjoining Collection Chamber Gate groove (4 nos) 2nd stage concrete completed up to EL 742.5.

Desilting Basin:

1. Excavation for divide wall between Desilting Basin (DB) and Barrage is complete.
2.
3. DB-2, DB-3 & DB-4 L/S, intermediate & R/S wall completed up to EL 742.5
4. Collection chamber U/S & D/S wall raised up to final level EL 742.5
5. U/S DB 1 is complete and reached final level EL 742.5
6. U/S guide wall block-1, block-2, block-3, block-4, Block-5, Block-6, Block-7 and Block-8 reached final level EL 742.5
7. Desilting basin D/S 500mm slab is complete and re ached final level 742.5
8. Silt flushing d/s Collection chamber 1.4m diameter pipe 21.692 m length & 1.0m diameter 61.1m length is complete.

Power Intake:

1. Concreting of left abutment completed up to EL 742.0.
2. Power Intake reached final level El 742.5
3. Power intake 650mm thick slab at EL 742.5 is complete

Water Conductor System:

1. Excavation of HRT is almost complete (99.89%) except for 13.39m length
2. CC lining of HRT is completed up to 65.21%.
3. Surge shaft is complete is complete
4. Excavation for VPS and LHPS is complete
5. Steel lining of LHPS is 10.46% completed.

Power House Complex:

1. Excavation of Power house complex is almost complete (97.93%) and 671 cum is balance.
2. Concreting work is about 75.63% completed only 6005 cum is balance.
3.

2.4. Overall project completion as on 01.07.2019

S.no.	Particulars	% of Work Balance	% of work Completed	Weighted %*	% of Completion of individual Work	Contribution to overall works	% Completion of Work in overall

								progress
		A	B	C	D=(Bx C)	E	F	G=(DxF)
1	Excavation of Barrage, Desilting basin , collection chamber and Intake civil works	0.00 %	100.00 %	30%	**100.00%**	100.00%	**13.23%**	13.23%
	Concreting of Barrage, Desilting basin , collection chamber and Intake civil works	0.00 %	100.00 %	70%				
2	HM Works of supply & erection of Barrage Gate & Hoist, desilting basin gate & gantry, intake gate & hoist and Tail race gate & hoist	50.00 %	50.00%	22%	***11.00 %***	*11.00 %*	**2.52%**	1.26%
3	Head Race Tunnel and ADITS Excavation (14466.98 Meter)	0.09 %	99.91%	50%	***49.96 %***	*91.30 %*	***41.51%***	37.90%
	HRT Concrete Lining, Grouting & Plugging	38.70 %	65.39%	25%	***16.35 %***			
4	Excavation in Surge Shaft and pressure shaft	0.00 %	100.00 %	20%	***20.00 %***			
	Concrete lining in surge shaft	0.00 %	100.00 %	5%	***5.00 %***			
5	Hydro Mechanical works of supply & erection for UHPS, VPS and LHPS	69.74 %	30.26%	78%	***23.60 %***	*23.60 %*	**8.74%**	2.64%
6	Excavation of Power House complex- Tail race duct & switchyard	2.26 %	97.74%	30%	***29.32 %***	*82.20 %*	***4.86%***	4.00%
7	Concreting of Power House complex- Tail race duct & switchyard	25.96 %	75.55%	70%	***52.88 %***			
8	Electro Mechanical Supply	40.00 %	89.11%	50%	***44.56 %***	*72.56 %*	***21.81%***	15.82%
	Electro Mechanical Service- Erection & Commissioning	50.00 %	56.00%	50%	***28.00 %***			
9	Transmission Line & Switching Substation & Line Charging	65.00 %	35.00%	100%	***35.00 %***	*35.00 %*	***7.34%***	2.57%
	Over all % of Works completed							**77.42 %**

2.5. Balance works

The balance works at barrage complex are erection of hydro-mechanical component like gates, counter weights, stop- log gates, Stanchion, gate lifting mechanism and top deck of barrage. Balance work of water conductor system involves excavation of HRT in 13.39m length, lining in 4383.38m length and steel lining of LHPS in 881.324 m length. Balance work under power house complex is 671cum excavation and 6005 cum concreting work besides erection of Electro-mechanical equipment/plant and TRC.

2.6. Need for the Project and its Importance to the Country or Region

The need for Rongnichu HEP in Teesta Basin, has therefore been considered in context of power shortage in the country as whole. The project has been conceptualized as R-o-R scheme. The H.E.P. after being operational and capacity enhancement from 96 MW to 115 MW would be able to provide an annual design energy (90% dependability) of 434 GWh.

2.7. Demand-Supply Gap

The annual power supply position in terms of energy requirement (1,36,522 MU) vis-à-vis energy availability (1,35,490 MU) of various States/ Systems during the year 2017-18 as assessed by CEA reveals that there was a deficit of 0.8% energy in eastern region which inter alia includes State of Sikkim. The annual energy requirement of Sikkim has been assessed as 486 MU vis-à-vis energy availability (485MU), which reveals that there was a deficit of 0.2% energy. Actual power supply position in terms of Peak Demand vis-à-vis peak met of various in the state of Sikkim neither there is surplus nor deficit.

2.8. Imports vs. Indigenous Production

All energy power production in the state is due to hydro power as the total installed capacity of state as on 30.6.2019 is 2221.12 MW and does not have any contribution from other mode of power such as coal, diesel, nuclear, which involve imports. Thus, the production is purely indigenous.

2.9. Export Possibility

In wake of the Guidelines for Import/Export (Cross Border) of Electricity-2018, issued on 18.12.2018, by Ministry of Power, Government of India, as per para 5.1, Indian entities may import electricity from the generation projects located in neighboring country(ies) directly or through Government or a Government Company or a licensed trader of that country after taking approval of the Designated Authority as laid down in para 4.4 of the Guidelines; provided that the generation project(s) has the permission to export power to India from the respective Government of the neighboring country.

2.10. Employment Generation

The implementation of project has generated employment opportunities in the project areas the skilled, semi-skilled and un-skilled local youth were also engaged by contractors of various packages of contracts.

3.0 PROJECT DESCRIPTION

3.1. Type of Project Including Interlinked and Interdependent Projects, If any

The project has been conceived as R-o-R scheme for harnessing river water and available gross head of 425.5m for hydro power generation. It is an intervention on Rongnichuu river and *per se* an independent project and is not interlinked with any other project.

3.2. Location

The barrage location is about 2 Km downstream of Namli village and 16 Km south of Gangtok along NH-31A. The powerhouse is proposed on the right bank of Rangpo River 2.5 km from Rangpo Town on Rangpo-Rongli State Highway.

3.3. Size or Magnitude of Operation

As per MoEF notification dated 14th September 2006 and subsequent amendments, Rongnichu HEP of original installed capacity 96 MW installed capacity to be enhanced to 115 MW, falls under project category "A". Hydro power projects do not make consumptive use of water and after utilizing the potential energy of water release it into river.

3.4. Project Description with Process Details

The project has been conceived with chief aim of utilizing vast power potential of Sikkim in general and Rongnichhu in particular for generation of hydro power by diverting water from barrage into water conductor system and utilizing the available/regulated discharge and available head at surface powerhouse.

The process involved shall be regulation of barrage, as per regulation manual, by gradually operating the gates to store water in the reservoir without exceeding the FRL, and by surpassing the flood waters through operation of gates without bringing a sudden drawdown in the reservoir and without exceeding the maximum allowable differential level on either side of divide walls and piers from the structure safety consideration. Utmost round the clock vigil shall be carried out during monsoon season by inspecting the downstream floor of the spillway, flow pattern of the river on upstream and regulating gates for avoiding any flow parallel to barrage. The regular inspection of barrage and appurtenant works shall be carried out. Regular watch and ward and maintenance of hydro-dynamic and electro-mechanical equipment/power plant besides structures shall be conducted.

3.5. Raw Material Required along with Estimated Quantity

The total raw material requirement for sand and stone shall be 1.75 lakh cum and 11.86 lakh ton. Sand and boulder/metal has been met from the approved Quarry and consumptive use of muck retrieved from sites.

3.6. Resource Optimization/ Recycling and Reuse

The muck excavated (5.0 lakh) is being utilized as raw material for captive Brick Plant, a part is also being used for filling/leveling low lying area and the balance muck is being disposed of at Pre-Identified Dump yards. On saturation the Muck Dump Yards will be Rehabilitated and Resorted as per pre-defined methodology. About 50% excavated material shall be consumed in formation of coffer dam, backfill and on road embankment and balance shall be dumped at designated location on downstream of dam.

3.7. Availability of Water Its Source, Energy / Power Requirement and Source

3.7.1. Water Requirement

The total water requirement during construction shall be 115KLD of which 85KLD shall be sourced through tunnel seepage. The domestic requirement shall be 30KLD which shall be met from the filtration plant. Post construction the domestic and Fire Fighting requirement shall be 2 KLD only. There are no competitive users from these sources.

3.7.2. Power

During construction electricity requirement of 2MW power is being met from the existing transmission network in the area. During operation electricity requirement shall be power 0.50MW.

3.8. Quantity of Wastes to be Generated (Liquid and Solid)

3.8.1. Solid Waste Generation& its Disposal

About 60T/year solid municipal waste is being generated from staff colony (60T/year).The collected bio-degradable waste is being disposed at suitable landfill sites, organic waste will be suitably processed to for compost while the non-bio-degradable waste shall be incinerated. Commercial waste shall be stored and periodically disposed by auction. The muck excavated is being utilized as raw material for captive Brick Plant, a part is also being used for filling/leveling low lying area and the balance muck is being disposed of at 10 Nos of Pre-Identified Dump yards.

3.8.2. Liquid Effluent

During Construction the tunnel seepage water is being drained to a settling tank for sedimentation of Silt and discharged back to river.

At Adit 3 where the discharge point is at a longer distance, filtration plant has been installed and the filtered water is being supplied in nearby villages.

There will be no waste water generation from project activities as regulation of barrage and power house involves no effluent per se. The surplus water from the reservoir during flood shall be passed into the river course by opening the spillway gates. The liquid effluent resulting through the labour camps and staff colony shall be treated through septic tank/soak pit.

4.0 SITE ANALYSIS

4.1. Connectivity:

The barrage location is about 2 Km downstream of Namli village and 16 Km south of Gangtok along NH-31A. The powerhouse is proposed on the right bank of Rangpo River 2.5 km from Rangpo Town on Rangpo-Rongli State Highway.

4.2. Landform, Land use and Land Ownership

4.2.1. Landform

The project area lies in mountainous area of east Sikkim.

4.2.2. Land Use

The predominant land use of the catchment area upto barrage site is open forest (29.77%) followed by open scrub (25.37%),agriculture and settlement (22.08%), dense forest (18.44%),barren and rock land (2.87%) and alpine meadows (1.26%).

4.2.3. Land Ownership

The ownership of the private land acquired from villagers shall vest with the project proponent (state). The ownership of the revenue land to be transferred to the project proponent shall vest with them.

4.2.4. Land Requirement

The total land requirement under the project for barrage, submergence, appurtenant works, has been assessed as 71.1836 ha of which private land is 33.9483 ha, forest land 25.1388 ha, Power Department land 0.707 ha and revenue land is 11.3895 ha. The present status of land acquired/ transferred is shown in **Table-4.1**

Table 4.1 : Present Status of Land Acquisition(ha)

Category of Land	Total Requirement	Land Acquired or transferred	Balance to be acquired or to be transferred
Private land	33.9483	33.9483	0.00
Forest Land	25.1388	25.1388	0.00
Revenue(river)	11.3895	11.3895	0.00
Power Department	0.707	0.707	0.00
Total	**71.1836**	**71.1836**	**0.00**

4.2.5. Status of Forest Land Diversion.

Stage-I Forest clearances for diversion of 26.2313 ha forest land has been accorded on 17.1.2008 and Stage-II clearance on 18.5.2019. Further diversion of additional 2.5325 ha of forest land for the project and surrender of 3.6250 ha of forest land diverted under 26.2313 ha for the project was approved on 10.22012. As such, total forest land in possession at present is 25.1388 ha.

4.2.6. Presence of important economic mineral deposit, if any

No major occurrence of economic deposit (major mineral) has been found in the reservoir/pond area, except materials like boulder/stone which is a minor mineral and important as the construction material. There are no mining activities in the project area as it has no presence of deposits of any major mineral resource

4.3. Geography

Geographically, East Sikkim occupies the south-east corner of the State. It is bounded by North District in the north, China and Bhutan in the East, Darjeeling district of the state of West Bengal in the South and South District in the western side. East District is located at 88°27’ to 88°56’E longitude and 27°9’ to 27°25’ N latitude. The total geographical area of the district is 954 sq. km.

4.3.1. Topography

The topography is characterized by high ridges, steep to moderately steep slopes broken by occasionally detached scar faces with falls of 20 to 100 m. The area is drained by the tributaries of Rongni Chhu and Rangpo Chhu, the main drainage system.

4.3.2. Rongni Chhu

Rongni Chhu is 36 km long before its confluence with Teesta and in its initial stretch it flows as Rora Chhu. Several small streams join it all along its course on either side. Rora Chhu originates from the western slope of a peak (3,924 masl) in East Sikkim. Rora Chhu is joined by Yali Chhu at 1,400 m, and Rishi Khola at 1,240 m on its left bank. The longitudinal profile of Rongni indicates presence of several two points along its course, probably corresponding with zones of structural discontinuities. It is clear from these longitudinal profiles of Rongni Chuu and its tributaries that the tributary Rang Chhu (Kali Khola) is down cutting its bedrock at a relatively higher rate compared to the Rora Chhu. In the initial 12 km stretch, Rongni Chhu flows through deep gorges, steep slopes and dense forests at a very steep gradient (1:5). Thereafter, the gradient decreases to 1:22 for next 15 km where it passes through a knick point. Further downstream, the river passes through a channel gently dipping towards east till its confluences with Teesta at 350

4.3.3. Basin Characteristics

River Rongni Chhu basin is a canoe shaped basin. The streams of this basin are rainfed as well as spring fed. The important left bank tributaries of Rongni Chhu are Yali Chhu, Reshu Chhu, Lakh Khola,Taksom Chhu,Aho Khola, Andheri Khola and Rondu Khoa. The right bank tributaries are Rang Chhu, Chhuba Khola,Pagla Khola, Martam Khola and Sang Khola

4.3.4. Drainage Pattern

Drainage is the single most entity, which defines the network antecedent river. The drainage pattern of the study area exhibits dendritic pattern. The majority of the area possesses a dendritic to sub-dendritic drainage containing irregular branching of the smaller tributaries. The closeness of these small branches is depending on the permeability of the underlying rocks and the amount and nature of precipitation. It is the most common drainage pattern of hillside slopes of the study area. The sub-parallel drainage pattern comprises a series of streams which run approximately parallel to each other. They are evolved in areas of uniformly dipping rocks.

4.4. Geology

4.4.1. Regional Geology

Within the state of Sikkim the exposed rocks are i) Daling Group: Proterozoic-Precambrian metamorphic rocks of low to medium grade, ii) Darjeeling and Kanchanjunga gneisses: high grade gneisses, iii) Chunthang formation: Quartzite, calc-silicate rocks, marbles, graphite schist and occasionally amphibolites with intrusive granites (Lingtse granite gneiss), and iv) Phanerezoic rocks: includes a) Gondwana Group of Permian age contains sandstone, shale and carbonaceous shale with occasionally thin bands of coal and pebbly shale horizons, b) Palaeozoic and Mesozoic Tethyan fossiliferous sequence in the northeastern part of Sikkim.
The sequence of the strata in the project and adjoining area is given in **Table -4.2.**

Table 4.2 : Geological Succession Table

Age	Formation	Lithology
Upper Carboniferous to Lower Permia	Gondwana	Sandstone, shale and carbonaceous Shale with occasionally thin beds of Coal and pebbly horizon
Upper Proterozoic	Daling	Interbedded quartzite and chlorite sericite phyllite / schist.
Proterozoic	Chungthang	Interbedded quartzite and garnetiferous Quartzbiotite schist. calc-silicate rock/ marble
Older Proterozoic	Central crystalline Gneissic Complex	Banded Gneiss with Augen Gneiss and Quartz-biotite gneiss.

4.4.2. Local Geology

The district is a part of the Eastern Himalayas and exhibits identical geological features as in other parts of Eastern Himalayas. Five Geological units encountered in the district are Kanchenjunga gneiss, Darjeeloing gneiss, Chunthang Schists and gneiss, Lingtse granite gneiss and Daling group of rocks consisting of Phyllite, slates, quartzites and schist of Pre-Cambrian age. Quaternary deposits of alluvium are sporadically developed along the streams and rivers Geologically, the project area is located in the Gorubathan Formation of the Daling Group of rocks, which is a monotonous thick assemblage of green slate, bedded and intrusive epidiorites and chlorite feldspathic greywacke at the base of Daling Group. Lingtse granite gneiss is also reported within this group as well as at the contact of this group of rocks with the Central Crystallines exposed north of Gangtok.

4.4.3. Seismicity

As per seismic zoning map of India (IS: 1893:2000), the project area falls within Zone-IV.

4.4.4. Hydrogeology

The ground water occurs in largely disconnected localized bodies under favorable geological structures, such as joints, fractured zones in various lithological units, weathered zones in the phyllite, schist, gneisses and quartzite. The ground water is available from source perennial springs from nallas present in all geological formations in the area. Due to higher relief and steep gradient of the area, the subsurface flow of ground water is intercepted with manifest as seepages and springs. The area is characterized by high rainfall which is primary source of ground water. The springs are not deep seated. Direct infiltration and rainfall through joints, fracture, weathered zones of the rocks and through soil covers is the principal mode of recharge of the springs. Due to steep slope most of the precipitation in the area is lost as surface run off through streams, kholas and intermittent springs which are tapped through pipe lines and distributed by gravity method for domestic use. Precipitation is the main source of recharge of ground water but glacier melt water is also recharging the ground water considerably. Discharge of the springs occurring in different types of rock formations in the area varies from 0.25 to 1.8 lps though the discharge decreases generally from December-January to May and maximum discharge is recorded during post monsoon period i.e., September to November.

4.5. Hydrology

4.5.1. Dependable Flows (50% ,75% and 90%)

The details of 10-daily flow from constructed water availability series for Rongni Chhu in 50%,75% and 90% dependable year are given in **Table 4.3.**

Table 4.3 : 10 daily Flow in 50%,75% and 90% dependable years

Month	Period	50% Dep. Year (1979-80)	75% Dep. Year (2006-07)	90% Dep. Year (1996-97)
Jun	I	6.80	23.42	19.62
	II	14.21	30.48	14.84
	III	18.83	31.73	22.40
Jul	I	18.94	37.01	25.40
	II	34.83	36.97	36.83
	III	66.11	42.70	35.26
Aug	I	57.51	40.39	32.84
	II	27.54	38.49	42.62
	III	40.69	39.08	34.83
Sep	I	53.10	38.90	29.20
	II	36.81	34.21	25.07
	III	20.76	29.32	26.13
Oct	I	22.17	22.10	38.94
	II	25.52	19.98	19.81
	III	13.96	15.78	14.31
Nov	I	14.70	13.39	9.89
	II	12.53	10.87	7.85
	III	11.69	9.70	4.62
Dec	I	15.16	8.97	4.59
	II	10.17	8.02	5.43
	III	8.91	7.83	5.89
Jan	I	8.07	6.24	3.91
	II	6.25	5.63	2.98
	III	6.26	6.03	4.62
Feb	I	6.22	6.09	5.65
	II	6.08	5.85	4.52
	III	5.78	4.83	4.71
Mar	I	5.76	3.63	5.25
	II	7.07	3.91	5.22
	III	7.38	4.41	4.31
Apr	I	9.65	4.23	6.91
	II	13.39	4.99	9.24
	III	17.49	6.36	8.29
May	I	9.27	5.66	9.30
	II	13.48	6.63	10.60
	III	25.68	9.42	12.90

4.5.2. Flood Frequency and Design Flood

The design flood peak for different flood frequency, SPF and PMF is tabulated in **Table-4.4.** Based on these the spillway has been designed for passing SPF (920 cumecs); whereas free board has been based on PMF.

Table 4.4 : Design Flood

S.N.	Particular	Discharge (cumecs)
1	25-year flood peak	640
2	50-year flood peak	705
3	100-year flood peak	775
4	SPF	920
5	PMF	1195

4.6. Existing Infrastructure & Sensitive Ecological Locations

Fambong Lho Wildlife Sanctuary exists within 5.5 km from the project area. No archaeological monument of national importance lies either in the project area or in its submergence area. There is also no structure of national heritage in the area. The environmental sensitivity is discussed in **Table -4.5.**

Table 4.5 : Environmental Sensitivity

S.N.	Sensitive Ecological Features	Name	Aerial Distance (in km.) from project boundary
1.	National Park/Wildlife Sanctuary	Fambong Lho WLS	5..5
2.	Tiger Reserve/Elephant Reserve/ Turtle Nesting Ground	None	0.00
3.	Core Zone of Biosphere Reserve	None	-
4.	Stream/Rivers	Rongnichu	0.00
5.	Estuary/Sea	None	-
6.	Mangroves	None	-
7.	Mountains/Hills		-
8.	Notified Archaeological sites	None	-
9.	Industries/Thermal Power Plants	None	-
10.	Defense Installation	Army station at Bardang Village	2 km from adit-2
11.	Airports	Pakyong	145
12.	Railway Lines	New Jalpaiguri	136
13.	National Highway	NH-31A	1 KM

4.7. Climatic Data from Secondary Sources

The district is characterized by cool and humid climate. It receives adequate rainfall from south-west monsoon, which sets in the latter half of June and continues up to the middle of October. Pre-monsoon rains are received during March-April. Maximum and minimum temperature as recorded are 27.5˚ and 1.5˚C. The nearest IMD station is Gangtok. The climatological data at IMD, Gangtok is shown in **Table 4.6.**

Table 4.6 : Climatologically Summary for IMD Station Gangtok (1981-2010)

Month	Mean max. temp (^{0}C)	Mean min. temp (^{0}C)	Monthly Rainfall (mm)	R.H.at 8:30 (%)	R.H.at 17:30 (%)	Av.Wind Velocity (kmph)
January	12.3	4.7	27.1	83	77	1
February	13.8	6.1	72.2	85	78	1.3

Month	Mean max. temp (^{0}C)	Mean min. temp (^{0}C)	Monthly Rainfall (mm)	R.H.at 8:30 (%)	R.H.at 17:30 (%)	Av.Wind Velocity (kmph)
March	17.5	9.2	126.4	80	76	1.8
April	20.5	11.8	296.9	78	78	2.2
May	21.4	14.0	496.4	87	85	1.8
June	22.0	16.4	609.8	93	89	1
July	21.6	17.0	626.3	95	92	0.6
August	22.2	16.9	565.9	94	92	0.7
September	21.4	15.9	438.7	94	90	0.8
October	20.4	12.8	173.4	87	83	1.1
November	17.1	9.1	37.9	82	79	1
December	13.9	6.2	19.5	81	77	0.9
Average Total	**18.7**	**11.7**	**3490.4**	**86**	**83**	**1.2**

- **Temperature**

The mean daily maximum temperature recorded is 18.7° C while mean daily minimum temperature recorded is 11.7° C. The highest recorded temperature is 29.9 ° C (16.08.1990) while lowest temperature observed to be -2.2° C (10.1.1956).

- **Relative Humidity**

The During the monsoon season, relative humidity generally varies between 87 to 94% in the morning. The air becomes dry after the withdrawal of the north-west monsoon.

- **Rainfall**

The south west monsoon during the month of June, July, August and September chiefly contributes the rainfall. The total annual rainfall is 3490.40 mm (1981-2010). The maximum total monthly rainfall is 1281.30 mm, which occurred in June ,1997 and minimum monthly rainfall in monsoon is 188 mm which occurred in September,1996. There are about 161 rainy days in a year). The heaviest fall for 24 hours was 470.10 mm (12.08.1984).

- **Wind Pattern/ Direction**

Predominant wind direction is North and south. For about 96% of days in a month calm prevails. The average velocity is 1.2 kmph.

• Cloudiness and Special Weather Phenomena

The skies are generally moderately to heavily cloud during the monsoon season. The skies are mainly clear or lightly clouded during November to January months. The highest incidences of thunderstorms occur in the period March to May to. Hail, dust storm and squalls are rare in the region. Occasional fog occurs in the winter season.

5.0 PLANNING BRIEF

5.1. Planning Concept

For planning and design all relevant code of practices as laid down under various BIS codes and guidelines fixed for hydrological studies by the CWC were followed. The principal levels were fixed based on detail studies for various past floods at the site and other nearby structures. The optimization studies and power potential studies have been on the basis of guidelines for "Formulation of Detailed Project Reports for Hydro Electric Schemes, their

Acceptance and Examination for Concurrence, New Delhi, January ,2015(Revision 5.0), issued by the CEA. Power potential studies and installed capacity have been carried out as per provision of Appendix-2.

5.2. Amenities/Facilities

5.2.1. Residential/Non-residential buildings

Camp area has been created at suitable sites near to work sites. O&M staff complex has been developed near powerhouse. Temporary non-residential buildings like offices, store and fabrication yard have been created.

5.2.2. Water Supply

Potable/treated water is being supplied for human consumption at camp area near headworks and also office and O&M staff complex near barrage and powerhouse.

5.2.3. Power Supply

During construction electricity requirement of 2MW power is being met from the existing transmission network in the area. During operation electricity requirement shall be power 0.50MW. In case of power failure, the power supply required for the lighting residential buildings and site offices etc. will be met from the DG sets of adequate capacity (250KVA).

5.2.4. Transport of Men and Material

Most of the employee stay put in the colony which are located very near to the project site and those who live outside report to the duty on own means.

5.2.5. Communication

Land line and Mobile phones are being be used for communication.

6.0 PROPOSED INFRASTRUCTURE

6.1. Industrial Area (Processing Area)

Arrangements like site office, control cabin, project road to barrage and other components have been provided.

6.2. Residential Area (Non-Processing Area)

A small colony and site office has been be developed at site for the staff looking during construction of the works .

6.3. Green Belt

The green belt has been developed in area around head works and vacant government land. The saturated muck disposal sites have been stabilized with vegetal cover. The places where the vegetal cover is less, avenue plantation shall be carried out along service roads and on spoil banks.

Green Belt plantation around barrage area is proposed after completion of construction of barrage, permanent approach road at Barrage, Power House and Adit 2B.

6.4. Social Infrastructure

Adequate social Infra structure exist in the area being not far away from state capital Gangtok (16 km)

6.5. Connectivity

The project site is well connected to NH/SH/MDR.

6.6. Drinking Water Management

The domestic requirement of water (30 KLD) which is being met from the filtration plant. Post construction the domestic requirement shall be 2 KLD only.

6.7. Sewerage System

Labour camps have well designed drainage system along with septic tank attached with soak pits.

There is no colony envisaged to be constructed for the project.

6.8. Industrial Waste Management

During construction empty cement bags is being sold to authorized recyclers. And the used/spent oild generated from the workshops is being utilized for lubrication of gantries and shutters. Application for grant of authorization for under Hz waste rule 2016 has already been made to SPCB however due to someprocedural delays land lac of guidelines the grant of authorization is pending.

Not applicable, as the operation and maintenance of the completed project components shall not generate any effluent and industrial waste.

6.9. Solid Waste Management

The muck generation from excavation has been assessed as (5.00 lakh cum). The muck excavated is being utilized as raw material for captive Brick Plant, a part is also being used for filling/leveling low lying area and the balance muck is being disposed of at Pre-identified Dump yards. On saturation the Muck Dump Yards will be Rehabilitated and Resorted as per pre-defined methodology. About 5000 kg/month municipal waste is generated from Septic Tanks which is vermi-composed and used as manure for green belt development

6.10. Power Requirement & Supply/ Source

During construction electricity requirement shall be power 2MW which is being met from the existing transmission network in the area.

7.0 REHABILITATION AND RESETTLEMENT (R&R) PLAN

As there shall be no displacement of people thus no Resettlement and Rehabilitation site shall be warranted. The package proposed for the affected families has been completely followed.

8.0 PROJECT SCHEDULE & COST ESTIMATES

8.1. Likely Date of Start of Construction and Likely Date of Completion

All the works including testing of power plant and other components of project are scheduled to be completed by April 2021.

8.2. Estimated Project Cost

Techno-Economic Clearance of 115 MW Rongnichu HEP DPR was granted by Government of Sikkim vide letter dated 02.08.2019 to expedite the implementation of the project. The revised cost of Project is 1187.45 Cr Cr.The cost per megawatt has been assessed as 10.32 Cr.

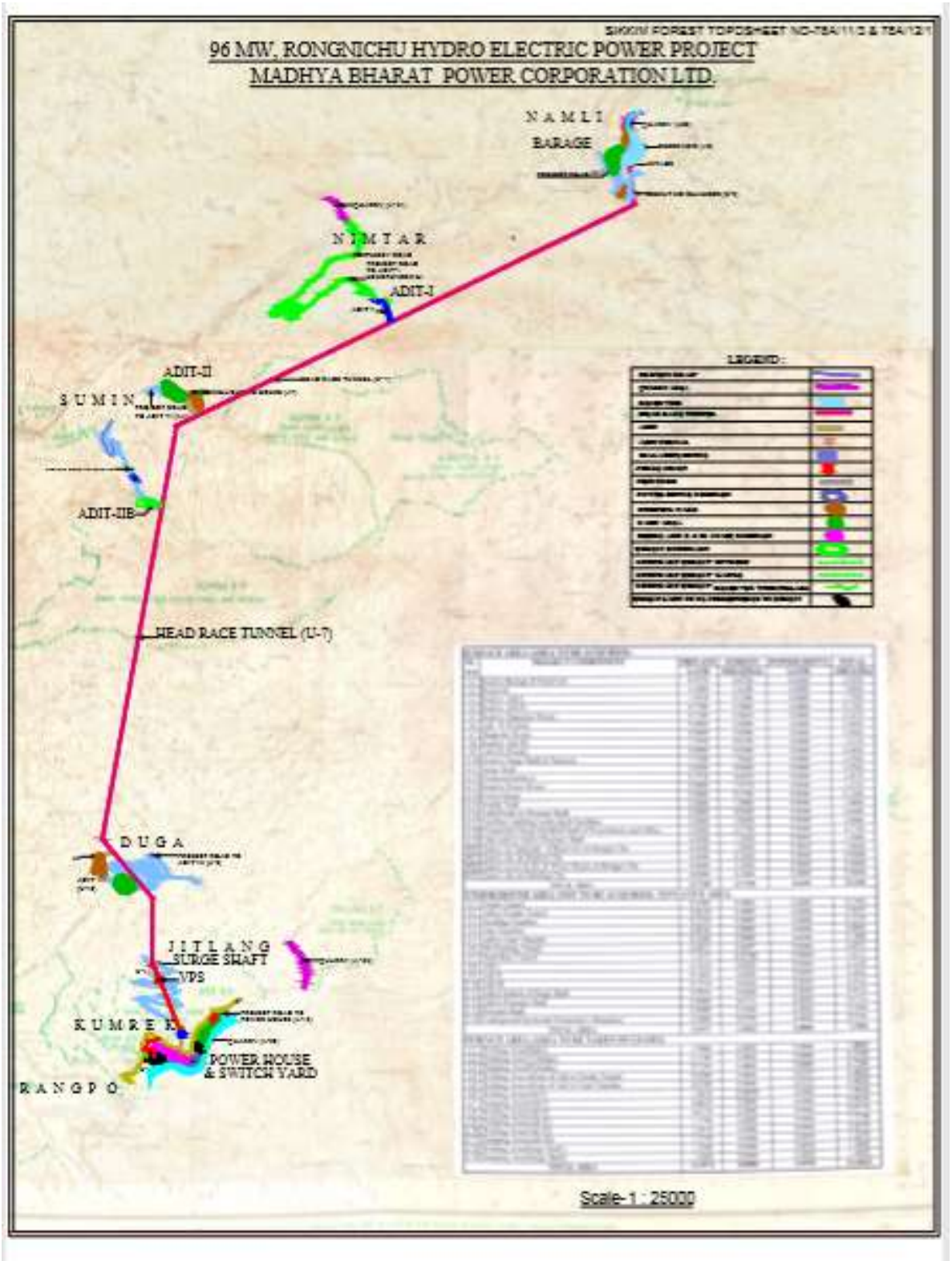

Figure 1: Layout Map of Project

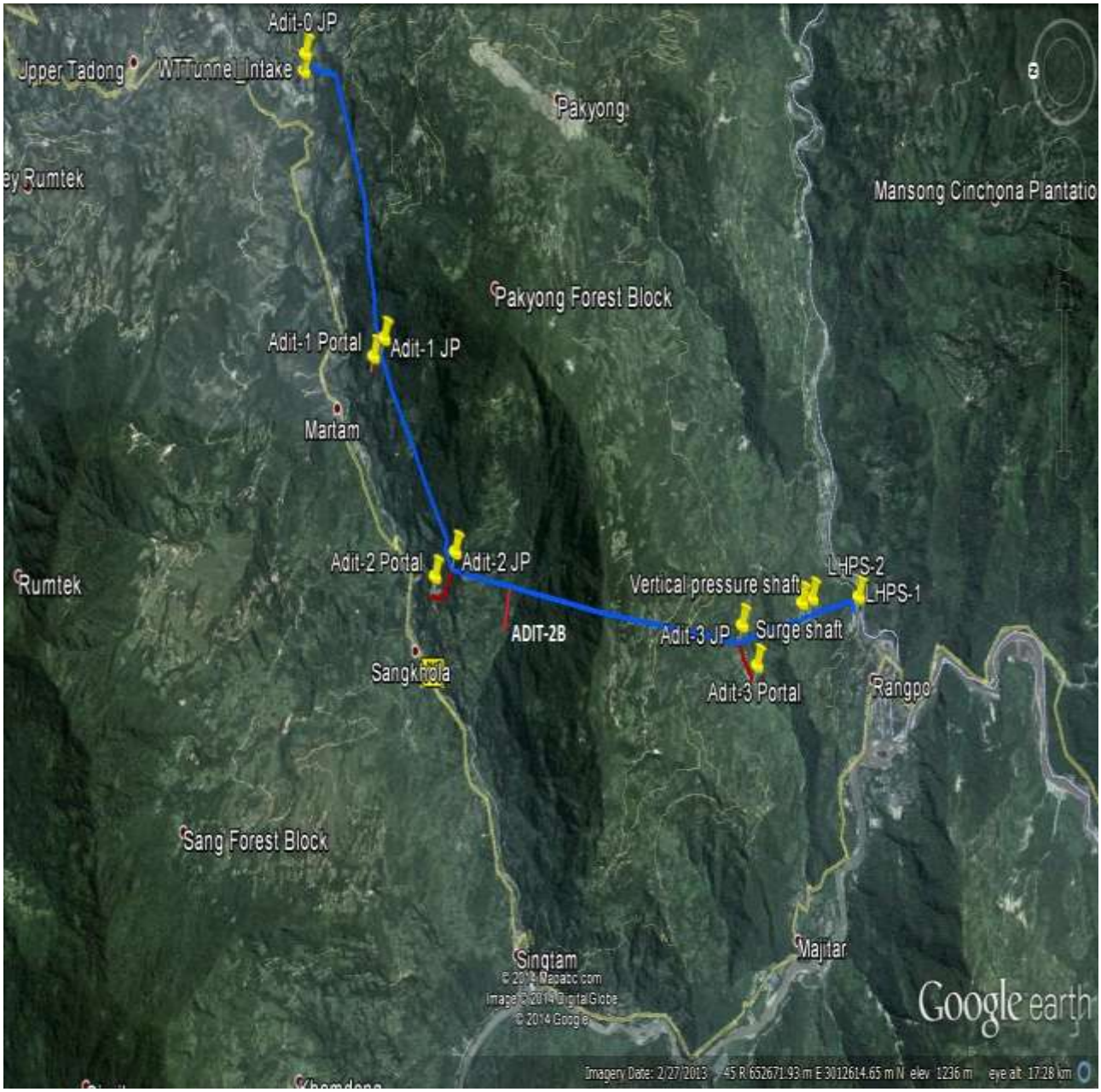

Figure 2: Satellite Image Showing Project Component

Figure 3: Overall View of Barrage Structure

Figure 4: Final Concrete Lining HRT Face-5

Figure 5: Surge Shaft Lining

Figure 6: Steel Liner work of LHPS in Progress

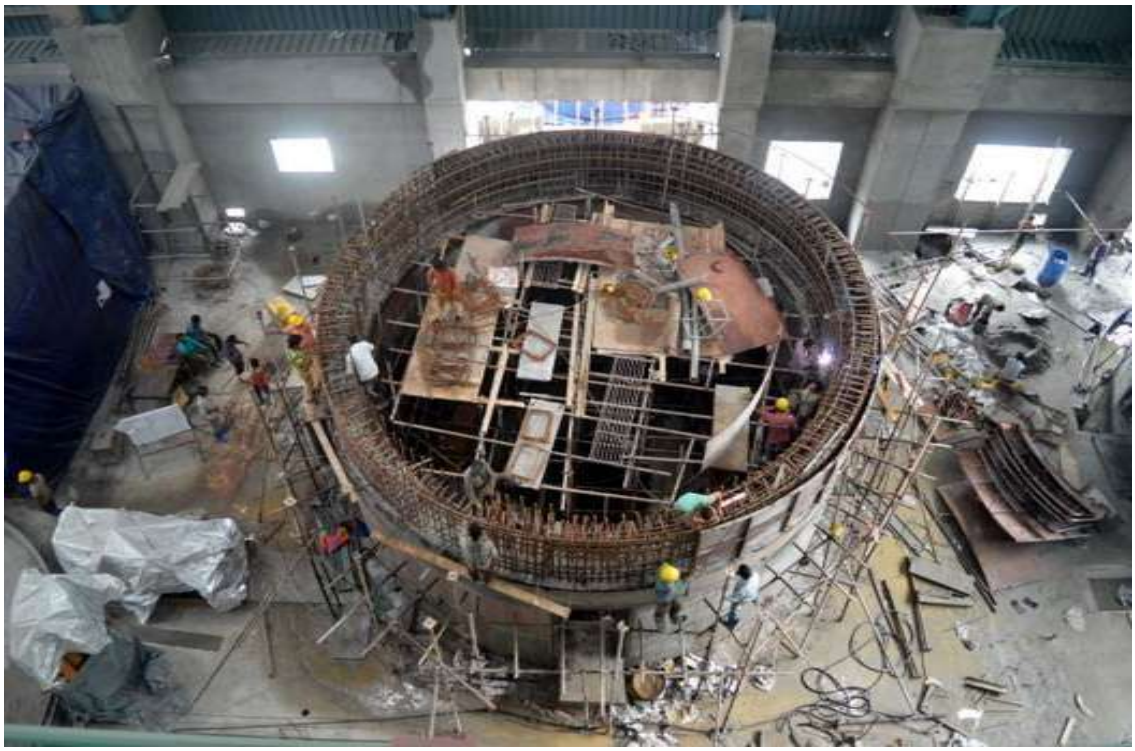

Figure 7: Concreting of Generator Barrel Unit-1

Figure 8: Concreting of Generator Barrel Unit-2

Figure 9: Control Room False Ceiling work in Progress

Figure 10: Service Bay Main Entrance Shutter Erection work in Progress