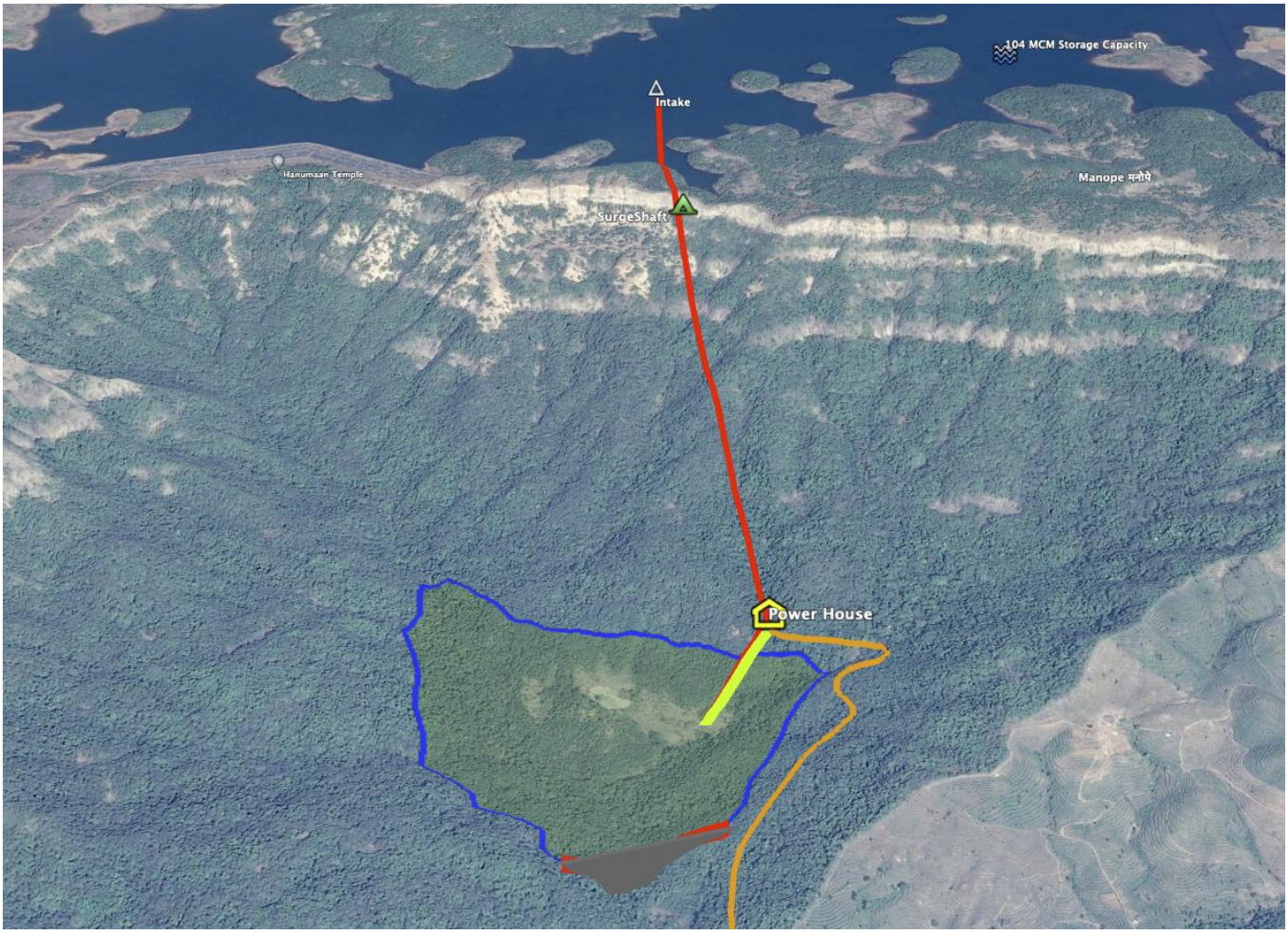
PATGAON PUMPED STORAGE PROJECT

(2,100 MW)

PRE-FEASIBILITY REPORT



Adani Green Energy Limited
26th July 2022

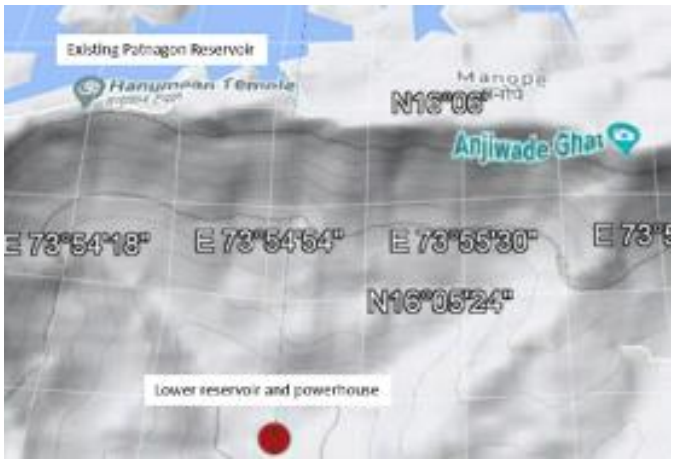
adani
Renewables

INDEX

CHAPTER – 1

EXECUTIVE SUMMARY

The proposed 2,100 MW (6*300 MW + 2*150 MW) Patgaon Pumped Storage Hydroelectric Project (the Project) with a storage capacity of 12.6 GWh is constructed across Vedganga River in Bhudargad Taluka of Kolhapur District (upper Reservoir) and Power House and Lower Reservoir near village Anjiwade of Kudal Tehsil, Sindhudurga District in Maharashtra State. The existing Patgaon Reservoir constructed in 1998 for irrigation purposes provides an opportunity for constructing a pumped storage scheme between this reservoir as upper reservoir and a new reservoir to be constructed as lower reservoir on a seasonal stream in the valley located about 400 m below near village Anjiwade of Sindhudurga District.



The existing reservoir has a gross volume of 105.26 Mm3 (live 90.26 mm3) and a historic minimum live volume of 17 Mm3 before onset of the monsoon. A lower reservoir with a similar volume can be established by about 500 m long dam with a maximum height of 57.5 m. The live storage volume works out to about 12.9 Mm3 equivalent to 12.6 GWh for the actual head and will hence determine the capacity of the Project. For a generation period of 6 hours the installed capacity will be 2,100 MW for a rated discharge of 592.72 m3/s. Static heads will vary between 390 m and 441.1 m.

The physical features of the Project consist of twin intake towers in the Patgaon Reservoir followed by twin 230 m long concrete lined low pressure tunnels to twin surge shafts and twin 1380 m / 1481 m long steel lined pressure tunnels branching to 8 units, (six generating/pumping units of 300 MW generating capacity each and two units of 150 MW each) in an open shaft powerhouse. Alternatives like surface penstock with surface power house, and vertical shaft below Upper reservoir, underground power house with a long tail race tunnel were also explored on a broad basis. But the arrangement of underground head race system of pressure tunnel up to open shaft type surface power house closer to lower reservoir with relatively short length of tail race tunnels has been found advantageous and has been adopted. On the downstream side of the powerhouse the draft tubes combine to three 8 m diameter 500 m long concrete lined tunnels and three outlet/intake towers in the lower reservoir. One of the two head race conduits will cater for 1200 MW (four units of 300 MW) and the other for 900MW (2 X 300 MW + 2 X 150 MW units). The diameters of components of the water conductor system are therefore different, namely 11 m and 10 m diameter for the headrace tunnels, 9.0

m and 7.8 m diameter for steel lined shafts pressure tunnels reducing to 4.5 m for single unit pressure shafts. Transformers and 400 kV gas insulated switchgear will be located on the ground near the powerhouse. The Project will connect to the grid at MSETCL substation at Kolhapur, Maharashtra (68 km) or PCGL substation at Mapusa, Goa (48km).

The construction period is estimated to be 42 months following a period of 18 months for all pre-construction activities including full feasibility study, design, procurement, financing, licensing and arrangements for utilization of the existing reservoir. About 140.25 ha land is required for the Project. Total cost at present cost level is estimated at Rs. 8374 crores including grid connection, all charges and interest during construction which is equivalent to Rs. 3.98 crores/MW. Annual consumption and injection of energy is estimated to be 5,707 GWh and 4,372 GWh, respectively. Assuming cost of energy for pumping at 3.00 Rs./kWh, the levelised tariff according ro CERC guidelines becomes 7.53 Rs./kWh.

Suggested next steps:

- While Adani Green approaches Govt of Maharashtra and Government of Maharashtra Irrigation Department (GoMID), following shall be highlighted and mutually agreed in the MoU
- The reservoir drawdown, all outage/maintenance of upper reservoir (Patgaon) related equipment impacting water level and contents shall be planned and coordinated with Adani Green
- GoMID/Warana should maintain the current low-level water of 615 m reservoir level in dry season with contents of approx 22 Mm3, (though 16 Mm3 content has been recorded in a few years)
- The quantity of water used for Generation, Pumped water, evaporation losses (lower pond) and water balance will be accounted monthly
- Adani Green can pump approximately 30 Mm3 of west flowing water, presently unutilized, to east (inflow from its own catchment) if the compensation is right. Some of this shall be allowed to be adjusted for evaporation losses and seepage from the lower reservoir
- To avail Construction water from the same lake
- Even if this scheme lies entirely within the state of Maharashtra and there is no consumption per se, intimation shall be given to Riparian states and KWTDA committee

CHAPTER – 2

BACKGROUND INFORMATION

2.1 Introduction

At the 26th UN Climate Change Conference of the Parties (COP26) in Glasgow in November 2021, India announced its intention to achieve 500GW of its installed power generation capacity through non-fossil fuels and 50% of its energy requirement from renewable energy by 2030. As the current capacity of renewable energy is about 100 GW, this means a very ambitious investment in 400 GW of renewable capacity over the next 10 years. Thermal plants will be replaced by wind and solar based generation which offers the lowest cost of new energy. However, their inherent unpredictable and variable output presents a huge challenge for providing sufficient and stable supply of electricity at all times. As long as storage of large quantities of energy in batteries is in its infancy and an extremely expensive option, storage of energy in hydropower reservoirs is the only viable option to convert non-firm renewable energy to firm energy. Pumped storage hydropower, whereby water is pumped by reversible pump turbines from a lower reservoir to an upper reservoir during times of cheap surplus energy and is turbined during times of energy shortage, is a unique and viable solution to overcome the timing and reliability shortcomings of wind and solar energy generation. At present, pumped storage projects present the lowest cost of energy storage, grid management, frequency regulation and renewable energy integration.

The existing Patgaon Reservoir located at village in Bhudargad Taluka of Kolhapur District in Maharashtra offers an excellent opportunity for development of a pumped storage project. The escarpment to the south of the reservoir allows for a head in the order of 400 m over a very short distance between the Patgaon reservoir and a lower reservoir to be created in the valley below the reservoir.

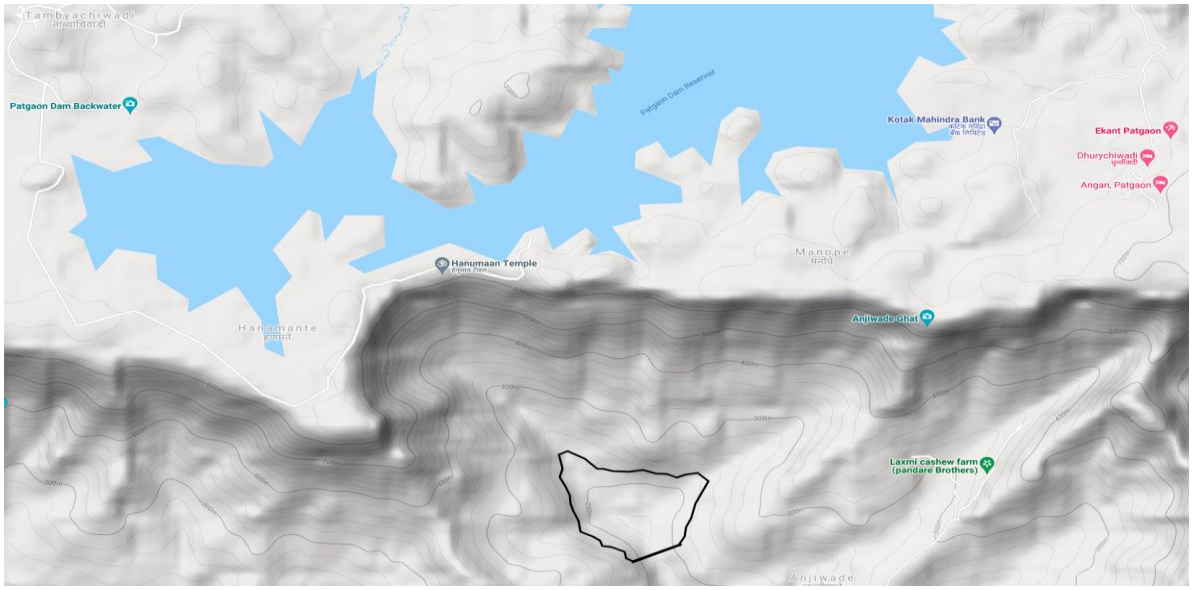


Figure 1: Project Location

Patgaon Reservoir constructed in 2011 with 104.77 Mm3 live storage and 0.47 Mm3 dead storage, currently caters mainly for irrigating the sugar cane fields in the east. The water is stored and released through a 2.5 MW mini hydro power plant for irrigating the crops in the east. It is observed that the residual lowest recorded contents of around 17 Mm3 are normally available in the reservoir in the months of April, May and June before onset of monsoon.

Preliminary estimates indicate an economic storage volume equivalent to about 12.6 GWh. The peak demand in the Indian grid in the foreseeable future extends for about 6 hours. Approximately 12.9 Mm3 will suffice to meet generation of 2,100 MW for 6 hours. Hence the installed generation capacity should be about 2,100MW in order to fully utilize the available storage. The pumping capacity should be sufficient to take advantage of cheap or surplus power. For practical purposes and due to the variability of wind and solar energy, it is recommended to install all seven units as reversible pump turbines.

2.2 JUSTIFICATION OF THE PROJECT:

The intention to increase wind and solar based generation to 500 GW by 2030, and further to become carbon neutral by 2050, is not only an ambitious resource mobilization goal, but also a significant operational challenge in order to provide a safe and reliable supply of electricity. As stated above, wind and solar based energy is weather dependent and therefore variable and unpredictable. Hence, hydropower, gravity and pumped storage, are at present the only alternatives to ensure reliable supply when the sun is down and the wind is not blowing. In addition, hydropower offers spinning reserve capacity which can mitigate sudden load changes and maintain stable voltage and frequency. Several outages with serious consequences have been recorded due to lack of spinning reserve capacity, notably a recent incident on 9th August 2019 in Great Britain* which affected over 1 million customers with knock-on effects for several days. (*Source- GB POWER SYSTEM DISRUPTION – 9 AUGUST 2019 Energy Emergencies Executive Committee: Interim Report from Department of Business, Energy and Industrial strategy)

The energy output in terms of plant factor from solar and wind generation is low as compared to conventional generation plants, typically 25% to 40%. Plant factors of pumped storage projects are also low because of the pumping period and normally a very short generation period. Pumped storage plants also consume more energy than they produce, typically the generation is 75% of consumption. It is therefore estimated that with 50% wind and solar capacity in a power system with a continuous demand of 100 MW will require 345.45 MW renewable capacity (PLF @ 23% for solar & 30% wind) and 100 MW pumped storage capacity (6 hours generation) in order to maintain quality supply.

Given the ambitious renewable goals, there is hence an enormous demand for pumped storage projects. On the above assumptions 500 GW renewable will require 144.7 GW conventional or pumped storage hydropower. The Project is therefore well justified.

Supply Load Balance

Table 2.1 shows the supply balance for the year 2020/21 from Load Balance Report 20-21 of CEA. The country has surplus capacity at 9.1% and surplus energy at 2.7%. For the Western Region the surplus is 5.8% and 3.3%, respectively. Projections for 2026-27 show an increase in peak demand of 73GW for the country and 24 GW for the Western Region as shown in Table 2.2.

The Western Region comprises Goa, Daman and Diu, Gujarat, Madhya Pradesh, Chhattisgarh, Maharashtra,Dadra and Nagar Naveli. The installed capacities and generation mix of the Western States is shown in Table 2.3 and the demand projections for 2026-27 in Table 2.4.

According to CEA's National Electricity Plan of 2018, 42 GW thermal plants will be retired by 2027. Further, 4 GW gas plants are currently idle due to high gas prices. While new clean coal plants of 32 GW capacity are under planning, there is hence an urgent need for additional 14 GW to replace existing capacity in addition to meet the projected demand increase of about 73 GW by 2027.

An updated report of CEA on Load Generation Balance Report 21-22 is available now at File No.CEA-GO-12-31/1/2021-GM Division of CEA. The updated report is on similar lines as 20-21 report.

Table 2.1: India Peak Power and Energy Demand 2020-21

Region	Peak Power (MW)				Energy (MU)			
	Demand	Availability	Surplus(+)/ Deficit (-)		Requirement	Availability	Surplus(+)/ Deficit (-)	
Northern	70,200	74,543	4,343	6.2%	4,21,300	4,41,030	19,730	4.7%
Western	**61,310**	**64,888**	**3,578**	**5.8%**	**4,02,799**	**4,16,164**	**13,364**	**3.3%**
Eastern	26,404	28,501	2,098	7.9%	1,74,925	1,70,464	-4,461	-2.6%
North-Eastern	3,094	3,242	148	4.8%	18,542	19,054	513	2.8%
Total	1,99,348	2,17,507	18,160	9.1%	14,07,527	14,45,085	37,558	2.7%

Source CEA - Load Generation Balance Report 2020-21

Table 2.2: India Peak Load and Energy Demand Projections

Region	Energy Demand (MU)		Peak Demand (MW)	
	2021-22	2026-27	2021-22	2026-27
Northern	4,68,196	6,16,345	73,770	97,182
Western	**4,81,501**	**6,27,624**	**71,020**	**94,825**
Southern	4,20,753	5,50,992	62,975	83,652
Eastern	1,71,228	2,17,468	28,046	35,674
North-Eastern	23,809	34,305	4,499	6,710
A and N Islands	475	632	97	129
Lakshadweep	62	73	11	13
All India	15,66,023	20,47,434	2,25,751	2,98,774

Table 2.3: Western Region Installed Capacity, Peak Power and Energy Demand

State	Thermal	Hydro	Renewables*	Nuclear	Total	Peak Power		Energy	
	(MW)	(MW)	(MW)	(MW)	(MW)	Demand (MW)	Availability (MW)	Requirement (MU)	Availability (MU)
Goa	559.94	2.00	7.83	0.00	595.77	722.00	740.00	4,492.00	4,705.00
Daman and Diu	208.08	0.00	40.55	7.00	255.63	365.00	365.00	2,631.00	2,642.00
Gujarat *	23,359.78	772.00	12,530.96	559.00	37,221.74	19,400.00	19,996.00	116,447.0	120,131.0
Madhya Pradesh	16,787.09	3,223.66	5,205.57	273.00	25,489.32	16,560.00	17,000.00	80,878.00	83,269.00
Chhattisgarh	12,246.89	233.00	573.38	48.00	13,101.27	5,504.00	5,800.00	32,544.00	34,179.00
Maharashtra	**29,876.9**	**3,331.84**	**10,266.8**	**690.00**	**44,165.62**	**24,160.0**	**25,000.0**	**156,648.0**	**162,073.0**
Dadra and Nagar Haveli	494.33	0.00	5.46	9.00	508.79	873.00	874.00	6,851.00	6,854.00
Central-unallocated	2,968.59	0.00	0.00	228.00	3,196.59	0.00	0.00	0.00	0.00
Total	86,501.61	7,562.50	28,630.60	1,840.0	124,534.70	61,310.00	64,888.00	402,799.0	416,164.0

*Classic case of weak grid with high RE penetration and low grid inertia. Source: Energy Emergencies Executive Committee: Interim Report from Department of Business, Energy and Industrial strategy

Table 2.4: Western Region Peak Demand and Energy Projections

Region	Energy Demand (MU)		Peak Demand (MW)	
	2021-22	2026-27	2021-22	2026-27
Goa	5593	6932	858	1096
Gujarat	136159	178693	21429	28387
Chhattisgarh	37840	51088	6208	8518
Madhya Pradesh	99871	125394	15676	19682
Maharashtra	**189983**	**249628**	**28866**	**39828**
Dadra and Nagar Haveli	9343	12373	1291	1798
Daman and Diu	2712	3517	426	553
Eastern Region	**4,81,501**	**6,27,624**	**71020**	**94825**

2.4 Hydrology

The month-on-month contents for the past 11 years have been considered. In all but two years the content has remained > 16 Mm3. Only in two years the upper reservoir was drained for some hydraulic structure maintenance. Hence the Pumped Storage plant will reliably work. There is also frequent overflow from the upper reservoir towards east into Krisha river. The lower pond has a catchment area of 6.9 sq.km and @ 6350 mm rainfall per will have around 30 Mm3 inflow.

Lower Dam catchment, situated on western slopes of Western Ghats, falls under a high rainfall zone with average annual precipitation is around 6300 mm. No records of hour wise rainfall are available to estimate a peak design storm. However, considering the hilly region in the high rainfall zone, a storm of 150 mm in one hour, has been adopted, at this stage of study, as Design Storm. The valley has steep slopes -longitudinal 1 in 5.75 and cross slope 1 in 3. Hence, infiltration rate is low, and time of concentration is also low, resulting in high runoff coefficient and high peak inflow. For the present study with assumed runoff coefficient of 0.9 under saturated condition, a peak flood by a storm of 150 mm/ hour over a catchment of 6.9 sq km, is estimated to be 518 cumecs.

2.5 Installed Capacity

The Patgaon Pumped Storage Project is proposed with a rating of 2,100 MW and with a storage capacity of 12,600 MWh. This Project comprises 6 units of 300 MW each & 2 units of 150 MW each. The installed capacity of a pumped storage scheme is influenced by the requirements of daily peaking power requirements, flexibility in efficient operation of units, storage available in the reservoirs and the area capacity characteristics. The Project will generate 2,100 MW by utilizing a design discharge of 592.72 Cumec and rated head of 404.77 m. The Patgaon PSH will utilize 2,332 MW @ 0.95 pf to pump 12.81 Mm3 of water to the upper reservoir in 7 hours. The Key parameters of Patgaon PSH are as follows:

Sl. No	Parameter	Unit	Value
1	Energy Storage Capacity	MWh	12,600 (6 hrs)
2	Rating	MW	2,100 @ 0.85 pf
3	No. of Units	Nos.	8
4	Rated Net Head in Turbine mode	meter	404.77
5	Total Design Discharge	Cumec	592.72
6	Design Discharge per unit of 300 MW	Cumec	84.67
7	Water Requirement	MCum	12.81
8	Generation Duration	Hrs	6.00
9 a	Generator Capacity – 6 Units	MW	300 MW @0.85 pf (+10% overload)
9 b	Generator capacity - 2 units	MW	150 MW @0.85 pf (+10% overload)
10	Annual Energy Generation @ 95% availability considering transformation loss	MU	4372
11 a	Pump Capacity – 6 Units	MW	334 @ 0.95 pf
11 b	Pump capacity - 2 units	MW	117 @ 0.95 pf
12	Rated Head in Pump mode	meter	416.87
13	Pumping Duration	Hrs.	7
14	Expected Cycle Efficiency	%	75.79

The volume of water required for Pumped turbine operation is 12.81 Mm3 plus evaporation and seepage losses. The anticipated inflow from its own catchment area of around 6.9 sq.km is 30

Mm3. This will be able to compensate for this. Annual energy generation by Patgaon PSH in Turbine mode is 4372 MU, with 95% machine availability, after considering transformation loss

2.6 Power Evacuation

It is proposed to use QMDC 400 kV Transmission Line to connect to the grid at best possible locations mentioned below evacuation of generated Power and for Supply of power during pumping mode.

- 765 kV MSETCL Substation at Kolhapur, Maharashtra (**68 KM)**
- 400 kV PGCL Substation at Mapusa, Goa (**48 KM)**

The twin double circuit lines will be either quad moose or twin moose high ampacity conductors depending on the terrain

2.7 Environmental Aspects

Hydel Projects are categorized as an 'A' Category as per the EIA Notification and will call for a comprehensive Environmental Impact Assessment and appropriate Environment Management Plan. The process as laid down under the EIA notification will be followed by applying for the Terms of Reference (TOR) for the EIA study, by filling in the Form 1 and providing the requisite project details. Based on the TOR the EIA Study will be done, followed by Public Consultation and due process of securing the Environment Clearance. In case there is a requirement of Forest land, the requisite Forest Conservation Act will be complied with. India has an elaborate legal framework with several laws relating to environmental protection, as applicable to Industrial projects. Key national Acts that are created and implemented for the control of polluting the Environment are tabulated below. Based on the project and its specific location, some of these statutes may be applicable or not applicable. Additionally, there could be some additional statutory requirements, based on the project criteria.

This project is proposed in the Western Ghat and already **has an existing upper reservoir**. The use of the existing upper reservoir significantly reduces the amount of land required. Although this project is in the Western Ghats, the location selected is not in any proximity of Sanctuary or national park etc. Please refer to Page 94, which depicts the various notified areas in Maharashtra. The proposed project is marked on this map. Based on this map, the proposed location is located approx 10.3 km away from the nearest WLS (Radhanagari WLS), as depicted on page 90. The project does require land that comes under the Forests and will comply with the Forest Conservation Act. Overall, the siting and environmental impacts of the project will have the least impact on the region and could be a boon to the region with proper planning and implementation

2.8 Construction Planning and Schedule

It is proposed to construct the project within a period of 42 months for construction work and 18 months for pre-construction work. Hence the total construction period will be 5 years. The investigations, DPR preparation and getting clearances will be 18 months. Overall, it will be 60 months to CoD.

2.9 Project Cost Estimate

The capital cost of the project includes all costs associated with investigations, design, construction, and maintenance during the construction period of the project.

For preparation of cost estimates of civil works, the unit costs of labor, materials and equipment necessary to perform the work designated in the various pay-items for the proposed construction are determined based on Schedule of Rates for the year 2020-21 of Maharashtra Irrigation and Water Resources Department and for items for which the rates are not available, the accepted schedule of rates of similar ongoing/recently executed projects adopted. The rates of major items have been worked out by rate analysis. The quantities of Civil Works are estimated based on designs and drawings prepared for various components of the project.

The total project cost works out as given below:

S.NO.	Description of Item	Cost in Crores
1	Cost of Civil Works	3426
2	Land & Infra development	300
3	Cost of Power Plant Electro-Mechanical Equipment including Transmission line	3264
4	Total Hard Cost	6990
5	Interest during Construction	1384
6	Total cost of the Project	**8374**

CHAPTER – 3

PROJECT DESCRIPTION

3.1 SALIENT FEATURES OF THE PROJECT

NAME OF THE PROJECT	Patgaon Pumped Storage Project
Location	
Country	India
State	Maharashtra
District	Sindhudurg District
Village near Powerhouse	Anjivade
Geographical Coordinates	
Patgaon PSH Upper Reservoir (Existing)	
Latitude	16° 6'47.81" N
Longitude	73°55'8.10" E
Lower Reservoir - (Now Proposed)	
Latitude	16° 4'57.98" N
Longitude	73°54'58.76" E
Access To Project Site	
Airport	Sindhudurg Airport, 48 km away
Rail head	Kudal Railway Station, 31 km away
Road	NH66, Vasoli-Anjiwade Rd

Type	Pumped Storage Project
Storage Capacity	12,600 MWh
Rating	2,100 MW
Peak Operation Duration	6 hours

Details of Water Conductor System			
Particular	**Unit**	**Unit 1 to 4**	**Unit 5 to 8**

Installed Capacity	**MW**	1200 MW (4 X 300 MW + 10% overload)	900 MW (2 X 300 + 2X 150 MW + 10% overload)
Rated Discharge	**Cumecs**	338.70 (4X 84.67)	254.02 (3 X84.67)
Discharge at min net head	**Cumecs**	358.79(4*89.70)	269.01(3*89.70)
Upper Reservoir (combined for 8 Units)			
FRL	**EL – m**	626.6	626.6
MDDL	**EL – m**	615.0	615.0
Gross Storage up to FRL	**Mm3**	105.26	105.26
Gross Storage up to MDDL	**Mm3**	15.0	15.0
Live Storage	**Mm3**	90.26	90.26
Approach Channel to HRT (Combined for 8 Units)			
Length	**M**	50	50
Width	**M**	70	70
Crest Level at start	**M**	605	605
Bed Level near Intake	**M**	598	598
Head Race Tunnel (combined for 8 Units)			
Type		**Circular Concrete Lined**	**Circular Concrete Lined**
Diameter	**M**	1 * 11	1 * 10
Length from Intake to Surge haft	**M**	230	230
Rated Velocity of Flow	**m/sec**	3.57	3.24

Max velocity of flow	**m/sec**	3.78	3.43
Bed Gradient		1 in 300	1 in 300
Starting level at Intake	**M**	585	585
Intake Type		**Morning Glory Vertical shaft Intake**	**Morning Glory Vertical shaft Intake**
Bell mouth Lip Level	**EL – m**	605	605
Bell mouth Diameter	**M**	13	11
Trash Rack Operating Platform level	**EL – m**	628	628
Surge Shaft	**Open well type simple surge shaft 17 m diameter & 21 m diameter**		
Combined for		**Units 1-4**	**Units 5-8**
Total Height	**M**	62	62
Diameter EL 582m to EL 630 m	**M**	18	16
Diameter EL630 m to EL 650 m	**M**	21	19
Pressure Shaft			
Combined for		**Units 1-4**	**Units 5-8**
Diameter	**M**	9.0	7.8
Velocity of Flow	**m/sec**	5.37	5.34
Diameter wise Lengths	**M**		
9 m diameter for 4 units / 7.8 m for rest 4 units		1 * 265 m	1 * 318 m
6. 4 m diameter		2 * 137 m	-

4.5 m diameter /3.4 m		4 * 1115 m	4.5 m - 2*1163 m +1*1138 m , 3.4 m – 2 *25 m
Total length		1517 m	1,481 m
Tail Race Tunnel from Collection Gallery to Lower Reservoir		**Combined for 8 Units**	
Number		3 Number (Combined for 8 Units)	
Length of each tunnel	**M**	500	
Diameter of each tunnel	**M**	8	
Pumping Intakes	**M**	Morning Glory Vertical shaft Intake	
Setting of Intake Lip	**M**	8.5 m below MDDL	
Diameter of Bell mouth of Intake	**M**	10.4	
Lower Reservoir (combined for 8 units)			
Location		On a natural stream near village Anjiwade	
Catchment area	**Sq km**	6.9	
Average Annual Runoff	**Mm3**	Approx 30 Mm3	
FRL	**EL – m**	225	
MDDL	**EL –m**	185.5	
Gross Storage	**M**	13.75	
Dead Storage	**M**	0.85	
Live Storage	**M**	12.9	
Height of dam above riverbed level	**M**	57.5	
Length of dam	**M**	500	
Type of Dam		Concrete / Colgrout masonry	

Powerhouse	
Type	Well type surface PH
Centre line of Unit	130.0 m EL
Dimensions (Excluding Service Bay)	Two circular shafts of 26 m diameter *90 m (H), (for access, power evacuation, ventilation, drainage & dewatering pump discharge), leading directly to service bays n both sides of the cavern type PH 184m (L) * 35.5 m (W) * 52 m (H)Turbine deck height
Size of Service Bay	40 m (L) * 26 m(W)
Service bay level	140 m

Rated Head - Upper Reservoir	**EL**	622.772		
Rated Head - Lower reservoir	**EL**	211.00		
		Rated	Max	Min
Gross Head	**m**	411.77	441.1	390.0
Discharge Q m3/sec 4 m/c		338.70	314.12	357.87
Discharge Q m3/sec 3 m/c		254	236.68	268.4
Head Loss (G)	**m**	7.0	6.1	7.9
Net head	**m**	404.77	435	382.1
Max / Min Head				1.13
Head Loss (Pumping)	**m**	5.1	4.7	5.7
Rated net head (Pumping)	**m**	416.87	445.8	395.70

Electromechanical Equipment		
Pump Turbine		
Type	Vertical Reversible Francis Turbine (6) & Variable speed (2)	
Installed Capacity	**MW**	2100
Installed Capacity per unit (G)	**MW**	6 X 300 MW + 2X150 MW (+10% overload)
Number of unit	**Nos.**	8

Upper Reservoir		
Full Reservoir Level (FRL)	**EL - Meter**	626.6
Minimum Draw Down Level (MDDL)	**EL - Meter**	615
Lower Reservoir		
Full Reservoir Level (FRL)	**EL - Meter**	225
Minimum Draw Down Level (MDDL)	**EL - Meter**	185.5
Water Conductor Losses		
Total Losses in water conductor system (Generation Mode)	**Meter**	7
Total Losses in water conductor system (Pumping Mode)	**Meter**	5.1
Turbine Characteristics		
Rated Turbine Head	**Meter**	404.77
Rated Pump Head	**Meter**	416.87
Rated Speed	**RPM**	300
Rated Discharge (Turbine)	**m3/sec**	84.68
Rated Discharge (Pump)	**m3/sec**	72.66
Centerline of Pump Turbine	**EL - Meter**	130 m
Generator-Motor		
Type	3 phase AC Synchronous Generator – Motor, Semi Umbrella Type	
Rated Capacity	**MVA**	6 * 353 / 2 * 177
Generator-Capacity	**MW**	6 * 300 @ 0.85 pf / 2 * 150 @ 0.85 pf (+10% overload)
Motor Capacity	**MW**	6 * 334 @ 0.95 pf / 2 * 117 @ 0.85 pf
Rated Voltage	**kV**	18
Power Factor Generator		0.85

Power Factor Motor		0.95
No. of Poles		20
Rated Speed	**rev/min**	300
Turbine center	**EL - Meter**	130
Main Transformer		
Type	Outdoor, oil immersed, 3 phase transformers with OLTC	
Numbers	**Nos.**	8
Rated Capacity	**MVA**	6 * 400 +2* 200
Rated Voltage	**kV**	18 kV/ 400 kV
Connection		LV Delta / HV Star
Power House Dimensions		
Power House size (Max. Dim.	**Meter**	Two well shaft entries directly on to Service bays of a cavern TG deck. 184m (L) * 35.5 m (W) * 90 m (H)
Erection Bay length	**Meter**	40 m on both sides
Transformer Hall Dimensions	Outdoor	
EOT Crane from ground level to service bay		
Number of Unit	**Nos.**	2
Crane Capacity	**Ton**	TBD later
400 kV GIS		
Configuration	**Bus section 1**	Twin bus with bus coupler, 4 incomer bays for machines and 2 outgoing lines
Incoming power 2500 MW/ 2750 MVA	**Bus section 2**	Twin bus with bus coupler, 43 incomer bays for machines, 2 Bus reactor and 2 outgoing lines

63 kA 3 sec capacity	**Bus section bays**	2

POWER EVACUATION	
Voltage Level (kV)	400 kV
No. of Transmission Lines	2 * double circuit Quad Moose or 2* double circuit 2* High ampacity conductors
Total Length	QMDC 400 kV Transmission Line to connect to the grid at best possible locations mentioned below evacuation of generated Power and for Supply of power during pumping mode. ● 765 kV MSETCL Substation at Kolhapur, Maharashtra (68 KM) ● 400 kV PGCL Substation at Mapusa, Goa (48 KM)

3.2 HYDROLOGY and POWER POTENTIAL STUDIES

The month-on-month contents for the past 11 years have been tabulated in Annexure 2. In all but two years the content has remained > 16 Mm3. Only in two years the upper reservoir was drained for some hydraulic structure maintenance. Hence the Pumped Storage plant will reliably work. There is also frequent overflow from the upper reservoir towards east into Krisha river. The lower pond has a catchment area of 6.9 sq.km and @ 6350 mm rainfall per will have around 30 Mm3 inflow.

Lower Dam catchment, situated on western slopes of Western Ghats, falls under a high rainfall zone with average annual precipitation is around 6300 mm. No records of hour wise rainfall are available to estimate a peak design storm. However, considering the hilly region in the high rainfall zone, a storm of 150 mm in one hour, has been adopted, at this stage of study, as Design Storm. The valley has steep slopes -longitudinal 1 in 5.75 and cross slope 1 in 3. Hence, infiltration rate is low, and time of concentration is also low, resulting in high runoff coefficient and high peak inflow. For the present study with assumed runoff coefficient of 0.9 under saturated condition, a peak flood by a storm of 150 mm/ hour over a catchment of 6.9 sq km, is estimated to be 518 cumecs.

The Key parameters of proposed Patgaon PSH Upper Reservoir (existing) are as follows:

Sl. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	EL - M	626.6
2	Minimum Draw Down Level (MDDL)	EL - M	615

3	Revised Live Storage	Mm3	(104.79 - 16) = 88.79
4	Dead Storage	Mm3	(16+0.47) = 16.47
5	Gross Storage	Mm3	105.26

The Key parameters of the proposed Patgaon PSH lower reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	EL - Meter	225
2	Minimum Draw Down Level (MDDL)	EL - Meter	185.5
3	Live Storage	Mm3	12.9
4	Dead Storage	Mm3	0.85
5	Gross Storage	Mm3	13.75
6	Maximum Height of Concrete/Colgrout masonry dam	M	57.5

3.2.1 Discharge Series

Based on the storage capacity of the proposed lower reservoir, power potential study was carried out to assess the installed capacity. The Patgaon PSH is envisaged to utilize 12.81 Mm3 of water for power generation and will get stored in the reservoir through seasonal flow of water in the tributary /nala whenever it is available. The project is a pumped storage scheme and hence, no consumptive utilization of water is required for its operation.

3.2.2 Operation of Patgaon Pumped Storage Project

The Patgaon PSH is proposed with a Storage Capacity of 12,600 MWh with Rating of 2,100 MW. This project consists of 6 units of 300 MW each & 2 units of 150 MW each. The Project will generate 2,100 MW by utilizing a design discharge of 592.69 Cumec and rated head of 404m. The Patgaon PSH will utilize 2,338 MW to pump 12.81 Mm3 of water to the upper reservoir in 7 hours. The generation simulation is enclosed in **Annexure III.**

3.2.3 Interstate River water treaties:

KRISHNA WATER DISPUTES TRIBUNAL AWARD (PATGAON PSH and KWTDA). East flowing **Krishna River**, which is a major river in Southern part of India rises at Mahabaleshwar in Maharashtra State and traverses through the States of Karnataka, Andhra and Telangana before joining the Bay of Bengal. Along its 1400 Km route, several small tributaries join it. All the 4 states largely depend on Krishna River water for their Irrigation, Hydro Power, Drinking Water supply, Industries and all such essential

requirements. Hence there had been instances of disputes among stakeholders for increased share in water distribution.

In 1969 a Tribunal was established by Govt of India to resolve the Water sharing Disputes and it was named as **KRISHNA WATER DISPUTES TRIBUNAL** (KWDT). After detailed studies, deliberations and hearings with stakeholders, the Tribunal gave an **Award** which is referred to as KWDTA**.**

In the first Award declared in 1976, water share of 3 States (Telangana was a part of Andhra State at that time, hence not included) was fixed as Maharashtra --560 TMC, Karnataka-- 700 TMC and Andhra-- 800 TMC.

Subsequently, another meeting of the Tribunal was held to review the ground realities and to resolve new disputes. In 2010, KWDT declared an award for surplus flows with revised additional water share as 81 TMC for Maharashtra, 177 TMC for Karnataka and 190 for Andhra.

In the following years, despite Interstate Water Disputes, all the four States have been adhering to the stipulated water share as awarded by the Tribunal. In the State of Maharashtra, Irrigation Deptt is the sole Authority to further allot, distribute water and monitor correct utilization of the awarded share of water for different requirements.

As per the Award, the State will not allow water utilization or diversion outside Krishna Basin and shall maintain and monitor systematic record of water utilization. Since the runoff and annual rainfall cannot be correctly ascertained in advance, reservoirs have to retain some quantity of water for emergencies arising out of delayed monsoon. Moreover, it is practically impossible to store and fully utilize the allotted quota behind the dam in the same ‘water year.’

To overcome this issue, KWDT has further stipulated that States shall ensure that total average Water Consumption in any rolling period of consecutive 5 years shall not exceed the allotted quota.

KWDTA Limitations and Patgaon PSH

Patgaon reservoir was completed in the year 1998 by harnessing inflow of Vedganga River which is a tributary of East flowing Krishna river. This reservoir is located on the Western Ghat Plateau very close to the ridge line. Proposed New Powerhouse and the lower Reservoir required for Patgaon PSP are located on the west side at about 1.5 Km from the rim of the upper reservoir. Tail race discharge from the new Powerhouse shall be fully stored in the Lower reservoir and during off peak period shall be pumped back to the upper reservoir. Capacity of the lower reservoir and that of Powerhouse Units have

been so designed that no extra water shall be required to run the Powerhouse for peak power demand. Lower reservoir has its own catchment of 6.9 Sq Km and the runoff drains into west flowing Karli River which finally joins the Arabian sea in a few km distance.

Clause X of KWTDA

1. The State of Maharashtra shall not out of the water allocated to it divert or permit the diversion of more than 67.5 T.M.C. of water outside the Krishna River basin in any water year from the river supplies in the Upper Krishna (K-I) sub-basin for the Koyna Hydel Project or any other project. Provided that the State of Maharashtra will be at liberty to divert outside the Krishna river basin for the Koyna Hydel Project water to the extent of 97 T. M. C. annually during the period of 10 years commencing on the 1st June, 1974 and water to the extent of 87 T.M.C. annually during the next period of 5 years commencing on the 1st June, 1984 and water to the extent of 78 T.M.C. annually during the next succeeding period of 5 years commencing on the 1st June, 1989
2. The State of Maharashtra shall not out of the water allocated to it divert or permit diversion outside the Krishna River basin from the river supplies in the Upper Bhima (K- 5) sub-basin for the Projects collectively known as the Tata Hydel Works or any other project of more than 54.5 T.M.C. annually in any one water year and more than 213
3. T.M.C. in any period of five consecutive water years commencing on the 1st of June 1974
4. Except to the extent mentioned above, the State of Maharashtra shall not divert or permit diversion of any water out of the Krishna River basin

It is very likely that Irrigation Deptt may levy charges for the quantum of water required for the first time Generation with Tail Pond empty condition.

Since the project is entirely in Maharashtra and does not consume water except some seepage and evaporation losses, only information to the stakeholders is adequate. Before commencing the work of Lower reservoir, statutory permission from Irrigation Deptt needs to be sought. Since the max. The height of the lower dam is more than 50 m, designs of the dam need to be ratified by the Central Designs Organization, Nasik.

3.3 DESIGN FEATURES OF MAJOR COMPONENTS

3.3.1 Introduction

The Patgaon Pumped Storage envisages construction of lower reservoir near Anjivade village in Sindhudurg district and use the existing patgaon lake as upper reservoir in Bhudargad Taluka, Kolhapur district.

The scheme will involve using the existing patgaon lake as upper reservoir with 105 Mm3 as gross capacity. The lower reservoir in this project envisages construction of Concrete/ Colgrout masonry dam with the maximum height of 57.5 m for short reach for creation of lower reservoir of 13.75 Mm3 gross capacity. The Patgaon PSH is proposed in between two reservoirs i.e. Patgaon lake (existing) and Patgaon PSH Lower (to be constructed newly) and the required quantum of water for power generation will get stored in the reservoir through seasonal flow of water in the tributary /nala whenever it is available. Water will be let out from the Patgaon PSH upper reservoir through Power Intake, then a 50 m long approach channel where after through a system of HeadRace Tunnels, a 11 m diameter concrete lined tunnel for Units 1 to 4 and a 10 m diameter tunnel for units 5 to 8, each 230 m long. Each HRT will terminate into its own surge shaft. General Layout of the proposed scheme is enclosed in the **drawing no. 002**. Water conductor tunnel, further downstream of the surge shaft, will steeply slope down to meet the Powerhouse. This portion between the surge shaft and powerhouse will be subjected to higher water heads and is therefore called the Pressure Shaft (PS). Because of high internal water pressures, this tunnel will be steel plate lined with concrete backfill behind. Pressure shaft 1, for the four units will be of 9.0 m diameter and the other pressure shaft for the remaining three units will be of 7.8 m diameter. Velocity of flow in pressure shafts, corresponding to full load generation will be 5.4 m/sec which is well within normal range in practice. Optimization of Pressure shaft diameters will be done at Feasibility/DPR stage when Tariff for pumping energy and for generation will be known.

3.3.2 Alternative Studies

The site selection process of PHS is based on following approaches:

1. Based on proximity to Wildlife Sanctuary / Tiger reserve, potential R & R issues, Geology, interstate issues, EIA, Head, low variation in net head, Water conductor system length vs head, hydrology, constructability & approach available, a broader area for project is identified
2. Possible locations and alternative locations of Reservoirs and powerhouse are identified in the proposed area and their suitability is examined with respect to technical parameters

3.3.2.1 Alternatives for the lower reservoir:

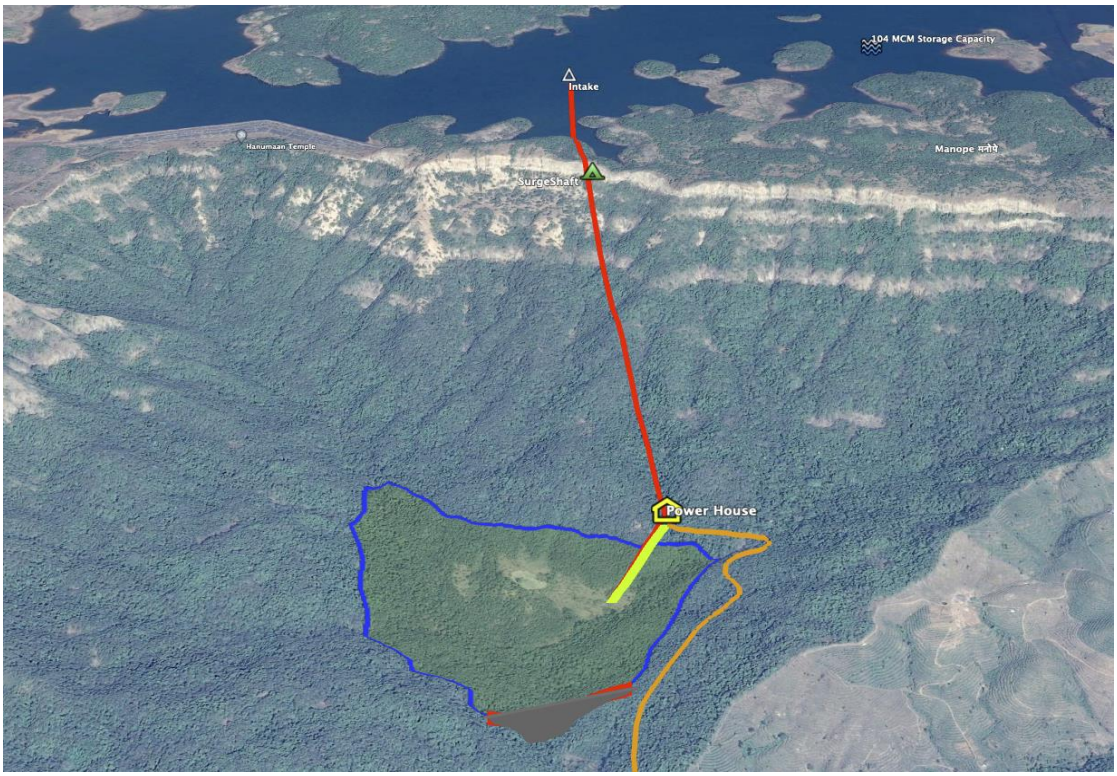
The Topography of the proposed area of Lower reservoir depicts small depressions around the hill area showing possibility of creation of reservoir at two locations.

Alternative 1: Upstream of Bhat – Gawasalwadi village

Topographically, the site - 1 is in flat / gradually sloping land which is found suitable and allows to create the desired live storage capacity with a higher head of about 30 meters. But this location is ruled out due to,

1. Proximity of the Gawasalwadi village
2. Relatively high R & R (70-80 houses and lots of farm lands) created due to submergence
3. Disastrous impact in case of dam break. Close to 150 houses very close to lower dam

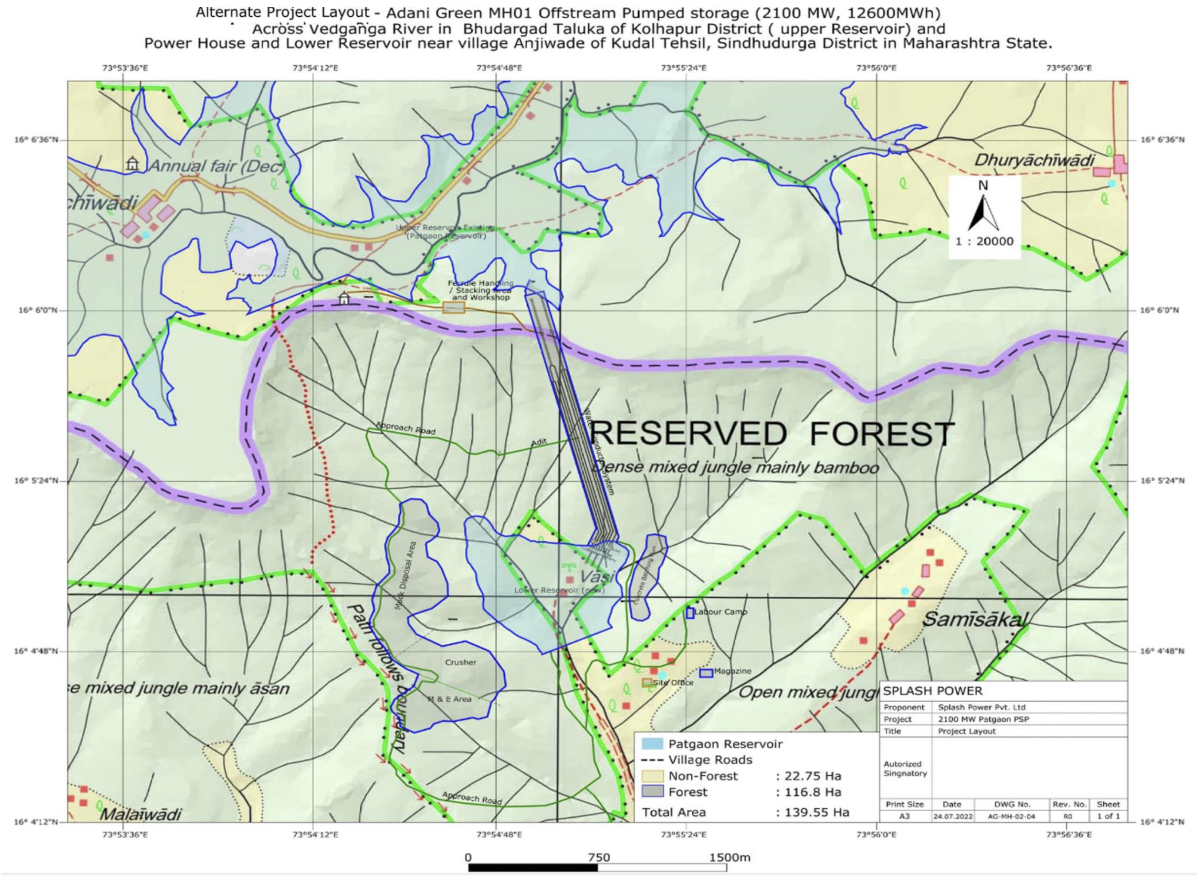
Alternative 2: South of Patgaon Reservoir



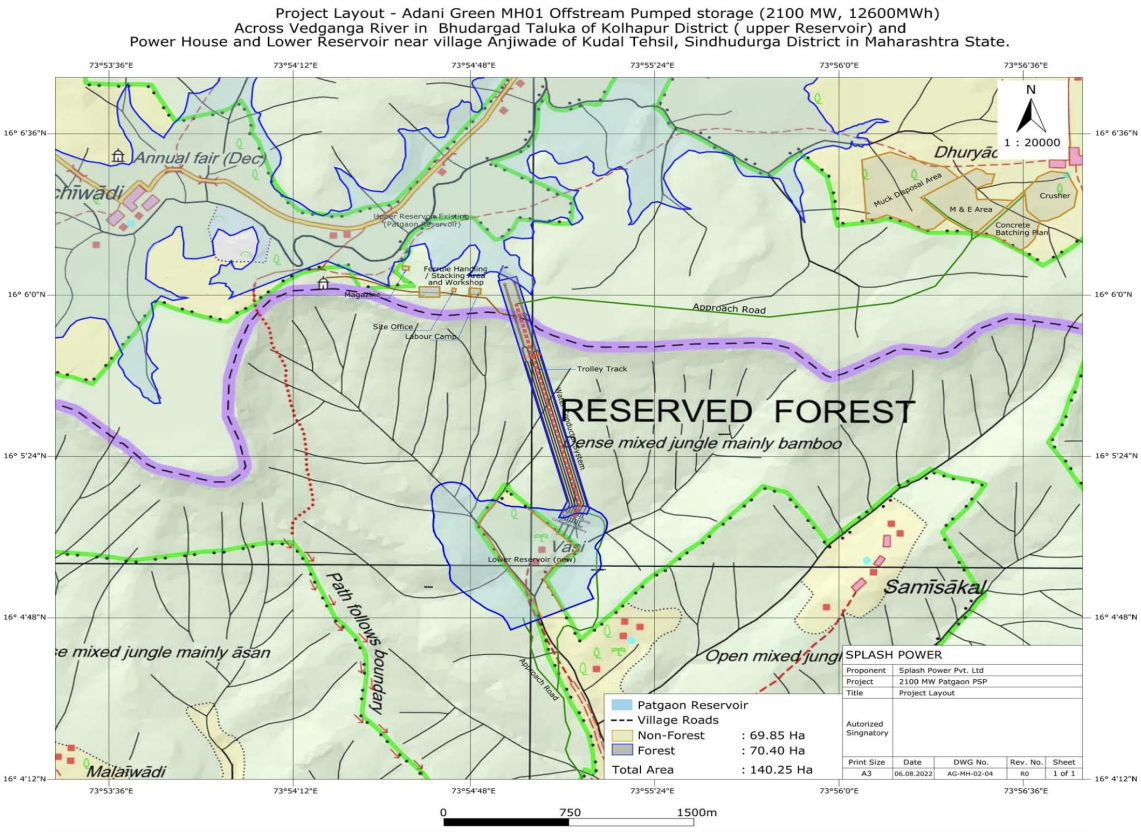
The land in the proposed Site - 2 is partly in forest land (non forest area is about 21 Ha) wherein vegetation density is fairly high. The proposed area is geologically competent. After detailed testing if any abnormalities are found that portion will be covered by geotextile membrane to prevent water seepage. Since the site is compact it is selected for a lower reservoir for further development of the project. The quantity of water required to meet sediment volume and seepage are met from the dead storage of this lower reservoir. The evaporation is met by the west flowing water (to the tune of 30 MCM). Pumped to the upper reservoir if required. Hence this is the most optimal option.

3.3.2.2 Infrastructure layout wrt Lower Reservoir on South of Patgaon Reservoir:

Alternative 1: Infrastructure needed to facilitate construction like area for crusher, concrete batching plant, muck disposal, site office, magazine, labour camp, E & M store, etc will be kept closer to the permanent structures of WCS, PH & Lower reservoir in the forest area, to reduce the transportation and construction time. There will an approach road & interconnecting all facilities. Most of these areas will be in forest area needing dense vegetation to be cleared. The total land requirement in this alternative is about 139.55 ha; out of which 116.8 ha is forest land and 22.75 ha.



Alternative 2 (Selected layout): Infrastructure needed to facilitate construction like area for crusher, concrete batching plant, muck disposal, site office, magazine, labour camp, E & M store, etc will be kept away from forest area and moved to non-forest area. Only the permanent structures of WCS, PH & Lower reservoir will be in the forest area. This will avoid destruction of forest to a great extent. The trolly system planned on the right of way of the water conductor system and strategically located access shafts will be used to transport men and material and in removal of muck. Only one access road to power house and lower reservoir dam will be there. The total land requirement in this alternative is about 140.25 ha; out of which 70.4 ha is forest land and 69.85 ha, hence this alternative is selected to avoid destruction of forest area.



The lower reservoir on the southern side and to avoid damage to forest area, non site specific activities like construction facilities area, crusher plants, batching plants, muck disposal sites, labor camps etc proposed in non-forest area.

The transportation of muck and finished penstock spools will be through trolleys, traversing in the same but reduced right of way of the Water conductor system over the mountain surface. To optimize the forest land with minimal impact, Alternative 2 is selected.

3.3.2.3 Powerhouse Layout:

Alternative - 1: Layout with cavern Powerhouse and other components of this scheme are Upper reservoir, Intake structure, Penstock / Pressure Shaft, Cavern powerhouse, Tail Race Tunnel, Tail Race Outlet, Tail Race Channel and Lower reservoir. The underground powerhouse requires Adits viz., Main Access Tunnel to Powerhouse service bay and Transformer Hall, Adit to Powerhouse cavern top, Adit to Transformer cavern top, Bus duct tunnels etc. Most of the components of this alternative are underground except for reservoirs, intake and outfall structure.

Considering the works involved as mentioned above, the investigation time and completion of DPR for this alternative will take about 18 months. The total physical construction time for the project is estimated to be around 42 months after completion of DPR. Further the cost of the project will be higher because of most of the components being underground. The construction duration and the cost of the scheme is very important which will impact the overall financial viability of the project adversely.

Alternative -2: Layout with underground Powerhouse accessible with two access shafts directly leading to two service bays. These will also carry power cables, ventilation ducts, lifts, emergency staircase, drainage & dewatering outlet, etc. The shaft and cavern powerhouse involves minimum excavation because the main access tunnel and other tunnels are not there.

Investigation time and preparation of DPR will also take about 18 months and construction time for completion of this alternative is estimated to be around 42 months excluding pre-construction works. The advantage of this scheme is the risks will be less due to less underground activities. Considering the risks and the cost overrun in comparison to alternative 1, this option is chosen.

3.2.2.4 Upper reservoir Intake:

Alternative 1:

Upper reservoir has two design MDDLs, one for Irrigation outlet which is EL 597.7 and other for Power outlet which is 609.35 m. Daily cycling of water up and down (Pumping and Generation) will be 12.81 Mm3. Hence, the upper reservoir should always have a storage capacity of minimum 12.9 Mm3 which is not available with current Irrigation MDDL. It is merely 0.47 Mm3. However, as seen from Lake operation data of previous years, the lake does not get depleted below 15 Mm3 that is below EL 615m, except only on one occasion, when the lake was emptied for major repairs. Hence, the requirement of a Pumping station will be always met, if we go by historical data.

Alternative 2:

There is another alternative possible if the above requirement cannot be ensured. A high-level Pond of requisite capacity will be created at higher level ground near and above FRL within the reservoir by constructing a peripheral bund and such suitable location is available. This pond will serve as Upper reservoir and operation of Irrigation reservoir will have no impact on this pond.

For the present PFR study, Option 1, that is an existing reservoir to serve as an upper pond with no modifications in the existing reservoir and MDDL 615.0 m, has been adopted, since the in-principle approval has been given by the Government of Maharashtra after scrutinizing.

The WCS & Lower reservoirs are situated south of Patgaon reservoir on west side of the ridge. The following aspects have been considered for formulation of alternative layouts:

1. Topography of the area and other factors like location, length of water conductor system etc.
2. Potential R & R issues
3. Reduce & Reuse waste
4. Utilization of available head at project site and to the maximum extent feasible
5. Development of economical and optimized layout
6. Ease of Construction
7. Minimal area of land acquisition to accommodate various project components

Selected Layout:

The lower reservoir is finalized on the southern side, the powerhouse is Shaft / well type powerhouse, the intake is directly into the existing Patgaon reservoir with revised MDDL and the infrastructure facilities needed to facilitate construction proposed on non-forest land. The transportation of muck and finished penstock spools will be through trolleys, traversing in the same but reduced right of way of the Water conductor system over the mountain surface.

3.3.3 WATER CONDUCTOR SYSTEM

Existing Patgaon dam reservoir will serve as an Upper Reservoir for the proposed Pumped Storage Scheme. Hence, two Head Race Tunnels (HRT) will take off from this upper reservoir (11m diameter & 10 m diameter). To draw a full load generation discharge of 600 cumecs for the 8 TG units, it is proposed to provide, an approach channel 50 m long and 70 m wide, between upper reservoir and intake, two unlined 11 m diameter & 10 m diameter

HRTs between intake and surge shaft, 230 m long will be there. From the surge shaft, one 9m diameter catering to 4 units and the other of 7.8 m diameter catering to the remaining 4 units. The Head race tunnels are relatively low-pressure tunnels with maximum water head of around 60 m and hence will be only concrete lined. Please refer Schematic layout of the Water Conductor System (Ref drawing number 7). Velocity of flow in a concrete tunnel under full load generation will be less than 4.0 m /sec within acceptable limits for a concrete lined tunnel. Optimization of the diameters will be done at Feasibility / DPR stage when tariff for Pumping Energy and for Generation will be known.

- Upper reservoir has two design MDDLs, one for Irrigation outlet which is EL 597.7 and other for Power outlet which is 609.35 m. Daily cycling of water up and down (Pumping and Generation) will be 12.81 Mm3. Hence, the upper reservoir should always have a storage capacity of minimum 12.9 Mm3 which is not available with current Irrigation MDDL. It is merely 0.47 Mm3. However, as seen from Lake operation data of previous years, the lake does not get depleted below 15 Mm3 that is below EL 615m, except only on one occasion, when the lake was emptied for major repairs. Hence, the requirement of a Pumping station will be always met, if we go by historical data.
- Necessary provision of scouring sluice at Upper and at Lower reservoir will also be made, as is the normal practice.It is suggested, to take care of bed load material, carried by the stream during high flows, we construct an overflow weir of small height 3m- 4m across the stream, as a check dam, which will arrest the bed load material and prevent its entry into the active storage of the lower reservoir. The check dam can be dredged every year in summer season when the stream will go dry and keep it ready for the next year to receive and trap bed load material.

- **INTAKE STRUCTURE**

Intake structure of the head race tunnel will have to be set sufficiently below MDDL of upper reservoir to avoid entry of air and vortex formation, during generation mode, even when the reservoir is at its lowest operating level. Two types of Intakes were considered: horizontal intake and vertical shaft type intake. As per the hydraulic design requirements, setting of horizontal intake works out to 20 m below MDDL level whereas that of Vertical shaft type, 10 m below MDDL. It is proposed to adopt Vertical shaft type intake to minimize excavation in riverbed for approach channel and setting will be with reference to MMDL 615 m instead of 597.70 m. This will simplify construction of Intake without too deep underwater excavation for the approach channel. Schematic arrangement of 11 m diameter tunnel intake is shown in drawing PATGAON-PSH-007

The lip of Bell mouth intake, by hydraulic requirement, cannot be higher than EL 605 m. An approach channel will be excavated in the reservoir to carry water to the intake structure The

channel, sloping down to intake level 603.0 m, will have to be around 70 m wide to accommodate two intakes and to satisfy minimum side clearances for the two intakes from hydraulic consideration. Length of approach channel will depend upon actual bed level contours, but is expected to be not more than 50 m. Also, we have to ensure that, meeting of the approach channel with the reservoir bed is not higher than EL 611 m, to ensure adequate depth of flow (4 m) at MDDL condition over channel crest to feed required water to intake through approach channel. With 70 m width, the four m depth on the crest is more than adequate for full load supply at MDDL situations. The intake will be at the edge of the reservoir abetting the hill.

The intake will be bell mouth shaped with an entry diameter of 13 m; trash rack panels will be set around the 20 m diameter periphery of Bellmouth deck slab and will be operated from a supporting structure platform set above MWL of reservoir. Closure Gate for the tunnel will be in the form of a drum sitting on the tunnel mouth or in the form of a vertical lift gate and operated from the trash rack operating platform. The tunnel, considering its large diameter, will be 500 mm thick RCC lined and grouted with contact and consolidation grouting.

HRT C/L will be EL 585 m at intake and considering adequate rock cover requirement over the tunnel, the tunnel will extend towards PH direction up a distance of 230m. This will end at the point where the rock surface is at EL 620 m, where the pressure shaft will start. Length of HRT will be 230 m from intake to surge shaft and will have a longitudinal bed slope of 1 in 300 to facilitate emptying of the tunnel for inspection and repairs.

- **SURGE SHAFT**

Open well type simple surge shaft is proposed at the end of HRT where after steel lined pressure shaft will start. The shaft will be for its major portion of height below the ground and will be located where Ground level is around EL 635 m. Water level in the surge shaft, even under MDDL condition, will remain filled up to a 30 m depth and hence, surge shaft diameter in the lower portion which decides down surge levels can be of smaller diameter compared to upper portion which comes into picture during upsurge. Preliminary hydraulic calculations indicate, that the shaft diameter from tunnel level to EL 630 m , that is a level close to reservoir MWL, a 17 m diameter shaft will be adequate for the 10 m diameter HRT, whereas a larger 21 m diameter shaft will be required in upper portion from EL 630 to EL 650 m to contain the maximum upsurge even with 10 % overload generation and reservoir full condition. It will be possible to further optimize the shaft diameters by adopting a restricted orifice type or a differential surge tank. These fine detailed studies will be carried out in the DPR stage.

- **PRESSURE SHAFT**

Water conductor tunnel, further downstream of the surge shaft, will steeply slope down to meet the Powerhouse. This portion between the surge shaft and powerhouse will be subjected to higher water heads and is therefore called the Pressure Shaft (PS). Because of high internal water pressures, this tunnel will be steel plate lined with concrete backfill behind. Pressure shaft 1, for the four units will be of 9.0 m diameter and the other pressure shaft for the remaining three units will be of 7.8 m diameter. Velocity of flow in pressure shafts, corresponding to full load generation will be 5.4 m/sec which is well within normal range in practice. Optimization of Pressure shaft diameters will be done at Feasibility/ DPR stage when Tariff for pumping energy and for generation will be known.

Preliminary calculations indicate that the PS diameters being large, only up to 200 m water head, high tensile strength steel plate lining can be managed with steel plates up to 80 mm thick. Beyond that, it becomes unmanageable and Pressure shafts will have to branch out into 6.4 m diameter for two units up to 310 m water head and beyond that 4.5 m diameter individual pressure shafts, separately for each unit. Even with that also required plate thickness works out to 80 mm near the powerhouse where the head will be around 445 m. In view of above, the pressure shaft profile shall be so planned so that maximum possible length, without allowing negative pressures to develop, will be below 200 m water head and then after branching, individual pressure conduits will slope down to meet the power house. This detailed planning can be done in the DPR stage. Diameter wise tentative lengths for water head criteria mentioned above work out and marked on the L sectional profile are as below:

3.3.4 POWERHOUSE

Powerhouse to accommodate 6 TG Units of 300 MW & 2 of 150 MW, will be a "Well shaft entry cavern type" Powerhouse. There will be two shafts for transporting material , lifts, emergency staircases, ventilation shafts, cable raceways, etc. There will be a large underground cavern for Machine Hall, for Draft Tube gate operation gallery, etc with separate cranes for handling from service bays.

Draft tube discharge from the 8 TG units will flow into a common collection gallery and each draft tube will be provided with a stop log gate at its exit end in the collection gallery to isolate the unit for maintenance and repairs. Three Tailrace Tunnels, each of 8 m diameter and about 500 m long will carry the water from the collection gallery down to Lower Reservoir During Generation mode. The same tunnels will act as suction conduits during pumping mode. Hydraulic calculations indicate that setting of the vertical bellmouth intakes on the tunnels at exit end will have to be set at least 8.5 m below MDDL and 30 m apart of Lower Reservoir to avoid air entry and vortex formation during pumping mode.

3.3.5 LOWER RESERVOIR

Lower Reservoir will be created by constructing a dam on a natural stream near village Anjiwade, as shown in the Location Map (Lat 16 ^{0} 50 ' N, Long 77 ^{0} 55 ' E). A 2 km long approach road will be required to be constructed to reach the dam site. The valley is very steep rising through a height of 460 m just in a 2.8 km length, thus offering a drop of more than 400 m requiring relatively short length of water conductor system from Upper Reservoir and is, therefore, ideally suited for a lower reservoir for a Pumped Storage Scheme (PSS).

For a 2100 MW generation for a 6-hour daily operation, required net live storage is 12.9 Mm3. If we provide additional storage capacity to account for Evaporation loss and Seepage loss from lower reservoirs during the eight-month post-monsoon period, the total required live storage will be 15 Mm3. The stream, which has a catchment of 6.9 km2, will have an average annual runoff of more than 30 Mm3 and therefore can easily cater to this additional requirement. Also, it will provide necessary water for initial filling of the reservoir in the first year of operation. If, post monsoon period losses are taken care of by lower reservoirs, it will ensure that the present Utilization pattern of Upper Reservoir for Irrigation and Power generation, will not be affected at all. Also, since annual runoff at lower reservoirs from its own catchment is multiple times the Evaporation and Seepage losses, the Owners can earn revenue, in low rainfall years, by pumping extra water into Upper Reservoir to meet their deficit, if cost economics permits.

Elevation wise capacity of lower reservoir, estimated based on Google Map contours, is presented in Table 3.1.

TABLE 3.1

Lower Reservoir Capacity			
EL	**Incremental**	**Cumulative**	**Remarks**
	Volume	**Volume**	
m	Thousand m3	Thousand m3	
164.27	0	0	
169.27	1.42	1.42	
174.27	40.02	41.44	
176.6		136.40	NZL

179.27	203.78	245.22	
184.27	442.64	687.86	
185.5		853.70	MDDL with Vertical Intake
189.27	674.15	1362.01	
194.27	936.5	2298.51	
195.00		2473.84	MDDL with Horizontal Intake
199.27	1200.92	3499.43	
204.27	1472.6	4972.03	
209.27	1759.74	6731.77	
214.27	2035.83	8767.6	
219.27	2261	11028.6	
224.27	2370.38	13398.98	
225.00		13749.12	FRL has no provision for Evapo and Seepage losses
229.27	2398.21	15797.19	
229.4		15859.75	FRL if Vertical Intake
232.75		17471.95	FRL if Horizontal Intake
234.27	2406.26	18203.45	

3.3.6 While deciding on MDDL of the reservoir, it will be necessary to consider silt deposition in the reservoir spread over the life of 100 years. Silt gets deposited over the entire water spread, coarser nearer to the rim of the reservoir and finer particles nearer to the dam body. The accurate estimate of total silt entering the reservoir and its deposition distribution over the entire water spread area will require detailed analysis and collection of field data - nature of catchment area, collection of river water samples during monsoon

period, sediment grain size analysis etc. However, for the present Pre-feasibility study, empirical thumb rule parameters have been used to assess total silt load volume entering the lower reservoir and its percentage deposition near dam intake to determine New Zero Level (revised bed level due to silting). The Intake structure must be set above the NZL to avoid obstruction and reduction of waterway for entry of water into intake and to avoid entry of silt in the water conductor system. NZL estimated works out as EL 176.6 m.

3.3.7 While deciding MDDL, two possible situations arise, with Horizontal intake or with vertical shaft type intake. MDDL must provide adequate water cover over intake opening, so as to avoid vortex formation and entry of air during low reservoir water level periods. The proposed Tail Race system envisages three Tunnels each of 8 m diameter. There are various empirical formulas to decide required water depth at MDDL over intake. Based on that, the required MDDL for Horizontal orientation of intake and for Vertical shaft type intake work out to EL 195.0 m and EL 185.5 m respectively. FRL of reservoir to provide required live storage above MDDL work out as below:

Type	MDDL	Required Live Storage (Mm3)	Required Gross Storage (Mm3)	FRL of Lower Reservoir	Total Height of dam above deepest riverbed level (m)
Horizontal Intake	EL 195.0 m	15.0	17.47	EL 232.75 m	63.75m + Free board 1.5 m
Vertical Shaft type intake	EL 185.5 m	15.0	15.85	EL 229.40 m	60.40 m+ Free board 1.5 m
Vertical shaft Type intake, but no provision for losses	EL 185.5 m	13.0	13.81	EL 225.00 m	56.00 m + Free board 1.5 m

3.3.8 It can be seen from above, that a Vertical shaft type intake with MDDL as EL 185.5 m will be the preferred arrangement.

3.3.9 The total length of Lower Dam will be about 560 m. Required Free board above FRL / MWL depends on expected wave height which in turn depends upon – Reservoir spread, Average reservoir water depth, maximum wind velocity etc. In the present case, based on preliminary details, the required Free Board works out to 2.5m plus a 1.0 m high parapet wall.

3.3.10 Reservoir level will daily drop down by 45 m in a period of 6 hours of generation. Such

rapid drawdown of lake level by 45 m, can cause slippages at upstream face of dam if embankment (Earthen or Rockfill) dam is constructed due to residual pore pressures. Hence, a Gravity dam either a Concrete dam or a Colgrout Masonry dam, will be desirable. Further, another advantage with Gravity dam will be, part of it can be converted into overflow dam (spillway) to allow monsoon floods to pass down. Embankment dam will require a composite dam with concrete overflow dam and Embankment in the remaining length or a side chute spillway. But topography does not seem suitable to locate such a chute spillway on either flank. The dam can be :

a)Normal conventional concrete dam
b)Roller Compacted Concrete (RCC) dam
c)Colgrout masonry dam
d)Hard fill concrete dam

3.3.11 The first three alternative types have been in vogue for quite some time and are a proven technique. Hard fill dam is relatively a new type. In this, the dam body is formed by lean concrete and made up of available material: pebbles, gravel, sand, stone chips and rolled. The upstream and downstream faces will have Reinforced concrete thick slab cover as membrane. The cross section for the first three alternatives will be more or less the same. Cross section of Hard fill dam will be almost double of the first three types in the area because of the low strength of hard fill. If the foundation strata is relatively weak, we can think of a Hard fill dam, because, because of its wider base width, loading intensity on foundation strata will be low. The actual type will be decided during the DPR stage when geological field investigations (exploratory drilling) will be carried out. For the present study, a Colgrout masonry dam which will be cheaper compared to Concrete dam, has been adopted. Typical section of the dam is presented in drawing PATGAON-PSH-005

3.3.12 Generation Simulation Study: refer **Annexure III**

3.3.13 Hydrology

3.3.14 Lower Dam catchment, situated on western slopes of Western Ghats , falls under a high rainfall zone with average annual precipitation of around 6300 mm. No records of hour wise rainfall are available to estimate a peak design storm. However, considering the hilly region in the high rainfall zone, a storm of 150 mm in one hour, has been adopted, at this stage of study, as Design Storm. The valley has steep slopes -longitudinal 1 in 5.75 and cross slope 1 in 3. Hence, infiltration rate is low, and time of concentration is also low, resulting in high runoff coefficient and high peak inflow. For the present study with assumed runoff coefficient of 0.9 under saturated condition, a peak flood by a storm of 150 mm/ hour over a catchment of 6.9 sq km, is estimated to be 518 cumecs.

3.3.15 Spillway

3.3.16 The spillway structure is proposed to be an ungated overflow structure to avoid continuous monitoring and operation of spillway gates during monsoon months, because any excess surplussing through the gates could affect operation of the power station. In this case, since the entire live storage is just equal to daily operational requirement, the gate operation must be very accurate and fine-tuned. Even a slightest excess surplussing because of inefficient gate operation could affect generation of the power station. Hence, a failsafe arrangement of an ungated spillway has been suggested, though it means a longer spillway. For the present study, a depth of flow of 2.25 m over the crest of spillway has been considered which results in a required spillway length of 75 m and allowing for obstruction by bridge piers, the gross length will be 80 m and remaining 480 m long portion will be non-overflow dam. Spillway crests will be given Ogee profile to maximize discharging efficiency.

3.3.17 Spillway portion of Lower Dam is proposed to be in the central river channel with a horizontal stilling basin type energy dissipation structure at the toe. The required length of the stilling basin along the river course is 40 m. Width of the basin will of course be the same as the Spillway length 80 m. Setting of the basin works out about 9 m below riverbed level. Hence, the river channel downstream of basin will be excavated to give a reverse slope till it meets the natural bed level This portion of river channel will be protected from erosion by rip rap if it is a soft erodible strata.

3.3.18 Further optimization:

During Feasibility / DPR stage, further optimization will be carried out as listed below:

a) Reduce length of spillway (and hence width of stilling basin) by allowing higher depth of flow over spillway. This will require raising the height of the 480 m long non-overflow portion of the dam

b) To locate spillway on the flank thereby reducing the drop (fall) of overflowing water, This will reduce dimensions and thicknesses of stilling basin structure. But the spills will have to be taken down to the river channel through a tail channel, which will be of concrete to withstand high velocities. An energy dissipation structure will be required at the end of the tail channel in the river bed where a hydraulic jump will be formed because of the meeting of a fast moving water mass (with super critical velocity) with a relatively slow moving water mass in the river channel.

c) At this stage, we do not have field data River Cross sections, Riverbed rock properties and strength. Hence, other options to Stilling basin as energy dissipation structure such

as Roller bucket, Ski jump bucket etc have not been considered. The same can be studied and evaluated during the DPR stage when all the necessary field data will be generated.

3.3.19 Key Parameters of Upper and Lower Reservoirs

The Key parameters of the Patgaon PSH Upper Reservoir (**existing**) are as follows:

Sl. No.	Parameter	Unit	Value
1	Top of Bund	EL - M	629.6
2	Full Reservoir Level (FRL)	EL - M	626
3	Minimum Draw Down Level (MDDL)	EL - M	615
4	Live Storage	Mm3	104.79
5	Dead Storage	Mm3	0.47
6	Gross Storage	Mm3	105.26

The Key parameters of the Patgaon PSH Lower Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Top of Bund	EL -M	227.5
2	Full Reservoir Level (FRL)	EL -M	225
3	Minimum Draw Down Level (MDDL)	EL - M	185.5
4	Live Storage	MCM	12.9
5	Dead Storage	MCM	0.85
6	Gross Storage	MCM	13.75
7	Maximum Height of dam	M	57.5

3.3.20 Powerhouse

It has been proposed to have Powerhouse and all associated components on a well type shaft power house. As the proposed Powerhouse involves little deeper excavation, in order to reduce excavation quantities and improve stability, two shafts of 26 m diameter are provided from surface to service bays on both ends of the -1 elevation. This will house, Lift, staircase, D & D pump outlet, ventilation pipe & power conduits. A separate crane is planned for lowering materials from surface to -1 elevation. From the service bay two tandem operated cranes will be used for erection works. An alternative of a cavern

powerhouse has been ruled out due to excessively long approach tunnels & adits

The project envisages the utilization of the Rated head of 404m. The Pumped storage plant comprises 8 units.

The Key parameters of Storage Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Energy Storage Capacity	MWh	12,600
2	Rating	MW	2,100
3	No. of Units	Nos.	8
4	Rated Head in Turbine mode	M	404.77
5	Total Design Discharge	Cumec	592.69
6	Design Discharge per unit of 300 MW	Cumec	84.67
7	Water Requirement	Mm3	12.9
8	Generation Duration	Hrs	6
9	Generator Capacity – 8 Units	MW	6 * 300 MW +2*150 MW
10	Annual Energy Generation	MU	4372
11	Pump Capacity – 8 Units	MW	6 * 334 @ 0.95 p 2 * 117 @ 0.95 pf
12	Rated Head in Pump mode	M	416.87
13	Pumping Duration	Hrs.	7
14	Expected Cycle Efficiency	%	75.79

Pumping operation is proposed at 7 hours/day. Each day, the volume of water discharged through generation is equal to the Pumped volume.

3.3.21 Machine Hall

The internal dimensions of the powerhouse have been proposed with length 184.00 m and width 35.50 m. The units have been kept at about 26.00 m spacing while the erection bay has been proposed as 40m long on both ends. For housing control room and various auxiliaries/offices, 4 nos. floors have been proposed on the D/s side of the Powerhouse over the draft tube. The main inlet valve is proposed to be housed in the powerhouse just

u/s of the turbine. 2 Nos. of EOT crane of suitable capacity shall be installed in erection bay and unit bay to facilitate erection and repair of heavy equipment including main inlet valves.

The machine floor is designed to carry loads of machines, live load and thrust transferred through turbines, generators, and other machinery. The machine floor is designed as an RCC raft with adequate openings as required for equipment foundations and cable trenches etc.

The cranes from surface to the service bay will be used to lower / raise machine parts through a 26 m diameter shaft on both ends opening directly into the service bay.

3.4 ELECTRO- MECHANICAL EQUIPMENTS

The Electro-Mechanical equipment required for the proposed pumping scheme comprises of the following

MECHANICAL EQUIPMENT:

The Mechanical equipment consists of Turbine, Spherical Valve, Governor, Guide vane & guide vane servo motor, shaft seal and sleeve, Thrust & guide bearings, Bearing oil pumps and coolers, instrumentation and control system, HP/LP Air Compressor system, oil pumping system, cooling water system, Drainage, Dewatering system, crane etc.

3.4.2.1 SPHERICAL VALVE:

Each Turbine is provided with a Spherical valve to act as a main inlet valve to achieve quick closing to cut off the water supply for the Turbine in the event of any machine tripping on a lock out fault. The Spherical valve shall be normally opened and closed by hydraulic system and also have a backup closing system with counterweight for closing during emergency. Hydraulic operated Bypass needle valve is provided across the Spherical valve for smooth operation with pressure balance condition. It shall have a service seal and a maintenance seal.

3.4.2.2 TURBINE/PUMP - Mode changes:

In case of ternary machines, the turbine will be high efficiency peloton / francis, the type of turbine will be reversible vertical shaft Francis type directly coupled to the vertical **synchronous generator/asynchronous generator-motor**. The turbine will have adjustable guide vanes for control of the flow. The normal modes of operation are,

1. Hot Standby - With all aux on and primed up to start

2. Synchronous condenser Generator mode - machine running with water depressurized in the direction of generation in synchronized condition. SV closed condition.

3. Synchronous condenser Pump mode - machine running with water depressurized in the direction of generation in synchronized condition. SV closed condition.

4. Pump mode

5. Generator mode

During peak demand hours the pump draws power from the grid and water gets pumped into the higher reservoir. When the peak hours arrive, and the demand is high, the machine reverses, using high pressure to generate electricity through the turbine. Design of the Turbine components would be tweaked for better efficiency if needed, after carrying out the Model Test of Turbine.

3.4.2.3 GOVERNING SYSTEM:

The turbine will be controlled by an electronic governor. The Governor in general shall be designed in accordance with IEC 61362.The guide vanes will be actuated by guide vane servo motor through the governor. The system will be so designed that the main functions of speed control, power control are handled as separate program parts and shall be programmed to suit Francis turbines having adjustable guide vanes. Electrical Inertia as per the Indian Electricity Grid Code.

3.4.2.4 AUXILIARY SYSTEMS:

i) Air Conditioning System:

Chiller units of adequate capacity shall be provided for air-conditioning of the important areas of the plant. Chiller units are to be placed in the transformer cavern. Detailed design of the same shall be done at the DPR stage.

ii) Ventilation System:

The two vertical shafts themselves act as cable raceways in grooved areas , house a lift & staircase and also have a ventilation duct running in another recess.. the vertical shaft acts as a return path for the air.

iii) Crane and Hoists:

Two nos. EOT cranes of suitable capacity each will be installed in the ground level and will be used for lowering equipment into the two vertical shafts of the well type powerhouse. Two more tandem operated EOT cranes are in the powerhouse building **for** handling equipment during erection and maintenance. For handling of intake and draft tube gates suitable electrically operated hoisting mechanisms will be provided individually.

iv) Dewatering, Drainage System and Flood water System:

For Dewatering of turbine casing water up to the Tail race gate, a required number of submersible pumps with suitable capacity will be provided. The Dewatering sump will be located on the station below the draft tube level and a pipe from the submersible pump discharge will be taken up vertically towards the tail race above the max flood level. An isolation valve will be provided in this pipe which will be opened during Dewatering. Necessary level switches will be provided in the Dewatering sump to facilitate auto start/stop of the pumps. Sizing of pumps will be done during preparation of DPR. The control panel for the same will be kept at surface level and not in the pit.

v) Fire Protection System:

CO2 fire protection and water spray are provided for the generator which are activated by temperature and differential fault. The proposed fire protection system shall be designed to provide adequate safety measures in the area susceptible to fire in the power station. TAC classifies hydel power generating stations as “Light hazard Occupancy” and hence the system shall be designed accordingly. This system is designed as per applicable requirements of NFPA 70.

vi) HP Air Compressor System for blow down

The High-Pressure air system will cater to the needs of Tail water depression whenever the Machine is required for starting the unit in pump modes and to be operated in the Condenser mode from other modes or standstill. The runner and upper cone of the draft tube need to be blown out from water by depressing tail water level by feeding high pressure compressed air into the draft Tube, Runner and Bottom Ring for startup of Pump Turbine in Pump mode and commence condenser operation.

Centralized redundant compressor station with common and unit dedicated air receiver tanks are envisaged. Each unit dedicated tank will be designed for 2 blow downs.

3.4.1 ELECTRICAL EQUIPMENT:

The Electrical scheme shows the major system, such as the Generator and its connections to 400 kV Switchyard for Power evacuation, 11kV Switchgear and 415V Auxiliary Power distribution.

3.4.3.1 Synchronous/Asynchronous Motor:

The Synchronous/Asynchronous generator/Motor will be 3 phase with 0.9 PF (lag), 50 Hz with Static type excitation system/AC Excitation (VSI) for variable speed machines, suitable for parallel operation with the grid. The generator neutral (star point) will be

grounded through a suitably rated neutral grounding transformer with a loading resistor connected to the secondary side to restrict earth fault current to a safe limit. Six terminals of the generator, 3 on the phase side and 3 on the neutral side will be brought out for external connection. The short circuit ratio of the generator shall be greater than 1 (for Fixed Speed machine) for better stability on faults.

3.4.3.2 Static Frequency Converter and DC Excitation System (For Fixed speed machine)

SFC can be used for starting a machine in Pumping mode. For starting of the machine in pump mode the Static Frequency Converter or Variable frequency Drive equipment, Starting Circuit Breaker panels and starting isolator's cubicles, DC link reactor along with associated equipment are envisaged. The machines will be started in **Back-to-Back mode** of starting and the last machine will be started with SFC equipment.

The ceiling voltage of the excitation system will be at least 200% of the normal field voltage and response ratio will be about 2.0. Excitation system consists of a Dry type of Excitation transformer, a set of thyristor converters, and a field flashing circuit during generation mode.

3.4.3.3 Voltage Source Converter (AC Excitation System) and Control System (for variable speed Machines)

The excitation system shall enable the operation of the generator motor units in frequency regulation, voltage regulation modes within the capability diagram of the units. The excitation system shall manage the DFIM operating point parameters such as active power, reactive power or stator voltage, shaft, or runner speed according to desired P, Q set points (given by operator through SCADA system) and optimizing rules.

<u>The excitation system shall include two types of controls:</u>

- A guide vane regulation controlling the guide vane opening and thus the mechanical torque on the shaft.
- A rotor current regulation controlling the electromagnetic torque in air gap and the magnetizing current of the DFIM.

The excitation system shall be connected to the SCADA system.

The harmonic content injected into the neighboring power grids must comply with IEC 61000-2-4 class 3 and IEC 61000- 3-6 standard.

The excitation system shall include two control strategies which can switched from one to the other

(a) Active and reactive loads are controlled by the voltage source inverter (VSI) while the speed of the shaft line is controlled by turbine governor.

(b) Speed and reactive load are controlled by the VSI while the active load is controlled by turbine governor.

3.4.3.4 STEP-UP TRANSFORMERS:

Power generated will be stepped up to 400 kV by means of a Three Phase, 18 kV/400 kV, 400 MVA- 6 numbers & 200 MVA - 2 numbers, oil filled power transformers/Unit i.e., total **8** Numbers of three Phase 21kV/400kV Power transformers for 8 units.

3.4.3.5 400 kV GIS:

in order to save space an Indoor metal-enclosed phase segregated type SF6 gas insulated switchgear system rated for 400 kV, 3 phases, 63 KA/3 twin Bus sections and twin bus with each bus section catering to four incomers two outgoing lines one bus coupler and bus section breakers and bus reactor. sec 50 Hz SF6 gas insulated metal enclosed bus bars complete with Generator transformer, Line, Bus coupler, SAT bays. The Local control cubicle shall contain all the equipment required for controlling and monitoring the bay

3.4.2 CONTROL, INSTRUMENTATION and PROTECTION SYSTEMS:

There shall be one control panel each for the Turbine governing unit and its auxiliaries, station and its auxiliaries, GIS and its auxiliaries. It should be able to synchronize the units either manually through these control boards or through the SCADA system located in the control room. Protection panel for turbine, units, generator transformer, GIS, auxiliary transformers, line protections etc. The protection system adopted should be state of art type with latest practices in compliance with CEA requirements.

3.4.3 COMMUNICATION SYSTEM:

To communicate inside the powerhouse and pothead yard internally, to HO and LDC following communication systems are considered.

a) Internal Telephone System
b) External Communication.
c) Power Line Carrier Communication/OPGW

3.4.4 POWER EVACUATION

It is proposed to use QMDC 400 kV Transmission Line to connect to the grid at best possible locations mentioned below evacuation of generated Power and for Supply of power during pumping mode. Various existing substation details are given below.

- 765 kV MSETCL Substation at Kolhapur, Maharashtra (**68 KM)**
- 400 kV PGCL Substation at Mapusa, Goa (**48 KM)**

However, the final connecting point for evacuation of generated/consumption of pumping power will be finalized considering bay availability, existing transformer capacity and transmission line route feasibility up to receiving end during DPR Stag

CHAPTER - 4

PLANNING BRIEF

General

The Patgaon PSH is proposed in between two reservoirs i.e., Patgaon PSH Upper reservoir (existing) and Patgaon PSH Lower (to be constructed newly) and the required quantum of water for power generation will get stored in the reservoir through seasonal flow of water in the tributary /nala whenever it is available.

In the generation mode, water will flow from the Patgaon PSH upper reservoir through Power Intake and Penstock/Pressure shaft of 1,440 m long two parallel penstocks with one feeding four units and other feeding three units. The upper reservoir has a storage Capacity of 12,600 MWh with Rating of 2,100 MW. This project comprises 6 units of 300 MW each & 2 units of 150 MW each. The water after power generation will be conveyed to a lower reservoir through TRT. The total design discharge for the proposed scheme is 592.72 Cumec with the rated net head of 404.77 m.

Planning Concept

The proper selection of construction methodology, project scheduling followed by strict monitoring during construction are the major tools available in the hands of developers for ensuring completion of projects within scheduled time and cost. The project implementation schedule of the scheme is divided in to five stages as follows:

1. Preparation of DPR
2. Clearances and Permits
3. Pre-Construction Activities
4. Construction Activities
5. Testing and Commissioning

Please refer to Annexure-I for timelines

The preparation of Detailed Project Report including Topographic Survey and Geotechnical Investigation, the Clearances and Permits includes Forest land clearance, Environmental clearances, DPR approval and other permits and licenses activities will be completed within 18 months.

Pre-Construction activity involves construction infrastructure works like access road to project site and construction of building for accommodating men and materials, Award of tender for design works, Preparation of tender for Civil, H&M and E&M works, floating of tenders, Bid Evaluation, award of work and Mobilization to Site. This activity is proposed to be completed in 6 months.(part of 42 month construction period)

The main Construction activities will be taken up once Pre-Construction activities are completed. The Construction work for Civil, H&M and E&M will be carried out either by EPC contract or based on item rate contract. Quality control of civil, H&M and E&M works will be taken care through internal / external agencies. Based on the specific work of the project, equipment planning will be taken up and state of art equipment will be deployed at site during execution. It is proposed to get the Civil, Hydro-Mechanical and Electro-Mechanical works done through reputed contractors who have been doing similar kinds of works.

The Testing and Commissioning including water filling in the system will be taken up once the construction works are completed. The total construction of the project including testing and commissioning are proposed to be completed within 42 months.

CHAPTER - 5

PROPOSED INFRASTRUCTURE

General

Patgaon PSH is located in Kudal Taluka, Sindhudurg district and Bhudargad Taluka of Kolhapur District of Maharashtra. It envisages construction of lower reservoirs near Anjivade village in Sindhudurg district and use the existing patgaon lake as upper reservoir in Bhudargad Taluka, Kolhapur district. The project is about 31 km from Kudal Railway station. Nearest airport is Sindhudurg Airport. The Installed capacity of the Project is proposed as 2,100 MW.

Access

Roads to Project

The project sites are accessible from village road near Anjiwadi village from where Project Road takes off and the distance to project site is approximately 1.6Km.

Existing Road and Bridge Improvements

The conditions of Existing roads need to be improved.

Roads in the Project Area

The access road to the project site takes off from village road near Anjiwadi village from where Project Road takes off. The specification of access road has been kept in the equivalent category. Internal roads required to reach various project components shall be of temporary nature and shall be constructed using available muck. Road reaching the Dam site and to the Adit to PH shall be constructed as permanent roads

The permanent colony, office and other temporary facilities shall be planned along the access road discussed above.

Construction Power Requirement

The requirement of construction power will be met from the existing transmission network in the area. There is a 2.5 MW Small hydro plant at the upper reservoir. The transmission network can be extended to meet the requirements.

Telecommunication

Adequate provision required for telecommunications including:

- Development of the existing telephone system to provide sufficient capacity for both voice and data transmission.
- Provision of radio and microwave facilities.
- Provision of VSAT connection at site for communication with head office

Project Colonies / Buildings

- The contractors for Civil, Electro-Mechanical and Hydro-Mechanical works are planned to be hired for execution of this project. The skilled, semi-skilled and unskilled labor will be arranged by these contractors. Contractors shall themselves arrange for housing facilities for its work force in nearby villages.
- In addition, the developer will have his own staff or supervision of the works. Some of the existing houses in the nearby areas / villages will be hired on rent during construction period. It is proposed to construct residential as well as non-residential buildings for the project. Office buildings, guesthouses, security post, dispensary, etc. will also be constructed. These facilities shall be permanent in nature and shall also be used by O & M staff, once the construction is over.

Job Facilities

Workshop is proposed to facilitate the various preparatory works, batching plants, Crushing plants, steel liner plates bending etc. The major fabrication and assembling of hydro- mechanical equipment can be done in this workshop and later can be transported to the desired sites. To avoid damage to forest area, non site specific activities like construction facilities area, crusher plants, batching plants , muck disposal sites, labor camps etc proposed in non-forest area.

Water Supply

The provision of adequate water supplies for both the construction purposes and the use of personnel shall be done. To avoid any deterioration in water quality and subsequent changes in the aquatic biota, a proper sewage disposal system in and around various labor colonies shall be planned to check the discharge of waste.

Explosive Magazine

One explosive magazine store has been proposed in the project area. Portable magazines shall be kept at the sites of work for day-to-day requirements. Location of the Magazine shall be selected after commencement of the work in consultation with Licenced Blaster and following statutory requirements

Medical Facilities

Medical facilities are provided at Kolhapur by State District Hospital and are equipped with almost all medical facilities.

CHAPTER – 6
ENVIRONMENT AND ECOLOGICAL ASPECTS

INTRODUCTION

The proposed Patgaon PSH will spread across the districts of Kolhapur and Sindhudurg of Maharashtra. Project consists of the upper reservoir, which is the existing Patgaon Reservoir in Kolhapur district and the lower reservoir is proposed near Anjivade village in Sindhudurg district. The Proposed upper reservoir is operated with a live storage of 104.79 Mm3 and a gross storage of 105.26 Mm3. The filling of the reservoir will be taken from the Vedganga River of the Krishna Basin. The total design discharge for the proposed scheme is 592.72 cumecs with the net head of 404.77m. The location of the project is as shown in figure 1.1: Project Location.

Regulatory Environmental Clearance (EC) process involves three major steps as stipulated in EIA notification of September 2006, viz. Scoping (Terms of Reference), Public Consultation and Appraisal.

Hydel projects cover a large area and hence will interfere with the environment in the proposed area and its surroundings. Proper assessment of environmental impacts and its mitigation measures during the planning stages of the projects will help in reducing the adverse impacts. A brief description of environmental impacts with the proposed Pumped Storage Project is presented in the chapter. However, detailed EIA and EMP Studies shall be carried out in the DPR stage.

STUDY AREA OF THE PROJECT

For collection of the baseline environmental data and prediction of impacts the environmental study will be delineated as Project area or the direct impact area within 10 km radius of the main project components like Powerhouse, Balancing reservoirs and approach road etc.

ENVIRONMENTAL BASELINE STATUS

Data on the existing environment quality is to be collected to understand the present setting of the environment at the project site. To complete the EIA study, it is important to collect baseline data for various physio-chemical and biological environmental components in the project study area comprising Vegetation Community Structure, Wildlife, Soil Quality, Noise levels, Ambient Air Quality, Traffic density, Socia-economic aspects of the project area.

Physiography

The project area is in the Kolhapur and Sindhudurg districts of Maharashtra. The project area lies in the Krishna Basin. The study area of the proposed project consists of hilly terrain of Western ghats with steep to moderately sloping, exposed rocks, and scrub vegetation.

However, there are some pockets that depict some dense vegetation.

River System

The upper reservoir of the Patgaon PSH is an existing reservoir and serves the Warna Patgaon Power Project. The lower reservoir and the lower dams of Patgaon PSH are proposed to be constructed. All other facilities will be constructed to build up the requisite infrastructure for the pumped Storage Project.

Meteorology

The Upper Krishna (K-1) Sub Basin is in a semi-arid climate. The major meteorological attributes are temperature, humidity, evaporation, wind direction and speed and sunshine hours. If we observe the meteorological data from 2002 to 2013, the minimum temperature observed at these stations was 6 deg Celsius and maximum temperature was 43 deg Celsius. The hydrological parameters are useful in analysing the quantum of water available in the basin while the meteorological parameters are useful to work out the crop water requirement and seasonal irrigation planning.

The climate in the Sindhudurg district can be termed as generally humid. The nearest weather station from the IMD is at Vengurla and historic meteorological parameters can be collected from this data, during the EIA studies. The average maximum and minimum temperatures over the last 21 years is at 34.21 and 18.91 deg C, respectively, with an annual average rainfall of ~ 2500 mm..

Water Quality

The data on surface and ground water shall be collected to evaluate the quality of the water in the proposed area during the DPR stage. Based on secondary information, the Patgaon reservoir appears to have a good water quality as there are no major habitations in the vicinity of the reservoir. All the samples of surface water shall be collected and tested during the DPR stage as per the Water Quality standards of BIS and CPHEEO.

Flora

The Western Ghats region is considered as one of the eight 'hottest' biodiversity hotspots of the 34 identified biodiversity hotspots worldwide. The region boasts of a tremendous diversity of plant and animal life. The diverse natural wealth of the region is an important source of livelihood for a number of ethnic communities inhabiting the region. For instance, local communities harvest nearly 150 uncultivated food plants and more than 500 medicinal plants from forests for food and medicine. The forests are also a source of varied non timber forest products (NTFPs) and industrial raw materials. Nearly 2,227 species of plants belonging to 1,023 genera of 182 families have been recorded for Kolhapur district. The details of the flora

in the area of interest will be assessed during the EIA Stage to identify any specific species of interest that need conservation.

Wildlife

Kolhapur forest division is rich in forest fauna. As many as 47 species of mammals, 264 species of avifauna, 59 species of reptiles and 66 species of butterflies have been reported in the district. 7 species of mammals of endangered status namely Leopard, Sloth bear, Gaur, Mouse deer and Pangolin and two endangered species of reptiles namely Indian python and Indian Monitor lizard are also found in the district. The commonly occurring fauna in this district are as follows:

a. Mammals Tiger (Panthera tigris), Panther (Panthera pardus), Jungle cat (Felis chaus), Hyena (Hyaena hyaena), Jackal (Canis aureus), Indian grey mongoose (Herpestes edwardsi), Ruddy mongoose Kolhapur Forest Division Working Plan- 2008-09 to 2017-18 (Herpestes smithis (grey), Common fox (Vulpes bengalensis), Indian wild dog (Cuon alpinus), Sambar (Cwrvus unicoolor), Barking deer (Muntiecus mutjak), Gaur (Bos gaurus), Wild boar (Sus scrofa), Sloth bear (Melursus ursinus), Common langur (Presbytis entellus), Bonnet macaque (Macaca radiata), Indian pangolin (Manis crossicaudata), Indian crested porcupine (Hystrix indica), Five striped palm squirrel (Funambulus pennanti), Jungle palm squirrel (Funambulus tristriatus), Three striped palm squirrel (Funambulus palmarum), Giant squirrel (Ratufa indica), Small Indian civet (Viverricula indica), Common palm civet (Paradoxurus hermaphroditus), Indian flying fox (Pteropus giganteus), Short nosed fruit bat (Cyonopterus sphinx), Flvous fruit bat (Rousettus leschenaulti), Madras shrew (Anathana ellioti), Madras shrew (Anathana ellioti), House shrew (Suncus murinus), Indian long tailed mouse (Vandeleuria oleracea), Soft furred field rat (Millardia meltada), House rat (Rattus rattus), House mouse (Mus musculus), Little Indian field mouse (Mus booduga), Indian brown spiny mouse (Mus platythrix), Indian bush rat (Golunda ellioti), Indian hare (Lepus nigricollis).

b. Birds Jungle bush quail (Prodigal asiatica), Gray partridge (Francolinus pondicerianus), Gray quail (Coturnix coturnix), Rain quail (Coturnix coromandelica), Painted partridge (Francolinus pictus), White breasted kingfisher (Halcyon smyrnensis), Golden oriole (Oriolus oriolus), Babbler (Chrysomma sinense), Green imperial pigeon (Dacula aenea), Imperial pigeon (Dacula badia), Yellow legged green pigeon (Treron phoenicoptera), Blue rock pigeon (Columba livia), Green bee eater (Merops orientalis), Indian robin (Saxicoloides fulicata), Tree pipit (Anthus trivialis), Purple sunbird (Nectarinia asiatica), Little grabe (Podiceps ruficollis), Cormorant (Phalacrocorax carbo), Indian shag (Phalacrocorax fuscicollis), Little cormorant (Phalacrororax niger), Paddy bird (Ardeola grayii), Cattle egret (Bubulcus ibis), Ardea alba (Large egret), Smaller egret (Egretta intermedia), Little egret (Egretta garzetta), Night heron (Nycticorax nycticorax), Little bittern (Ixobrychus minutus), Black winged kite (Elanus caeruleus), Honey buzzard (Pernis ptilorhyncus), Brahminy kite (Haliastur indus).

c. Reptiles Python (Python molurus), Banded krait (Bungarus fasciatus), Common Indian krait (Bungarus caeruleus), Indian cobra (Naja naja), Russell's viper (Vipera russelli), Bamboo pit viper (Trimeresurus gramineus), Rat snake (Ptyas mucosus), Mugger Crocodylus palustris.

Details of flora and fauna that exist in the study area of the project will be identified during the EIA studies to be taken up at DPR Stage. It may be pertinent to note that the location of this project is quite a distance away from the nearest Sanctuary or any torah national park. Please refer to Annexure, which depicts the various notified areas in Maharashtra. The proposed project is marked on this map. Based on this map, the proposed location is located approx 10.3 km away from the nearest notified protected area.

SOCIO-ECONOMIC PROFILE

The collection of data on the socio-economic status should be delineated within 10km radius of the main project components such as upper reservoir, lower reservoir, water conducting systems, powerhouse, muck disposal area etc., the proposed area lies in the two districts of Maharashtra.

The socio-economic should include

- Collection of baseline data on human settlements, health status of the community and existing infrastructure, educational facilities, source of livelihood, job opportunities and surrounding population.
- Information on Agricultural practices, cultural and aesthetical sites.
- Demographic profile, Ethnographic Profile, Economic structure and
- Development profile.
- Impact on socio-cultural and ethnographic aspects due to proposed project.
- List of all the project affected persons with their names, education, land holdings, other properties, occupation, source of income, land etc.

PREDICTION OF IMPACTS

Majority of the environmental impacts attributed to construction works are temporary in nature, lasting mainly during the construction phase and often do not extend much beyond the construction period. However, as the construction phase of the Pumped Storage Project is large and extends over some years, if these issues are not properly addressed, the impacts can continue even after the construction phase. Even though the impacts due to construction are temporary in nature, they need to be reviewed closely as they could be significant due to the nature and intensity of the impacts.

Impact on Land

The impact on the land mainly occurs due to the construction works, migration of laborers, vehicular and heavy machinery movement in the area. Extension of the construction timeline beyond the scheduled construction may have an impact for longer duration although which is temporary in nature.

Impacts due to immigration of Construction Workers

At the time of peak construction work in the project, Majority of people are required than the planned persons who have their permanent shelters in nearby villages or temporary homes constructed for the project purpose. Majority of the people will be migrating from other areas. Only the migratory manpower will stay at site camp. Immigration of such a large population for a long duration in remote areas can cause serious impact on various environmental resources including socio-economic profile of local population.

The congregation of a large number of construction workers during the peak construction phase is likely to create problems of sewage disposal, solid waste management, tree cutting to meet fuel requirements, spread of sexually transmitted diseases etc. Appropriate mitigating measures will be suggested in EMP, which needs to be implemented to minimize such impacts. This population is expected to reside in the vicinity of the project area during the construction phase.

a) Impact due to Construction of Main Project Components

For construction of main project components major activities are excavation and concreting. Excavation will have an impact in terms of muck generation and de-vegetation. Excavation and concreting process will require use of various construction equipment such as batching plants, aggregate processing plants, dumper trucks, excavators, dozers, shotcrete machines, jack hammers, generators, pumps, etc. leading to generation of pollution in terms of emissions, wastewater, noise and solid waste. Further, based on the flora cover of the areas of interest, there will be an impact on the land due to vegetative clearing and accordingly the green cover will have to be compensated.

b) Operation of Construction Plant and Equipment

During the construction phase, various types of equipment will be brought to the site and construction plants and repair workshops will be set up. These include crushers, batching plants, drillers, earth movers, rock bolters, concrete mixing plants etc. The siting of these construction equipment would require a significant amount of space. In addition, land will also be temporarily acquired, i.e., for the duration of project construction; for storage of the quarried material before crushing, crushed material, cement, steel, explosives etc.

The siting of these construction plants/equipment would require a clear piece of land, in the proximity of the project. Proper siting of these facilities will reduce the impact due to their

location. Their locations will be identified, keeping in view the technical and economic criteria; however, same can be further refined during setup, keeping in view:

- Proximity to the site of use
- Sensitivity of forests in the nearby areas
- Wildlife, if any, in the nearby area
- Proximity from habitations
- Predominant wind direction
- Natural slope and drainage

Such activities are planned on land that can be leased and completely avoiding the forest area; to minimize the impacts of tree cutting. Land will be restored to its near original status once the project construction is complete.

Operation of construction plants and machinery will have an impact on ambient air quality due to fugitive emissions associated with material handling; emission due to operation of DG sets to meet the power requirements and other equipment; impact on water quality due to wastewater generation and impact on soil due to solid and hazardous waste generation. Management of such impacts with operation control and appropriate pollution control equipment is essential to minimize their effect on the surrounding environment including local population and wildlife and should be elaborated in the Environment Management Plan. Environmental Monitoring will also be required during the construction phase of the project. In case there is a need for blasting, then a proper Disaster Management Plan should be put in place taking into account the storage of explosive material, isolation and security of these materials from other consumables at the site.

Muck Disposal

Construction work would involve soil and rock excavation. The area designated for muck disposal should be sufficient enough to take into account the swelling factor. This muck would require disposal, with minimum environmental impacts. Muck, if not securely transported and dumped at pre-designated sites, can have serious environmental impacts, such as:

- Can be washed away into the natural water bodies which can cause negative impacts on surface and ground water quality and get deposited in low lying areas.
- Can lead to impacts on various aspects of the environment. Normally, the land is cleared before muck disposal. During clearing operations, trees are cut, and undergrowth perishes because of muck disposal.
- In many of the sites, muck is stacked without adequate stabilization measures. In such a scenario, the muck moves along with runoff and creates soil erosion like situations.
- Normally muck disposal is done at low lying areas, which get filled up due to stacking of muck. This can sometimes affect the natural drainage pattern of the area leading to a change in the natural hydrological pattern.

- A detailed Muck Disposal Plan will be prepared to minimize the impact and addressed in the Environmental Management Plan.

c) Road Construction

A network of roads would be required to approach various project components for construction, operation and maintenance. Proper planning for these roads needs to be done so that this is a one-time activity. As far as possible, develop the existing cart track for use of the project into project roads. As such, no adverse impact is envisaged with road construction, as long as these are planned properly and executed from a long-term perspective.

d) Impact due to Acquisition of Land

For the development of the Patgaon PSH, Approximate land that would be required for construction of project components, reservoir area, muck dumping, construction camps and colony, etc are estimated below.

Major impact of land acquisition is permanent change of land use, which is unavoidable. Additionally, land acquisition has impacts on local population by way of loss of their agriculture land and hence livelihood and also impact on flora and fauna by way of loss of forest land and clearing of vegetation on acquired land. These impacts will be mitigated by implementing Landscaping Restoration and Green Belt Development Plan and Biodiversity Conservation and Wildlife Management Plan, and the detailed study will be taken in EMP studies. For temporary land requirement during construction, the land can be leased and used for the construction and restored back to its original condition, before site evacuation. The total land requirement for the proposed project is about 140.25 ha; out of which 70.4 ha is forest land. The details are given in **Table 7.1**

Table 7.1: Details of Land Requirement

S/N	PROJECT COMPONENT	FOREST	NON-FOREST	TOTAL
1	Site Office	0	0.05	0.05
2	Concrete Batching Plan	0	7.3	7.3
3	Ferrule Handling / Stacking Area and Workshop	0	0.6	0.6
4	Labour Camp	0	0.3	0.3
5	M & E Area	0	11.6	11.6
6	Muck Disposal Area	0	20	20
7	Crusher	0	8	8
8	Trolley Track (Part of Item No. 12)	0	0	0
9	Upper Reservoir (existing)	0	0	0
10	Lower Reservoir (new)	47.7	21.6	69.3
11	Approach Road to Project Component	3.7	0.3	4
12	WCS, PH	19	0	19
13	Magazine	0	0.1	0.1
TOTAL		**70.4**	**69.85**	**140.25**

Out of the total land required for the project, the forest land will be diverted as per the guidelines issued under the Forest (Conservation) Act, 1980 and government land, if any, will be transferred to the project from the competent authority as per the laid-out process. The Non- Forest (private) land identified for the project will be purchased directly from respective landowners through private negotiations on land price and completed on a mutual agreement.

The private land if required for the project is proposed to be purchased through a voluntary sale with a willing buyer and seller process. The process is undertaken through direct negotiations between landowners and Project Proponent with no obligation on the seller. The landowners are informed in advance, and each landowner negotiates on the price of land as part of land take.

The some of the steps in the land procurement process included the following:

- Identification of land required for the project and due diligence of land through verification of Revenue Records.
- Undertake consultation and negotiations with the landowners about the project and private land requirement.
- After negotiations on all aspects of purchase the voluntary sale of land is completed through a registered sale agreement.

e) Impact on Water Quality

Sewage from Construction Sites due to worker Camps

The disposal of untreated sewage can lead to water pollution, resulting in increase in coliforms and other various pathogens, which can lead to incidence of water borne diseases. In order to avoid any deterioration in water quality due to disposal of untreated sewage from labor camps, appropriate sewage treatment facilities shall be constructed in the labor camps. As far as possible the treated wastewater should be used for horticulture and any greenbelt development.

Effluent from Construction Plants and Workshops

Discharge of untreated wastewater will adversely affect the water quality of the receiving water body. Turbidity and oil and grease levels will increase substantially in small tributaries, especially in lean season. To minimize the impact, such effluent needs to be treated in situ before discharge to any water body or for land application.

Disposal of Muck

The major impact on the water quality arises when the muck is disposed along the river bank. The project authorities should identify suitable muck disposal sites which are not located near the river banks or in the path of monsoon run-off

f) Impact on Terrestrial Flora

Due to the increased level of human interference in and around the project area, there will be impact on the flora. Tree cutting for fuelwood, construction of houses, furniture by the workers to meet their requirements also impact the flora. Normally in such situations, a lot of indiscriminate use or wastage of wood is also observed, especially in remote or inaccessible areas. Thus, it is necessary to implement adequate surveillance to mitigate the adverse impacts on terrestrial flora during the project construction phase.

g) Impact on Terrestrial Fauna Disturbance to Wildlife

During the period of construction, a large number of machinery and construction workers are mobilized, which results in the disturbance of the wildlife population in the vicinity of the project area. The operation of various equipment will generate significant noise, especially during blasting which will have adverse impact on fauna of the area. The noise may scare the fauna and force them to migrate to other areas. Likewise setting of construction plants, workshops, stores, labour camps etc. could also lead to adverse impact on fauna of the area. During the construction phase, accessibility to the area will lead to an influx of workers and the people associated with the allied activities from outside will also increase. Increase in human interference could have an impact on the terrestrial ecosystem.

The other major impact could be the blasting to be carried out during the construction phase. This impact needs to be mitigated by adopting controlled blasting and strict surveillance regime and the same is proposed to be used in the project. This will reduce the noise level and vibrations due to blasting to a great extent.

h) Impact on Noise Environment

Sources of noise will be from the vehicles, heavy machinery and equipment for excavation and stationary equipment, including concrete batch plant located at the construction sites, explosions, drilling machines and quarrying and crushing activities.

i) Impact on Air Quality

The sources and activities that might affect the air quality in the project area are vehicular movement, dust arising from unpaved village roads and domestic fuel burning. The air environment around the project site is free from any significant pollution source as there are no industries in the vicinity and therefore, it is presumed that the ambient air quality is quite good in and around the project area.

j) Traffic Analysis

Traffic analysis shall be carried out to understand the existing load carrying capacity of the roads near to the project site and connecting main roads in the area. Accordingly, the road infrastructure could be strengthened, based on the long term anticipation of increase in traffic.

k) Impact on Socio-economic Environment Positive Impacts on Socio-Economic Environment

The following positive impacts are anticipated on the socio-economic environment of the local people of villages of project area during the project construction and operation phases:

- Several marginal activities and jobs would be available to the locals during the construction phase.
- Developers bringing large scale investment to the area will also invest in local area development and benefit will be reaped by locals. Education, medical, transportation, road network and other infrastructure will improve.
- The availability of alternative resources provided by developers in the rural areas will reduce the dependence of the locals on natural resources such as forest.
- There is an opportunity for small-scale and cottage industries to develop in the area.

Negative Impacts on Socio-Economic Environment

Positive impact on the socio-economic environment may also bring a certain amount of negative impact due to influx of outside population. Workforce will reside in that area for the period of construction and there will be an influx of drivers and other workers on a temporary basis. This influx of people in otherwise isolated areas may lead to various social and cultural conflicts during the construction stage. Developers need to take help from local leaders, Panchayat and NGOs to ensure minimum impact on this count.

Increased incidence of Diseases

Large scale activity in the area due to the proposed project may become a cause of spread different types of diseases in the project area due to following reasons:

- Project requires long-term input of labour from outside the area.
- Project requires that significant numbers of project employees be separated from their families for long periods of time
- Project involves the creation of large, temporary construction camp(s).
- Increases mobility of people in and out of the area (job seekers, formal and informal service providers).
- Requires participation / resettlement of the local population.

I) Impact During Operation Phase

On successful completion of the construction, land used for construction activities will be restored. Construction workers will move out of the project site. By ensuring all the mitigation and management measures to minimize the impact of the construction phase, a large part of the area will be restored to the pre-construction stage. However, there will be some permanent changes such as reservoir formation, powerhouse and project colony, and road infrastructure. The project is planned as a clean source of renewable energy as there is no significant pollution generation during project operation. There is no air and water pollution from the project operation. Similarly, generation of solid and hazardous waste is also insignificant.

Other impacts of the construction phase include formation of reservoirs impacting the water quality, pollution generation from colony and plant and positive as well negative impacts on socio-economic environment mainly due to improved infrastructure in the area.

Proposed pumped storage project consists of an existing upper reservoir and new lower reservoir. Water will remain in circulation from upper to lower during power generation and vice versa during non-generation hours daily. Reservoir water requirements will be met once and thereafter only small quantities will be added to compensate for evaporation losses/leakages.

During the operation phase, due to absence of any large-scale construction activity, the cause and source of water pollution will be much different. Since only a small number of O&M staff will reside in the area in a well-designed colony with sewage treatment plant and other infrastructural facilities, the problems of water pollution due to disposal of sewage are not anticipated. The treated sewage will be reused for gardening and green belt around the colony.

ENVIRONMENTAL MANAGEMENT PLAN

Biodiversity Conservation and Wildlife Management Plan

Hydel projects, on account of large inundation of land have an impact on the biodiversity of the region. Hence a Biodiversity and Wildlife management plan would be required to maintain the biodiversity culture of the region, even after the project is in operation. In view of the anticipated impacts, the main objectives of biodiversity conservation and wildlife management plan shall be follows:

- Maintenance of ecological balance through preservation and restoration of wherever it has been disturbed due to project developmental activities,
- Conservation and preservation of natural habitats in catchment and project area
- Rehabilitation of critical species (endangered, rare, and threatened species), with provisions for in situ or ex situ conservation. This should be applied to the flora and fauna in the region of impact.

- Mitigation and control of project induced biotic and/or abiotic pressures/ influences that may affect the natural habitats,
- Habitat enhancement in project area and catchment area by taking up afforestation and soil conservation measures,
- Creating all round awareness regarding conservation and ensuring people's participation in the conservation efforts and minimizing man-animal conflict
- Compliance and restoration of the conversion of Forest land.

Muck Dumping Plan

The project would generate a substantial quantity of muck from the excavation of various structures and lower reservoirs. The total quantity of muck likely to be generated from excavation including construction of roads after the utilization of muck for different project components and after considering the swell factor of muck appropriate area will be allocated, keeping in mind secondary polluting aspects of run-off, siltation etc.

Solid waste management from labor camps

The territorial area of the project complex/ colony shall be responsible for the implementation of the provision of Solid Wastes Management. Facilities for collection, conveyance and disposal of solid waste shall be developed. Any solid waste generated in the project complex/ project colony/ labour colony, shall be managed, and handled appropriately. Various aspects of solid waste management include:

- Reuse/Recycling
- Storage/Segregation
- Collection and Transportation
- Disposal

Since a lot of material comes in plastic wrapping, specific attention ought to be given to the plastic waste as this could have long term impacts on the environment and on the project itself.

Public Health Delivery System

Medical services at secondary level play a vital and complementary role to the tertiary and primary health care systems and together form a comprehensive district-based health care system. Following activities are proposed:

- Ambulances with all the basic Medicare facilities and small DG set, etc. to cater for villages in the project area
- Budget for running the ambulances including driver, fuel, and maintenance
- First aid posts including sheds, furniture, and basic equipment
- Budget for running the first aid post including cost of medico, para-medico/Nurses and attendant, consumables, etc.

- Budget for strengthening existing medical facilities
- Budget for Health Awareness/ Vaccination Camps

Energy Conservation Measures

Fuel for cooking is an essential requirement and in the absence of adequate fuel availability the manpower may resort to tree cutting for use of fuel wood. Therefore, adequate arrangements such as Community kitchen, Supply of Kitchen fuel, efficient cooking facilities and Solar Lantern could be provided.

Landscaping, Restoration and Green Belt Development Plan

The proposed project would involve construction of artificial reservoir, powerhouse, residential and staff colonies, roads, batching plants, etc. These activities will result either in the modification or destruction of the existing landscape of the area. Therefore, restoration work should be carried out in these disturbed landscapes to similar or near-similar pre-construction conditions and land use.

Green belt development will consist of plantations at various places like alongside roads, around the periphery of reservoir rim, and at different project offices and colonies. During the operation phase, regular plantation drives should be carried out in the catchment zones to increase the green cover and avoid any run-off from silting the reservoirs.

Air and Water Management Plan

Various mitigation and management measures will have to be planned to reduce the impacts of air, noise and water pollution and implement safety measures to ensure that impacts on these counts are reduced to minimum possible during the entire construction phase. To implement such measures, it is important to prepare a budget of such measures and include in the project cost so that lack of funds should not constrain their implementation.

Cost for mitigation measures and monitoring of Air, Water and Noise quality in the project area will be covered under the Environmental Monitoring Plan.

Environmental Monitoring Plan

Monitoring shall be performed during all stages of the project (namely: construction and operation) to ensure that the impacts are no greater than predicted, and to verify the impact predictions. The monitoring program will indicate where changes to procedures or operations are required, in order to reduce impacts on the environment or local population. The monitoring program for the proposed project will be undertaken to meet the following objectives:

- To monitor the environmental conditions of the project area and nearby villages;
- To check on whether mitigation and benefit enhancement measures have actually been adopted and are proving effective in practice.

REHABILITATION AND RESETTLEMENT

As discussed, the landowner family may be losing part of their total land, none of the landowners is losing any house or any other assets such as borewell, Cattle shed, trees etc. None of the landowner family is displaced due to the proposed project.

In view of the above it is noted that the total private land proposed to be purchased through private negotiations. If the total private land required exceeds the specified limits by the relevant rules notified by the State Government, if any related to rehabilitation and resettlement under RFCTLARR, 2013 shall apply for the proposed Project.

The detailed requirements for the R&R plan, if applicable, will be based on the social-economic survey and land utilization for the project. Due consideration ought to be given to the societal requirements in developing the R&R plan.

CHAPTER - 7
GEOLOGY

The pumped storage project is proposed between the existing upper reservoir (Patgaon) and lower reservoir near Anjivade in Kolhapur and Sindhudurg districts, respectively. The scheme comprises upper reservoir, lower reservoir, water con-ducting system, Pressure shaft, Surge shaft, Access tunnel, Underground powerhouse and tail race system.

The proposed PSH is in the Krishna Basin. The Physiography of the upper Krishna sub basin has given rise to three major characteristics landforms

i) The hills, Ghat and plateau

ii)The foothill zones

iii) And the plains.

The Upper Krishna Basin is entirely covered by Deccan trap lava flows. The Deccan Basalt are volcanic basic lava, eruption of special type being predominantly continental sub-aerial and believed to have piled up and spread laterally like flood of liquid magma. The nature of the lava eruption and structure formed as a result of cooling are quite complicated, but they have important bearing on the movement of the groundwater. Detailed description of Upper Krishna basinK-1 is given below

A) Deccan Basalt: - The basalt of the upper Krishna sub basin (K-1) comprises a number of flows of variable thickness. The contacts of the flow are distinguished by- a) Presence of red bole bed, b) Fragmented basalt overlain by dense basalt and c) Vesicular basalt overlain by dense basalt. Formation Age Alluvium Recent Laterite Pleistocene to recent Deccan Basalt Upper Cretaceous to Lower Eocene Each of the basaltic flows consists mainly of two trap units viz(i)massive unit and vesicular unit, the former occupying the lower portion. The massive one constitutes the main trap unit forming 60 to 85 % of individual flows. These are mostly fine grained, dense, and compact and greenish to dark grey in colour. The vesicular trap unit forms the upper horizons of each flow and constitutes the individual flows. These are soft, fine grained and greenish to brownish in colour. The vesicles are oval-shaped which are either open and interconnected or filled with secondary minerals like zeolites, quartz, calcite etc. The intensive weathering of trap units results in formation of black cotton soil of variable thickness. Deccan trap exhibits characteristic spheroidal weathering and forms rounded boulders. These boulders are generally seen scattered along the foothills of the valley terrain throughout Kolhapur district Joints are common in Deccan Basalt thin lava flows have developed into innumerable jointed blocks. The orientation of most of the jointed blocks is normal. Thick basalt lava has developed columnar jointing at few places. At the bottom set of thick and well-formed columns stand essentially normal to the base of the flow. Rarely, columns are separated by joints parallel to the flow surface. Deccan Trap - Percentage of

Deccan Trap in this basin is 98 %

B) Laterite the Laterite occurs on the plateau top as a tabular mass (cap rock). They are Reddish Brown in color. The laterite is well exposed in the Panchgani area.

C) Alluvium- The alluvium normally rests directly over the Deccan basalt and comprises lose to semi-consolidated material such as sand, gravels, clayey, silts etc. A few isolated patches of recent alluvium varying in thickness from 2 to 20 m occur along the banks of Krishna, the Nira,the Man and the yerala river and there major tributaries.In Kolhapur district especially in taluka Panhala, hatkangale minor occurrences of alluvial deposit encountered. Mahabaleshwar (Dist. Satara) plateau and in plateau on either side of river Koyna. As it extends toward the southern part of the basin towards Dandoba hill (Dist. Sangli) as well Laterite is usually noticed at the altitude of 900 meters or more throughout the Kolhapur district. Alluvium percentage Percentage of Alluvium in this basin is 2 %

Seismicity: The project area falls under Zone III as per IS-1893 (Part 1) 2002, Seismic Zoning Map of India.

CHAPTER - 8
COST ESTIMATES AND ECONOMIC EVALUATION

General

Construction of Patgaon PSH including erection of 8 generating units are planned to be completed in a period of 42 months including Pre-constructions works period of 6 months for creation of infrastructure facilities viz. additional investigations, improvement of road network, colonies etc.

Two shift working is considered economical for surface works. Opting 25 working days in a month, shift wise scheduled working hours annually are proposed to be adopted.

8.1 Target Schedule

The Total Construction period is scheduled as follows.

Preconstruction Period incl. Statutory Clearances	:	18 months
Construction Period (Main Works)	:	42 months
Total Construction Period	:	60 months

8.2 Cost Estimates

The Civil Cost Estimates of the project has been prepared as per "Guidelines for preparation of estimates for the river valley projects" issued by CWC and Indian Standard IS: 4877 "Guide for Preparation of Estimate for River Valley Projects".

Rates of major items of works have been prepared based on SoR of Maharashtra and local prevailing rates are adopted for the items not covered by the SoR wherever quantification has not been possible at the present stage of design, lump sum provisions have been made based on judgement / experience of other projects.

8.3 Preparation of Estimates

The capital cost of the project includes all costs associated with investigations, design, construction and maintenance during construction period of the project.

For preparation of cost estimates of civil works, the unit costs of labor, materials and equipment necessary to perform the work designated in the various pay-items for the proposed construction are determined based on Schedule of Rates for the year 2018-19 of Maharashtra Irrigation and Water Resources Department and for items for which the rates are not available, the accepted schedule of rates of similar ongoing/recently executed projects adopted. The rates of major items have been worked out by rate analysis. The quantities of Civil Works are estimated based on designs and drawings prepared for various components of the project. The Daily wage rates have been taken as per Maharashtra I&CAD Schedule of Rates for the year 2018-19. Provision for contingencies are considered at 3% of the works cost and are provided in the detailed

works estimates prepared on the heads of item rates and quantities of works to be executed. These percentage provisions are not considered on lump-sum items.

The total project cost works out as given below:

S.NO.	Description of Item	Cost in Crores
1	Cost of Civil Works	3,426
2	Land & Infra development	300
3	Cost of Electro-Mechanical Equipment including Transmission line	3,264
4	Total Hard Cost	6990
5	Interest during Construction (IDC)	1,384
6	Total cost of the Project	**8,374**

Input Parameters

The proposed Pumped Storage Scheme (2,100 MW) envisages peak annual energy generation of 4372 MUs. The estimated project cost is Rs.8,374 Crores including IDC and FC at 2020-21 price level. The Conversion Cost (which excludes Cost of Pumping energy) has been calculated and financial analysis has been carried out for Return Equity on "post-tax basis" i.e.,16.50 % for a period of 40 years.

The parameters considered in the economic evaluation of the project have been listed below and the tariff calculations are carried out as per CERC guidelines.

Input Parameters for Economic Valuation			
Parameter	**Unit**	**Value**	**Remarks**
Capacity	MW	2100	
Plant Life	Years	40	as per the CERC guidelines
Basic Project Cost	Rs. Crores	6,990	
IDC	Rs. Crores	1,384	
Total Cost Including IDC	Rs. Crores	8,374	
Debt	%	70%	

Equity	%	30%	
Debt: Equity Ratio	Ratio	70:30	as per the CERC guidelines
Rate of O&M Charges	%	3.50%	as per the CERC guidelines
Annual Increment in O&M Charges	% p.a	4.77%	as per the CERC guidelines
Spares (as % of O&M Charges)	%	15%	as per the CERC guidelines
Interest on Working Capital	%	10.50%	as per the NREDCAP
Interest on Term Loan	%	10.50%	as per the NREDCAP
Return on Equity (RoE) (Post-Tax)	%	16.50%	as per the CERC guidelines
Rate of Depreciation	%	5.28%	as per the CERC guidelines
Discounting Rate	%	10.87%	Calculated
Annual Energy Generation	MUs	4,372	Estimated
Auxiliary Consumption (AUX)	%	1.2%	as per the CERC guidelines

Phasing of Expenditure

The Project is proposed to be completed in 5 years and the phasing of expenditure is given below. The phasing has been worked out based on the Proposed Construction Programme for the implementation of Civil and Electro-mechanical works which is based on experience in similar Projects.

Project Cost Disbursement	Total	1	2	3	4	5
Infrastructure Works (Land and Site Dev)	100%	10.0%	20.0%	30.0%	30.0%	10.0%
Major Civil Works	100%	10.0%	20.0%	30.0%	30.0%	10.0%
Plant and Equipment - Hydro-mechanical	100%	10.0%	20.0%	30.0%	30.0%	10.0%
Plant and Equipment - Hydro-electrical	100%	10.0%	20.0%	30.0%	30.0%	10.0%
Taxes and Duties	100%	10.0%	20.0%	30.0%	30.0%	10.0%

Construction and Pre-commissioning expenses	100%	10.0%	20.0%	30.0%	30.0%	10.0%
Overheads	100%	10.0%	20.0%	30.0%	30.0%	10.0%
Financing Charges	100%	10.0%	20.0%	30.0%	30.0%	10.0%
Other Costs	100%	10.0%	20.0%	30.0%	30.0%	10.0%

Interest During Construction

The finance for the Project is planned to be raised through upfront 30% equity and the balance 70% would be met by obtaining a loan from financial institutions with an expected interest rate of 10.5%. The interest during construction and financing charges have been worked out considering the phasing of expenditure

Construction Year>>	1	2	3	4	5	Total
IDC (Rs.Crores)	26.67	108.71	250.34	429.46	568.90	1,384.08

Levelized Cost of Generation

The levelized cost of generation for the proposed PSH has been estimated considering the cost of pumping as Rs 3.0/kWh as per the latest CERC guidelines applicable for hydroelectric projects. Accordingly, the levelized tariff has been estimated to be Rs 7.53/kWhr.

To evaluate project viability against different parameters and to facilitate project developers in identifying the best suitable combination of financial parameters, a sensitivity analysis has been carried out considering varying cost of pumping, rate of interest and post-tax return on equity and the resulting levelized cost of generation considering a plant life of 40 years is furnished below

Cost of Pumping (Rs./kWh)	Post-Tax RoE	Levelized Tariff (Rs/kWh)		
		At Rate of Interest (%)		
		6.00%	8.00%	10.50%
0.00	8.0%	2.693	2.803	2.963
	10.0%	2.842	2.951	3.118
	12.0%	2.978	3.093	3.265

	16.5%	3.283	3.412	**3.600**
2.00	8.0%	5.320	5.425	5.586
	10.0%	5.464	5.573	5.739
	12.0%	5.599	5.714	5.887
	16.5%	5.904	6.034	**6.221**
3.00	8.0%	6.628	6.733	6.891
	10.0%	6.775	6.884	7.050
	12.0%	6.910	7.025	7.198
	16.5%	7.215	7.344	**7.532**

As seen from the above table, the levelized cost of generation is highly sensitive to the Cost of Pumping followed by Rate of Interest and Post-Tax Return on Equity.

Annexure - Financial Analysis – Tariff for 40 Years - @Rs.0.00/Unit cost of pumping

Year	Loan Outstanding	Interest On Loan	Depreciation	Repayment of Loan	Return on Equity	O & M Charges	O & M for 1 Month	Receivables	Spares	Working Capital	Interest on WC	Pumping Costs	Total Charges	Saleable Energy	Tariff	Discounting Factor	Discounted Tariff
#	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Mus	Rs./Unit	Factor	Rs./Unit
1	5,430.36	592.84	357.67	493.67	497.87	238.00	19.83	286.91	35.70	342.45	35.96	-	1,722.34	4,319.58	3.99	1.00	3.99
2	4,936.69	544.27	357.67	493.67	497.87	249.35	20.78	282.50	37.40	340.69	35.77	-	1,684.94	4,319.58	3.92	0.90	3.54
3	4,443.02	492.44	357.67	493.67	497.87	261.25	21.77	278.19	39.19	339.15	35.61	-	1,644.83	4,319.58	3.86	0.81	3.14
4	3,949.35	440.60	357.67	493.67	497.87	273.71	22.81	273.97	41.06	337.84	35.47	-	1,605.32	4,319.58	3.81	0.73	2.79
5	3,455.69	388.76	357.67	493.67	497.87	286.76	23.90	269.86	43.01	336.77	35.36	-	1,566.43	4,319.58	3.75	0.66	2.48
6	2,962.02	336.93	357.67	493.67	497.87	300.44	25.04	265.85	45.07	335.95	35.28	-	1,528.19	4,319.58	3.69	0.60	2.20
7	2,468.35	285.09	357.67	493.67	497.87	314.77	26.23	261.96	47.22	335.40	35.22	-	1,490.63	4,319.58	3.64	0.54	1.96
8	1,974.68	233.26	357.67	493.67	497.87	329.79	27.48	258.18	49.47	335.13	35.19	-	1,453.78	4,319.58	3.59	0.49	1.74
9	1,481.01	181.42	357.67	493.67	497.87	345.52	28.79	254.53	51.83	335.16	35.19	-	1,417.68	4,319.58	3.54	0.44	1.55
10	987.34	129.59	357.67	493.67	497.87	362.00	30.17	251.02	54.30	335.48	35.23	-	1,382.36	4,319.58	3.49	0.40	1.38
11	493.67	77.75	357.67	493.67	497.87	379.27	31.61	247.63	56.89	336.13	35.29	-	1,347.86	4,319.58	3.44	0.36	1.23
12	-	25.92	357.67	493.67	497.87	397.36	33.11	244.39	59.60	337.11	35.40	-	1,314.22	4,319.58	3.39	0.32	1.09

13	-	-	357.67	-	497.87	416.31	34.69	201.90	62.45	299.04	31.40	-	1,303.25	4,319.58	2.80	0.29	0.81
14	-	-	357.67	-	497.87	436.17	36.35	203.34	65.43	305.11	32.04	-	1,323.75	4,319.58	2.82	0.26	0.74
15	-	-	357.67	-	497.87	456.98	38.08	204.93	68.55	311.56	32.71	-	1,345.23	4,319.58	2.85	0.24	0.67
16	-	-	357.67	-	497.87	478.77	39.90	206.71	71.82	318.42	33.43	-	1,367.75	4,319.58	2.87	0.21	0.61
17	-	-	357.67	-	497.87	501.61	41.80	208.66	75.24	325.70	34.20	-	1,391.35	4,319.58	2.90	0.19	0.56
18	-	-	357.67	-	497.87	525.54	43.79	210.80	78.83	333.43	35.01	-	1,416.09	4,319.58	2.93	0.17	0.51
19	-	-	145.44	-	497.87	550.61	45.88	213.14	82.59	341.61	35.87	-	1,229.79	4,319.58	2.96	0.16	0.46
20	-	-	145.44	-	497.87	576.87	48.07	215.69	86.53	350.29	36.78	-	1,256.96	4,319.58	3.00	0.14	0.42
21	-	-	145.44	-	497.87	604.39	50.37	218.45	90.66	359.48	37.75	-	1,285.44	4,319.58	3.03	0.13	0.39
22	-	-	145.44	-	497.87	633.22	52.77	221.45	94.98	369.20	38.77	-	1,315.29	4,319.58	3.08	0.11	0.35
23	-	-	145.44	-	549.81	663.42	55.29	233.49	99.51	388.29	40.77	-	1,399.45	4,319.58	3.24	0.10	0.34
24	-	-	145.44	-	696.29	695.07	57.92	261.82	104.26	424.00	44.52	-	1,581.32	4,319.58	3.64	0.09	0.34
25	-	-	145.44	-	702.96	728.22	60.69	266.70	109.23	436.62	45.84	-	1,622.47	4,319.58	3.70	0.08	0.31
26	-	-	145.44	-	709.19	762.96	63.58	272.10	114.44	450.13	47.26	-	1,664.85	4,319.58	3.78	0.08	0.29
27	-	-	145.44	-	713.79	799.35	66.61	279.21	119.90	465.73	48.90	-	1,707.49	4,319.58	3.88	0.07	0.27

28	-	-	-	-	611.62	837.48	69.79	268.51	125.62	463.92	48.71	-	1,497.81	4,319.58	3.73	0.06	0.23
29	-	-	-	-	613.56	877.43	73.12	275.78	131.61	480.51	50.45	-	1,541.44	4,319.58	3.83	0.06	0.21
30	-	-	-	-	615.28	919.28	76.61	283.34	137.89	497.84	52.27	-	1,586.84	4,319.58	3.94	0.05	0.20
31	-	-	-	-	616.83	963.13	80.26	291.23	144.47	515.96	54.18	-	1,634.13	4,319.58	4.05	0.05	0.18
32	-	-	-	-	618.17	1,009.07	84.09	299.44	151.36	534.89	56.16	-	1,683.41	4,319.58	4.16	0.04	0.17
33	-	-	-	-	619.39	1,057.20	88.10	308.01	158.58	554.69	58.24	-	1,734.84	4,319.58	4.28	0.04	0.16
34	-	-	-	-	620.49	1,107.63	92.30	316.96	166.15	575.41	60.42	-	1,788.54	4,319.58	4.40	0.03	0.15
35	-	-	-	-	621.46	1,160.47	96.71	326.31	174.07	597.08	62.69	-	1,844.62	4,319.58	4.53	0.03	0.14
36	-	-	-	-	622.30	1,215.82	101.32	336.07	182.37	619.76	65.07	-	1,903.20	4,319.58	4.67	0.03	0.13
37	-	-	-	-	623.08	1,273.82	106.15	346.28	191.07	643.50	67.57	-	1,964.46	4,319.58	4.81	0.02	0.12
38	-	-	-	-	623.75	1,334.58	111.21	356.95	200.19	668.36	70.18	-	2,028.50	4,319.58	4.96	0.02	0.11
39	-	-	-	-	624.37	1,398.24	116.52	368.12	209.74	694.38	72.91	-	2,095.52	4,319.58	5.11	0.02	0.10
40	-	-	-	-	624.92	1,464.93	122.08	379.81	219.74	721.62	75.77	-	2,165.62	4,319.58	5.28	0.02	0.09

Annexure - Financial Analysis – Tariff for 40 Years - @Rs.3.00/Unit cost of pumping

Year	Loan Outstanding	Interest On Loan	Depreciation	Repayment of Loan	Return on Equity	O & M Charges	O & M for 1 Month	Receivables	Spares	Working Capital	Interest on WC	Pumping Costs	Total Charges	Saleable Energy	Tariff	Discounting Factor	Discounted Tariff
#	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	Cr.	MUs	Rs./Unit	Factor	Rs./Unit
1	5,453.40	594.05	357.67	495.76	497.87	238.00	19.83	286.91	35.70	342.45	35.96	861.66	2,585.21	4,319.58	7.92	1.00	7.92
2	4,957.64	546.58	357.67	495.76	497.87	249.35	20.78	282.50	37.40	340.69	35.77	861.66	2,548.91	4,319.58	7.86	0.90	7.09
3	4,461.87	494.52	357.67	495.76	497.87	261.25	21.77	278.19	39.19	339.15	35.61	861.66	2,508.59	4,319.58	7.80	0.81	6.34
4	3,966.11	442.47	357.67	495.76	497.87	273.71	22.81	273.97	41.06	337.84	35.47	861.66	2,468.86	4,319.58	7.74	0.73	5.68
5	3,470.35	390.41	357.67	495.76	497.87	286.76	23.90	269.86	43.01	336.77	35.36	861.66	2,429.74	4,319.58	7.68	0.66	5.08
6	2,974.58	338.36	357.67	495.76	497.87	300.44	25.04	265.85	45.07	335.95	35.28	861.66	2,391.28	4,319.58	7.62	0.60	4.55
7	2,478.82	286.30	357.67	495.76	497.87	314.77	26.23	261.96	47.22	335.40	35.22	861.66	2,353.50	4,319.58	7.57	0.54	4.08
8	1,983.05	234.25	357.67	495.76	497.87	329.79	27.48	258.18	49.47	335.13	35.19	861.66	2,316.43	4,319.58	7.52	0.49	3.65
9	1,487.29	182.19	357.67	495.76	497.87	345.52	28.79	254.53	51.83	335.16	35.19	861.66	2,280.11	4,319.58	7.47	0.44	3.27
10	991.53	130.14	357.67	495.76	497.87	362.00	30.17	251.02	54.30	335.48	35.23	861.66	2,244.57	4,319.58	7.42	0.40	2.93
11	495.76	78.08	357.67	495.76	497.87	379.27	31.61	247.63	56.89	336.13	35.29	861.66	2,209.85	4,319.58	7.37	0.36	2.63
12	-	26.03	357.67	495.76	497.87	397.36	33.11	244.39	59.60	337.11	35.40	861.66	2,175.99	4,319.58	7.33	0.32	2.36

13	-	-	357.67	-	497.87	416.31	34.69	201.90	62.45	299.04	31.40	861.66	2,164.92	4,319.58	6.74	0.29	1.95
14	-	-	357.67	-	497.87	436.17	36.35	203.34	65.43	305.11	32.04	861.66	2,185.41	4,319.58	6.76	0.26	1.77
15	-	-	357.67	-	497.87	456.98	38.08	204.93	68.55	311.56	32.71	861.66	2,206.90	4,319.58	6.78	0.24	1.60
16	-	-	357.67	-	497.87	478.77	39.90	206.71	71.82	318.42	33.43	861.66	2,229.41	4,319.58	6.80	0.21	1.45
17	-	-	357.67	-	497.87	501.61	41.80	208.66	75.24	325.70	34.20	861.66	2,253.02	4,319.58	6.83	0.19	1.31
18	-	-	357.67	-	497.87	525.54	43.79	210.80	78.83	333.43	35.01	861.66	2,277.75	4,319.58	6.86	0.17	1.19
19	-	-	145.44	-	497.87	550.61	45.88	213.14	82.59	341.61	35.87	861.66	2,091.45	4,319.58	6.89	0.16	1.08
20	-	-	145.44	-	497.87	576.87	48.07	215.69	86.53	350.29	36.78	861.66	2,118.63	4,319.58	6.93	0.14	0.98
21	-	-	145.44	-	497.87	604.39	50.37	218.45	90.66	359.48	37.75	861.66	2,147.11	4,319.58	6.97	0.13	0.89
22	-	-	145.44	-	497.87	63311.22	52.77	221.45	94.98	369.20	38.77	861.66	2,176.96	4,319.58	7.01	0.11	0.80
23	-	-	145.44	-	562.84	663.42	55.29	235.70	99.51	390.50	41.00	861.66	2,274.37	4,319.58	7.21	0.10	0.74
24	-	-	145.44	-	697.66	695.07	57.92	262.05	104.26	424.24	44.54	861.66	2,444.37	4,319.58	7.57	0.09	0.71
25	-	-	145.44	-	704.51	728.22	60.69	266.96	109.23	436.88	45.87	861.66	2,485.71	4,319.58	7.64	0.08	0.64
26	-	-	145.44	-	710.88	762.96	63.58	272.39	114.44	450.42	47.29	861.66	2,528.24	4,319.58	7.72	0.08	0.59
27	-	-	145.44	-	715.56	799.35	66.61	279.51	119.90	466.03	48.93	861.66	2,570.95	4,319.58	7.81	0.07	0.53

28	-	-	-	-	611.17	837.48	69.79	268.43	125.62	463.84	48.70	861.66	2,359.02	4,319.58	7.66	0.06	0.47
29	-	-	-	-	613.16	877.43	73.12	275.71	131.61	480.44	50.45	861.66	2,402.70	4,319.58	7.76	0.06	0.43
30	-	-	-	-	614.93	919.28	76.61	283.28	137.89	497.78	52.27	861.66	2,448.15	4,319.58	7.87	0.05	0.39
31	-	-	-	-	616.48	963.13	80.26	291.17	144.47	515.90	54.17	861.66	2,495.44	4,319.58	7.98	0.05	0.36
32	-	-	-	-	617.87	1,009.07	84.09	299.39	151.36	534.84	56.16	861.66	2,544.77	4,319.58	8.09	0.04	0.33
33	-	-	-	-	619.12	1,057.20	88.10	307.96	158.58	554.64	58.24	861.66	2,596.22	4,319.58	8.21	0.04	0.30
34	-	-	-	-	620.21	1,107.63	92.30	316.91	166.15	575.36	60.41	861.66	2,649.92	4,319.58	8.33	0.03	0.28
35	-	-	-	-	621.21	1,160.47	96.71	326.26	174.07	597.04	62.69	861.66	2,706.03	4,319.58	8.46	0.03	0.25
36	-	-	-	-	622.08	1,215.82	101.32	336.03	182.37	619.72	65.07	861.66	2,764.64	4,319.58	8.60	0.03	0.23
37	-	-	-	-	622.85	1,273.82	106.15	346.24	191.07	643.47	67.56	861.66	2,825.90	4,319.58	8.74	0.02	0.21
38	-	-	-	-	623.55	1,334.58	111.21	356.92	200.19	668.32	70.17	861.66	2,889.96	4,319.58	8.89	0.02	0.20
39	-	-	-	-	624.17	1,398.24	116.52	368.09	209.74	694.34	72.91	861.66	2,956.98	4,319.58	9.04	0.02	0.18
40	-	-	-	-	624.72	1,464.93	122.08	379.77	219.74	721.59	75.77	861.66	3,027.08	4,319.58	9.21	0.02	0.16

CHAPTER – 9

RECOMMENDATIONS AND CONCLUSIONS

This project is a good fit as,

- Independent PSH tied to discom
- Firm RE power (RE integration)
- Coupling with lower variable cost thermal to increase PLF
- Ancillary services

Hence Adani Green to go ahead with the PSH proposal for seeking clearances.

Suggested next steps

While Adani Green approaches Govt of Maharashtra and Government of Maharashtra Irrigation Department (GoMID), following shall be highlighted and mutually agreed in the MoU.

- The reservoir drawdown, all outage/maintenance of upper reservoir related equipment impacting water level and contents shall be planned and coordinated with Adani Green
- Irrigation Department / Warana should keep the current low level water contents of approx 22 Mm3
- The quantity of water used for Generation, Pumped water, evaporation losses (lower pond) and water balance will be accounted monthly
- Adani Green can pump approximately 30 Mm3 of west flowing water to east if the compensation is right and after netting off evaporation loss, seepage loss of lower reservoir
- To avail construction water from the same lake
- Check whether the monsoon overflow to east can be diverted during the overflow days in monsoon months if there is margin in the KWTDA quota allotted to Koyna to meet irrigation command area development if any is planned downstream of proposed Patgaon PSH

Annexure I - LIST OF VARIOUS CLEARANCES

Sr No	Clearances	Authorized Agency
PREDEVELOPMENT		
Corporate		
1	Certificate of Incorporation, Commencement of Business	Registrar of Companies
2	Filing of Industrial Enterprise Memorandum	Ministry of Commerce and Industry
3	Sales Tax Registration	Sales Tax Department
4	IT PAN No.	IT Department
5	Offshore Financing Arrangements, Tax Confirmation, Insurance and IPO	Ministry of Finance / CBDT / RBI / SEBI
6	Mega Power Status	Ministry of Power
7	Memorandum of Understanding with State Govt.	State Govt.
Labour		
8	Registration under the State Employees Insurance Act 1948	Labour Department of State Government
9	Registration under Minimum Wages Act	Labour Department of State Government
10	Registration under Labour Act	Zonal Labor commissioner
11	Registration under the Provident Funds Act	Labour Department of State Government
Land Acquisition / ROW / Connectivity		
12	Approval for land requirement	State Govt.
13	Stamp Duty Exemption	State Investment Promotional Board

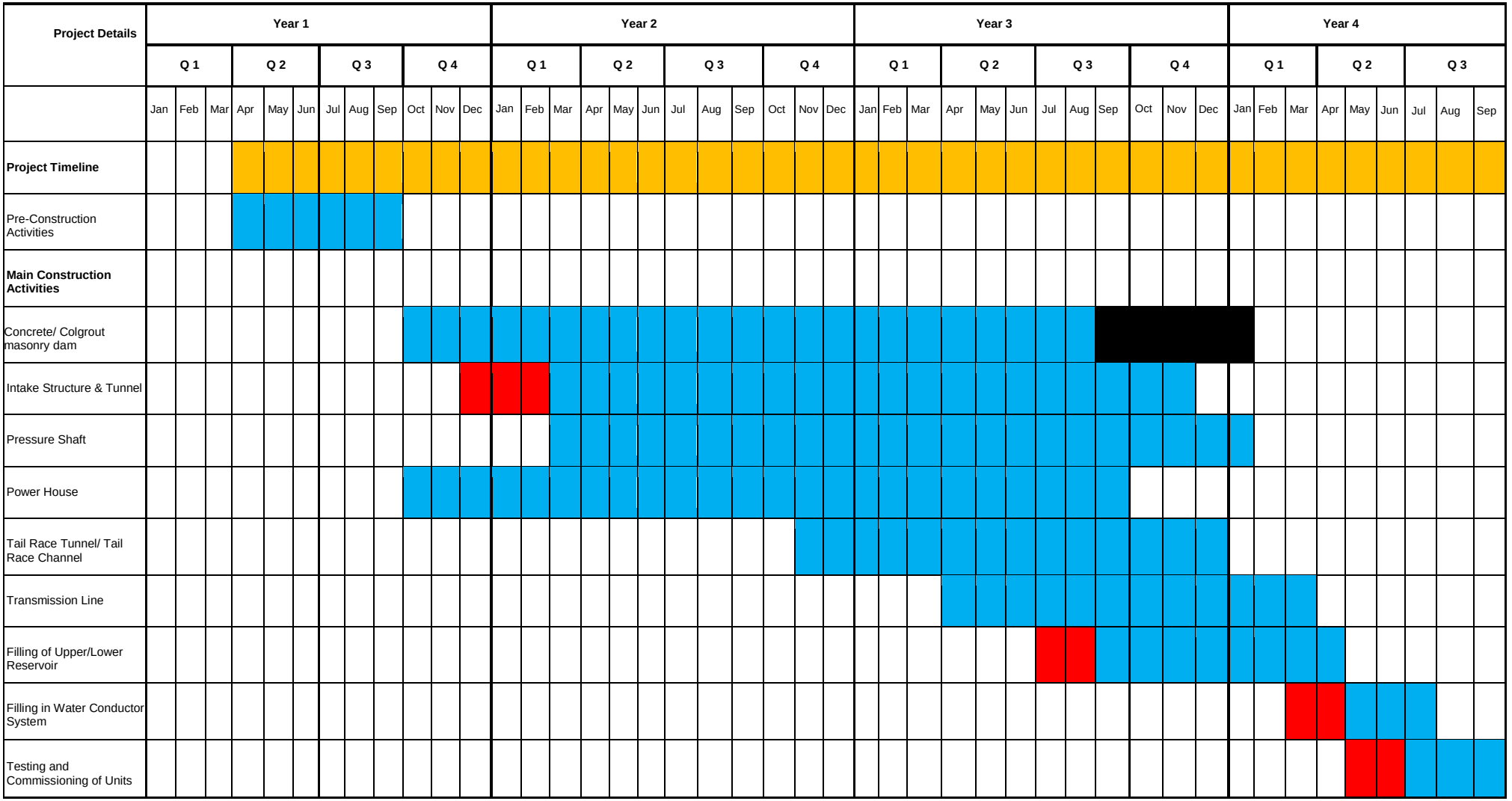
Sr No	Clearances	Authorized Agency
14	Private Land Acquisition	Ministry of Revenue / Industry / Energy / District Collector / State IDC / Local Grampanchayat and Private owners
15	Allocation of Govt. Land	State Industrial Development Corporation
16	Allocation of Forest Land	Chief Conservator of Forest (State Level)
17	Conversion of Land use to Non agriculture purposes	District Collector/ Revenue Department
18	Allocation of Tribal Land	State Govt.
19	Allocation of Land for Fuel Transport (Railway siding)	State Govt.
20	Water intake Pipeline - Right of Way	Individual Land Owners / Maritime Board if Coastal site
21	Land acquisition for Water intake Pump house	State Govt. / Individual Land Owners
22	Construction Power line - Right of Way	Individual LandOwners / State Electricity Distribution Co. (if subcontracted)
23	Power Evacuation Line - Right of Way	Individual LandOwners / State Electricity Transmission Co. (if subcontracted)
24	Airstrip and helicopter landing pad, and use of helicopter and / or other aircraft	Director General of Civil Aviation
25	Provision of telecommunications and satellite facilities,	Department of Telecommunication
Coastal Regulatory Zone (CRZ)		
26	CRZ Clearance	State Coastal Zone Management Authority
27	Water drawal permission	State Coastal Authority / MoEF (impact study – type of cooling system)
Water Linkage		
28	Approval for water drawal from Perennial River / Dam	State Water Resources / Irrigation Department / Central Water Commission
29	Approval for water intake system design	State Water Resources Department / Irrigation Department

Sr No	Clearances	Authorized Agency
30	Permission for use of ground water during construction	State Water Resources Department / Irrigation Department
Coal		
31	Coal Linkage / Supply Agreement / Application for allotment for coal block	Ministry of Coal, New Delhi
32	Permission for Railway siding / ROW for rail track	Ministry of Railways
33	Preparation and approval of Mining Plan	State Govt.
34	Fuel Transport Agreement	Ministry of Railways / Ministry of Coal
35	Approval for usage of waterfront and construction of Jetty (in case seafront is used for transport)	State maritime Board / Port Trust
Power Purchase Agreement (PPA)		
36	Power Purchase Agreement (PPA)	Regulator / Discom
Environmental Clearance		
37	No-objection Certificate / Consent to Establish	State Pollution Control Board (SPCB)
38	Approval of Rehabilitation and Resettlement Plan	MoEF
39	EIA Study, Public hearing, submission of report	SPCB / District Collector
40	Receipt of Environment Clearance	MoEF
Miscellaneous Clearances		
41	Permission for various imports / spares pursuant to the Foreign Trade (Development and Regulation) Act 1992.	Directorate General of Technical Development/ Director General of Foreign Trade
42	Clearance for transportation of heavy material /machinery on roads / bridge	State and National Transport Authority

Sr No	Clearances	Authorized Agency
43	NOC for Construction	Local Gram Panchayat
44	No Objection Certificate for storage of construction Materials and chemicals, etc.	Local Municipal Corporation
45	Chimney / Stack Height Clearance	Airport Authority of India
46	Approval of proposed design and construction of the project pursuant to section 6 of the factories act,1948.	Chief Inspector of Factories
47	Defence Clearance	Ministry of Defence
48	Construction Power Approval	State Electricity Distribution Company
49	Approvals as per Explosives Act for blasting and allied activities for site preparation	Chief Controller of Explosives
Power Evacuation and Open Access		
50	Approval from transmission utility	Central / State Transmission Utility
51	Execution of Bulk Purchase Transmission Agreement (BPTA) with concerned STU / CTU	
POST DEVELOPMENT		
52	Approval for Factories - Pre and Post installation	Chief Inspector of Factories
53	Essentiality certificate for import duty concession	State Energy dept
54	Approval for Electrical Layout - Pre and Post installation	Electrical Inspectorate
55	Approval and Registration of steam generator and allied pressure parts as per Indian Boiler Regulation	Chief Inspectorate of Boilers

Sr No	Clearances	Authorized Agency
56	Consent to Operate Plant	Pollution Control Board / MoEF
57	Customs Clearance for Capital Goods Import	Customs Department
58	Consent under the Factories Act 1948 relating to fire fighting capability	Fire Inspector
59	CEIG Clearance	Chief Electrical Inspector to Govt.
60	Approval of weigh bridge and weigh scales	Inspector of weights and Measures
61	Approval as per Indian petroleum Act and petroleum Rules for storage and transport of petroleum product	Chief Controller of Explosives
62	Approval as per gas cylinder rules and handling and transport of compressed gases	Chief Controller of Explosives
63	Review the frequency used for Power Line Carrier Communication (PLCC) system to ensure no interference with other power line users	Postal Telecommunication coordination Committee (PTCC)
64	Commissioning and COD certification	State Authority
65	Forest Conservation Act and Wildlife Protection Act	Chief Conservator of Forests and Chief Wildlife Warden (State and Central)

Annexure II - TENTATIVE CONSTRUCTION SCHEDULE



NOTES:

1. Red colour indicates in advance (start early) starting date of this activity
2. Black colour indicates activity should finish early. Finish early
3. Testing Commissioning time of only 3 machines is very short for SEVEN units hence need to be preponed
4. Filling of Lower/ Upper dam activity should commence just in July i.e. just prior to monsoon to take advantage of Rains
5. Normal practice is to commission the Project/Units before 31st March or 30th Sept (Closure of yearly /half yearly Financial Year)
6. This schedule covers all the site activities after LETTER OF INTENT/AWARD OF CONTRACT is issued which shall be covered in CONTRACTORS' SCOPE.
7. Pre construction activities such as preparation of DPR, EIA reports Statutory permissions, Activities viz. Site investigation, Detail survey. exploratory boring, etc are NOT included in this schedule. **This is PURELY CONSTRUCTION SCHEDULE**

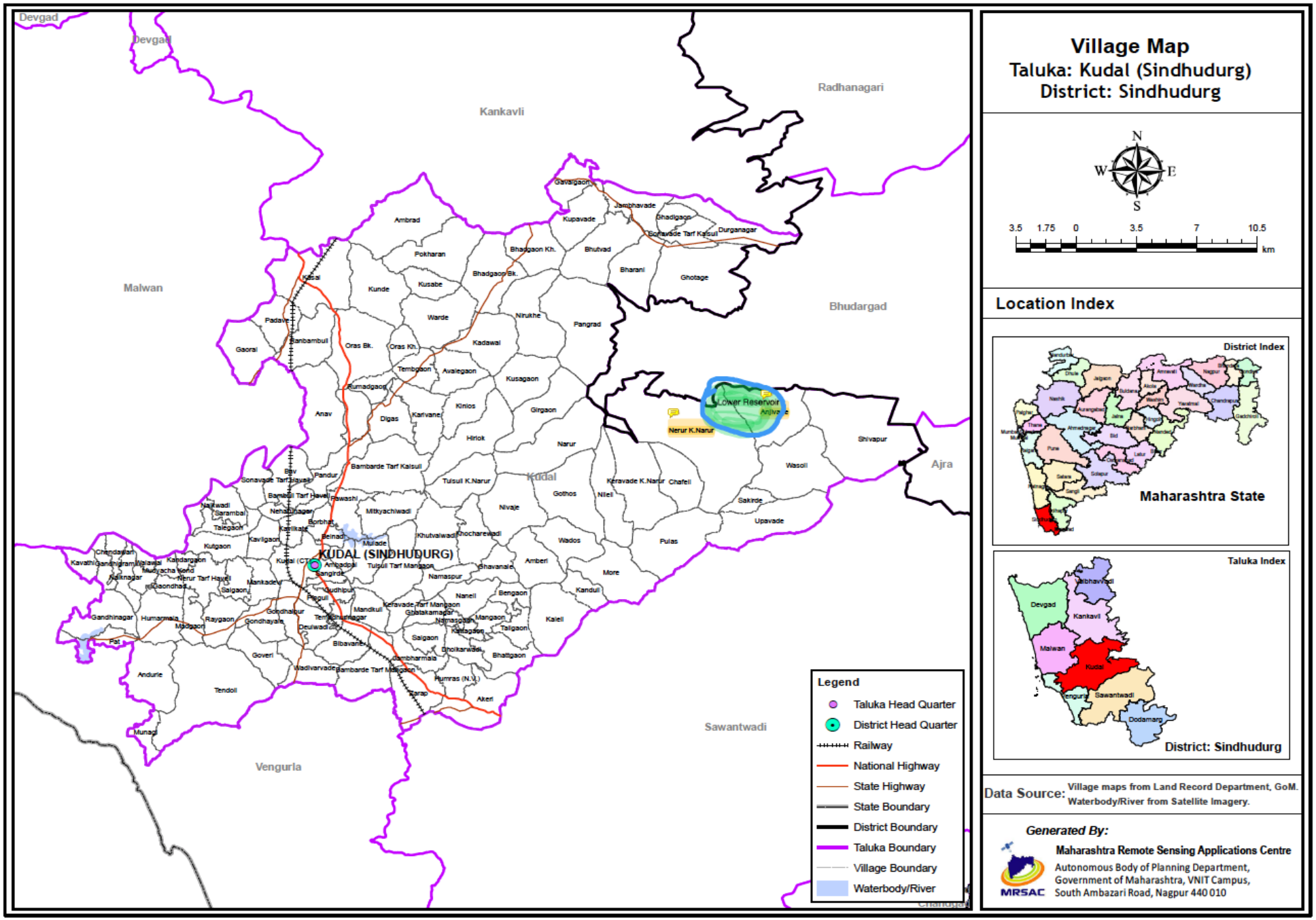
Annexure III - Generation Operation Simulation

							Generator Efficiency		0.98																	
Operating Levels and Storage available at Reservoirs							Turbine Efficiency		0.92	Scenario: Operating Levels considered for Operation Simulation of Pumping Mode																
Upper reservoir				Lower reservoir			Transformer Efficiency		0.99	Upper reservoir				Lower reservoir												
							Overall efficiency		0.892584																	
	Level	Storage			Level	Storage	Head	m																		
	(m)	(MCum)			(m)	(MCum)																				
FRL	626.6	105.26	FRL		225	13.75	Starting	437.272		FRL-PS	Level	626.6		FRL-PS Operation		225	13.75								
Rated Lake level	622.772	69.61	Av Lake level		210	7.03	gross h			Operation	(m)						-									
MDDL	615	0.46	MDDL		185.5	0.85	Starting	430.272		MDDL-PS	Level	615		MDDL-PS Operation		185.5	0.85								
Total Live Storage		104.8	Live Storage			12.9	net head			Operation	(m)			Pondage for PS Operation			12.9								
Rated Gross head	m	410.807	Rated Q	cumecs	592.23																					
Rated friction loss	m	7																								
Rated net head	m	403.807																								

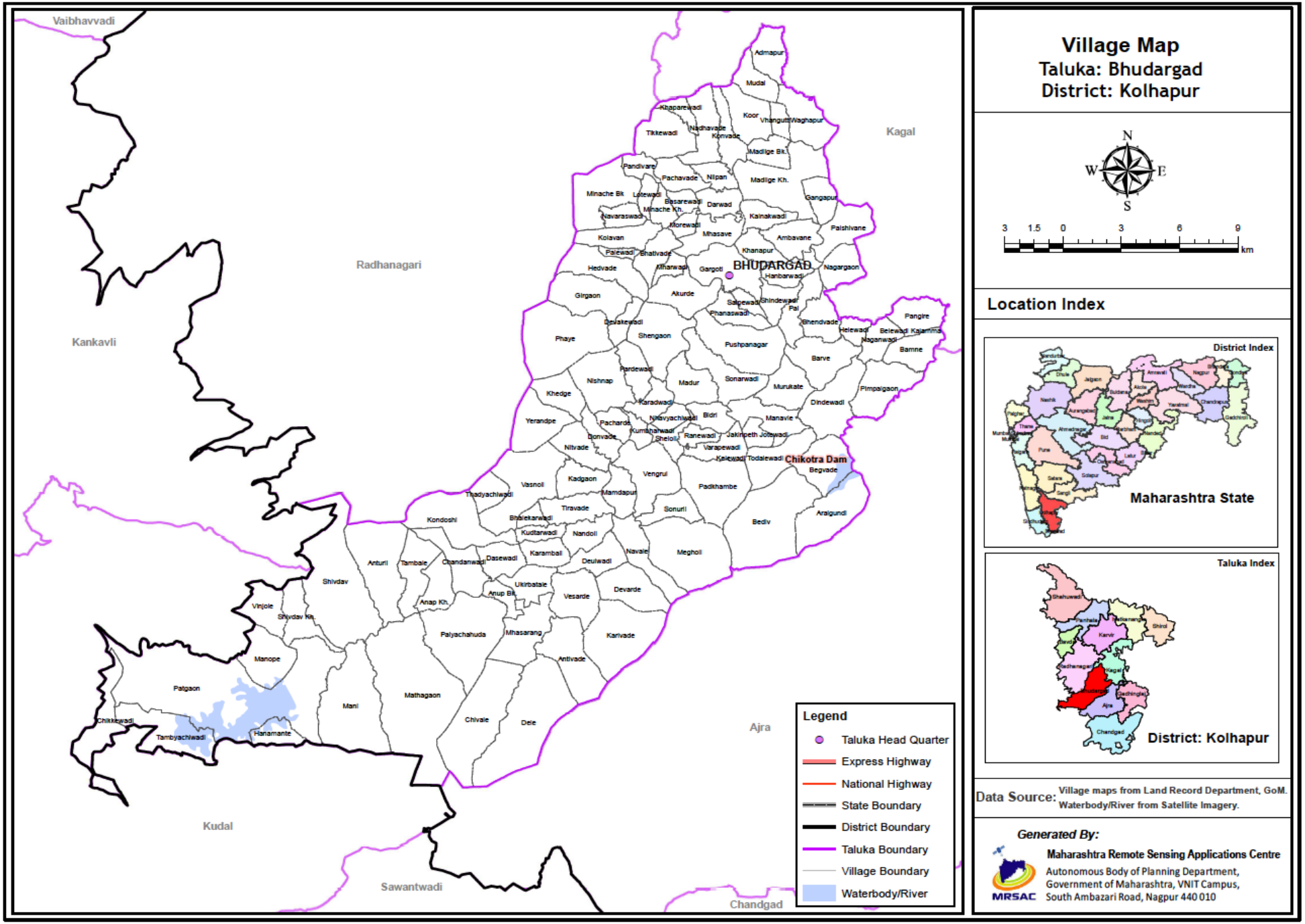
			Upper Pond							Lower Pond															
Interval No	Time Interval (Minutes)	Station Output (MW)	Initial Pond Level (m)	Initial Storage (MCum)	Initial Net head	Outflow from Pond (MCum)	Final Storage (MCum)	Final Pond Level (m)	Average Pond Level (m)	Initial Pond Level (m)	Initial Storage (MCum)	Inflow into Pond (MCum)	Final Storage (MCum)	Final Pond Level (m)	Average Pond Level (m)	Energy Generation (MWh)	Average Net Head (m)	Average Turbine discharge (cumecs)	Actual Friction loss of head(m)	Actual Average Head (m)	Actual Average Turbine Discharge cumecs	Actual Turbine Outflow (mcm)	Final Upper Pond Storage (mcm)	Final Upper Pond Level (m)	Final Lower Pond Storage (mcm)	Final Lower Pond Level (m)
1	10	2100	622.772	69.610	430.272	0.334	69.28	622.005	622.3887	185.5	0.850	0.334	1.18	186.263	185.882	350	429.507	558.381	6.223	430.284	557.373	0.334	69.276	622.005	1.184	186.263
2	10	2100	622.005	69.276	428.742	0.336	68.94	621.926	621.9655	186.263	1.184	0.336	1.52	187.942	187.102	350	427.863	560.527	6.271	428.593	559.573	0.336	68.940	621.926	1.520	187.942
3	10	2100	621.926	68.940	426.983	0.337	68.60	621.845	621.8852	187.942	1.520	0.337	1.86	189.591	188.767	350	426.118	562.822	6.322	426.796	561.928	0.337	68.603	621.845	1.857	189.592
4	10	2100	621.845	68.603	425.253	0.338	68.26	621.763	621.8039	189.592	1.857	0.338	2.20	219.67	219.66	350	395.144	606.940	7.352	394.792	607.482	0.364	68.238	621.757	2.222	191.335
5	10	2100	621.757	68.238	423.422	0.340	67.90	621.674	621.7151	191.335	2.222	0.340	2.56	219.71	219.7	350	395.015	607.138	7.357	394.658	607.687	0.365	67.874	621.668	2.586	193.035
6	10	2100	621.668	67.874	421.632	0.341	67.53	621.583	621.6255	193.035	2.586	0.341	2.93	219.75	219.74	350	394.885	607.337	7.362	394.524	607.894	0.365	67.509	621.578	2.951	194.694
7	10	2100	621.578	67.509	419.884	0.343	67.17	621.492	621.535	194.694	2.951	0.343	3.29	219.8	219.78	350	394.755	607.538	7.367	394.388	608.103	0.365	67.144	621.487	3.316	196.310
8	10	2100	621.487	67.144	418.177	0.344	66.80	621.400	621.4436	196.310	3.316	0.344	3.66	219.84	219.83	350	394.614	607.756	7.372	394.242	608.329	0.365	66.779	621.395	3.681	197.885
9	10	2100	621.395	66.779	416.510	0.345	66.43	621.308	621.3514	197.885	3.681	0.345	4.03	219.88	219.87	350	394.481	607.960	7.377	394.105	608.541	0.365	66.414	621.303	4.046	199.417
10	10	2100	621.303	66.414	414.886	0.347	66.07	621.214	621.2583	199.417	4.046	0.347	4.39	219.93	219.91	350	394.348	608.165	7.382	393.967	608.754	0.365	66.049	621.209	4.411	200.907
11	10	2100	621.209	66.049	413.302	0.348	65.70	621.119	621.1643	200.907	4.411	0.348	4.76	219.97	219.96	350	394.204	608.387	7.387	393.817	608.985	0.365	65.683	621.115	4.777	202.355
12	10	2100	621.115	65.683	411.760	0.349	65.33	621.024	621.0695	202.355	4.777	0.349	5.13	220.01	220	350	394.069	608.595	7.392	393.677	609.201	0.366	65.318	621.020	5.142	203.761
13	10	2100	621.020	65.318	410.259	0.351	64.97	620.928	620.9738	203.761	5.142	0.351	5.49	220.06	220.04	350	393.934	608.805	7.397	393.536	609.419	0.366	64.952	620.924	5.508	205.124
14	10	2100	620.924	64.952	408.800	0.352	64.60	620.831	620.8772	205.124	5.508	0.352	5.86	220.1	220.09	350	393.787	609.031	7.403	393.384	609.655	0.366	64.586	620.827	5.874	206.445
15	10	2100	620.827	64.586	407.382	0.353	64.23	620.733	620.7797	206.445	5.874	0.353	6.23	220.14	220.13	350	393.650	609.244	7.408	393.242	609.876	0.366	64.220	620.729	6.240	207.724
16	10	2100	620.729	64.220	406.005	0.354	63.87	620.634	620.6814	207.724	6.240	0.354	6.59	220.19	220.17	350	393.511	609.458	7.413	393.098	610.099	0.366	63.854	620.630	6.606	208.960
17	10	2100	620.630	63.854	404.671	0.356	63.50	620.534	620.5821	208.960	6.606	0.356	6.96	220.23	220.22	350	393.362	609.689	7.419	392.943	610.339	0.366	63.488	620.531	6.972	210.154
18	10	2100	620.531	63.488	403.377	0.357	63.13	620.433	620.4821	210.154	6.972	0.357	7.33	220.27	220.26	350	393.222	609.907	7.424	392.798	610.565	0.366	63.122	620.431	7.338	211.305
19	10	2100	620.431	63.122	402.126	0.358	62.76	620.332	620.3811	211.305	7.338	0.358	7.70	220.32	220.3	350	393.081	610.125	7.429	392.652	610.793	0.366	62.755	620.329	7.705	212.413
20	10	2100	620.329	62.755	400.916	0.359	62.40	620.229	620.2792	212.413	7.705	0.359	8.06	220.36	220.35	350	392.929	610.361	7.435	392.494	611.038	0.367	62.389	620.227	8.071	213.479
21	10	2100	620.227	62.389	399.748	0.360	62.03	620.126	620.1765	213.479	8.071	0.360	8.43	220.41	220.39	350	392.786	610.583	7.441	392.346	611.269	0.367	62.022	620.124	8.438	214.503
22	10	2100	620.124	62.022	398.621	0.361	61.66	620.022	620.0729	214.503	8.438	0.361	8.80	220.45	220.44	350	392.633	610.822	7.446	392.186	611.517	0.367	61.655	620.020	8.805	215.483
23	10	2100	620.020	61.655	397.537	0.362	61.29	619.917	619.9684	215.483	8.805	0.362	9.17	220.49	220.48	350	392.488	611.047	7.452	392.036	611.751	0.367	61.288	619.915	9.172	216.421
24	10	2100	619.915	61.288	396.494	0.363	60.92	619.811	619.863	216.421	9.172	0.363	9.54	220.54	220.52	350	392.343	611.273	7.457	391.886	611.987	0.367	60.921	619.810	9.539	217.316
25	10	2100	619.810	60.921	395.493	0.364	60.56	619.704	619.7567	217.316	9.539	0.364	9.90	220.58	220.57	350	392.187	611.517	7.463	391.723	612.240	0.367	60.553	619.703	9.907	218.168
26	10	2100	619.703	60.553	394.535	0.365	60.19	619.596	619.6496	218.168	9.907	0.365	10.27	220.63	220.61	350	392.040	611.746	7.469	391.571	612.479	0.367	60.186	619.595	10.274	218.978
27	10	2100	619.595	60.186	393.618	0.366	59.82	619.488	619.5415	218.978	10.274	0.366	10.64	220.67	220.66	350	391.882	611.993	7.475	391.407	612.736	0.368	59.818	619.487	10.642	219.744
28	10	2100	619.487	59.818	392.743	0.366	59.45	619.378	619.4326	219.744	10.642	0.366	11.01	220.72	220.7	350	391.733	612.226	7.481	391.252	612.978	0.368	59.450	619.378	11.010	220.467
29	10	2100	619.378	59.450	391.910	0.367	59.08	619.268	619.3227	220.467	11.010	0.367	11.38	220.76	220.75	350	391.573	612.476	7.487	391.086	613.238	0.368	59.083	619.268	11.377	221.148
30	10	2100	619.268	59.083	391.120	0.368	58.71	619.157	619.212	221.148	11.377	0.368	11.75	220.81	220.79	350	391.422	612.711	7.493	390.929	613.483	0.368	58.714	619.156	11.746	221.785
31	10	2100	619.156	58.714	390.372	0.369	58.35	619.044	619.1004	221.785	11.746	0.369	12.11	220.85	220.84	350	391.260	612.964	7.499	390.762	613.747	0.368	58.346	619.044	12.114	222.379
32	10	2100	619.044	58.346	389.666	0.369	57.98	618.931	618.9879	222.379	12.114	0.369	12.48	220.9	220.88	350	391.108	613.203	7.505	390.603	613.996	0.368	57.978	618.932	12.482	222.929
33	10	2100	618.932	57.978	389.002	0.370	57.61	618.817	618.8745	222.929	12.482	0.370	12.85	220.94	220.93	350	390.945	613.460	7.511	390.434	614.262	0.369	57.609	618.818	12.851	223.437
34	10	2100	618.818	57.609	388.381	0.371	57.24	618.703	618.7602	223.437	12.851	0.371	13.22	220.99	220.97	350	390.790	613.702	7.517	390.273	614.515	0.369	57.241	618.703	13.219	223.901
35	10	2100	618.703	57.241	387.802	0.371	56.87	618.587	618.645	223.901	13.219	0.371	13.59	220.99	220.97	350	390.675	613.883	7.521	390.154	614.703	0.369	56.872	618.588	13.588	224.322
36	10	2100	618.588	56.872	387.266	0.372	56.50	618.470	618.529	224.322	13.588	0.372	13.96	220.99	220.97	350	390.559	614.065	7.526	390.033	614.893	0.369	56.503	618.471	13.957	224.699

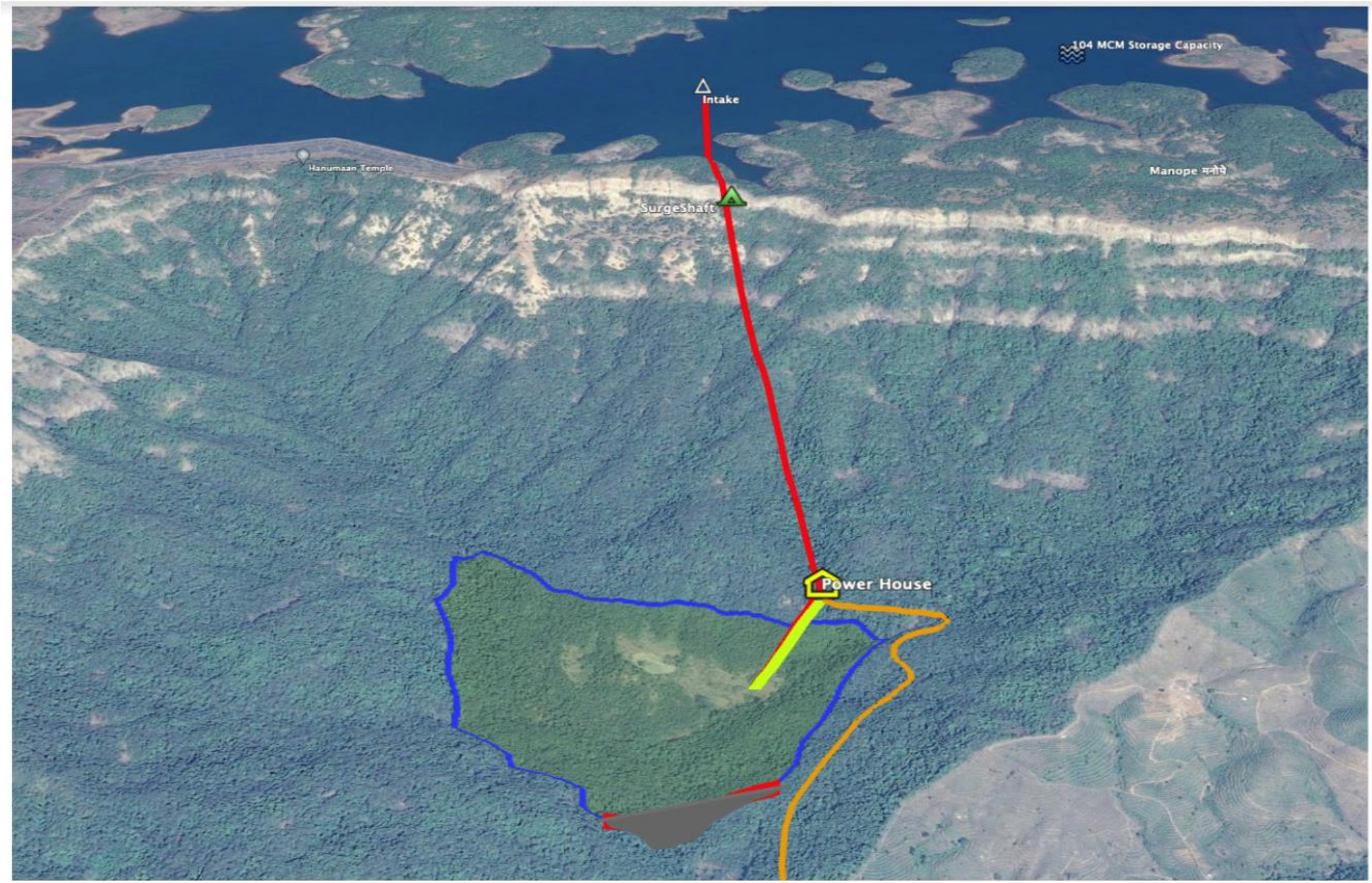
Drawing

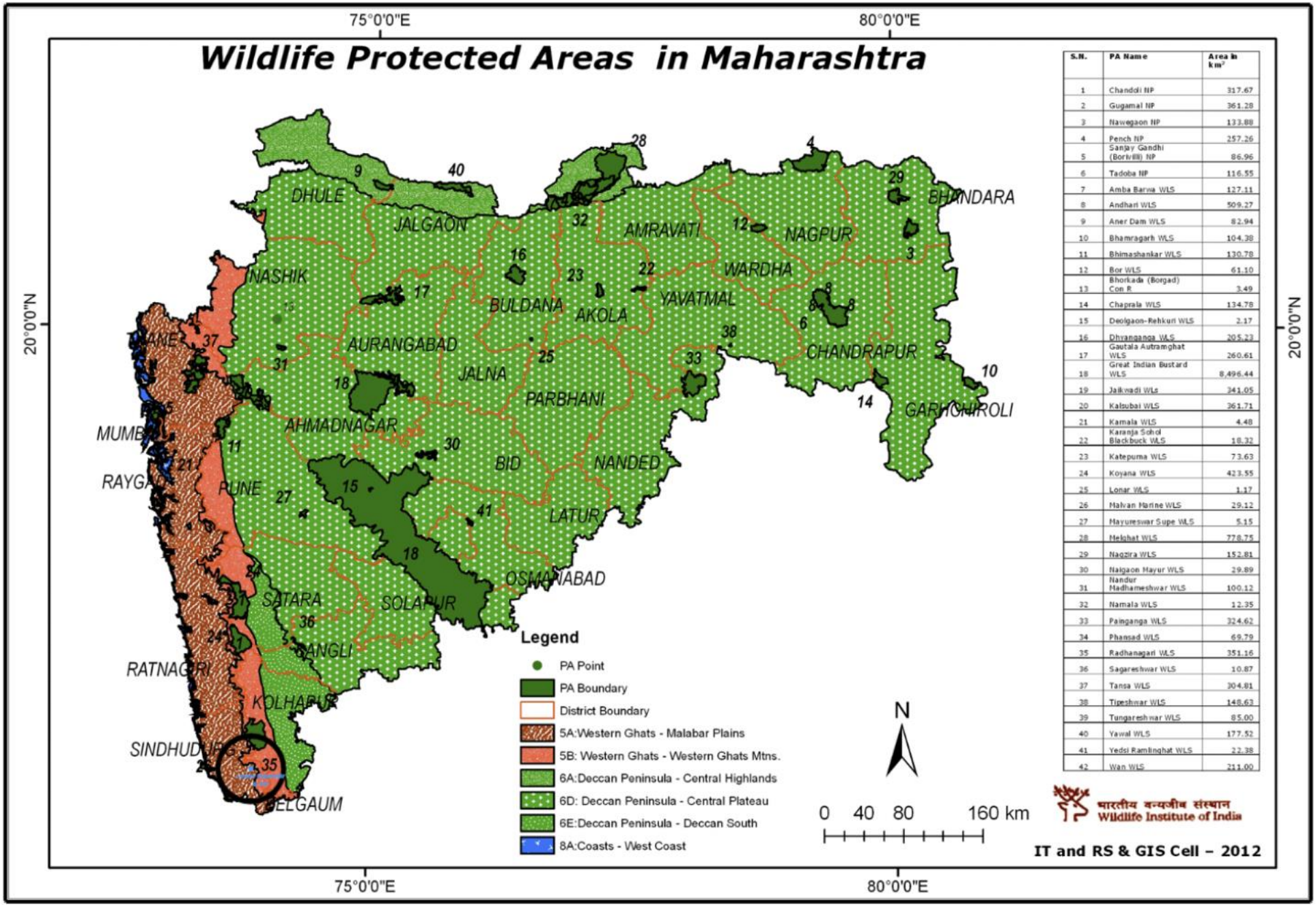
PROJECT LOCATION MAP, DRAWING NUMBER 001



PROJECT LOCATION MAP, DRAWING NUMBER 002

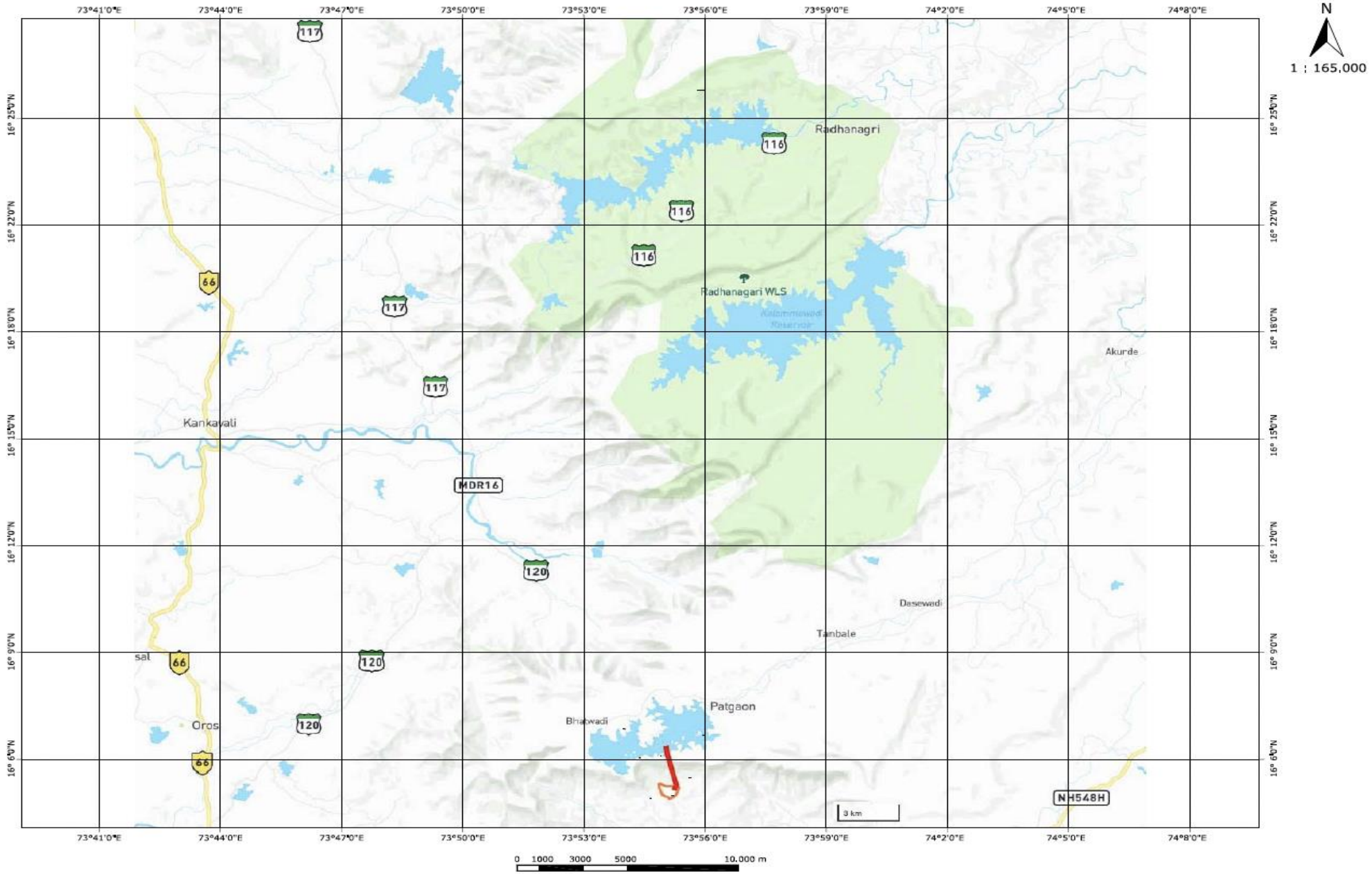


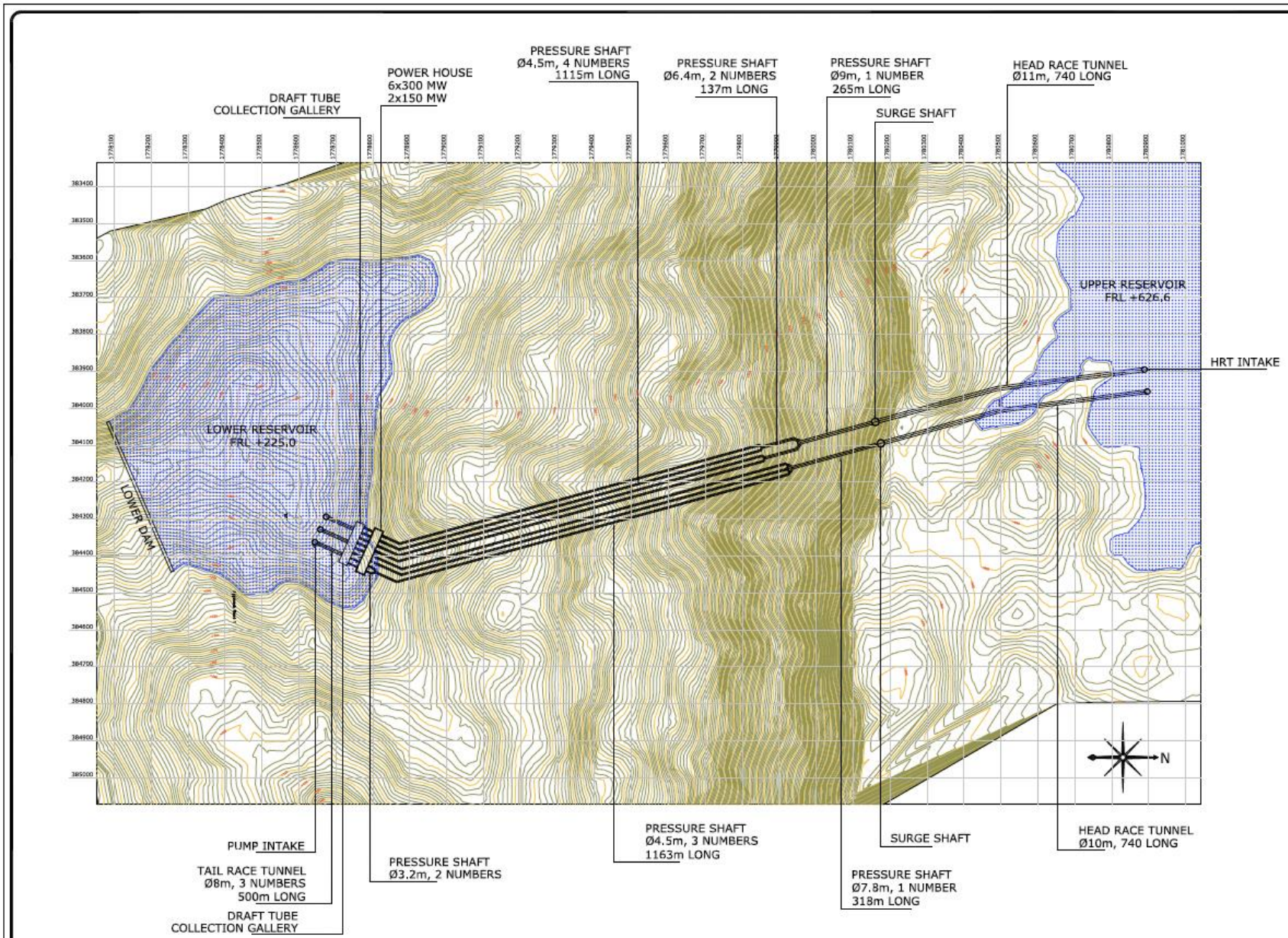

104 MCM Storage Capacity
Intake
Hanumaan Temple
Manope मनोपे
SurgeShaft
Power House



S.N.	PA Name	Area in km²
1	Chandoli NP	317.67
2	Gugamal NP	361.28
3	Nawegaon NP	133.88
4	Pench NP	257.26
5	Sanjay Gandhi (Borivili) NP	86.96
6	Tadoba NP	116.55
7	Amba Barwa WLS	127.11
8	Andhari WLS	509.27
9	Aner Dam WLS	82.94
10	Bhamragarh WLS	104.38
11	Bhimashankar WLS	130.78
12	Bor WLS	61.10
13	Bhorkada (Borgad) Con R	3.49
14	Chaprala WLS	134.78
15	Deolgaon-Rehkuri WLS	2.17
16	Dhyanganga WLS	205.23
17	Gautala Autramghat WLS	260.61
18	Great Indian Bustard WLS	8,496.44
19	Jaikwadi WLs	341.05
20	Kalsubai WLS	361.71
21	Kamala WLS	4.48
22	Karanja Sohol Blackbuck WLS	18.32
23	Katepurna WLS	73.63
24	Koyana WLS	423.55
25	Lonar WLS	1.17
26	Malvan Marine WLS	29.12
27	Mayureswar Supe WLS	5.15
28	Melghat WLS	778.75
29	Nagzira WLS	152.81
30	Naigaon Mayur WLS	29.89
31	Nandur Madhameshwar WLS	100.12
32	Namala WLS	12.35
33	Painganga WLS	324.62
34	Phansad WLS	69.79
35	Radhanagari WLS	351.16
36	Sagareshwar WLS	10.87
37	Tansa WLS	304.81
38	Tipeshwar WLS	148.63
39	Tungareshwar WLS	85.00
40	Yawal WLS	177.52
41	Yedsi Ramlinghat WLS	22.38
42	Wan WLS	211.00

WILDLIFE PROTECTED AREA PROXIMITY MAP:





SCHEMATIC PLAN OF THE SCHEME

SCALE 1 : 10,000

PLERIMINARY DRAWING

NOTES:

REVISION:		
NO	DATE	DESCRIPTION
.	.	.

OWNER:

adani

ADANI GREEN ENERGY LIMITED

Shantigram, Near Vaishnodevi Circle, S G Highway, Ahmedabad 382421, Gujarat, India.

CONSULTANTS:

Splash Power

Synergy Power Through Time

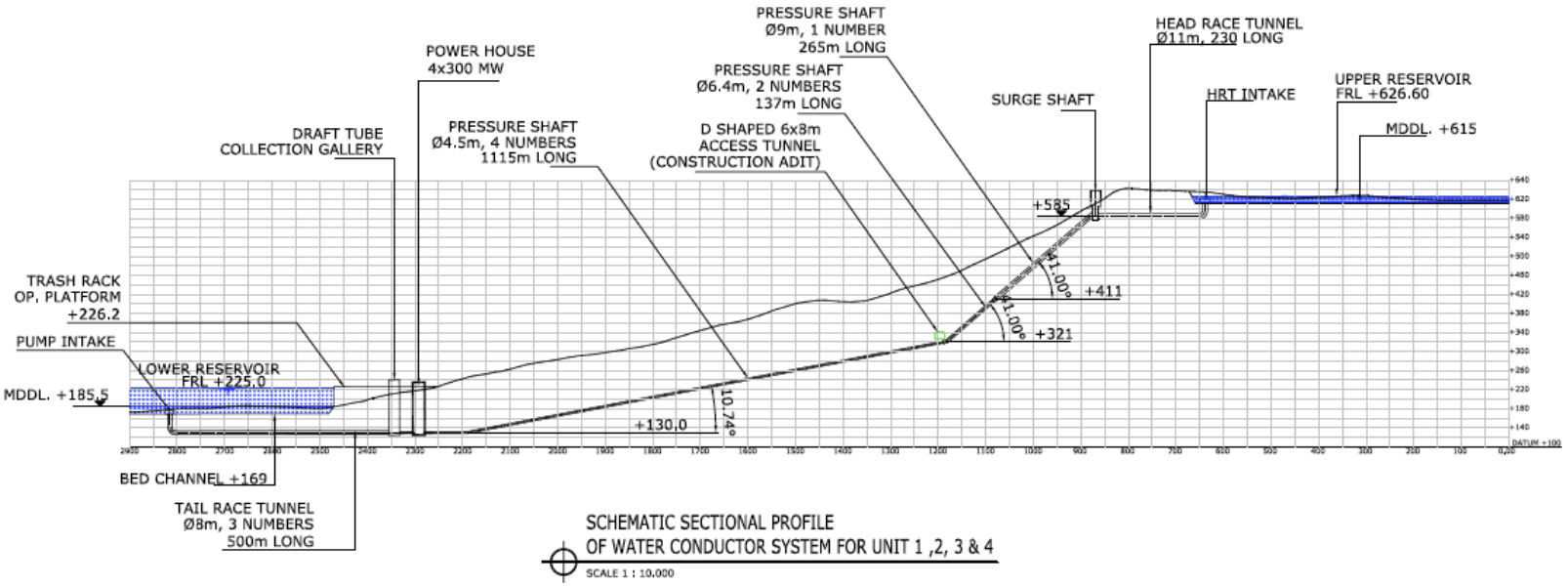
6x300 MW + 2x150 MW
PATGAON PSH

DRAWING TITLE:

SCHEMATIC LAYOUT
PLAN AND SECTIONAL PROFILE

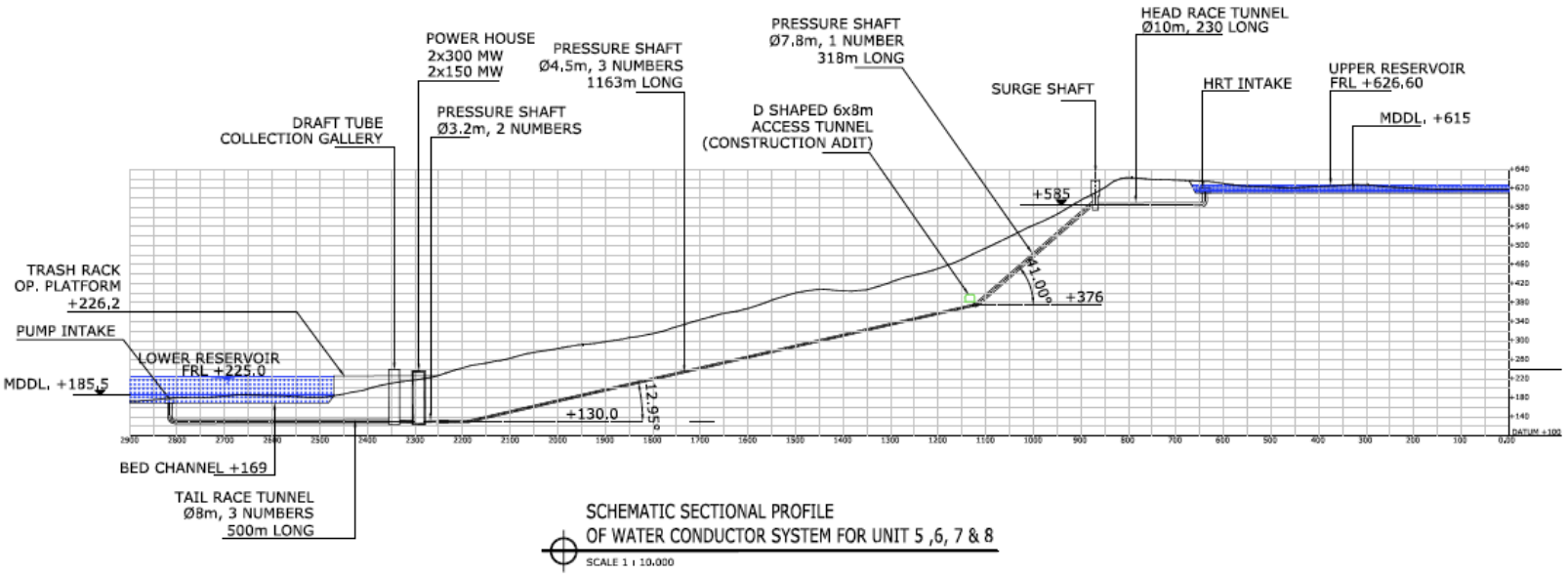
	SIGN	DATE
DRAWN BY	KHAIRUL AMRI	
APPROVED BY	Y.S.DANDEKAR	

DRAWING NO.	DATE	REVISION
AG-MH-02-01	09 JUL 2022	P0
SCALE AS SHOWN		
SHEET	1 OF 2	



SCHEMATIC SECTIONAL PROFILE
OF WATER CONDUCTOR SYSTEM FOR UNIT 1 ,2, 3 & 4

SCALE 1 : 10.000



SCHEMATIC SECTIONAL PROFILE
OF WATER CONDUCTOR SYSTEM FOR UNIT 5 ,6, 7 & 8

SCALE 1 : 10.000

PLERIMINARY DRAWING

NOTES:

REVISION:

NO	DATE	DESCRIPTION
.	.	.

OWNER:

adani

ADANI GREEN ENERGY LIMITED

Shantigram, Near Vaishnodevi Circle, S G Highway, Ahmedabad-382421, Gujarat, India.

CONSULTANTS:

Splash Power

Moving Power Through Time

6x300 MW + 2x150 MW
PATGAON PSH

DRAWING TITLE:

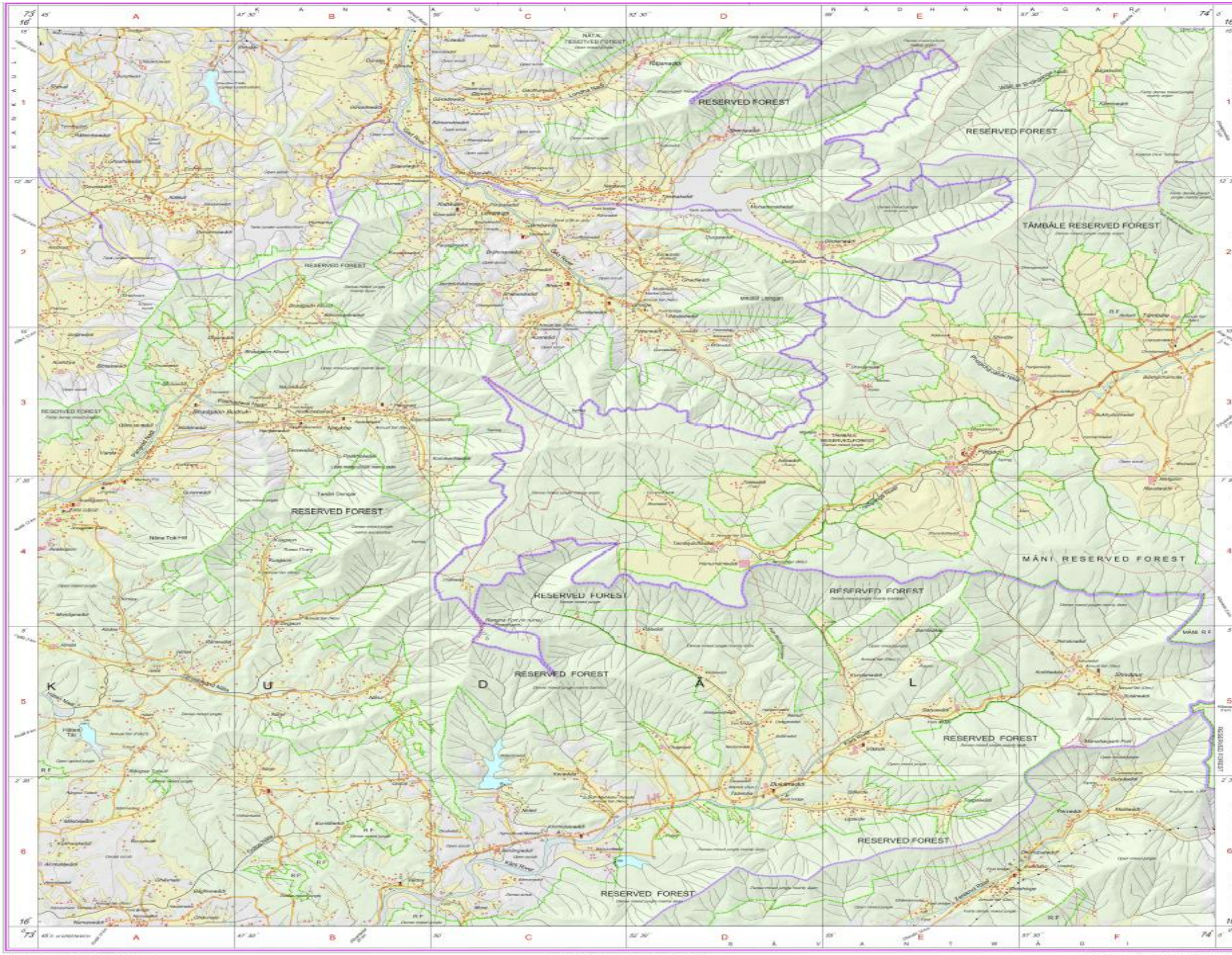
SCHEMATIC LAYOUT
PLAN AND SECTIONAL PROFILE

	SIGN	DATE
DRAWN BY	KHAIRUL AMRI	
APPROVED BY	Y.S.DANDEKAR	

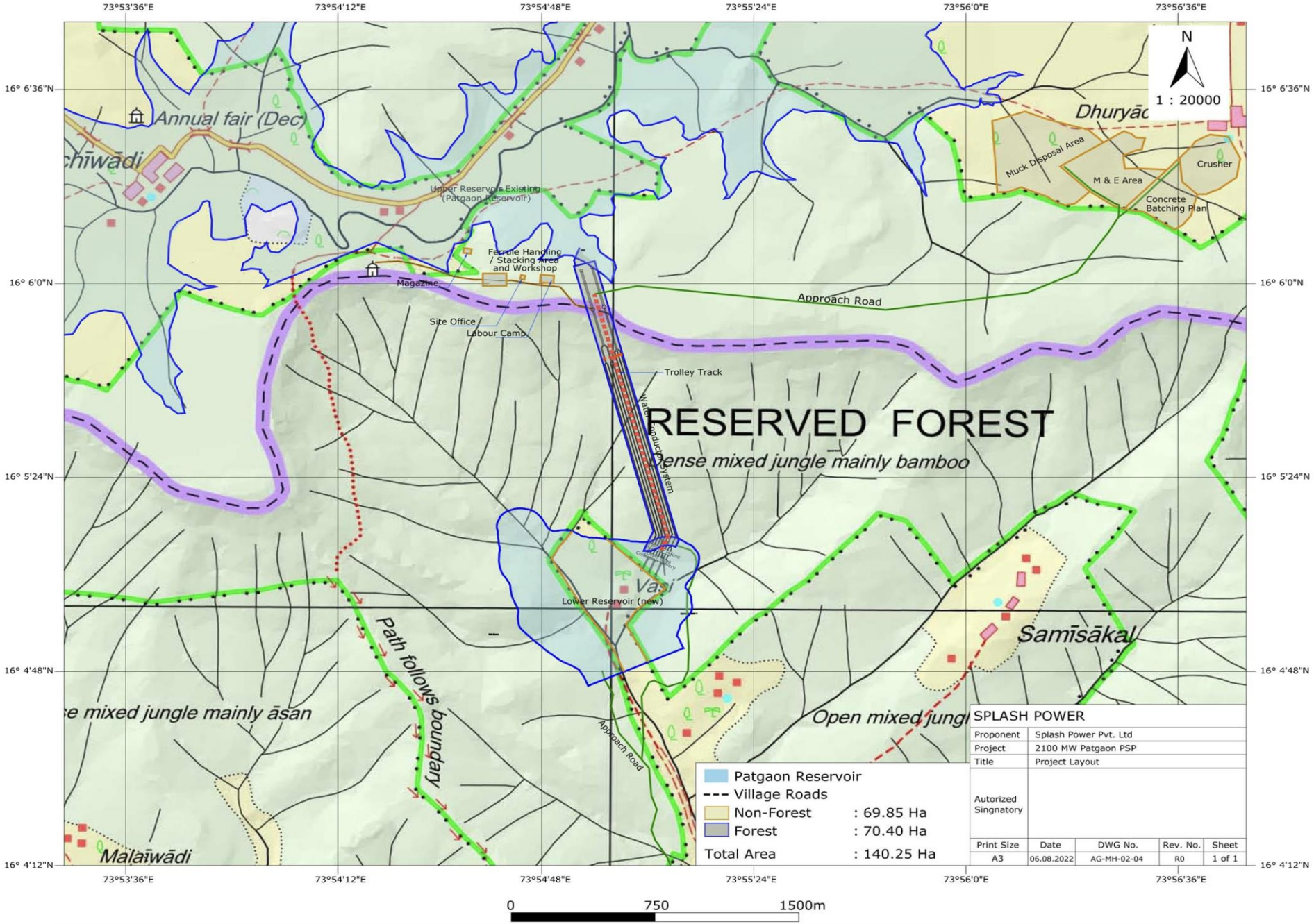
DRAWING NO.	DATE	REVISION
AG-MH-02-01	10 JUL 2022	P0

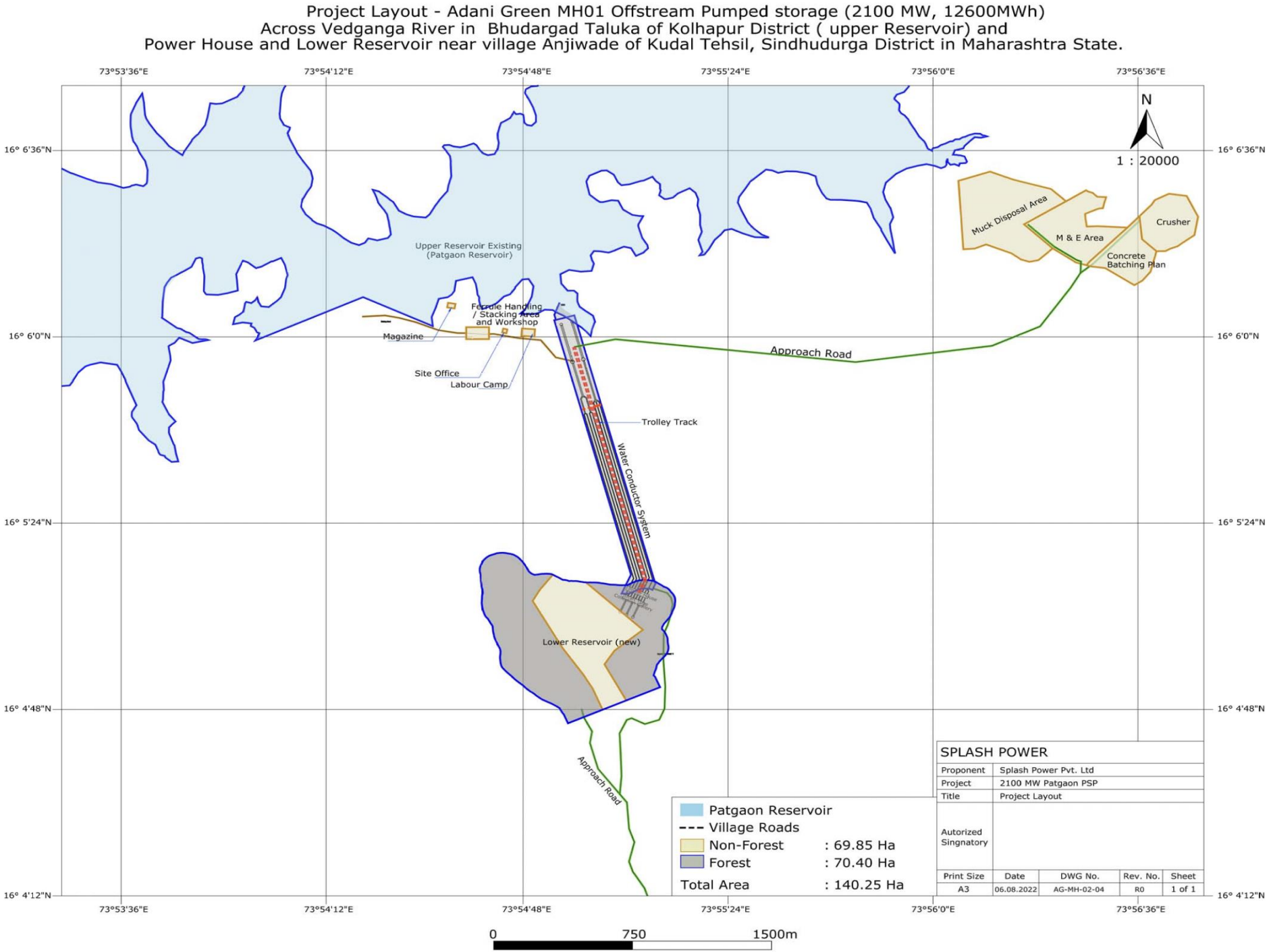
SCALE AS SHOWN

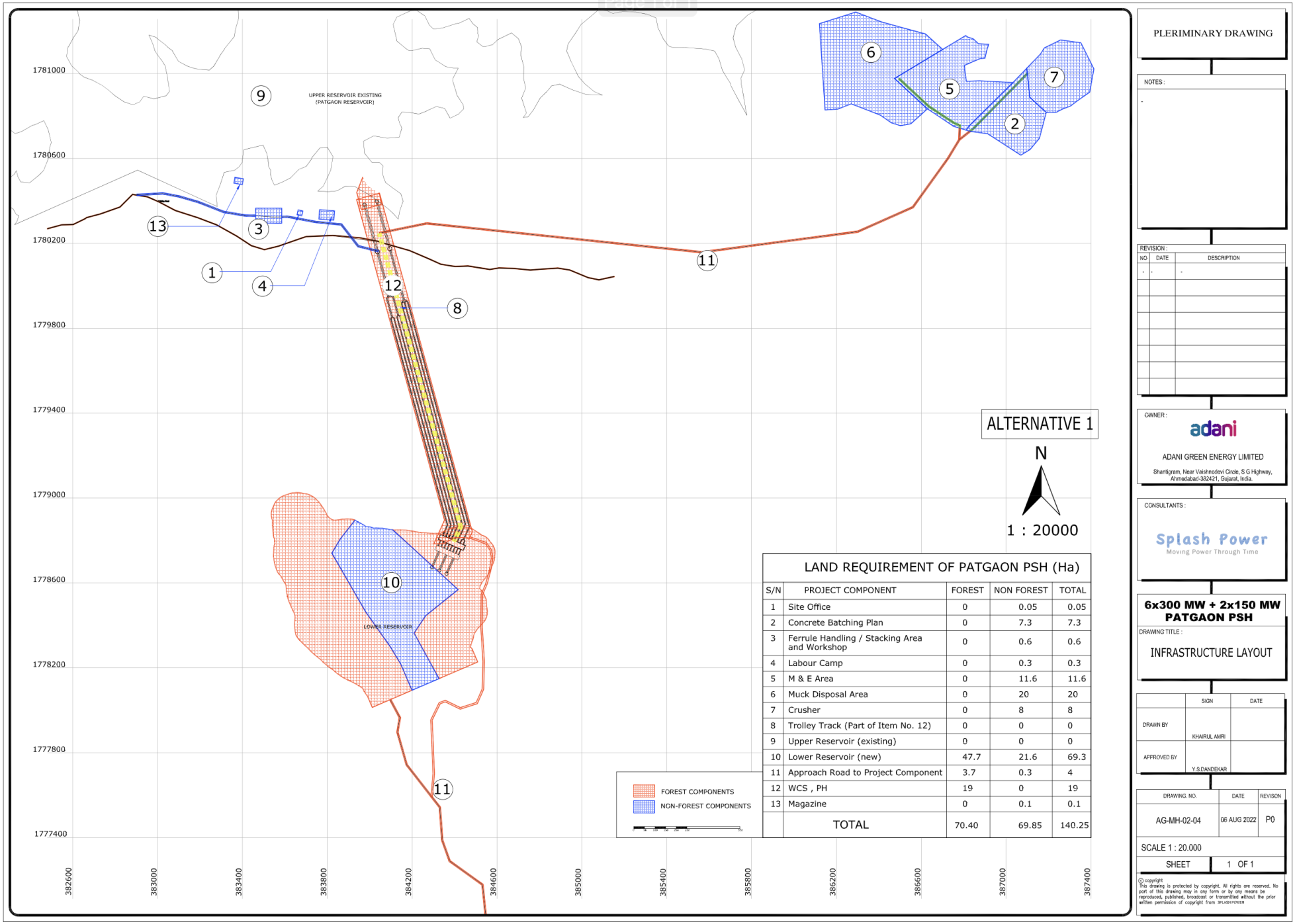
SHEET 2 OF 2


RESERVED FOREST
RESERVED FOREST
TĀMBĀLE RESERVED FOREST
RESERVED FOREST
RESERVED FOREST
MĀNI RESERVED FOREST
RESERVED FOREST
RESERVED FOREST
RESERVED FOREST
RESERVED FOREST
RESERVED FOREST
K U D Ā L
A
B
C
D
E
F
1
2
3
4
5
6

Project Layout - Adani Green MH01 Offstream Pumped storage (2100 MW, 12600MWh)
Across Vedganga River in Bhudargad Taluka of Kolhapur District (upper Reservoir) and
Power House and Lower Reservoir near village Anjiwade of Kudal Tehsil, Sindhudurga District in Maharashtra State.




Project Layout - Adani Green MH01 Offstream Pumped storage (2100 MW, 12600MWh)
Across Vedganga River in Bhudargad Taluka of Kolhapur District (upper Reservoir) and
Power House and Lower Reservoir near village Anjiwade of Kudal Tehsil, Sindhudurga District in Maharashtra State.
73°53'36"E
73°54'12"E
73°54'48"E
73°55'24"E
73°56'0"E
73°56'36"E
16° 6'36"N
16° 6'0"N
16° 5'24"N
16° 4'48"N
16° 4'12"N
N
1 : 20000
Upper Reservoir Existing
(Patgaon Reservoir)
Muck Disposal Area
M & E Area
Crusher
Concrete
Batching Plan
Ferrule Handling
/ Stacking Area
and Workshop
Magazine
Site Office
Labour Camp
Approach Road
Trolley Track
Water Conductor System
Lower Reservoir (new)
Approach Road
Patgaon Reservoir
Village Roads
Non-Forest : 69.85 Ha
Forest : 70.40 Ha
Total Area : 140.25 Ha
SPLASH POWER
Proponent Splash Power Pvt. Ltd
Project 2100 MW Patgaon PSP
Title Project Layout
Autorized Singnatory
Print Size A3
Date 06.08.2022
DWG No. AG-MH-02-04
Rev. No. R0
Sheet 1 of 1
0
750
1500m



LAND REQUIREMENT OF PATGAON PSH (Ha)

S/N	PROJECT COMPONENT	FOREST	NON FOREST	TOTAL
1	Site Office	0	0.05	0.05
2	Concrete Batching Plan	0	7.3	7.3
3	Ferrule Handling / Stacking Area and Workshop	0	0.6	0.6
4	Labour Camp	0	0.3	0.3
5	M & E Area	0	11.6	11.6
6	Muck Disposal Area	0	20	20
7	Crusher	0	8	8
8	Trolley Track (Part of Item No. 12)	0	0	0
9	Upper Reservoir (existing)	0	0	0
10	Lower Reservoir (new)	47.7	21.6	69.3
11	Approach Road to Project Component	3.7	0.3	4
12	WCS , PH	19	0	19
13	Magazine	0	0.1	0.1
	TOTAL	70.40	69.85	140.25

PLERIMINARY DRAWING

NOTES :
-

REVISION :

NO.	DATE	DESCRIPTION
-	-	-

OWNER :
adani
ADANI GREEN ENERGY LIMITED
Shantigram, Near Vaishnodevi Circle, S G Highway, Ahmedabad-382421, Gujarat, India.

CONSULTANTS :
Splash Power
Moving Power Through Time

6x300 MW + 2x150 MW PATGAON PSH

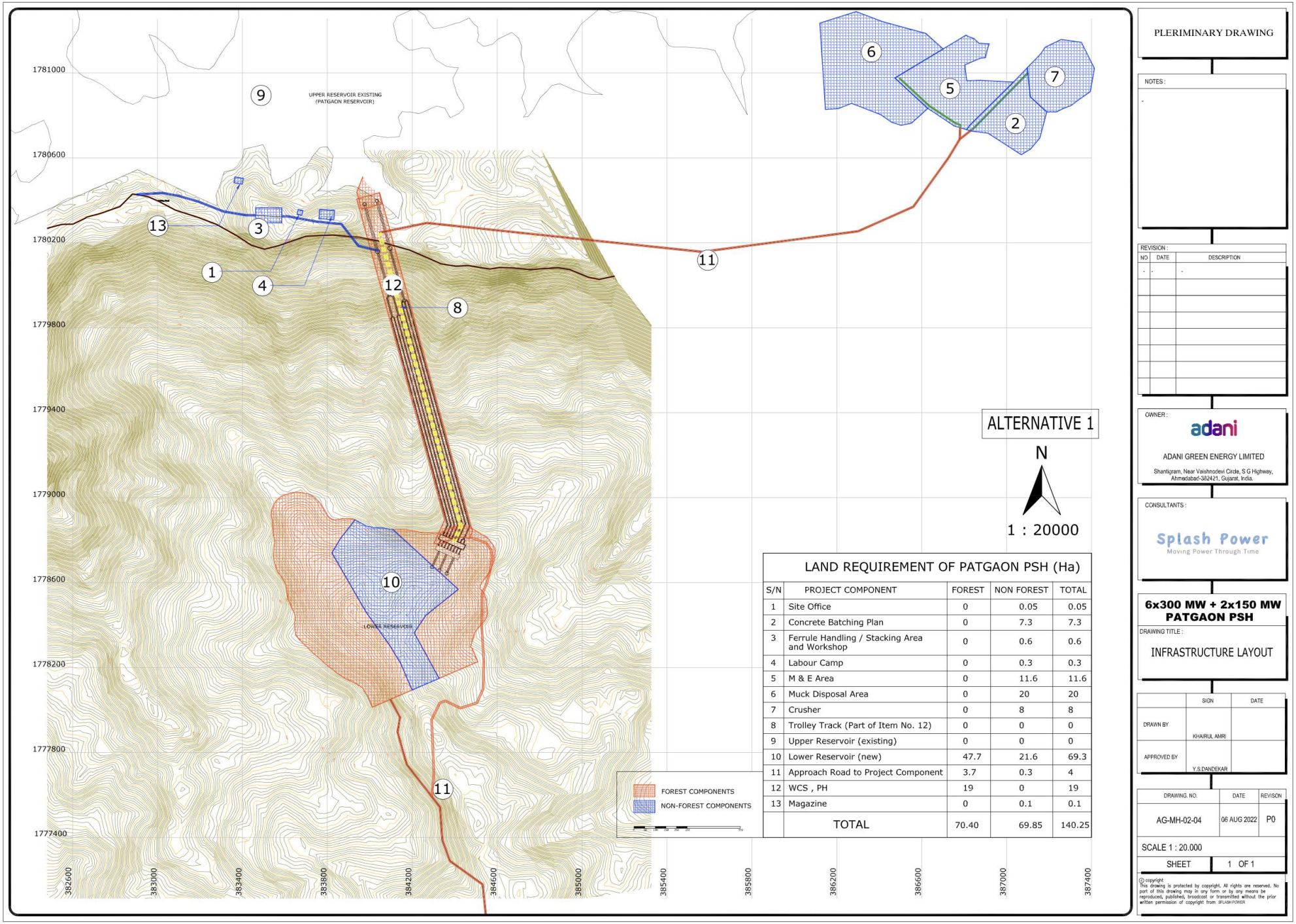
DRAWING TITLE :
INFRASTRUCTURE LAYOUT

	SIGN	DATE
DRAWN BY	KHAIRUL AMRI	
APPROVED BY	Y.S.DANDEKAR	

DRAWING. NO.	DATE	REVISON
AG-MH-02-04	06 AUG 2022	P0

SCALE 1 : 20.000

SHEET 1 OF 1



LAND REQUIREMENT OF PATGAON PSH (Ha)

S/N	PROJECT COMPONENT	FOREST	NON FOREST	TOTAL
1	Site Office	0	0.05	0.05
2	Concrete Batching Plan	0	7.3	7.3
3	Ferrule Handling / Stacking Area and Workshop	0	0.6	0.6
4	Labour Camp	0	0.3	0.3
5	M & E Area	0	11.6	11.6
6	Muck Disposal Area	0	20	20
7	Crusher	0	8	8
8	Trolley Track (Part of Item No. 12)	0	0	0
9	Upper Reservoir (existing)	0	0	0
10	Lower Reservoir (new)	47.7	21.6	69.3
11	Approach Road to Project Component	3.7	0.3	4
12	WCS , PH	19	0	19
13	Magazine	0	0.1	0.1
	TOTAL	70.40	69.85	140.25

PLERIMINARY DRAWING

NOTES :

-

REVISION :		
NO	DATE	DESCRIPTION
-	-	-

OWNER :

adani

ADANI GREEN ENERGY LIMITED

Shantigram, Near Vaishnodevi Circle, S G Highway, Ahmedabad-382421, Gujarat, India.

CONSULTANTS :

Splash Power
Moving Power Through Time

6x300 MW + 2x150 MW PATGAON PSH

DRAWING TITLE :

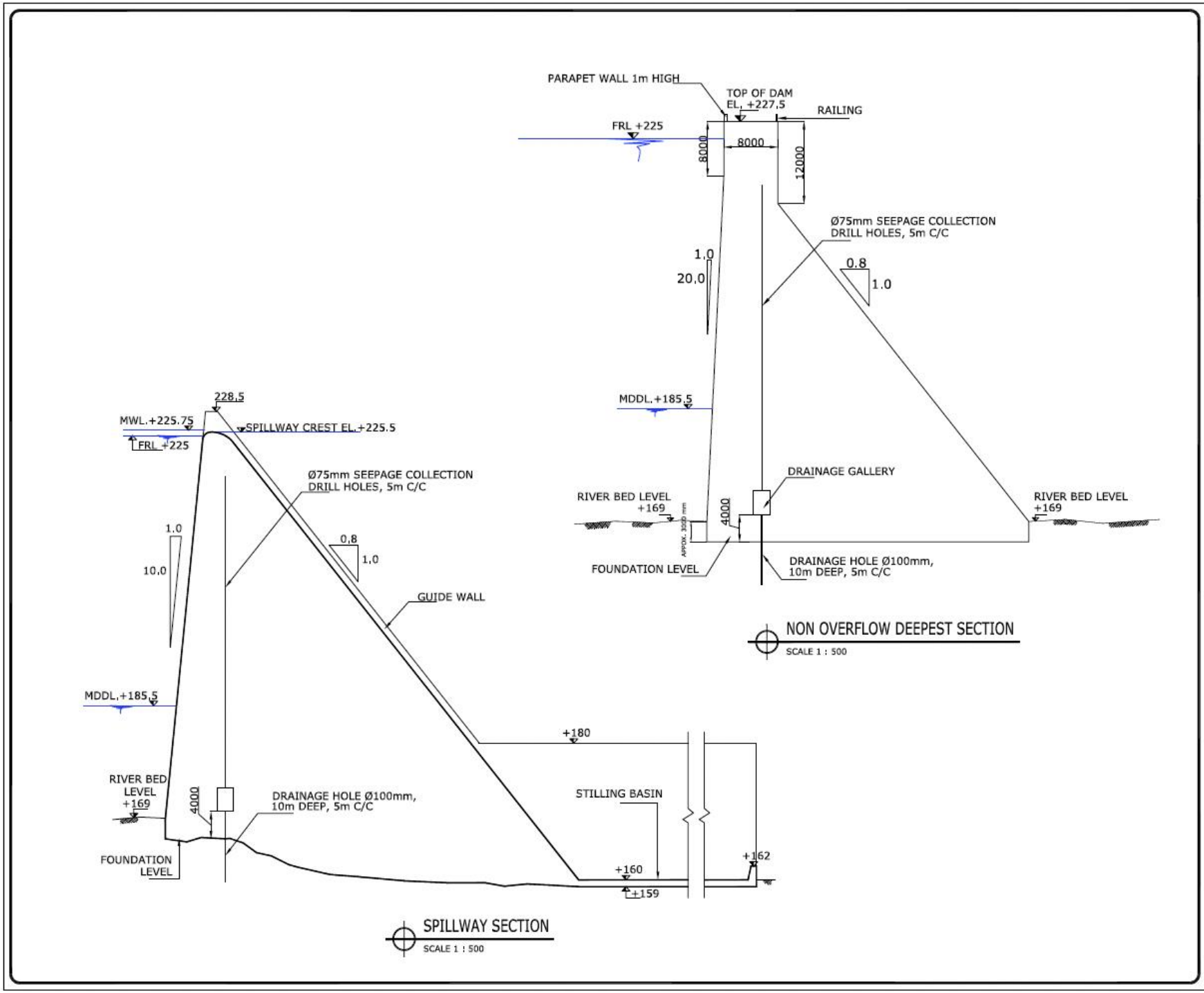
INFRASTRUCTURE LAYOUT

	SIGN	DATE
DRAWN BY	KHAIRUL AMRI	
APPROVED BY	Y.S.DANDEKAR	

DRAWING. NO.	DATE	REVISON
AG-MH-02-04	06 AUG 2022	P0

SCALE 1 : 20.000

SHEET 1 OF 1



PLERIMINARY DRAWING

NOTES:

REVISION:

NO	DATE	DESCRIPTION
.	.	.

OWNER:

adani

ADANI GREEN ENERGY LIMITED

Shantigram, Near Vaishnodevi Circle, S G Highway, Ahmedabad-382421, Gujarat, India.

CONSULTANTS:

Splash Power

Moving Power Through Time

6x300 MW + 2x150 MW
PATGAON PSH

DRAWING TITLE:

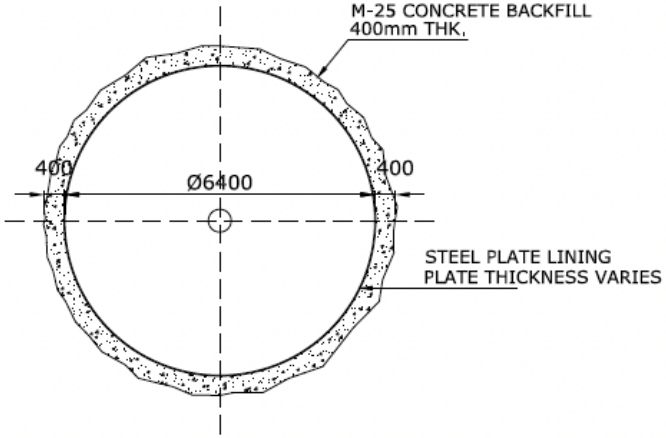
LOWER RESERVOIR DAM
OVERFLOW AND
NON OVERFLOW SECTIONS

	SIGN	DATE
DRAWN BY	KHAIRUL AMRI	
APPROVED BY	Y.S.DANDEKAR	

DRAWING NO.	DATE	REVISION
AG-MH-02-02	09 JUL 2022	P0

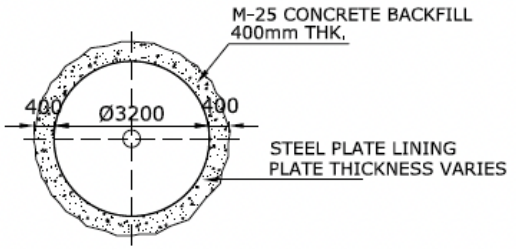
SCALE AS SHOWN

SHEET 1 OF 1



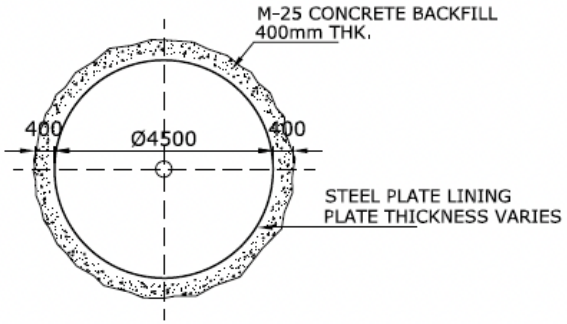
SECTION OF Ø6400 PRESSURE SHAFT
FOR 2 x 300 + 2 x 150 MW

SCALE 1 : 100



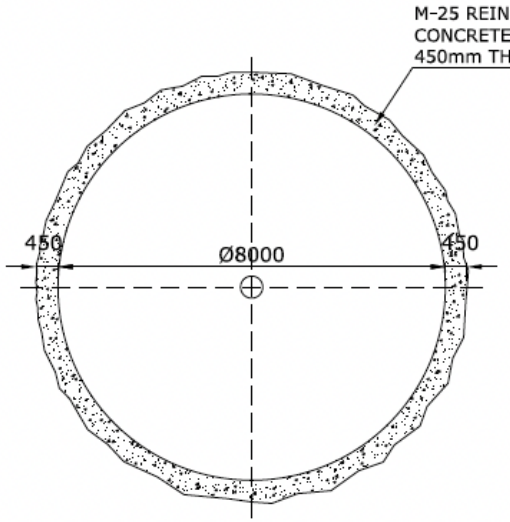
SECTION OF Ø3200
PRESSURE SHAFT FOR 2 x 150 MW

SCALE 1 : 100



SECTION OF Ø4500
PRESSURE SHAFT FOR 6 x 300 MW

SCALE 1 : 100



TAIL RACE TUNNEL SECTION

SCALE 1 : 100

PLERIMINARY DRAWING

NOTES:

- FOR OVERALL ARRANGEMENT OF WATER CONDUCTOR SYSTEM, PLEASE REFER SCHEMATIC LAYOUT DRAWING

REVISION:		
NO	DATE	DESCRIPTION
.	.	.

OWNER:

adani

ADANI GREEN ENERGY LIMITED

Shantigram, Near Vaishnodevi Circle, S G Highway, Ahmedabad-382421, Gujarat, India.

CONSULTANTS:

Splash Power

Moving Power Through Time

6x300 MW + 2x150 MW
PATGAON PSH

DRAWING TITLE:

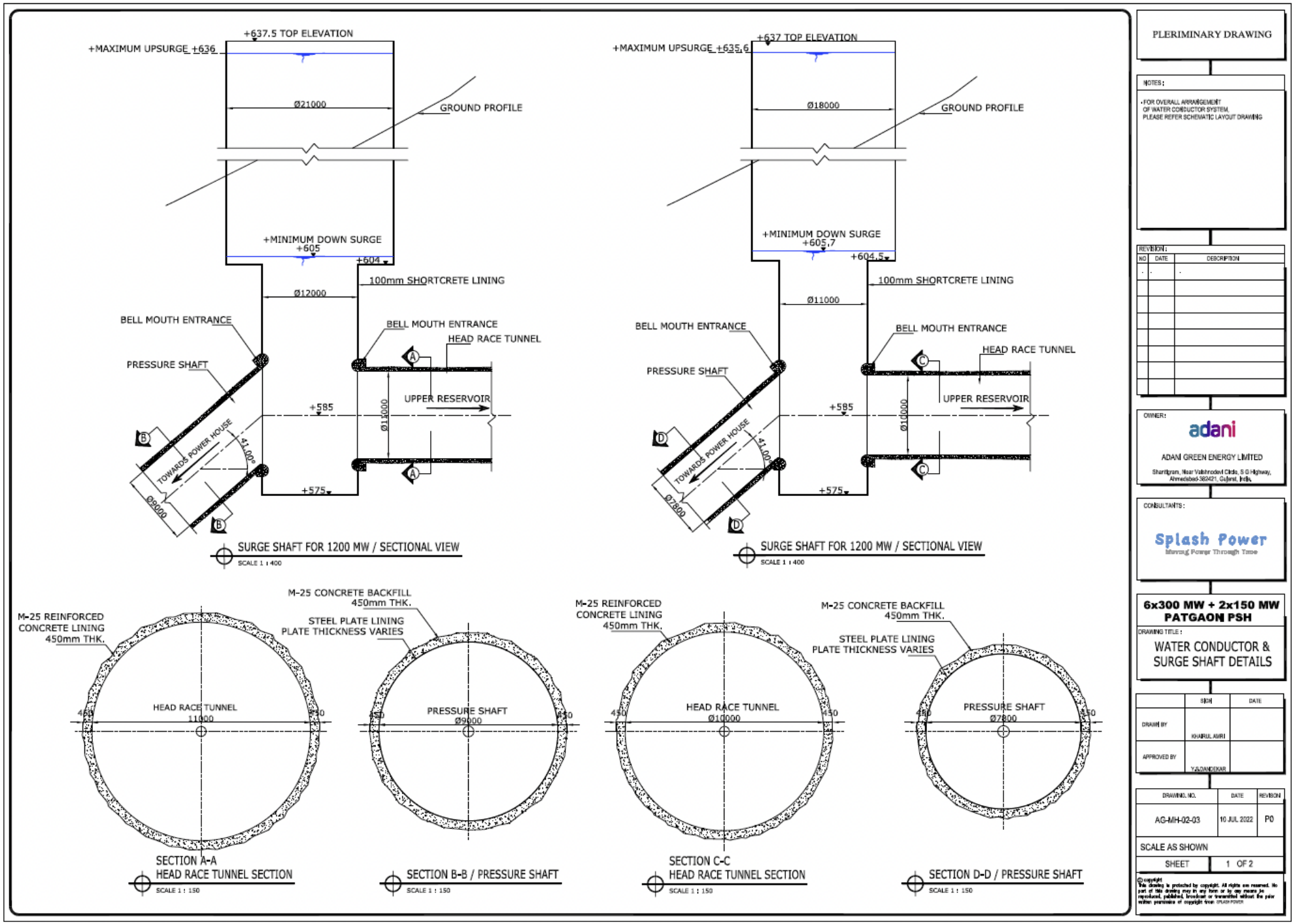
WATER CONDUCTOR & SURGE SHAFT DETAILS

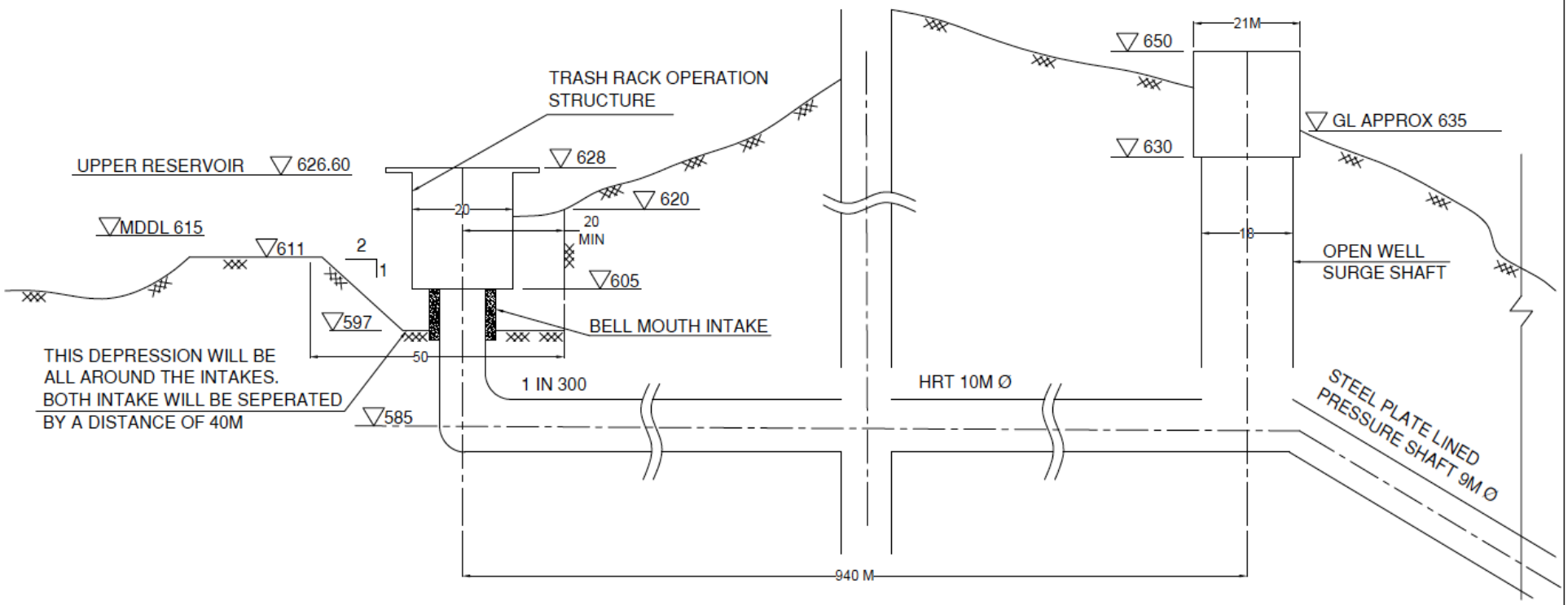
	SIGN	DATE
DRAWN BY	KHAIRUL AMRI	
APPROVED BY	Y.S.DANDEKAR	

DRAWING NO.	DATE	REVISION
AG-MH-02-03	10 JUL 2022	P0

SCALE AS SHOWN

SHEET 2 OF 2


+637.5 TOP ELEVATION
+MAXIMUM UPSURGE +636
Ø21000
GROUND PROFILE
+MINIMUM DOWN SURGE
+605
+604
100mm SHORTCRETE LINING
Ø12000
BELL MOUTH ENTRANCE
BELL MOUTH ENTRANCE
HEAD RACE TUNNEL
PRESSURE SHAFT
UPPER RESERVOIR
+585
Ø11000
TOWARDS POWER HOUSE
41.00°
Ø9000
+575
SURGE SHAFT FOR 1200 MW / SECTIONAL VIEW
SCALE 1 : 400
+637 TOP ELEVATION
+MAXIMUM UPSURGE +635.6
Ø18000
GROUND PROFILE
+MINIMUM DOWN SURGE
+605.7
+604.5
100mm SHORTCRETE LINING
Ø11000
BELL MOUTH ENTRANCE
BELL MOUTH ENTRANCE
HEAD RACE TUNNEL
PRESSURE SHAFT
UPPER RESERVOIR
+585
Ø10000
TOWARDS POWER HOUSE
41.00°
Ø7800
+575
SURGE SHAFT FOR 1200 MW / SECTIONAL VIEW
SCALE 1 : 400
M-25 REINFORCED CONCRETE LINING 450mm THK.
HEAD RACE TUNNEL 11000
450
SECTION A-A
HEAD RACE TUNNEL SECTION
SCALE 1 : 150
M-25 CONCRETE BACKFILL 450mm THK.
STEEL PLATE LINING PLATE THICKNESS VARIES
PRESSURE SHAFT Ø9000
SECTION B-B / PRESSURE SHAFT
SCALE 1 : 150
M-25 REINFORCED CONCRETE LINING 450mm THK.
HEAD RACE TUNNEL Ø10000
SECTION C-C
HEAD RACE TUNNEL SECTION
SCALE 1 : 150
M-25 CONCRETE BACKFILL 450mm THK.
STEEL PLATE LINING PLATE THICKNESS VARIES
PRESSURE SHAFT Ø7800
SECTION D-D / PRESSURE SHAFT
SCALE 1 : 150
PLERIMINARY DRAWING
NOTES:
•FOR OVERALL ARRANGEMENT OF WATER CONDUCTOR SYSTEM PLEASE REFER SCHEMATIC LAYOUT DRAWING
REVISION:
NO | DATE | DESCRIPTION
OWNER:
adani
ADANI GREEN ENERGY LIMITED
Shantigram, Near Vaishnodevi Circle, S G Highway, Ahmedabad-382421, Gujarat, India.
CONSULTANTS:
Splash Power
Moving Power Through Time
6x300 MW + 2x150 MW
PATGAON PSH
DRAWING TITLE :
WATER CONDUCTOR & SURGE SHAFT DETAILS
SIGN | DATE
DRAWN BY
KHAIRUL AMRI
APPROVED BY
Y.K.DANDEKAR
DRAWING NO. | DATE | REVISION
AG-MH-02-03 | 10 JUL 2022 | P0
SCALE AS SHOWN
SHEET 1 OF 2
© copyright
This drawing is protected by copyright. All rights are reserved. No part of this drawing may in any form or by any means be reproduced, published, broadcast or transmitted without the prior written permission of copyright owner SPLASH POWER

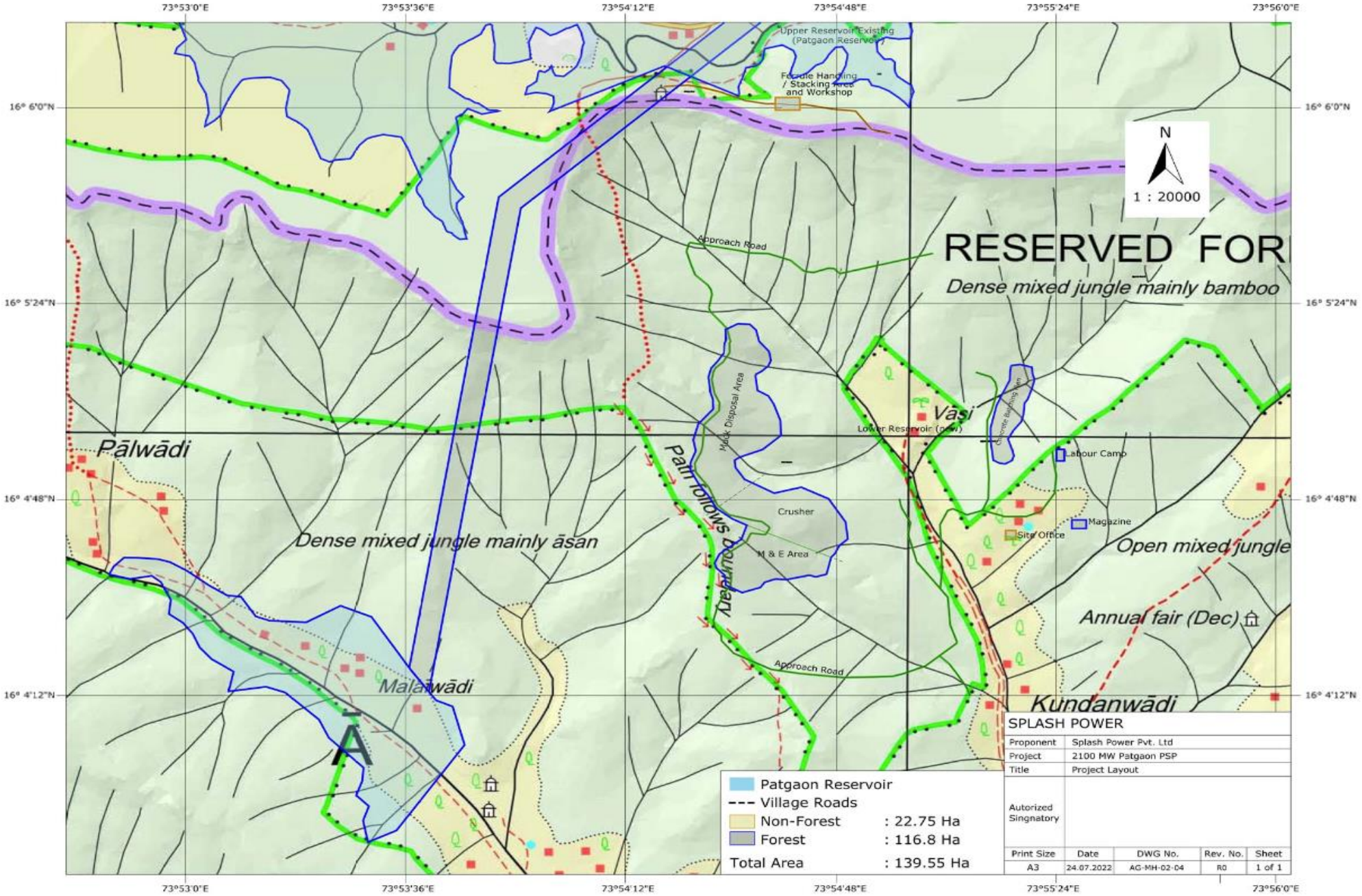


HRT - SCHEMATIC LAYOUT FROM INTAKE SURGE SHAFT (NTS)

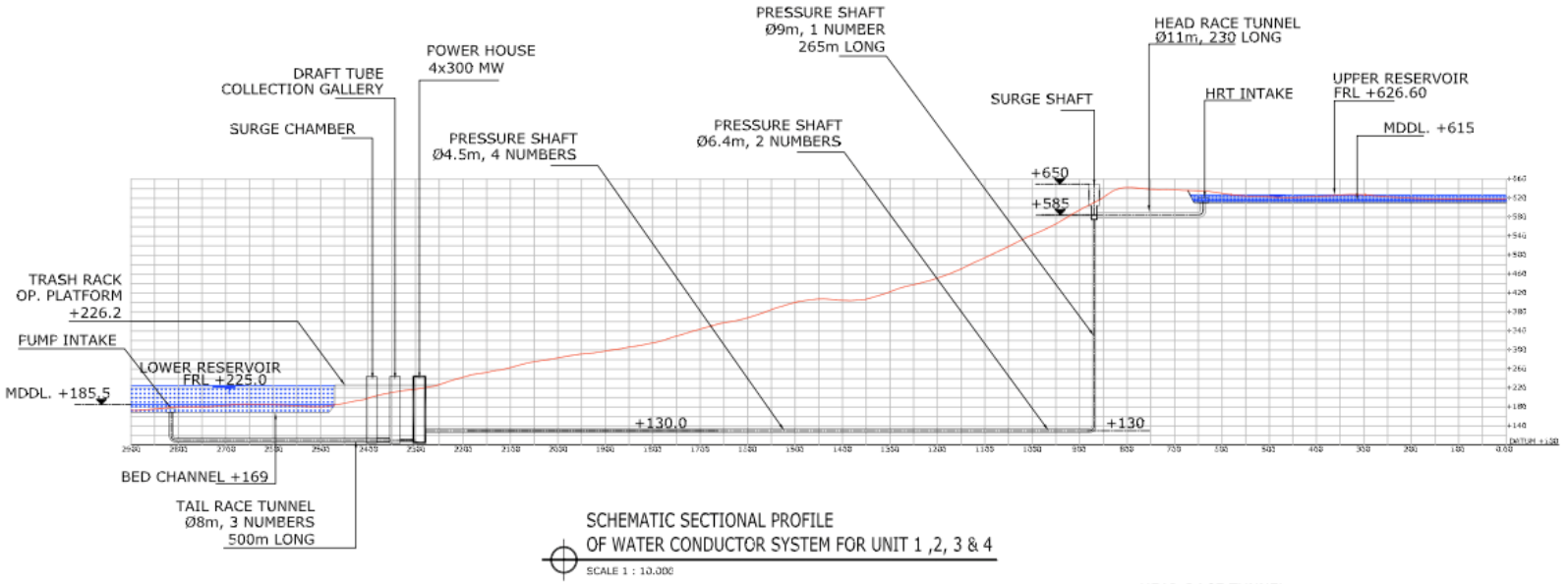
PROJECT	PATGAUN PUMPED STORAGE
OWNER	ADANI GREEN ENERGY LIMITED
CONSULTANT	SPLASH POWER
APPROVED BY	-
DATE	19.01.22
SCALE	NTS
DRG NO / REV	PATGAON - PSH - 006 / R0
DRAWING TITLE	**HRT - SCHEMATIC LAYOUT FROM INTAKE TO SURGE SHAFT (NTS)**

ALL DIMERNTIONS ARE IN METER

Alternate Project Layout - Adani Green MH01 Offstream Pumped storage (2100 MW, 12600MWh)
Across Vedganga River in Bhudargad Taluka of Kolhapur District (upper Reservoir) and
Power House and Lower Reservoir near village Anjiwade of Kudal Tehsil, Sindhudurga District in Maharashtra State.

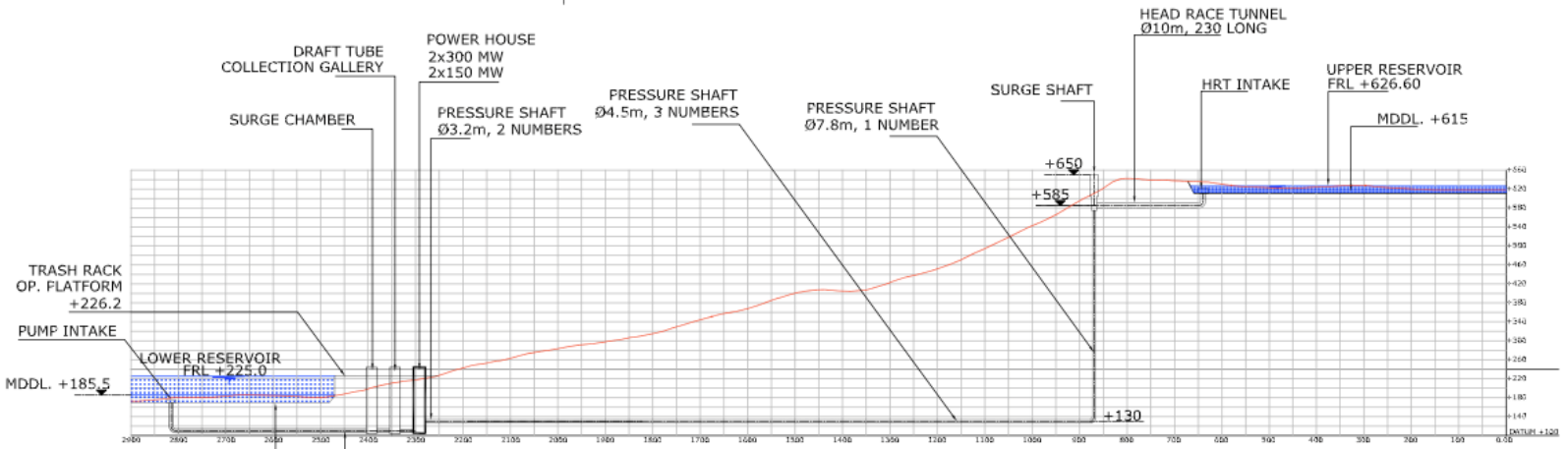


PATGAON ALTERNATIVE 2



SCHEMATIC SECTIONAL PROFILE
OF WATER CONDUCTOR SYSTEM FOR UNIT 1 ,2, 3 & 4

SCALE 1 : 10,000



SCHEMATIC SECTIONAL PROFILE
OF WATER CONDUCTOR SYSTEM FOR UNIT 5 ,6, 7 & 8

SCALE 1 : 10,000

PLERIMINARY DRAWING

NOTES:

REVISION :		
NO	DATE	DESCRIPTION

OWNER :

adani

ADANI GREEN ENERGY LIMITED

Shantigram, Near Vaishnodevi Circle, S G Highway, Ahmedabad-382421, Gujarat, India.

CONSULTANTS :

Splash Power
Moving Power Through Time

6x300 MW + 2x150 MW PATGAON PSH

DRAWING TITLE :

SCHEMATIC LAYOUT PLAN AND SECTIONAL PROFILE

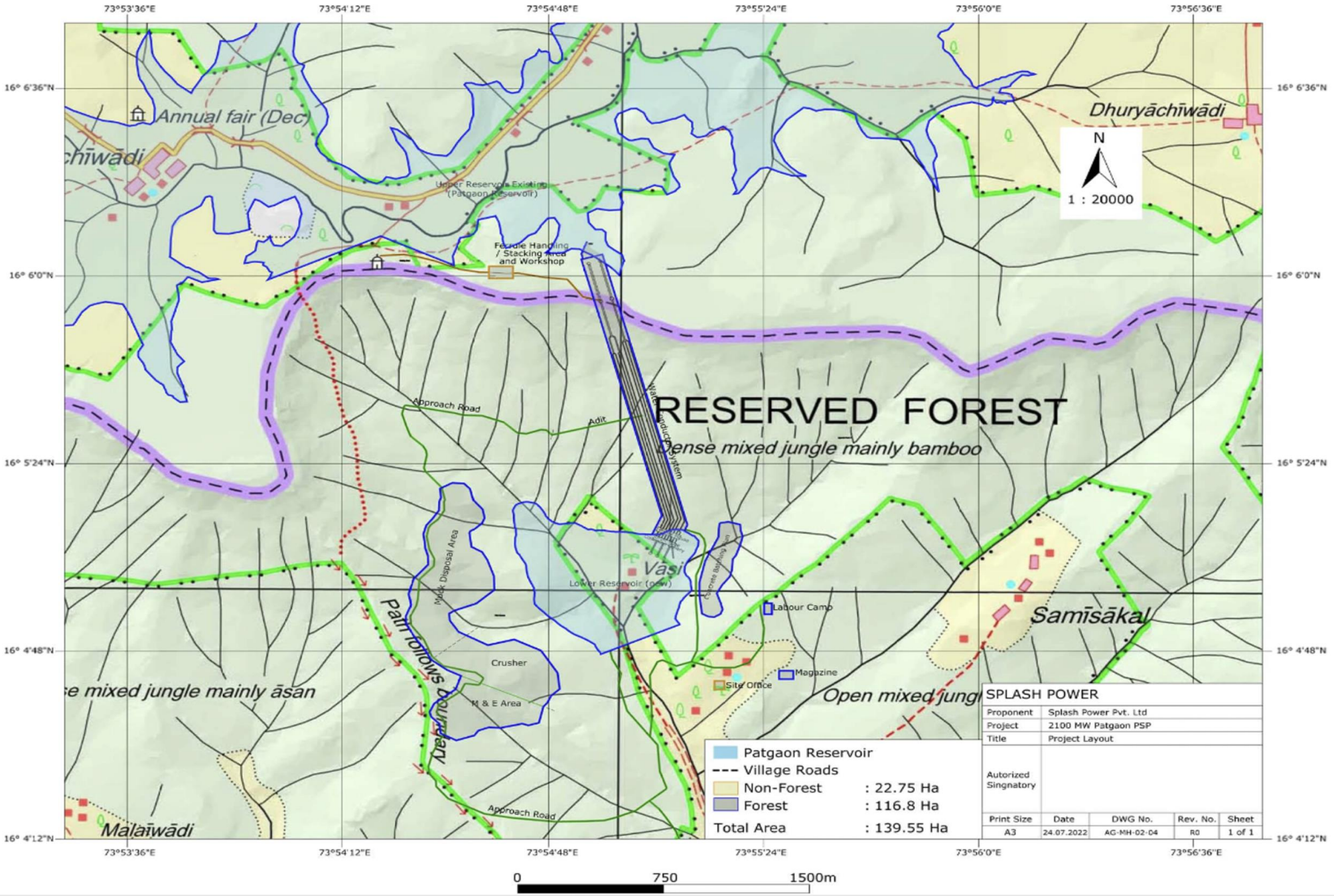
	SIGN	DATE
DRAWN BY	KHAIRUL AMRI	
APPROVED BY	Y.S.DANDEKAR	

DRAWING NO.	DATE	REVISION
AG-MH-02-01	02 AUG 2022	P0

SCALE AS SHOWN

SHEET 2 OF 2

Alternate Project Layout - Adani Green MH01 Offstream Pumped storage (2100 MW, 12600MWh)
Across Vedganga River in Bhudargad Taluka of Kolhapur District (upper Reservoir) and
Power House and Lower Reservoir near village Anjiwade of Kudal Tehsil, Sindhudurga District in Maharashtra State.



SPLASH POWER				
Proponent	Splash Power Pvt. Ltd			
Project	2100 MW Patgaon PSP			
Title	Project Layout			
Autorized Singnatory				
Print Size	Date	DWG No.	Rev. No.	Sheet
A3	24.07.2022	AG-MH-02-04	R0	1 of 1