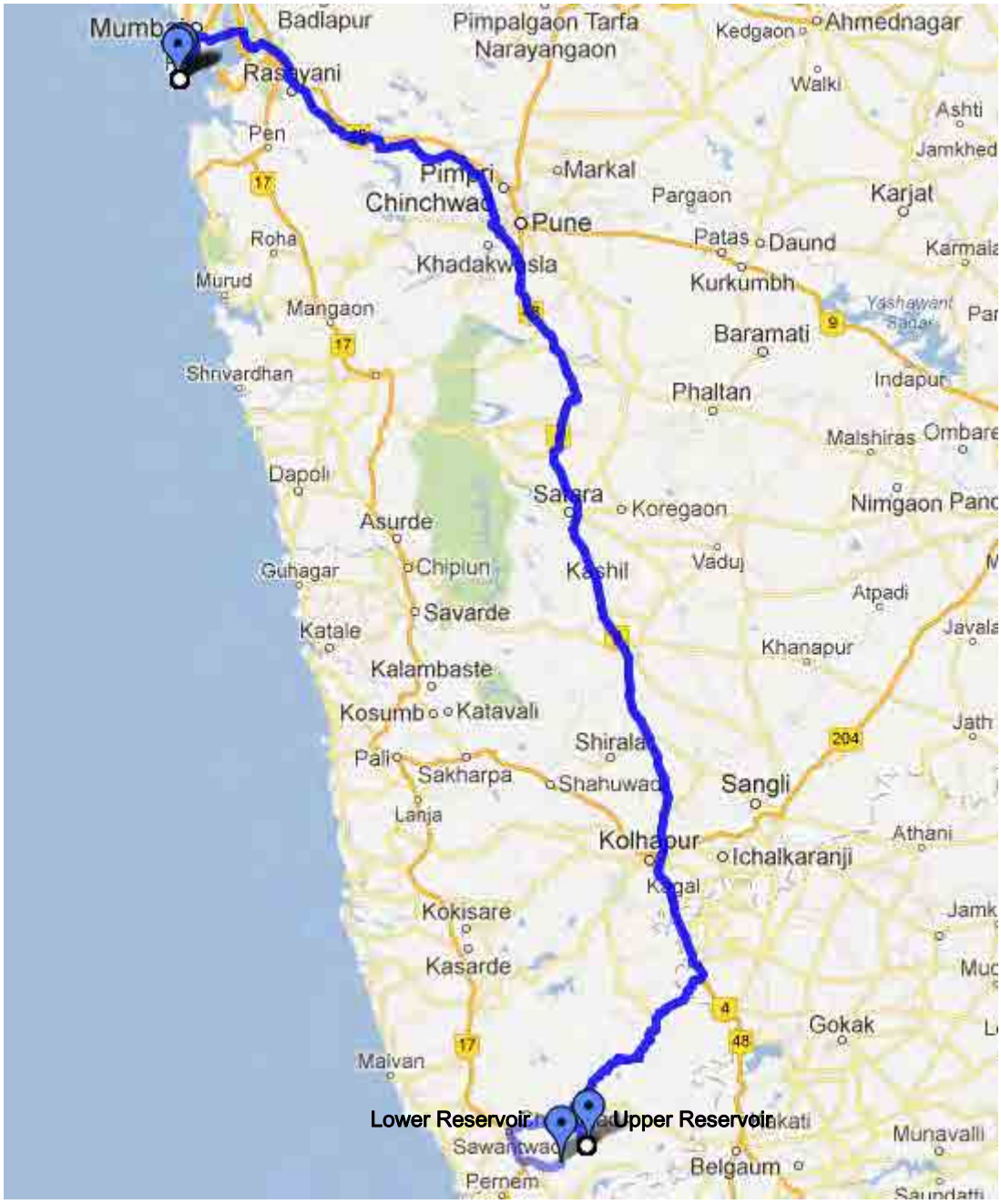


Figure 9.1.5-1 Road Map to Kumbhavde Ghat Upper Reservoir and Lower Reservoir

9.2 Landform and Geology

Site survey was conducted fot the 3 sites; Panshet, Warasgaon, and Varandh Ghat, and they were compared from physiographical and geological aspects.

9.2.1 Criteria

The basic criteria for feasibility assessment of dam construction are described below.

(1) Landform

1) Ability to store and sustain water

   i) Shape of reservoir: wide valley with a narrowing is ideal

   ii) Shape of dam axis: thick ridge for an abutment is ideal

2) Vertical distance: Large difference in elevation between the upper and the lower reservoirs

(2) Geology

1) Solidity of dam foundation

   i) Rock type: the harder the better

   ii) Weathering: the thinner (shallower) the better

   iii) Deterioration (fault, alteration, etc.): the less the better

   iv) Heterogeneity (facies change, layer contact, dipping, foliation, etc): the less the better

   v) Covering layer: the thinner the better

   Incidentally, as for Warasgaon Alternative (Upper) Reservoir, unlike the others, solidity is not recognized as preferable because the rocks are to be excavated in order to obtain space for water storage.

2) Low Permeability

   i) Porosity of rock: the less the better

   ii) Open cracks: the less (and less continuous) the better

   iii) Ground water level: not necessarily related to permeability, but generally preferred to be near the ground for dams.

(3) Hazard

Landslides, falls, and earthquakes are main causes of geology-related hazard.

9.2.2 Site Investigation Results

Site conditions were obtained from surface explorations. Since there had been no drilling, underground conditions discussed later in this section such as weathering depth and continuity of cracks were based on estimation.

9.2.2.1 Panshet

A. Panshet Upper Dam

(1) Landform

1) Ability to store and sustain water

i) Shape of the reservoir

The dam axis is located near the juncture, and the landform becomes open upstream, therefore it is likely to store water.

ii) Shape of the dam axis

Both left and right abutments are a tip of the ridge with enough height and thickness so as not likely to leak.

2) Vertical distance

The assumed vertical distance between the lower reservoir is over 600 m.

Figure 9.2.2.1-1 Near dam axis

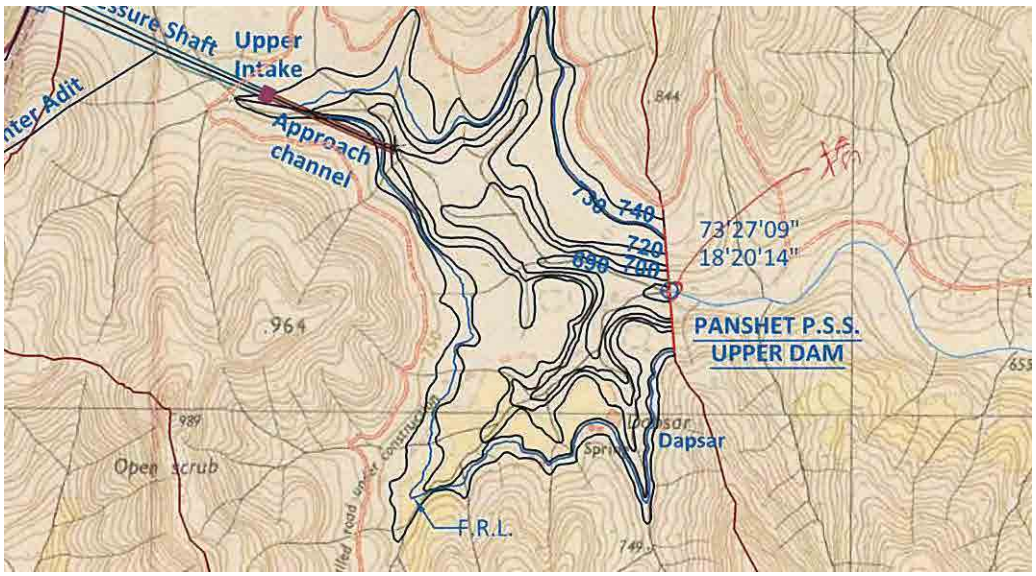


Figure 9.2.2.1-2 Topographic map

(2) Geology

1) Solidity of the dam foundation

i) Rock type

The observed rock type in outcrops is the compact basalt, which is dark gray in color, dense, and so hard as to make metallic sound when hit with a hammer.

ii) Weathering

Weathered portion is generally very thin; although it can extend as deep as a few meter deep in limited places, only changes in color on the surface or slight softening of 1 ~ 2 cm from the surface are noticeable in most cases.

iii) Deterioration

Although there are nearly vertical joints, they are widely spaced by the intervals of 30 ~ 100 cm, and no selective weathering along the joints is observed. Faults or hydrothermal alterations are not observed.

iv) Heterogeneity

Judging from the surface conditions, the rock beds seem to be massive and homogenous.

v) Covering layers

The thickness of riverbed deposit is 0.5 ~ 2 m, and that of overburden on slopes is about 1 m on the average but may be up to over 5 m at a part of the right bank.

Figure 9.2.2.1-3 Compact basalt exposed by road cut

Figure 9.2.2.1-4 Riverbed deposit

2) Permeability

i) Porosity of the rock

The compact basalt is very dense, hence has few pores. Therefore, the permeability of the rock itself must be very low.

ii) Open cracks

The joints are almost completely closed, so there seems to be very few continuous openings that may cause leakage of water within the rock beds.

iii) Ground water level

There was no running water observed in a channel during the surface explorations. Ground water level during the dry season must be considerably low.

(3) Hazard

Although there are very minor collapses near the surface, there is no collapse or fall that may be problematic. Hence, hazard of slope failure must be low.

Hazard of earthquakes is, according to the desk study, moderately high.

B. Panshet Lower Dam

(1) Landform

1) Ability to store and sustain water

i) Shape of the reservoir

The reservoir is surrounded by high cliffs in three directions, and the remaining direction is wide-open. Therefore, a very long dam body is necessary to form the reservoir.

ii) Shape of the dam axis

The right abutment is a tip of the large isolated ridge, and is very unlikely to leak water. On the other hand, the left abutment is a tip of the relatively thin ridge branching from the larger one behind it, so is needed to be cautious of leakage.

2) Vertical distance

The assumed vertical distance between the upper dam is over 600 m.

Figure 9.2.2.1-5 Near dam axis

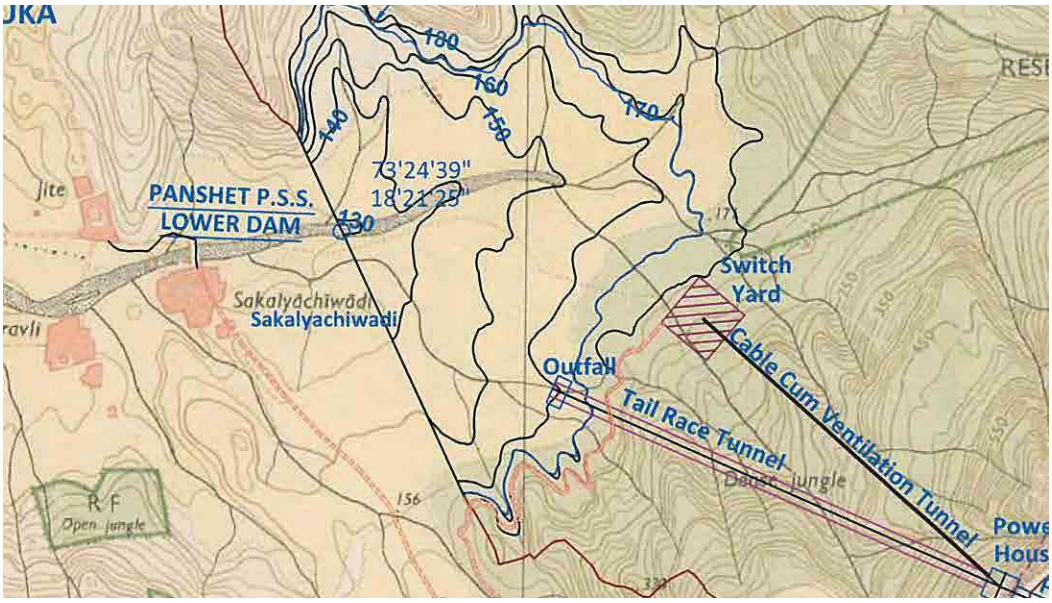


Figure 9.2.2.1-6 Topographic map

(2) Geology

1) Solidity of the dam foundation

i) Rock type

The observed rock type in outcrops is the compact basalt, which is dark gray in color, dense, and so hard as to make metallic sound when hit with a hammer.

ii) Weathering

Weathered portion is generally very thin; although it can extend as deep as 3 ~ 4 m deep in limited places, only changes in color on the surface or slight softening of a few centimeters from the surfaces are noticeable in most cases.

iii) Deterioration

Although there are nearly vertical joints, they are widely spaced by the intervals of 30 ~ 100 cm, and no selective weathering along the joints is observed. Faults or hydrothermal alterations are not observed.

iv) Heterogeneity

Judging from the surface conditions, the rock beds seem to be massive and homogenous.

v) Covering layers

The thickness of riverbed deposit is 0.5 ~ 2 m, and that of overburden on slopes is about the same.

Figure 9.2.2.1-7 Compact basalt outcrop

Figure 9.2.2.1-8 Deeply weathered basalt

2) Permeability

i) Porosity of the rock

The compact basalt is very dense, hence has few pores. Therefore, the permeability of the rock

itself must be very low.

ii) Open cracks

The joints are almost completely closed, so there seems to be very few continuous openings that may cause leakage of water within the rock beds.

iii) Ground water level

There was no running water observed in a channel during the surface explorations. Ground water level during the dry season must be considerably low.

(3) Hazard

Although there are very minor collapses near the surface, there is no collapse or fall that may be problematic. Hence, hazard of slope failure must be low.

Hazard of earthquakes is, according to the desk study, moderately high.

9.2.2.2 Warasgaon

A. Warasgaon Upper Dam

(1) Landform

1) Ability to store and sustain water

i) Shape of the reservoir

The valley is wide and the stream gradient is low, so it is suitable for a reservoir, but since there is no narrowing, a long dam body is necessary.

ii) Shape of the dam axis

The right abutment is a side of a very large flat-topped ridge, and is very unlikely to leak water. On the other hand, the left abutment is a tip of a relatively thin and low ridge, so it must be cautious of leakage.

2) Vertical distance

The vertical distance between the lower dam is over 600 m.

Figure 9.2.2.2-1 Dam axis seen from left abutment

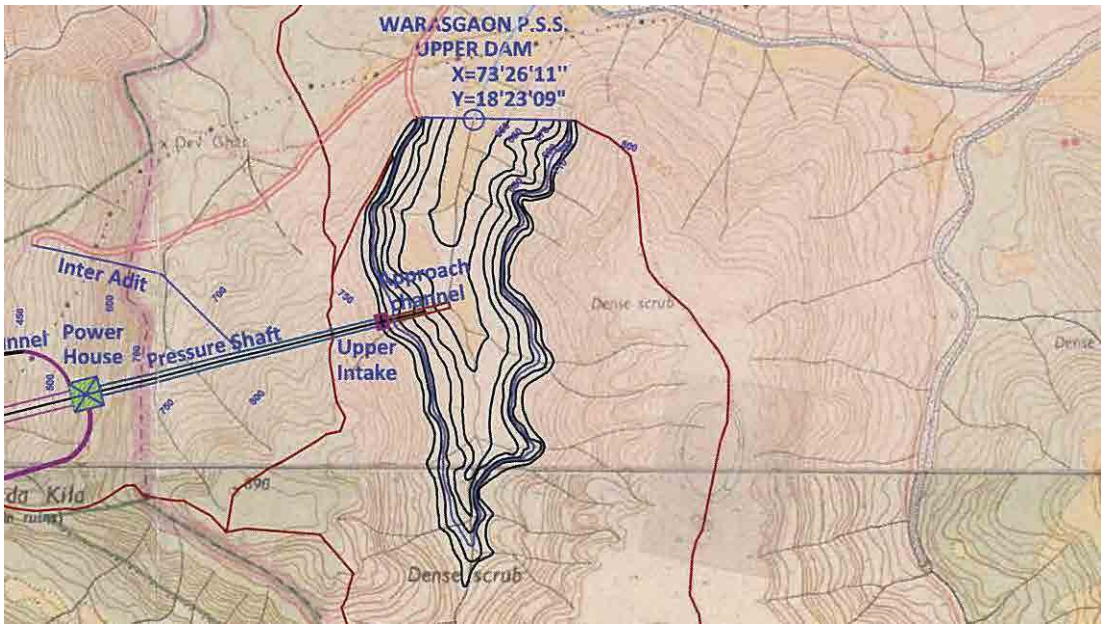


Figure 9.2.2.2-2 Topographic map

(2) Geology

1) Solidity of the dam foundation

i) Rock type

The observed rock type in outcrops is the compact basalt, which is dark gray in color, dense, and so hard as to make metallic sound when hit with a hammer. The vesicular basalt and the amygdaloidal basalt along with geodes are observer as floats, that means the compact basalt is not the only type distributed in the vicinity.

ii) Weathering

Weathered portion is generally very thin; only changes in color on the surface or slight softening of 1 ~ 2 cm from the surface are noticeable in most cases.

iii) Deterioration

Although there are nearly vertical joints, they are widely spaced by the intervals of 30 ~ 100cm, rarely less than 30 cm, and no selective weathering along the joints is observed. Faults or hydrothermal alterations are not observed.

iv) Heterogeneity

Judging from the surface conditions, the rock beds seem to be massive and homogenous.

v) Covering layers

The thickness of riverbed deposit is 0.5 m ~ 1 m, and that of overburden on slopes is 1 m ~ 3 m for the right bank, a few tens of meters for the left bank.

Figure 9.2.2.2-3 Compact basalt outcrop (Left bank)

Figure 9.2.2.2-4 Compact basalt boulder (Right bank)

2) Permeability

i) Porosity of the rock

The compact basalt is very dense, hence has few pores. The vesicles of the vesicular basalt are not interconnected, and those of the amygdaloidal basalt are filled with minerals. Therefore, the permeability of the rock itself must be very low.

ii) Open cracks

The joints are almost completely closed, so there seems to be very few continuous openings that may cause leakage of water within the rock beds.

iii) Ground water level

There was no running water observed in a channel during the surface explorations. Ground water level during the dry season must be considerably low.

(3) Hazard

Although there are very minor collapses near the surface, there is no collapse or fall that may be problematic. Hence, hazard of slope failure must be low.

Hazard of earthquakes is, according to the desk study, moderately high.

B. Warasgaon Lower Dam

(1) Landform

1) Ability to store and sustain water

i) Shape of the reservoir

The reservoir is surrounded by high cliffs in three directions, and the remaining direction is wide-open. Therefore, a very long dam body is necessary to form the reservoir.

ii) Shape of the dam axis

The abutments on both banks are relatively small ridges, therefore they must be cautious of leakage. Also, the dam axis is unfavorably bent at the right abutment along the crest line

2) Vertical distance

The vertical distance between the upper dam is over 600 m, and about 800 m for the alternative upper reservoir.

Figure 9.2.2.2-5 Dam axis seen from left bank

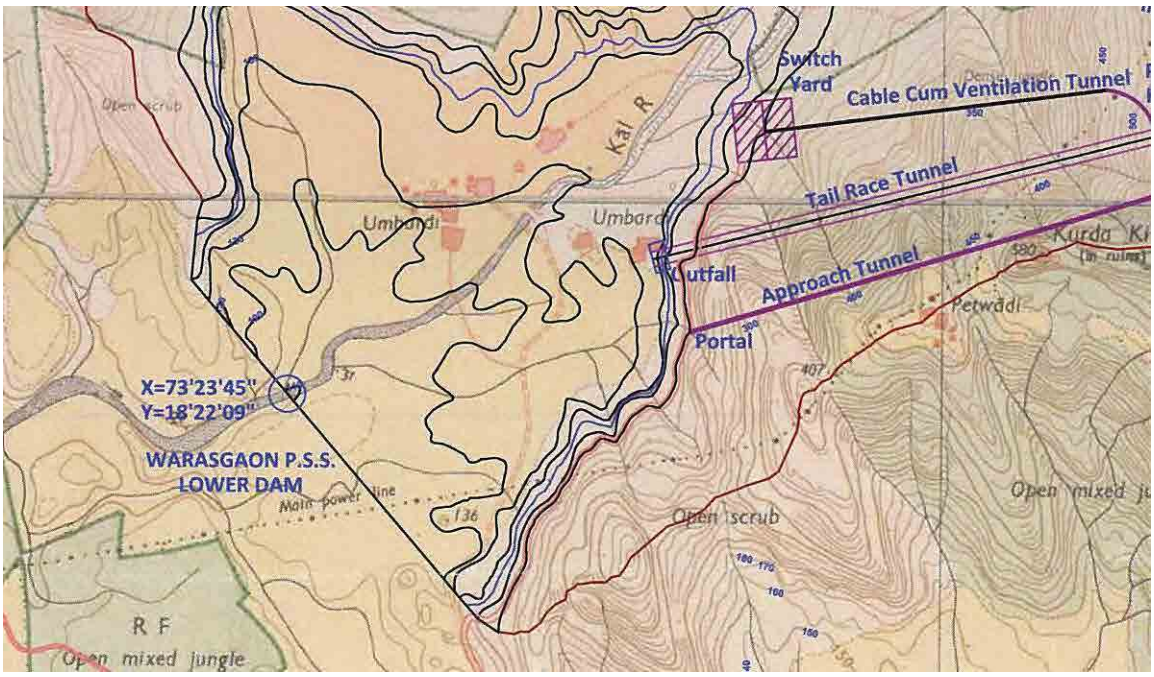


Figure 9.2.2.2-6 Topographic map

(2) Geology

1) Solidity of the dam foundation

i) Rock type

The observed rock type in outcrops is the compact basalt, which is dark gray in color, dense, and so hard as to make metallic sound when hit with a hammer.

ii) Weathering

Weathered portion is generally very thin; only changes in color on the surface or slight softening of 1 ~ 2 cm from the surface are noticeable in most cases.

iii) Deterioration

Although there are nearly vertical joints, they are widely spaced by the intervals of 30 ~ 70 cm, and no selective weathering along the joints is observed. Faults or hydrothermal alterations are not observed.

iv) Heterogeneity

Judging from the surface conditions, the rock beds seem to be massive and homogenous.

v) Covering layers

The thickness of riverbed deposit is 0.5 m ~ 2 m, and that of overburden on slopes is also 0.5 m ~ 2 m.

Figure 9.2.2.2-7 Compact basalt outcrop

Figure 9.2.2.2-8 Riverbed deposit

2) Permeability

i) Porosity of the rock

The compact basalt is very dense, hence has few pores. Therefore, the permeability of the rock

itself must be very low.

ii) Open cracks

The joints are almost completely closed, so there seems to be very few continuous openings that may cause leakage of water within the rock beds.

iii) Ground water level

There was no running water observed in a channel during the surface explorations. Ground water level during the dry season must be considerably low.

(3) Hazard

Although there are very minor collapses near the surface, there is no collapse or fall that may be problematic. Hence, hazard of slope failure must be low.

Hazard of earthquakes is, according to the desk study, moderately high.

C. Warasgaon Upper alternative reservoir

(1) Landform

1) Ability to store and sustain water

The alternative reservoir is not a dam as a barrier to hold back flowing water but a large artificial pond excavated on a flat hilltop. The hilltop is surrounded by high cliffs, therefore it must be very cautious of leakage.

2) Vertical distance

The vertical distance between the lower dam is very larger with about 800 m.

Figure 9.2.2.2-9 Flat-topped range

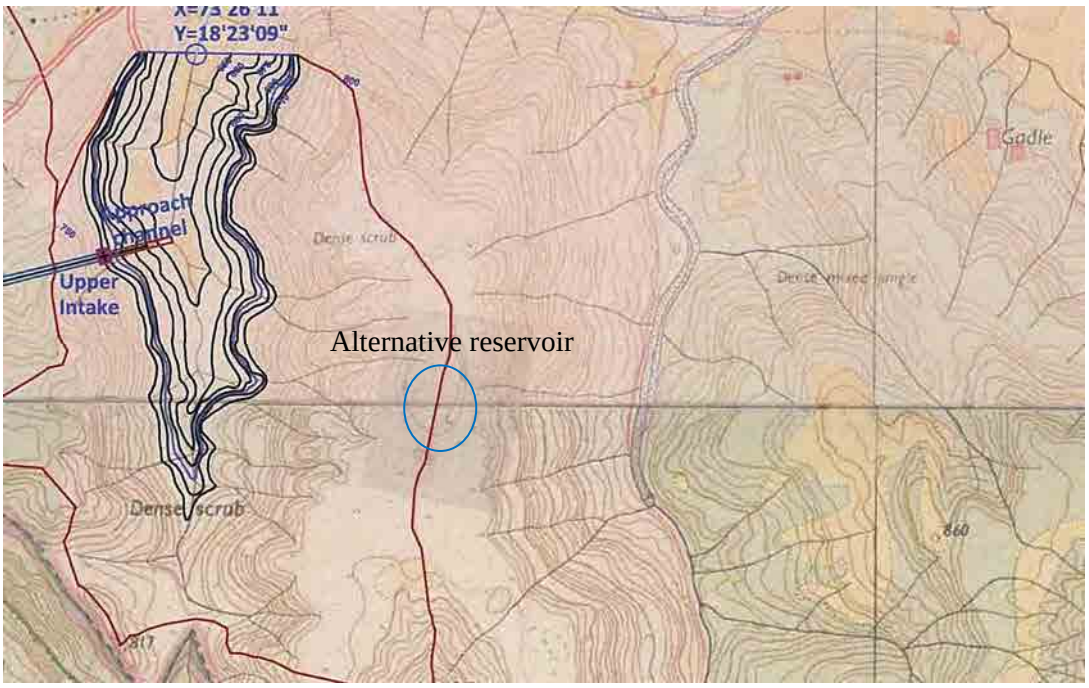


Figure 9.2.2.2-10 Topographic map

(2) Geology

1) Solidity of the rock beds

i) Rock type

The observed rock type in outcrops is mostly the dark gray dense compact basalt, and partially the vesicular basalt with vesicles. These are hard and makes slightly unclear metallic sound when hit with a hammer.

ii) Weathering

Weathering depth is estimated to be about 1 meter, but the intensity of weathering is rather low that the rock is hardly breakable with a hammer.

iii) Deterioration

There are well developed nearly vertical joints and the rocks appear like blocks 30 ~ 70 cm across bonded to one another. No selective weathering along the joints is observed. Faults or hydrothermal alterations are not observed.

iv) Heterogeneity

The rock beds consist mainly of the compact basalt and partly of the vesicular basalt. There is no significant difference in the quality of these, hence the rock beds as a whole are regarded as almost homogenous.

v) Covering layers

Overburden consisting of silt and gravels with a thickness less than a few tens of centimeters

is widely distributed. The basalt gravels are poorly sorted.

Figure 9.2.2.2-11 Compact basalt with columnar joints

Figure 9.2.2.2-12 Compact basalt with thin soil cover

2) Permeability

i) Porosity of the rock

The compact basalt is very dense, hence has few pores. The vesicles of the vesicular basalt are not interconnected. Therefore, the permeability of the rock itself must be very low.

ii) Open cracks

The columnar joints are tight as seen on the outcrop, but they are well developed all over the place therefore the possibility of continuity that may cause leakage cannot be denied.

iii) Ground water level

There was no running or stagnant water on the surface. The land is very dry, and judging from the landform, ground water level must be considerably low.

(3) Hazard

Since the hilltop is flat, there is no possible slide or collapse. On the slopes surrounding the hill top, only minor collapses near the surface can be seen, and there is no collapse or fall large enough to be concerned. However, the slopes are entirely steep, so they must be cautious of failure when excavated.

Hazard of earthquakes is, according to the desk study, moderately high.

9.2.2.3 Varandh Ghat

A. Varandh Ghat Upper Dam

(1) Landform

1) Ability to store and sustain water

i) Shape of the reservoir

The valley lies between long ridges in parallel and the stream gradient is low, so it is suitable to form a reservoir. However, since there is no narrowing, the dam body must be relatively long.

ii) Shape of the dam axis

Both abutments are relatively gentle valley walls with small streams, therefore they are very unlikely to cause leakage.

2) Vertical distance

The assumed vertical distance between the lower dam is less than 600 m.

Figure 9.2.2.3-1 Dam axis seen from left bank

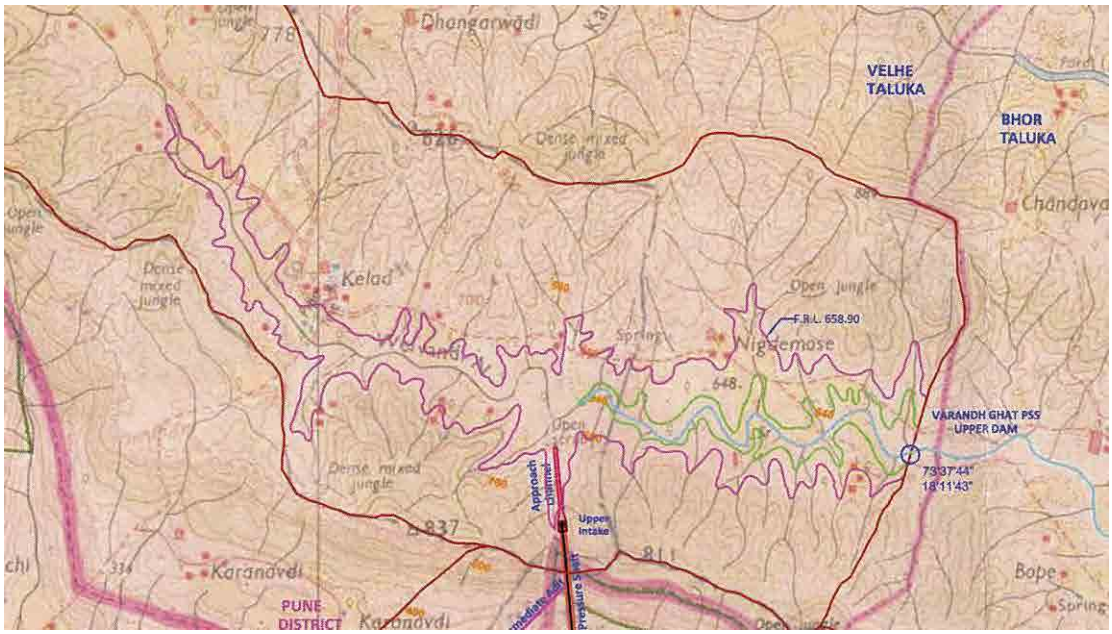


Figure 9.2.2.3-2 Topographic map

(2) Geology

1) Solidity of the dam foundation

i) Rock type

The observed rock type in outcrops is the compact basalt, which is dark gray in color, dense, and so hard as to make metallic sound when hit with a hammer.

ii) Weathering

Weathered portion is generally very thin; only changes in color on the surface or slight softening of 1 ~ 2 cm from the surface are noticeable in most cases, and laterite is rarely found.

iii) Deterioration

Although there are nearly vertical joints, they are widely spaced by the intervals of 30 ~ 80 cm, and no selective weathering along the joints is observed. Faults or hydrothermal alterations are not observed.

iv) Heterogeneity

Judging from the surface conditions, the rock beds seem to be massive and homogenous.

v) Covering layers

The covering layers are generally thin; riverbed deposit is about 0.5 m thick, and overburden on slopes is about 0.5~ 1 m thick.

Figure 9.2.2.3-3 Compact basalt outcrop at river floor

Figure 9.2.2.3-4 Thin overburden covering compact basalt

2) Permeability

i) Porosity of the rock

The compact basalt is very dense, hence has few pores. Therefore, the permeability of the rock itself must be very low.

ii) Open cracks

The joints are almost completely closed, so there seems to be very few continuous openings that may cause leakage of water within the rock beds.

iii) Ground water level

There was no running water observed in a channel during the surface explorations. Ground water level during the dry season must be considerably low.

(3) Hazard

Although there are very minor collapses near the surface, there is no collapse or fall that may be problematic. Hence, hazard of slope failure must be low.

Hazard of earthquakes is, according to the desk study, moderately high.

B. Varandh Ghat Lower Dam

(1) Landform

1) Ability to sore and sustain water

i) Shape of the reservoir

The valley is long, wide, deep, and has low stream gradient, therefore it is suitable to form a reservoir. However, since there is no narrowing, the dam body must be relatively long.

ii) Shape of the dam axis

Both abutments are large valley walls; hence they are very unlikely to cause leakage.

2) Vertical distance

The assumed vertical distance between the upper dam is less than 600 m.

Figure 9.2.2.3-5 Dam axis seen from left bank

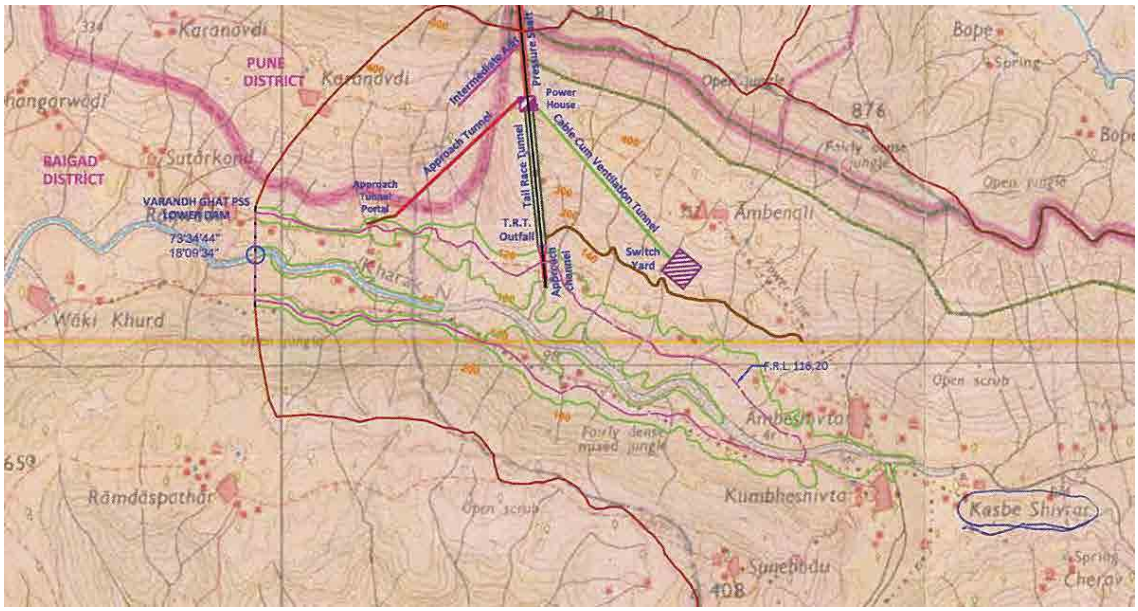


Figure 9.2.2.3-6 Topographic map

(2) Geology

1) Solidity of the dam foundation

i) Rock type

The observed rock type in outcrops is the compact basalt, which is dark gray in color, dense, and so hard as to make metallic sound when hit with a hammer.

ii) Weathering

Weathered portion is generally very thin; only changes in color on the surface are noticeable in most cases.

iii) Deterioration

Although there are nearly vertical joints, they are widely spaced by the intervals of 30 ~ 100 cm, and no selective weathering along the joints is observed. Faults or hydrothermal alterations are not observed.

iv) Heterogeneity

Various kinds of rocks such as the vesicular basalt, the amygdaloidal basalt, and the volcanic breccia, are found as gravels in the riverbed near the dam axis. The volcanic breccia, which contains rock fragments and is relatively soft, is interbedded within the compact basalt, however that is far upstream from the dam axis. Outcrops in the vicinity suggest that the rock beds at the dam axis seem to be massive and homogenous.

v) Covering layers

The covering layers are generally thin; riverbed deposit is about 0.5 ~ 2 m thick, and overburden on slopes is 1 m thick in general and 5 m at the most.

Figure 9.2.2.3-7 Compact basalt outcrop and boulders

Figure 9.2.2.3-8 Relatively thick soil cover

2) Permeability

i) Porosity of the rock

The compact basalt is very dense, hence has few pores. The volcanic breccia and the

amygdaloidal basalt are not porous, and the vesicles of the vesicular basalt are not interconnected. Therefore, the permeability of the rock itself must be very low.

ii) Open cracks

The joints are almost completely closed, so there seems to be very few continuous openings that may cause leakage of water within the rock beds.

iii) Ground water level

There was no running water observed in a channel during the surface explorations. Ground water level during the dry season must be considerably low.

(3) Hazard

Although there are no unstable slopes in particular currently, the slopes in this area are in all steep and very high. Therefore, this dam site has relatively higher hazard of slope failure than the others. Hazard of earthquakes is, according to the desk study, moderately high.

9.2.3 Evaluation and Comparison of the Sites

Table 9.2.3-1 Evaluation of field survey sites

Object		Location	Panshet		Warasgaon			Varandh Ghat	
		Reservoir	Upper	Lower	Upper	Lower	Alternative	Upper	Lower
Landform		Reservoir	◎	○	○	○	○	○	○
		Dam Axis	○	△	△	△	△	○	○
		Head	○	○	○	○	◎	○	○
Geology	Bed Rock	Rock Type	◎	◎	◎	◎	△ *	◎	◎
		Weathering	○	◎	○	◎	△ *	○	○
		Local Deterioration	◎	◎	◎	◎	◎	◎	◎
		Heterogeneity	○	○	○	○	○	○	○
		Overburden	○	◎	◎	◎	△ *	◎	○
	Permeability	Porosity	◎	◎	◎	◎	◎	◎	◎
		Open Crack	○	○	○	○	△	○	○
		Ground Water Level	△	△	△	△	△	△	△
Hazard		Landslide	○	○	○	○	○	○	○
		Rockfall	○	○	○	○	○	○	△
		Earthquake	○	○	○	○	○	○	○

Point	Symbol	Explanation of the symbol	Numbers of the symbol						
3	◎	No problem expected	4	5	4	5	3	4	3
2	○	No major problem expected	9	7	8	7	5	9	9
1	△	Some problems expected	1	2	2	2	6	1	2
0	×	Major problems expected	0	0	0	0	0	0	0

Total point for the single reservoir	31	31	30	31	25	31	29
Total point for the pair of the two reservoirs	62		61			60	
				56			

* As for Warasgaon Alternative reservoir, rocks are evaluated for excavation, not for foundation, therefore the same rocks have different results.

The sites were evaluated according to the criteria described earlier in this section. The result for each criterion was quantified, 3 for the best (◎) and 0 for the worst (×). Points for both upper and lower reservoirs were combined as a pair for each site.

The site with the highest point is Panshet, followed by Warasgaon, and Varandh Ghat is the lowest. The difference in terms of the points is very small and this evaluation method is not generalized or orthorized. Therefore, the difference should be regarded as negligible.

Because the geology for each site is the same Deccan Trapps, the rock types and features are basically equal despite there are slight differences in the thickness of weathered portions and covering layers.

Incidentally, Warasgaon upper alternative reservoir was treated in a different way; solidness of the rock beds was unfavorable for excavation as opposed to that it was favorable for dam foundation.

As far as only surface conditions are concerned, no major problem is expected for each site. All the three sites are geologically feasible to construct a dam as proposed and there is no significant difference among them.

If it is necessary to differentiate the three sites, in other words, to determine the best, additional information about underground condition must be obtained by drilling or other means.

9.3 Layout

In this chapter, layout of every structure is reviewed to three candidate sites planed by WRD in terms of topographic condition observed in the site survey.

9.3.1 Panshet

(1) Main Features

Main features of Panshet Pumped Storage scheme planned by WRD are as summarized in Table 9.3.1-1.

Table 9.3.1-1 Main Features of Upper Dam and Lower Dam

	unit	Upper Dam	Lower Dam
F.R.L.	EL.-m	738.00	176.50
M.D.D.L.	EL.-m	715.00	164.50
Available Depth	m	23.00	12.00
Dam Type	-	Roller Compacted Concrete	
Gross Capacity	MCM	19.78	33.44
Available Capacity	MCM	13.42	13.42
Dam Height	m	70.20	56.70
Crest Length	m	480.00	1395.00

(Source: Pumped Storage Hydro Electric Power Development in Maharashtra, WRD, 09th March 2012)

(2) Upper Dam

The planned dam site is generally as acceptable to the planned dam having dam height 70.20 m; however, following possible problems are observed.

1) Due to rather thinner ridges of both abutments, some treatments would be required to assure water tightness
2) As for height of backwater saddle, allowance to reservoir water level is around 50 m only, so that saddle dams may be required in the later detailed study.
3) Although the crest length is 425 m only, suitable dam type shall be selected from economic and technical point of view. In the present study, RCC (Roller Compacted Concrete) is adopted.
4) Large inflow discharge, as well as large sediment inflow, is not anticipated because of limited catchment area. Actually, no streak line implicating large discharge was observed at the site survey.
5) Reservoir capacity and dam height dam may have to be revised because the interval of contour line was 10 m against planned available depth of the reservoir 23 m due to limited accuracy of topographic map, scale 1/25,000, as well as rather complicated configuration of the reservoir area.
6) Approach channel having 425 m of total length and 14 m of width is planned in the reservoir. This would need large work volume, considering 23 m of available depth of the reservoir, so that alternative should be studied including change of waterway alignment.

(3) Lower Dam

The planned dam site is generally as acceptable to the planned dam having dam height 56.70 m; however, following possible problems are observed.

1) Because width of both sides' ridges of abutments is so thin and their height does not have enough allowance to reservoir water level, some counter measures, such as saddle dams, would be required to keep planed water level. Also, some treatment would be required to assure water tightness.
2) Reservoir capacity and dam height dam may have to be revised because the interval of contour line was 10 m due to limited accuracy of topographic map, scale 1/25,000, against planned available depth of the reservoir 12 m.
3) The planed crest length is considerably long and dam height is not so high; therefore, rock fill type dam would be favorable in economical point of view. In this concern, since cover soil in the reservoir area seems to be rather thin generally, available amount of embankment material, especially impervious one would be main issue in the later study.

4) Large inflow discharge, as well as large sediment inflow, is not anticipated because of limited catchment area. Actually, no streak line implicating large discharge was observed at the site survey. As for sediment yield in the catchment area, since most of reservoir slope zone is surrounded by steep rock cliff, source of sediment yield is also so limited.

(4) Others

1) Length of access tunnel to powerhouse is more than 2.0 km due to topographic condition around lower area, which would govern the project construction schedule because works relating powerhouse cannot be commenced until excavation of access tunnel is completed.
2) Considering the length of pressure conduit, such as Headrace and Penstock, surge tank has to be provided, however, available space for surge tank is so limited due to topographic condition of Upper Reservoir Area.
3) Rock cover above Headrace Tunnel would be rather thin, which is one of anxieties.
4) Judging from the length of tailrace tunnel, more than 1200 m, surge tank is to be provided; underground type of chamber is to be applied due to topographic condition.
5) Due to the topographic condition, such as steep and high rock cliff, the land of Switch yard would be so limited, which shall be well considered together with the alignment of Power Cable Tunnel.

Figure 9.3.1-1 Backwater Area of Panshet Upper Dam

Figure 9.3.1-2 Riverbed Condition of Upper Dam Downstream

Figure 9.3.1-3 Ridge of Right Abutment of Panshet Lower Dam

Figure 9.3.1-4 Riverbed Condition of Downstream of Panshet Lower Dam

9.3.2 Warasgaon

(1) Main Features

Main features of Warasgaon Pumped Storage scheme planned by WRD are as summarized in Table 9.3.2-1.

Table 9.3.2-1 Main Features of Upper Dam and Lower Dam

	unit	Upper Dam	Lower Dam
F.R.L.	EL.-m	695.50	144.50
M.D.D.L.	EL.-m	669.00	138.00
Available Depth	m	26.50	6.50
Dam Type	-	Roller Compacted Concrete	
Gross Capacity	MCM	13.82	39.26
Available Capacity	MCM	9.51	9.51
Dam Height	m	56.70	43.50
Crest Length	m	520.00	1720.00

(Source: Pumped Storage Hydro Electric Power Development in Maharashtra, WRD, 09th March 2012)

(2) Upper Reservoir

The planned dam site is generally as acceptable to the planned dam having dam height 56.70;

however, following possible problems are observed.

1) Due to limitation of ground level of left abutment, height dam is also limited. It is revealed by GPS measurement that planned dam height shall be lowered from original plan by WRD.
2) Height of backwater saddle does not have enough allowance to the reservoir water level. It is recommendable to reduce reservoir water level.
3) As one of alternatives site, plain behind left bank of planned reservoir could be taken, in which reservoir would become excavated reservoir type. In case of the said alternative, length of waterways would become longer than the original.
4) As the other alternatives site, top of the hill located at right bank of the reservoir is also taken, in which . However, according to the site reconnaissance, it was found that top of the hill have been covered by hard and tough rock to construct excavated reservoir, the length of waterway would become more longer than the original, which is extended to the underground of the reserved forest, profile of waterway would become complicated one due to the topographic condition, etc, so that these alternatives would not become better options.
5) Any streak line implicating large water flow has not been observed. And large sediment inflow has not been anticipated because of limited catchment area.

(3) Lower Reservoir

The planned dam site is generally as acceptable to the planned dam having dam height 43.50; however, following possible problems are observed.

1) Widths of both sides' ridges of abutments are thin and the height of them does not have enough allowance to planned reservoir water level, so that some treatment may be required, such as consolidation grouting to improve water tightness and saddle dams.
2) Reservoir capacity and dam height dam may have to be revised because the interval of contour line was 10 m due to limited accuracy of topographic map, scale 1/25,000, against planned available depth of the reservoir 6.5m. In this regard, 10 m of difference have been observed in the site survey between the elevation on the topographic map and GPS measurement.
3) The planed crest length is considerably long and dam height is not so high; therefore, rock fill type dam would be favorable in economical point of view. In this concern, since cover soil in the reservoir area seems to be rather thin generally, available amount of embankment material, especially impervious one, would be main issue in the later study.
4) Any streak line implicating large water flow has not been observed. And large sediment inflow has not been anticipated because of limited catchment area and most of reservoir slope zone surrounded by steep rock cliff.

(4) Others

1) Length of access tunnel to powerhouse is more than 1.8 km due to topographic condition around lower area, which would govern the project construction schedule because works relating powerhouse cannot be commenced until excavation of access tunnel is completed.
2) Considering the length of pressure conduit, such as Headrace and Penstock, surge tank has to be provided, however, available space for surge tank is so limited due to topographic condition of Upper Reservoir Area.
3) Rock cover above Headrace Tunnel would be rather thin, which is one of anxieties.
4) Judging from the length of Tailrace Tunnel, 1,700 m long in WRD's plan, surge tank is surely required. Due to topographic condition, underground surge chamber is to be selected.
5) Due to the topographic condition, such as steep and high rock cliff, the land of Switch yard would be so limited, which shall be well considered together with the alignment of Power Cable Tunnel

Figure 9.3.2-1 Ridge of Right Abutment of Warasgaon Upper Dam

Figure 9.3.2-2 Riverbed Condition of Warasgaon Upper Dam

Figure 9.3.2-3 Ridge of Right Abutment of Warasgaon Lower Dam

Figure 9.3.2-4 Riverbed Condition of Lower Reservoir

9.3.3 Varandh Ghat

(1) Main Features

Main features of Varandh Ghat Pumped Storage scheme planned by WRD are as summarized in Table 9.3.3-1.

Table 9.3.3-1 Main Features of Upper Dam and Lower Dam

	unit	Upper Dam	Lower Dam
F.R.L.	EL.-m	658.90	116.20
M.D.D.L.	EL.-m	655.00	112.10
Available Depth	m	3.90	4.10
Dam Type	-	Roller Compacted Concrete	
Gross Capacity	MCM	31.62	41.73
Available Capacity	MCM	4.85	4.85
Dam Height	m	40.90	50.70
Crest Length	m	560.00	700.00

(Source: Pumped Storage Hydro Electric Power Development in Maharashtra, WRD, 09th March 2012)

(2) Upper Reservoir

The planned dam site is generally as acceptable to the planned dam having dam height 40.90 m;

however, following possible problems are observed.

1) Reservoir capacity and dam height dam may have to be revised because the interval of contour line was 20 m due to limited accuracy of topographic map, scale 1/50,000, against planned available depth of the reservoir 3.9 m. In this regard, any significant difference has not been observed in the site survey between the elevation on the topographic map and GPS measurement.
2) Depth about 1 m of streak line have been observed at the river bed level and, judging from state of vegetation growth along river-bed bank slope, large inflow is not anticipated.
3) River bed has been covered by mainly around 10 cm size of cobble stones, so that extreme sediment yield is not anticipated.

(3) Lower Reservoir

The planned dam site is generally as acceptable to the planned dam having dam height 50.70 m; however, following possible problems are observed.

1) The reservoir available capacity and the dam height may have significant errors, because the interval of contour line was 20 m against resulted available depth 4.10 m in the study due to the topographic map applied to the study was scale 1/50,000
2) Around the planned dam axis, river terrace having thickness 10 m to 20 m is formed. If the said river terrace has large thickness of deposited soil, large volume of foundation excavation would be required. (According to the geological reconnaissance, it is judged that thickness of deposited soil is not significantly thick.)

(4) Others

1) Length of Access Tunnel to Powerhouse is shorter than those of other 2 schemes; around 1.2 km; however, river-crossing bridge is required for various construction works, because access road to site is reached to left bank and powerhouse, switchyard, portals of waterways, etc is located on right bank.
2) Surge Tank is to be provided to Tailrace Tunnel judging from the length of the tunnel; around 1,000 m, underground type would be chosen due to the topographic condition.

Figure 9.3.3-1 Ridge of Right Abutment of Varandh Ghat Upper Dam

Figure 9.3.3-2 Riverbed Condition of Varandh Ghat Upper Dam

Figure 9.3.3-3 Right Abutment of Varandh Ghat Lower Dam

Figure 9.3.3-4 Riverbed Condition of Varandh Ghat Lower Dam

9.4 Environmental and Social Considerations

9.4.1 Data Collection Sheet

Site survey at each candidate site was conducted in March and April 2012. The objectives of the survey are to collect further information on the sites for environmental and social considerations. Data collection sheet (Table 9.4.1-1) is prepared for the site survey.

Table 9.4.1-1 Data collection sheet for the reconnaissance surveys

Name of the site	
Date of the survey	
District	
Taluka	
Village	1. Name: 2. Distance from the site: 3. Population and tribe(s): 4. Main occupations: 5. Income level: 6. Infrastructures:
Land use pattern of the area	1. Agricultural land (farmland, fruit farm): 2. Pasture: 3. Forestry: 4. Others
River (s)	
River utilization especially in downstream areas	1. Fishery: 2. Irrigation: 3. Industrial utilization: 4. Others
Religious and cultural heritage	1. Temple: 2. Cemetery or crematorium: 3. Others
Forest cover	
Fauna & flora	It needs a survey on them.[1]
Mining concession	There is none according to the list of the Mining Department, Maharashtra[2].

[1] Due to time constraints, no survey on fauna and flora was conducted. Since the sites are within one of the Biodiversity Hotspots, a detailed survey on fauna and flora needs to be conducted in future if one of the sites is selected as the most promising one.

[2] There are no mining concessions in the sites according to the Notification (NO.MLV/MISC/270/2007/96) by Directorate of Geology and Mining, Govt. of Maharashtra, Nagpur on 07/01/2008.

9.4.2 Results

(1) Panshet

The results of the site survey on Panhset are presented as Table 9.4.2-1 (upper dam and reservoir) and Table 9.4.2-2 (lower dam and reservoir).

Table 9.4.2-1 Survey results on Panshet upper dam and reservoir

Name of the site	PANSHET Upper dam and reservoir
Date of the survey	31 March 2012
District	Pune
Taluka	Velhe
Village	The village is within the proposed reservoir. 1. Name: Daspar 2. Distance from the site: The centre of the village is about 500 m from the centre point of the proposed dam (based on the Topo Sheet No. 47-F/7, scale 1:25,000). 3. Population and tribe(s): It should be inquired at the Revenue office of Velhe. 4. Main occupations: It is observed that agriculture is their main occupation. They may get cash income from activities outside the village as migrant workers during dry season. 5. Income level: It should be inquired at the Revenue office of Velhe. 6. Infrastructures: There is a paved road and electricity line. There is a primary school from 500 m from the road. There is no health centre in the village according to WRD. No irrigation system is observed. Although there is a well for water supply, water supply system needs to be confirmed.
Land use pattern of the area	1. Agricultural land (farmland, fruit farm): There are some agricultural lands. 2. Pasture: Cows eat grasses in the village. 3. Forestry: It is unlikely because the trees are not suitable for forestry (small trees). But they collect fire woods. 4. Others
River (s)	Mose. There is the Panshet (Tanaji Sagar) reservoir about 3 km from the centre point of the dam.
River utilization especially in downstream areas	1. Fishery: At Daspar, it is unlikely that there is commercial fishery because of the size of the rivers (small and dry-up in the dry season). 2. Irrigation: No irrigation system is observed, and agricultural lands are in the vicinity of streams (or rivers) and they practice rain-fed agriculture. 3. Industrial utilization: None 4. Others
Religious and cultural heritage	1. Temple: There is one on a small hill in the middle of the proposed reservoir. 2. Cemetery or crematorium: To be confirmed. 3. Others
Forest cover	Along the streams, they are well covered with small trees. Based on the Topo Sheet, no reserved forest is overlapped with the project site.
Fauna & flora	It needs a survey on them.
Mining concession	There is none according to the list of the Mining Department, Maharashtra.

Agiricultural land in the reservoir area.

Well grown forest in the reservoir area.

Figure 9.4.2-1 Panshet upper site

Table 9.4.2-2 Survey results on Panshet lower dam and reservoir

Name of the site	**PANSHET Lower dam and reservoir**
Date of the survey	3 April 2012
District	Raigad
Taluka	Mangaon
Village	There are no houses observed within the proposed reservoir. There are agricultural lands within the proposed reservoir. An electricity line of 22,000 v is running within the proposed reservoir. 1. Name: Sakalyachiwadi 2. Distance from the site: The centre of the village is about 500 m from the centre point of the proposed dam (based on the Topo Sheet No. 47-F/7, scale 1:25,000). 3. Population and tribe(s): It should be inquired at the Revenue office of Mangaon. 4. Main occupations: It is observed that agriculture is their main occupation. They get cash income from activities outside the village as migrant workers during dry season, and some of them work in Mumbai. 5. Income level: It should be inquired at the Revenue office of Mangaon 6. Infrastructures: There is an unpaved road from Jite (until Jite, there is a paved road), and a bridge connecting to Jite is under construction. An electricity line. There is a primary school in the village. A health centre is in Nijampur, 6 km away from the village. No irrigation system is observed.
Land use pattern of the area	1. Agricultural land (farmland, fruit farm): There are agricultural lands in the proposed reservoir. 2. Pasture: Few cows are observed, but they feed grasses in the proposed reservoir. 3. Forestry: It is unlikely because the trees are not suitable for forestry (small trees). But they collect fire woods. 4. Others
River (s)	Kal
River utilization especially in downstream areas	1. Fishery: At Sakalyachiwadi, it is unlikely that there is commercial fishery because of the size of the rivers (small and dry-up in the dry season). 2. Irrigation: No irrigation system is observed, and agricultural lands are in the vicinity of streams (or rivers) and they practice rain-fed agriculture. 3. Industrial utilization: None. 4. Others
Religious and cultural heritage	1. Temple: There is one in the village. 2. Cemetery or crematorium: A villager told that there is a crematorium near the village (not in the proposed reservoir). 3. Others
Forest cover	Not well covered in the village including the agricultural lands. Around the proposed reservoir area, there are small trees and scrubs. Based on the Topo Sheet, no reserved forest is overlapped with the project site.
Fauna & flora	It needs a survey on them.
Mining concession	There is none according to the list of the Mining Department, Maharashtra.

	
Mixture of agricultural lands and Shrubs/small trees in the reservoir area.	Agricultural land in the reservoir area.

Figure 9.4.2-2 Panshet lower site

(2) Warasgaon

The results of the site survey on Warasgaon are presented as Table 9.4.2-3 (upper dam and reservoir), Table 9.4.2-4 (upper dam and resesrvoir, alternative site) and Table 9.4.2-5 (lower dam and reservoir).

Table 9.4.2-3 Survey results on Warasgaon upper dam and reservoir

Name of the site	Warasgaon Upper dam and reservoir
Date of the survey	02 April 2012
District	Pune
Taluka	Mulshi
Village	There are no houses in the proposed reservoir area. There are agricultural lands within the proposed reservoir. 1. Name: Dhamanhol 2. Distance from the site: The centre of the village is about 1 km from the centre point of the proposed dam (based on the Topo Sheet No. 47-F/7, scale 1:25,000). 3. Population and tribe(s): It should be inquired at the Revenue office of Mulshi. 4. Main occupations: It is observed that agriculture is their main occupation. They may get cash income from activities outside the village as migrant workers during dry season. 5. Income level: It should be inquired at the Revenue office of Mulshi 6. Infrastructure: There is a paved road and an electricity line. There is a primary school in the centre. A health centre in the village is not confirmed but it seems there is none. No irrigation system is observed.
Land use pattern of the area	1. Agricultural land (farmland, fruit farm): In the proposed reservoir, there are agricultural lands. 2. Pasture: The area of the proposed reservoir is used as a pasture of cows. 3. Forestry: It is unlikely because the trees are not suitable for forestry (small trees). But they collect fire woods. 4. Others
River (s)	Mose. There is a reservoir down stream of the river.
River utilization especially in downstream areas	1. Fishery: At Dhamanhol, it is unlikely that there is commercial fishery because of the size of the rivers (small and dry-up in the dry season). 2. Irrigation: No irrigation system is observed, and agricultural lands are in the vicinity of streams (or rivers) and they practice rain-fed agriculture.. 3. Industrial utilization 4. Others
Religious and cultural heritage	1. Temple: There are two near the village centre. There is none in the proposed reservoir.

	2. Cemetery 3. Others
Forest cover	The proposed reservoir area (on the hill) is covered by scrubs with small trees. Based on the Topo Sheet, no reserved forest is overlapped with the project site.
Fauna & flora	It needs a survey on them.
Mining concession	There is none according the list of the Mining Department, Maharashtra.

	
Agricultural land in the reservoir area which is maintained by the local people.	The reservoir area is also used as a grazing site for these cows.

Figure 9.4.2-3 Warasgaon upper site

Table 9.4.2-4 Survey results on Warasgaon upper dam and reservoir (alternative site)

Name of the site	**Warasgaon Upper dam and reservoir (alternative site)**
Date of the survey	16 April 2012
District	Pune
Taluka	Mulshi
Village	There are neither houses nor agricultural lands in the proposed reservoir area. Name: Dhamanhol Regarding the village, refer to Table 9.4.2-3.
Land use pattern of the area	The area of the proposed reservoir is used as a pasture of cows. The local people collect non-timber forest products such as fire wood.
River (s)	Mose. There is a reservoir down stream of the river.
River utilization especially in downstream areas	Refer to Table 9.4.2-3.
Religious and cultural heritage	1. Temple: There is none in the proposed reservoir. 2. Cemetery: There is none. 3. Others
Forest cover	The proposed reservoir area (on the hill) is covered by scrubs with small trees. Based on the Topo Sheet, no reserved forest is overlapped with the project site.
Fauna & flora	It needs a survey on them.
Mining concession	There is none according the list of the Mining Department, Maharashtra.

Oerview of the reservoir area. There are no agricultural lands in the area.

Although there are not forests because of its landform and geology, unique vegetations are found.

Figure 9.4.2-4 Warasgaon upper site (alternative site)

Table 9.4.2-5 Survey results on Warasgaon lower dam and reservoir

Name of the site	**Warasgaon Lower dam and reservoir**
Date of the survey	03 April 2012
District	Raigad
Taluka	Mangaon
Village	Almost the entire village is within the proposed reservoir area. 1. Name: Umbardi 2. Distance from the site: The village is within the proposed reservoir. 3. Population and tribe(s): It should be inquired at the Revenue office of Mangaon. According to a village person, the population is about 1,000 – 1,200. 4. Main occupations: According to the village person, agriculture is their main occupation (one crop: rice). They get cash income from activities outside the village as migrant workers during dry season, and some of them work in Mumbai. 5. Income level: It should be inquired at the Revenue office of Mangaon 6. Infrastructure: There is an unpaved road (paved only in the village) and an electricity line. There is a primary school in the centre. There is no health centre in the village but a medical officer visits the village once a week. No irrigation system is observed. A water tank and water supply system is observed.
Land use pattern of the area	1. Agricultural land (farmland, fruit farm): There are agricultural lands. 2. Pasture: The area of the proposed reservoir is used as a pasture of cows. 3. Forestry: It is unlikely because the trees are not suitable for forestry (small trees). But they collect fire woods. 4. Others
River (s)	Kal.
River utilization especially in downstream areas	1. Fishery: At Umbardi, it is unlikely that there is fishery because of the size of the rivers (small and dry-up in the dry season). 2. Irrigation: No irrigation system is observed, and agricultural lands are in the vicinity of streams (or rivers) and they practice rain-fed agriculture. 3. Industrial utilization 4. Others
Religious and cultural heritage	1. Temple: There is one in the village centre. 2. Cemetery or crematorium: A crematorium is located at the riverside of Kal river. 3. Others
Forest cover	The proposed reservoir area is mainly covered by agricultural lands with scattered trees and scrubs. Based on the Topo Sheet, no reserved forest is overlapped with the project site.
Fauna & flora	It needs a survey on them.
Mining concession	There is none according the list of the Mining Department, Maharashtra.

	
Oerview of the village in the reservoir area.	Houses in the village.

Figure 9.4.2-5 Warasgaon lower site

(3) Varandh Ghat

The results of the site survey on Varandh Ghat are presented as Table 9.4.2-6 (upper dam and reservoir) and Table 9.4.2-7 (lower dam and reservoir).

Table 9.4.2-6 Survey results on Varandh Ghat upperdam and reservoir

Name of the site	Varandh Ghat Upper dam and reservoir
Date of the survey	04 April 2012
District	Pune
Taluka	Velhe
Villages	There are two villages in the project site. The houses are not within the proposed reservoir, but their agricultural lands are within the reservoir area. 1. Name: Nigademose and Kelad 2. Distance from the site: The centre of Nigademose is about 1.5 km from the centre point of the proposed dam, and the centre of Kelad is about 4 km (based on the Topo Sheet No. 47-F/12, scale 1:50,000). 3. Population and tribe(s): It should be inquired at the Revenue office of Velhe. 4. Main occupations: It is observed that agriculture is their main occupation. They may get cash income from activities outside the village as migrant workers during dry season. 5. Income level: It should be inquired at the Revenue office of Velhe. 6. Infrastructure: There is a paved road to the villages and electricity line. There is a primary school in Kelad, but school in Nigademose is to be confirmed. A health centre in the villages is not confirmed but it seems there is none. No irrigation system is observed. A water tank is observed in Nigademose, and there is a pipe along the road. It needs to be confirmed whether it is a water supply pipe.
Land use pattern of the area	1. Agricultural land (farmland, fruit farm): In the proposed reservoir, there are agricultural lands. 2. Pasture: The area of the proposed reservoir is used as a pasture of cows, but many cows are not observed. 3. Forestry: It is unlikely because the trees are not suitable for forestry (small trees). But they collect fire woods. 4. Others
River (s)	Welvandi. There is a reservoir (Bhatghar Lake) down stream of the river (about 2.5 km).
River utilization especially in downstream areas	1. Fishery: At Nigademose and Kelad, it is unlikely that there is commercial fishery because of the size of the rivers (small and dry-up in the dry season). 2. Irrigation: No irrigation system is observed, and agricultural lands are in the vicinity of streams (or rivers). 3. Industrial utilization: None. 4. Others
Religious and cultural heritage	1. Temple: There is one in Nigademose, in Kelad the exisitance of a temple is not confirmed. There is none in the proposed reservoir.

	2. Cemetery or crematorium: Not confirmed. 3. Others
Forest cover	The proposed reservoir area is covered with agricultural lands and scrubs with small trees. Based on the Topo Sheet, no reserved forest is overlapped with the project site.
Fauna & flora	It needs a survey on them.
Mining concession	There is none according to the list of the Mining Department, Maharashtra.

	
An agricultural in the reservoir area.	The trees / shrubs behind the agricultural lands seem to be used by the local people.

Figure 9.4.2-6 Varandh Ghat upper site

Table 9.4.2-7 Survey results on Varandh Ghat lower dam and reservoir

Name of the site	**Varandh Ghat Lower reservoir**
Date of the survey	04 April 2012
District	Raigad
Taluka	Mahad
Villages	There are three villages in the project site. Several houses which are assumed to belong to Kumbheshivtar are observed along the road within the proposed reservoir, but it seems that they are temporal ones for agricultural activities. In the proposed reservoir, there are agricultural lands. 1. Name: Ranawadi (downstream), Kumbheshivtar and Ambeshivtar (upstream) 2. Distance from the site: Ranawadi is about 500 m, and Kumbheshivtar and Ambeshivtar are about 4.5 km from the centre point of the proposed dam. 3. Population and tribe(s): It should be inquired at the Revenue office of Mahad. 4. Main occupations: It is observed that agriculture is their main occupation. They get cash income from activities outside the village as migrant workers during dry season, and some of them work in Mumbai. 5. Income level: It should be inquired at the Revenue office of Mahad. 6. Infrastructure: There is an unpaved road (some parts are paved) and an electricity line. There is a primary school and no health centre in Ranawadi (there is a health centre in Birwadi). There is a well and there is a plan to build a water supply system in Ranawadi. No irrigation system is observed. Information on Kumbheshivtar and Ambeshivtar is not collected due to time constraints.
Land use pattern of the area	1. Agricultural land (farmland, fruit farm): There are agricultural lands in the proposed reservoir. 2. Pasture: The area of the proposed reservoir is used as a pasture of cows but a few of them are observed. 3. Forestry: It is unlikely because the trees are not suitable for forestry (small trees). But they collect fire woods. 4. Others
River (s)	Kharak (It is called “Shivathar” in Marathi, the local language)
River utilization especially in downstream areas	1. Fishery: At the villages, it is unlikely that there is fishery because of the size of the rivers (small and dry-up in the dry season). 2. Irrigation: No irrigation system is observed, and agricultural lands are in the

	vicinity of streams (or rivers), and they practice rain-fed agriculture. 3. Industrial utilization: None 4. Others
Religious and cultural heritage	1. Temple: There is one in the village centre of Ranawadi. 2. Cemetery or crematorium: Not observed. 3. Others: There is a saint place in Shivathar Ghal, the upper part of Kumbheshivtar. It is a cave, where Samarth Ramdas Swami Mabaraj, a famous saint in Maharashtra, dictated a holly book "Dassbodh" to his follower Kalyanswami. The place must NOT be submerged by the project, and WRD has already planed the project to avoid it.
Forest cover	The proposed reservoir area is mainly covered by agricultural lands with scattered trees and scrubs. Based on the Topo Sheet, no reserved forest is overlapped with the project site.
Fauna & flora	It needs a survey on them.
Mining concession	There is none according to the list of the Mining Department, Maharashtra.

An overview of the reservoir area. There are agricultural lands witjh scattered trees and shrubs.

Along the river, there is well grown vegetation.

Figure 9.4.2-7 Varandh Ghat lower site

9.4.3 Catchement Areas of the Dams and Reservoirs

Catchment area of each dam and reservoir are shown in Table 9.4.3-1. There is no catchment for the Warasgaon upper dam and reservoir (alternative).

Table 9.4.3-1 Catchment areas of each dam and reservoir[3]

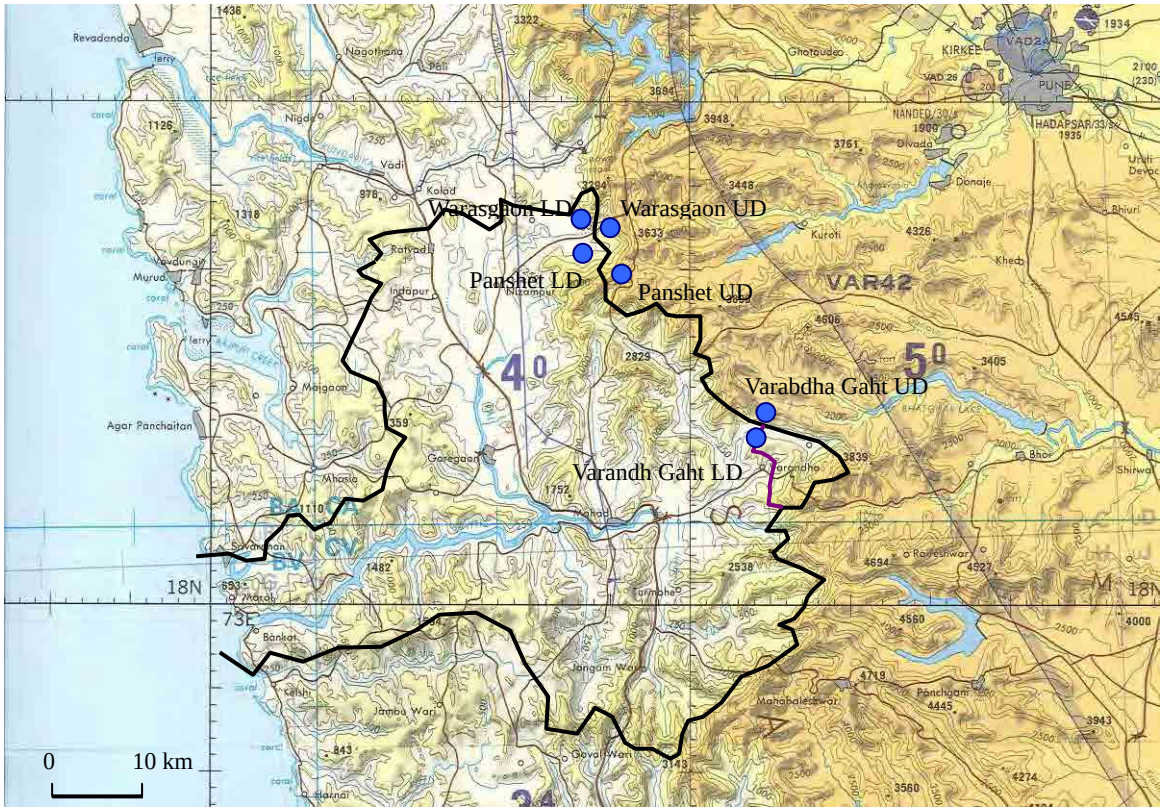
Name	Panshet	Warasgaon	Varandh Ghat
Upper (km^2)	**6.99**	**2.43**	**22.99**
Lower (km^2)	**8.92**	**19.66**	**54.01**

[3] A Note for meeting among J Power 9th March 2012 at Pune on Pumped Storage Hydro Electric Power Development in Maharashtra (Koyna Design Circle)

9.4.4 Downstreams of the Dams and Reservoirs

Upper dams and reservoirs: The rivers of the upper dams and reservoirs flow into the reservoirs located downstream of each site.

Lower dams and reservoirs: The rivers of the lower dams and reservoirs are tiributories of Savitri River. It is a main river which flows into the Arabian Sea. Figure 9.4.4-1 shows the locations of dams and reservoirs in the Savitri River basin.



(Source: JICA Study Team)

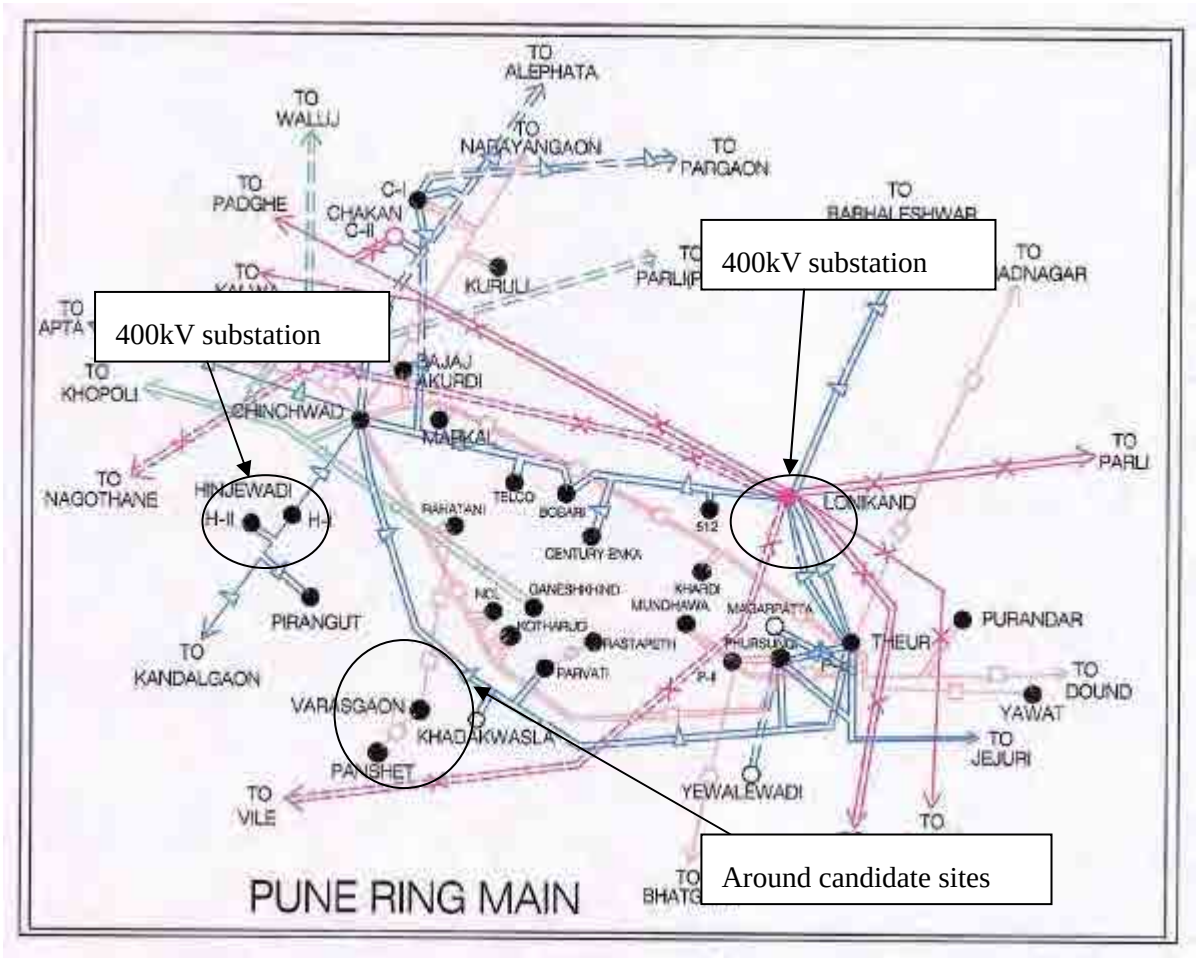
Original map: TACTICAL PILOTAGE CHART TPC J-8C (Scale: 1/500,000)

Figure 9.4.4-1 Dams and reservoirs in the catchment area of Savitri River

9.5 Transmission Line

9.5.1 Connecting Substation and the Distance

Figure 9.5.1-1 shows power map around the candidate sites. Table 9.5.1-1 shows the legend of Figure 9.5.1-1.



(Source: Map-existing&proposed)

Figure 9.5.1-1 Map-existing & proposed around the candidate sites

Table 9.5.1-1 Legend of Figure 9.5.1-1

Equipment	Existing	Proposed
132kV Single Line		
220kV Single Line		
400kV Single Line		
Substation 66kV and above		

(Source : Map-existing&proposed)

There are existing 220kV transmission lines near candidate sites. However it is appropriate that the site will be connected to 400kV power system because maximum installed capacity of the candidate sites is proposed to be 1,400MW.

There aren't 400kV existing substations and transmission lines near the candidate sites. However they

are proposed for STU_FIVE_YEAR_PLAN_2010-11 to 2014-15.

In addition, the schedule of the plan should be considered more detail in the future survey because there are the candidate sites around rocky mountain.

Connecting the candidate site to Lonikand or Hinjewadi Bus can be considered from figure above.

Table 9.5.1-2 shows distance between candidate site and connecting substations.

Table 9.5.1-2 Distance between candidate site and connecting substations.

Case	Substation	Distance (km)		
		Panshet	Warasgaon	Varandh Ghat
Case 1	Hinjewadi	99.4	100	128
Case 2	Lonikand	137	138	139

(Source: JICA study team)

Hinjewadi is nearer to the site than Lonikand from table above. Hinjewadi 400kV bus is proposed, however it is decided to be constructed.

Also, STU says that Hinjewadi – Jejuri transmission line is proposed near the casndidate site although it isn't written in the figure above. So Lonikand – Vile and Hinjewadi – Jejuri are axpected as the location to be connected to transmission line from candidate site.

9.5.2 Criterion of Transmission Line

Reliability of current carrying capacity of the transmission lines is defined that the remaining circuit is able to transmit the full power of candidate site as the one circuit is opend.

Voltage level is defined as 400kV due to installed capacity of candidate site.

Moose is selected to obtain the necessity for current carrying capacity and reducing corona losses. As result preconditions the following transmission lines are selected for the studies.

a. 400kV line: Quad Moose (Capacity of line: 2,600MVA)
b. 400kV line: Twin Moose (Capacity of line: 1,300MVA)

9.5.3 Power System Analysis

(1) Condition of Studies

1) Scope of Simulation Network

Scope of power system for studies is the 400kV transmission line between candidate site and connecting substation, and the circuit from substation bus to grid is simulated by the short circuit capacity.

Connecting substation is defined as Lonikand because Lonikand is more distant and is assumed to be harsher than Hinjewadi.

Twin Moose and Quad Moose are selected as conductor from 9.5.2. However installed capacity of Panshet is 1,400MW, Twin Moose is exceeded capacity of transmission line in the case of single circuit, therefore Quad Moose is selected if the candidate site is Panshet.

2) Mode of Disturbance

A system disturbance level to apply on the transmission line for verifying the power system stability is a 3-phase-ground-fault (3-ϕGF) and the fault clearing time is 0.1second (i.e. the faulted line is opened in 0.1second after the disturbance). But a high-speed re-closing operation is not simulated to reserve an improved stability with the effect of which for a margin.

3) Sequence of Fault and Control Functions

The sequence from the disturbance on the transmission line to the fault clearing is as follows.

- 1st time Instant Applying disturbance (3-ϕGF) on the line
- 2nd time 0.1 second Clearing the fault (open the faulted 1-line, but a high speed re-closing is not performed)

The function of automatic voltage regulator (AVR) and Power System Stabilizer (PSS) are added to

the generators of the candidate site, but Governor is neglected.

PSS is not usually added to all the generators, however the capacity of the candidate site is assumed to

be from 250MW to 350MW, therefore it is recommended that PSS is added to the generators.

(2) Calculation Results

Table 9.5.3-1 and Figure 9.5.3-1 – 10 show results of power stability calculations. Stability of candidate site is maintained in all the case from table below.

Table 9.5.3-1 Calculation results of power system stability

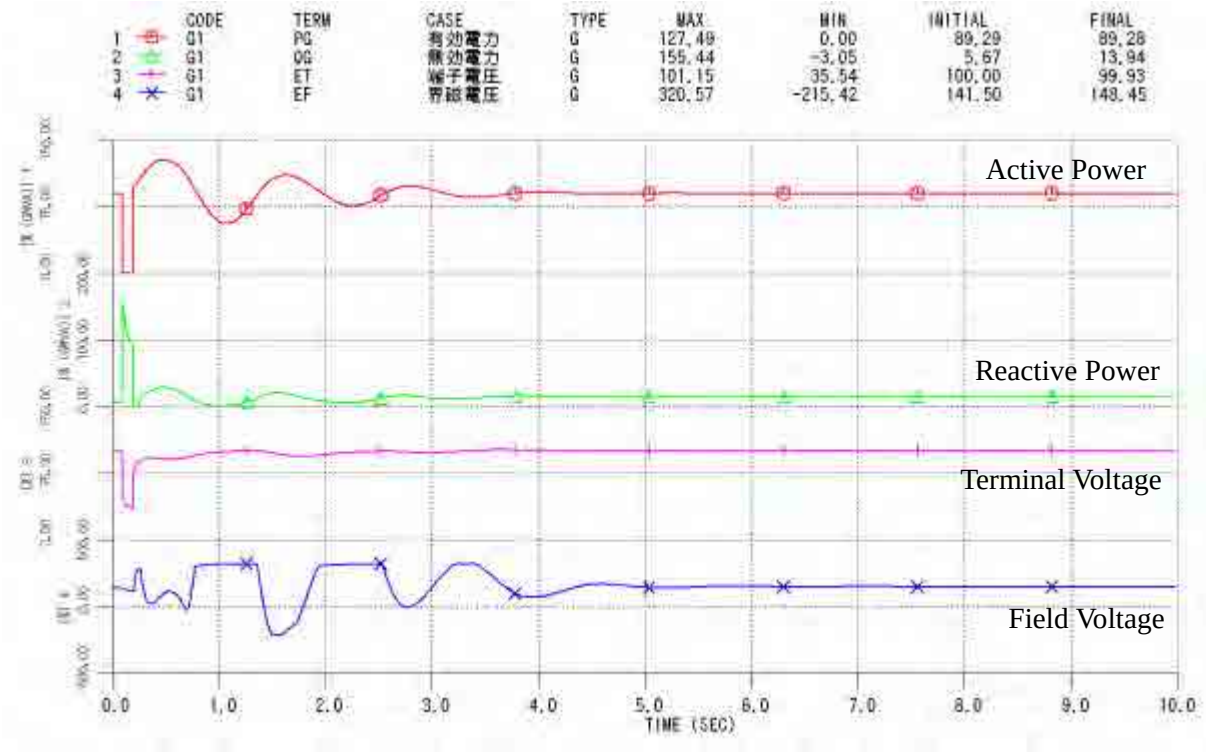
Case	P/S	Power(MW)	Mode of operation	Conductor	Calculation results
Case 1	Warasgaon	1,000	Generation	Twin Moose	Stable
Case 2	Warasgaon	1,000	Pumping	Twin Moose	Stable
Case 3	Warasgaon	1,000	Generation	Quad Moose	Stable
Case 4	Warasgaon	1,000	Pumping	Quad Moose	Stable
Case5	Varandh Ghat	1,100	Generation	Twin Moose	Stable
Case 6	Varandh Ghat	1,100	Pumping	Twin Moose	Stable
Case 7	Varandh Ghat	1,100	Generation	Quad Moose	Stable
Case 8	Varandh Ghat	1,100	Pumping	Quad Moose	Stable
Case 9	Panshet	1,400	Generation	Quad Moose	Stable
Case10	Panshet	1,400	Pumping	Quad Moose	Stable

(Source: JICA study team)

9.5.4 Method of Transmission

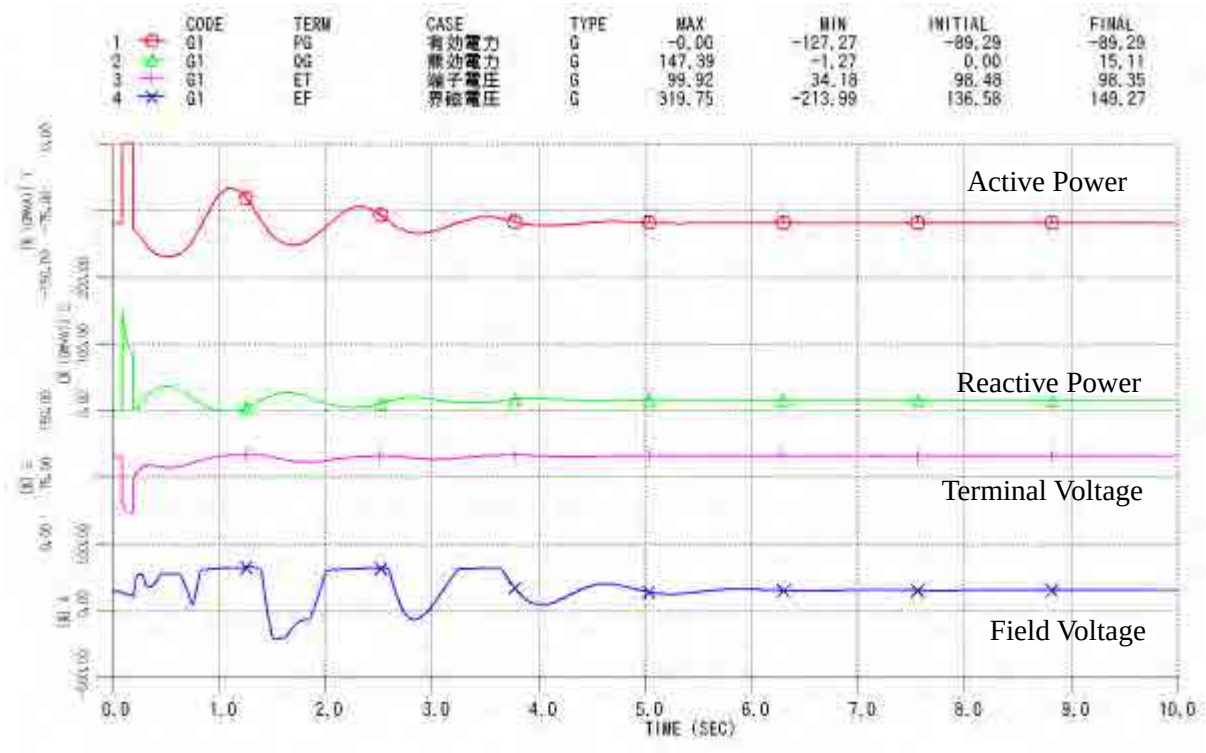
9.5.1 - 9.5.3 are collected as below.

- There are 4 candidate locations to connect transmission line
  - Hinjewadi 400kV bus
  - Lonikand 400kV bus
  - Hinjewadi - Jejuri
  - Lonikand - Vile
- Conductor is Moose
- As a result of power system analysis, stability of power system is maintained in the case that connecting substation is Lonikand assumed as harshest.
- PSS are added because the capacity of candidate site is large(250 – 350MW).
- In the future study, it will be needed to study for the location to connect by the detailed power system studies in accordance with the power flow of transmission line and the distribution of power demand in the Maharashtra.



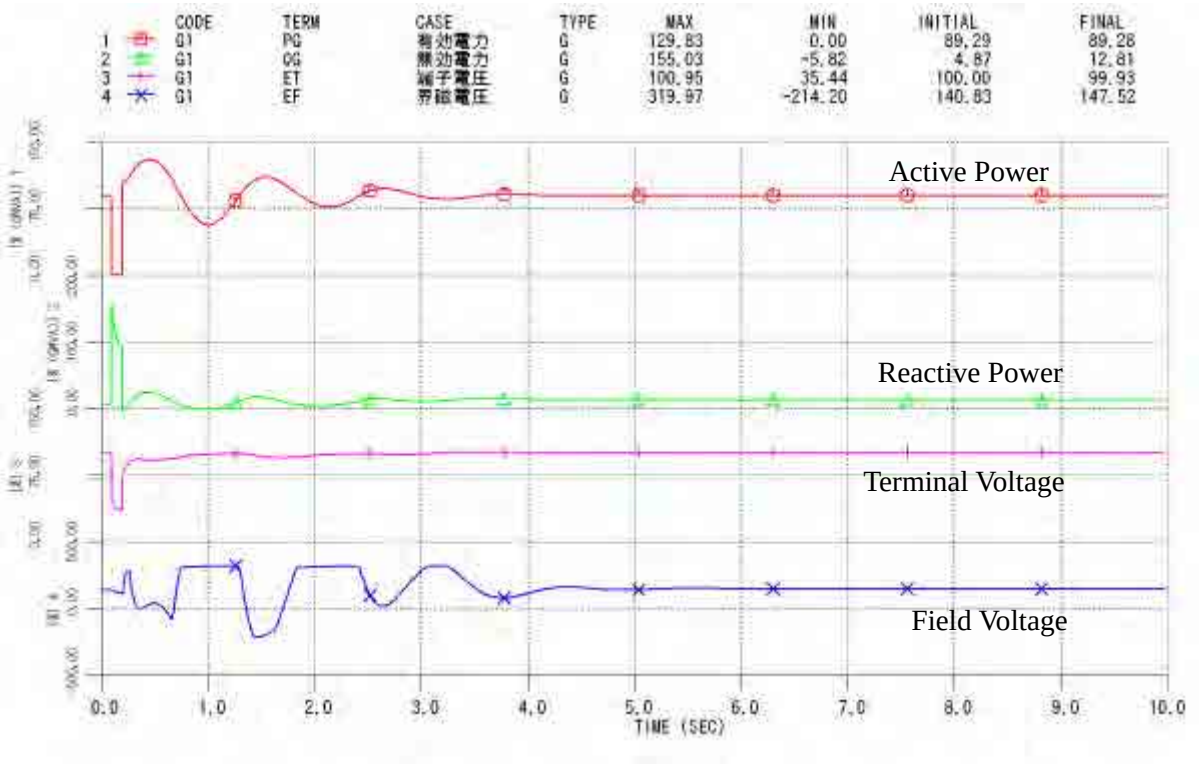
(Source: JICA study team)

Figure 9.5.3-1 Calculation results of power system stability (Case 1)



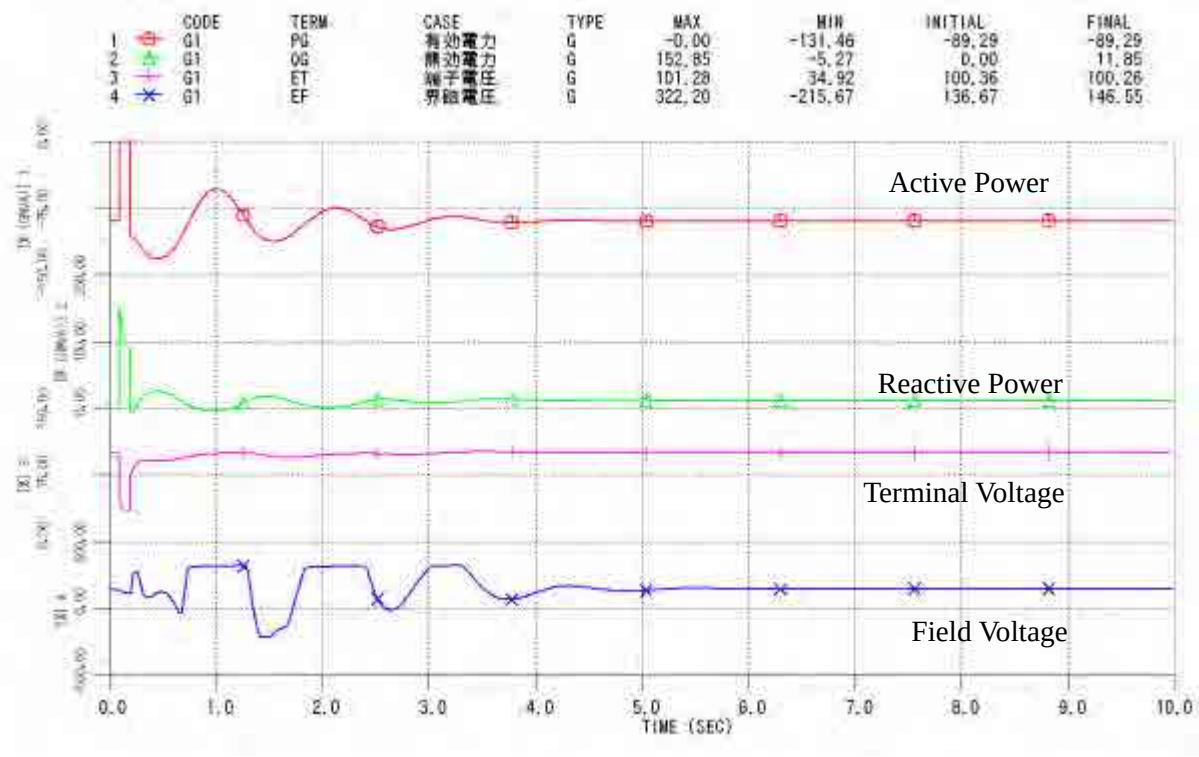
(Source: JICA study team)

Figure 9.5.3-2 Calculation results of power system stability (Case 2)



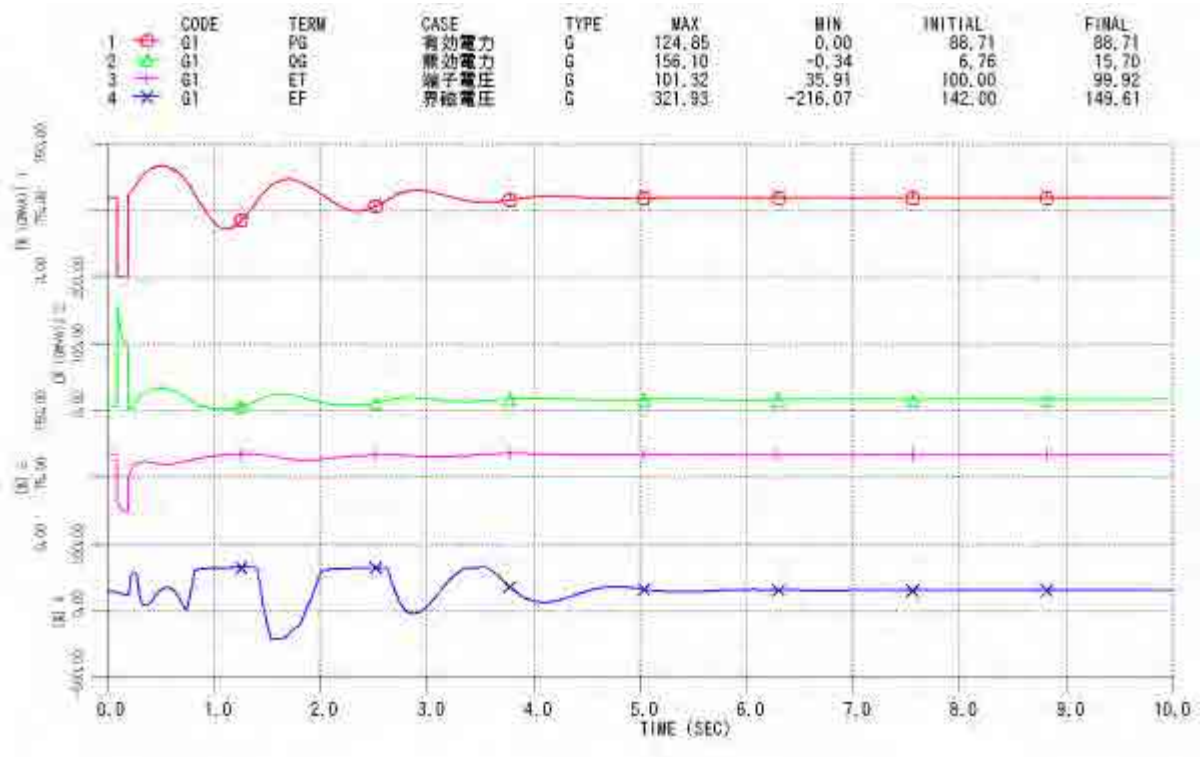
(Source: JICA study team)

Figure 9.5.3-3 Calculation results of power system stability (Case 3)



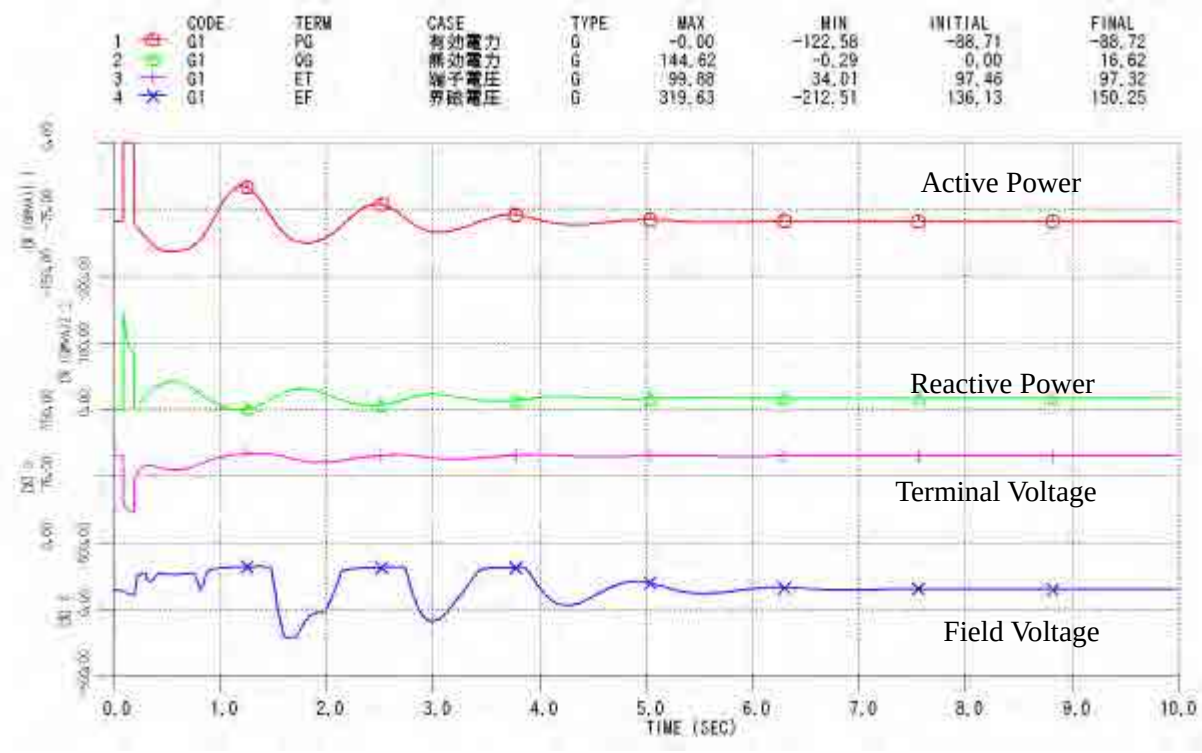
(Source: JICA study team)

Figure 9.5.3-4 Calculation results of power system stability (Case 4)



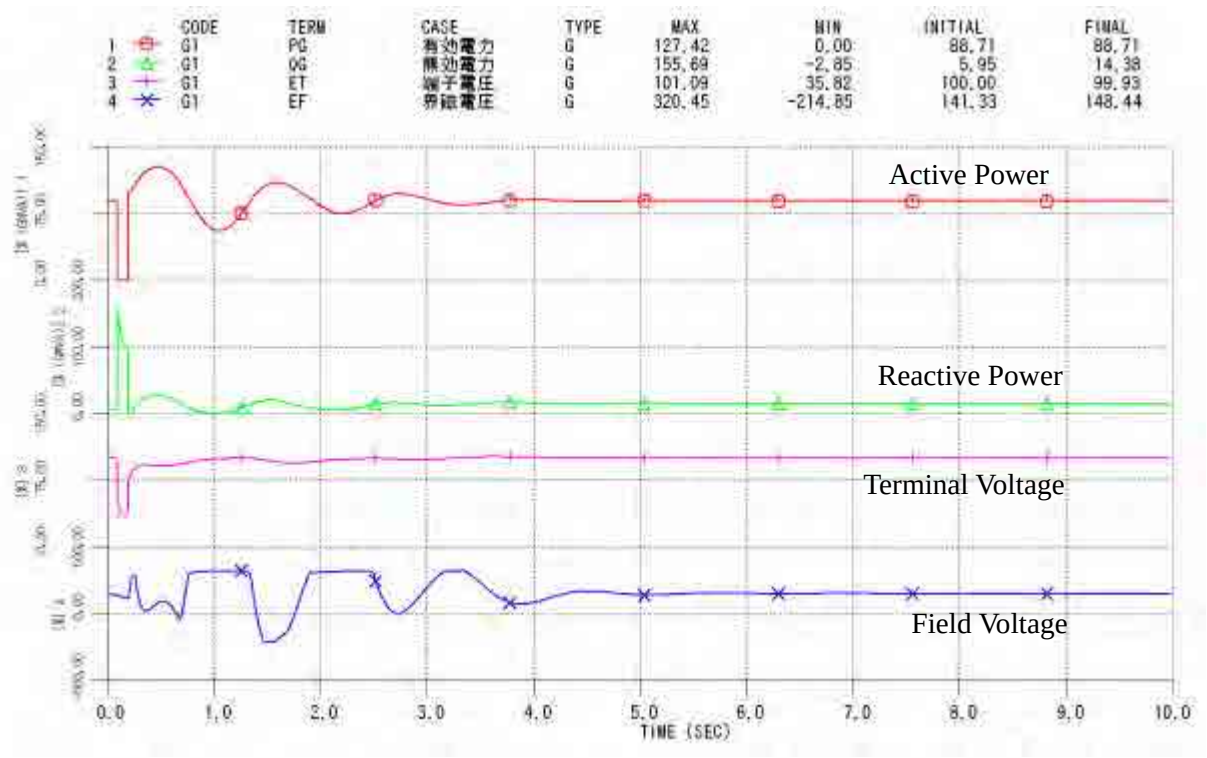
(Source: JICA study team)

Figure 9.5.3-5 Calculation results of power system stability (Case 5)



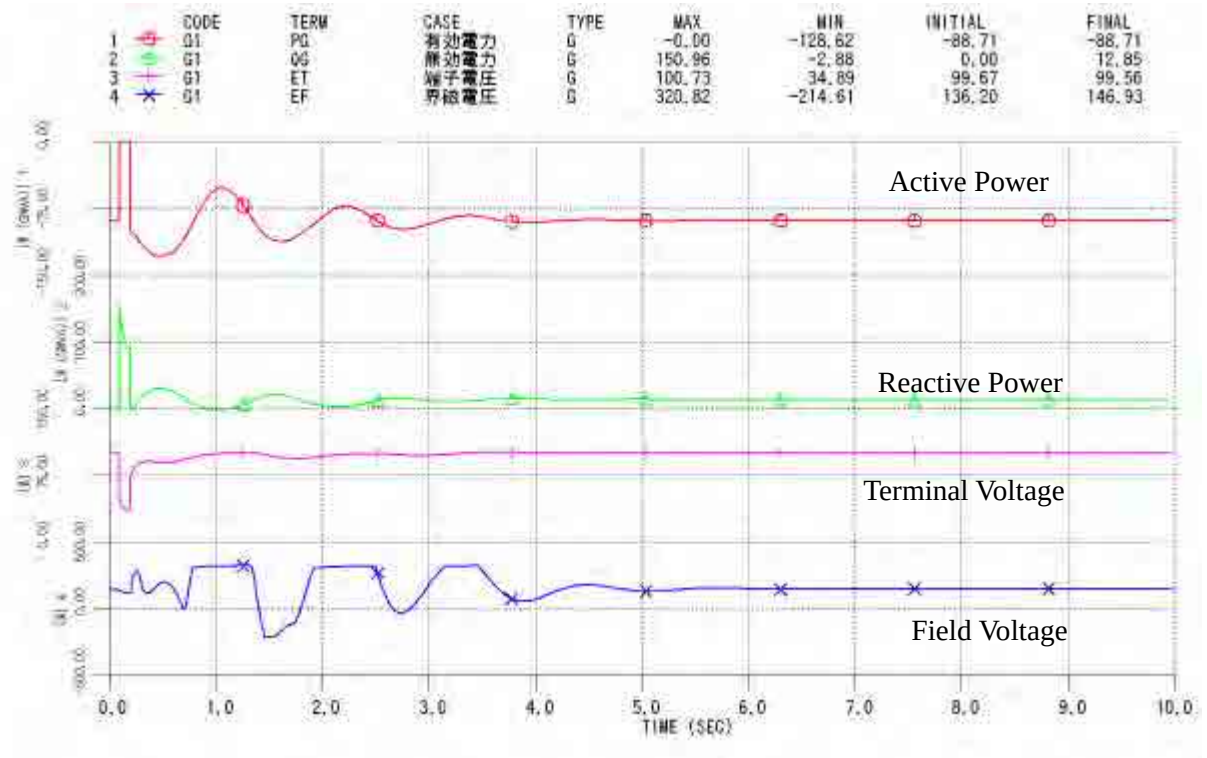
(Source: JICA study team)

Figure 9.5.3-6 Calculation results of power system stability (Case 6)



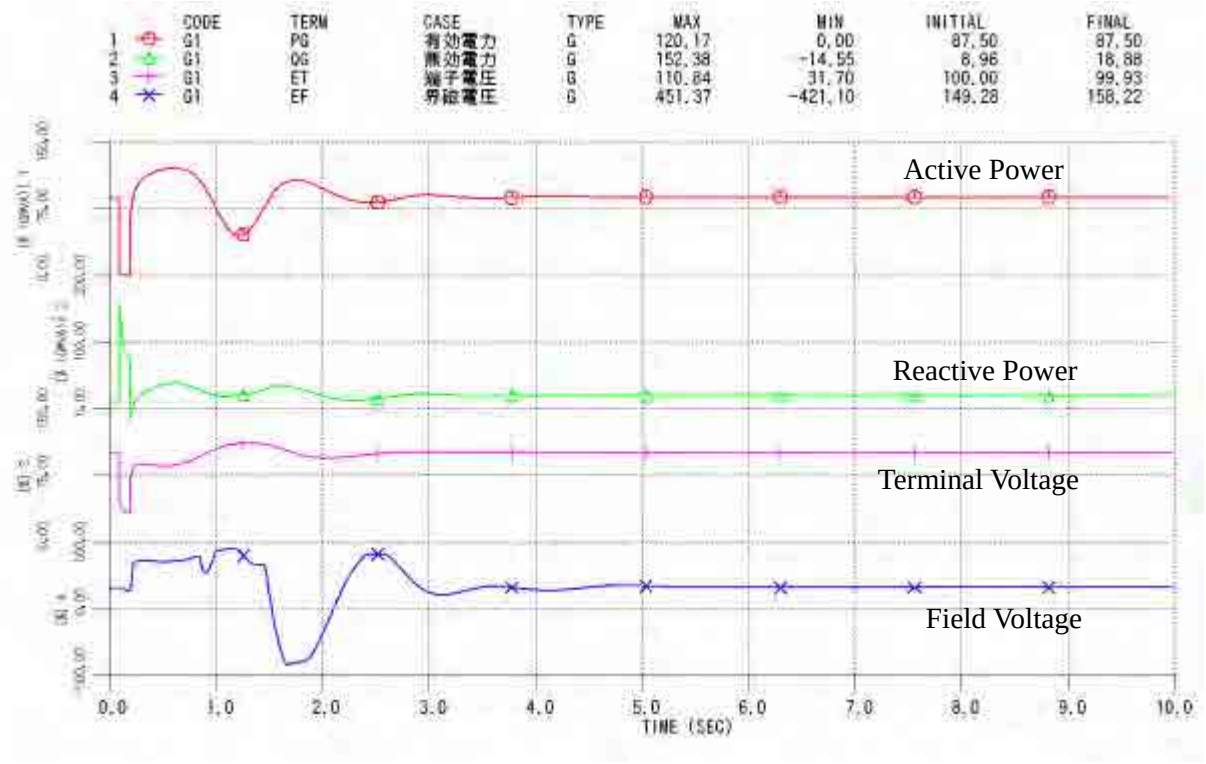
(Source: JICA study team)

Figure 9.5.3-7 Calculation results of power system stability (Case 7)



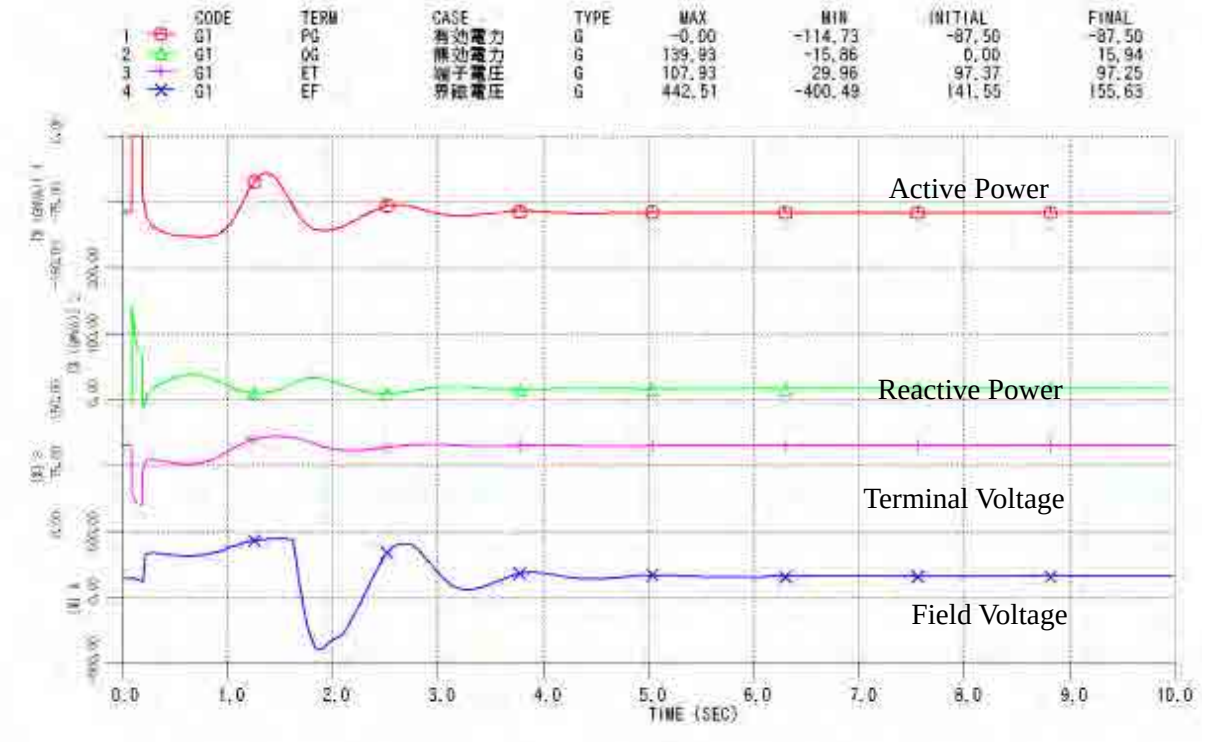
(Source: JICA study team)

Figure 9.5.3-8 Calculation results of power system stability (Case 8)



(Source: JICA study team)

Figure 9.5.3-9 Calculation results of power system stability (Case 9)



(Source: JICA study team)

Figure 9.5.3-10 Calculation results of power system stability (Case 10)

9.6 Selection of Promising Sites

The site reconnaissance surveys were carried out for the 3 selected sites. The actual site conditions including accessibility, topography, geology, social and environmental conditions, transmission lines and other conditions were confirmed.

After the discussion with the counterpart GOMWRD, it has been concluded that at this stage these threee sites are reserved for further studies as any one of these sites could be eliminated with the present evaluation.

GOMWRD plans to proceed to convey the site surveys on these three sites.

The additional information collected from the following surveys, including the data on the geology of each site, information on environmental and social issues, the finer design works based on the surveys, are the keys to determine development priority.

The site reconnaissance survey result was summarized in Table 9.6-1.

Table 9.6-1 Site reconnaissance survey result

		Panshet		Warasgaon		Varandha Ghat	
		Upper	Lower	Upper	Lower	Upper	Lower
Installed Capacity (MW)		1400		1000		500 (1,100)	
Gross Head (m)		540		544		534	
Accessibility		Relatively good, paved.	10km from the divide of SH97, relatively good, unpaved.	14km from the divide of paved road, relatively good, fairly paved.	12km from the divide of SH97, relatively good, unpaved.	48km from the divide of NH48, fairly paved.	7-8km from the divide of SH70, fairly paved.
Transmission line		220 KVA line in vicinity		220 KVA line in vicinity		No transmission lines in vicinity	
Geography (Topography)		Flat riverbed	Flat riverbed	Flat riverbed	Open landform toward upstream. Flat riverbed	Riverbed mild, suitable as dam site	Riverbed mild, suitable as dam site
		Both abutments at tip of the ridges	Right abutmnet: Good.	Right abutment : very large flat-topped ridge. Good.		No issues on both abutments.	Talus possibly on the bottom of abutment.
			Left abutment : Tip of the relatively thin ridge, not suitable enough	Left abutment: Tip of a relatively thin and low ridge, not suitable enough.	Left abutment: Tip of relatively small ridge		
Geology		Massive compact Basalt (very hard)	Massive compact Basalt (very hard)	Massive compact Basalt (very hard)	Massive compact Basalt (very hard)	Massive compact Basalt (very hard)	Massive compact Basalt (very hard)
		River deposit thin as 0.5-2m, excavation depth estimated shallow.	River deposit thin as 0.5-2m, excavation depth estimated shallow.	River deposit thin as 0.5-1m, excavation depth estimated shallow.	River deposit thin as 0.5-2m, excavation depth estimated shallow.	River deposit thin as 0.5-1m, excavation depth estimated shallow.	River deposit thin as 0.5-2m, excavation depth estimated shallow.
		Structural weak zones not observed.	Structural weak zones not observed.	Structural weak zones not observed.	Structural weak zones not observed.	Structural weak zones not observed.	Structural weak zones not observed.
Social Environment	District	Pune	Raigad	Pune	Raigad	Pune	Raigad
	Taluka	Velhe	Mangaon	Mulshi	Mangaon	Velhe	Mahad
	Village	Daspar	Sakalyachiwadi	Dhamanhol	Umbardi	Nigademose, Kelad	Ranawadi, Kumbheshivtar, Ambeshivtar
	Distance to Nearest village from dam center	appx. 500m, near reservoir but located in higher in elevation.	appx. 500m downstream of reservoir.	appx. 1km downstream of reservoir.	Center of vilage falls in the reservoir	appx. 1.5km(Nig.) -4km(Kel.). Outside of reservoir.	appx. 500m (Ran)-4.5km(Kum. Amb.). A few villager houses in reservoir.
	Population	Unconfirmed	Unconfirmed	Unconfirmed	1,000-1,200 (from interview)	Unconfirmed	Unconfirmed
	Occupations	mostly agriculture, presumably work emigrated in dry-season.	mostly agriculture, presumably work emigrated in dry-season.	mostly agriculture, presumably work emigrated in dry-season.	mostly agriculture, presumably work emigrated in dry-season.	mostly agriculture, presumably work emigrated in dry-season.	mostly agriculture, presumably work emigrated in dry-season.
	Inrastructure (of village)	Paved roads	Unpaved road connected from adjacent Jite vill.	Paved roads	Unpaved road connected from adjacent Jite vill.	Mostly paved roads connected	Mostly paved roads connected
		Electrified	Electrified	Electrified	Electrified	Electrified	Electrified
		Primary school	Primary school	Primary school	Primary school	Primary school in Kelad	Primary school in Ranawadi
	Agricultural land	A few on plateaus riverside	Some in reservoir area	Some in reservoir area	Some in reservoir area	Some in reservoir area	Some in reservoir area, with temporary houses in farming-season in reservoir
	Pasture	Unconfirmed but expected	Unconfirmed but expected	Unconfirmed but expected	Unconfirmed but expected	Unconfirmed but expected	Unconfirmed but expected
	Forestry	Firewoods gathering anticipated	Firewoods gathering anticipated	Firewoods gathering anticipated	Firewoods gathering anticipated	Firewoods gathering anticipated	Firewoods gathering anticipated
	River basin	Mose river	Kal river	Mose river	Kal river	Welvandi river	Kharak river
	Fishery	No commercial fishery anticipated	No commercial fishery anticipated	No commercial fishery anticipated	No commercial fishery anticipated	No commercial fishery anticipated	No commercial fishery anticipated
	Irrigation	No irrigation facility confirmed	No irrigation facility confirmed	No irrigation facility confirmed	No irrigation facility confirmed	No irrigation facility confirmed	No irrigation facility confirmed
	Religious and cultural heritages	1 temple	1 temple	2 temples	1 temple (in reservoir)	1 temple (in Nigademose)	1 temple (in Ranawadi), 1 sacred place (Shivatharghal) on upperstream of reservoir, reducing the scale of
	Mineral resurces	No license	No license	No license	No license	No license	No license
Natural Environment	Protected areas (National park, Sanctuary)	None	None	None	None	None	None
	Reserved Forest	None	None	なし	None	None	None
	Other forests	Forests in good condition along rivers, streams but hihly likely with human intervention.	Mixture of agriculutral lands and miscellaneous trees	Mixture of agriculutral lands and miscellaneous trees	Mixture of agriculutral lands and miscellaneous trees	Mixture of agriculutral lands and miscellaneous trees	Mixture of agriculutral lands and miscellaneous trees
	Important Bird Areas (IBAs)	None	None	None	None	None	None
	Fauna & flora (Endangered species)	Unconfirmed	Unconfirmed	Unconfirmed	Unconfirmed	Unconfirmed	Unconfirmed
		The project with crossing Water Divide		The project with crossing Water Divide		The project with crossing Water Divide	
Technical	Dam axis	Both abuttments rather thin, but feasible for dam axes.	Both abutments very thin, but feasible for dam axes.	The left abutment low and thin but feasble. No issues on the right.	The both abutments thin and low but feasble for dam axes.	The both abutments thin and low but feasble for dam axes.	No issues on the both abutments.
	Sedimentation	Probable initial sediment inflows into reservor due to progressive land use change.	Sediment inflows minimum because of the shelding steep cliff on the backwater area.	Large scale sediment inflows not anticipated because of the small restrcted catchment area.	Large scale sediment inflows not anticipated because of the small restrcted catchment area.	Extreme sediment inflow not likely although the catchment area is relatively large.	Excavation volume may increase as the terrace deposit 10-20m thick.
		No margin for the height of left ridge on backwater reservoir.	Long dam length		Long dam length		No issues on dam length
		Geographically surge tank location limited.	Geographically surge tank needs to be located underground.	Site for surge tank available	Geographically surge tank needs to be located underground.		Geographically surge tank needs to be located underground.
		Large excavation may be required for Inlet construction.	Location of switchyard needs to be studied considering the limit length of transimit cables.		Location of switchyard needs to be studied considering the limit length of transimit cables.	Potentially the power capacity and reservoir capacity may be increased with the dam height unchanged.	

Chapter 10

Development Plan

Chapter 10 Development Plan

10.1 Peak Flood Discharge

10.1.1 Purpose

In order to estimate construction cost of spillway structure in case of rock-fill type dam, it is necessary to know peak flood discharge of each dam. Since detailed hydrological data are not available so far due to preliminary study stage of every project, peak flood discharge is simply estimated with rational formula. In later stage, design flood of each dam shall be studied in detail because that is one of the important values governing dam safety.

10.1.2 Rainfall Data

Daily rainfall data measured at Kodapur Rainfall Station (1980-2003), Undergaon Rainfall Station (1981 - 2008), and Varandoli Rainfall Station (1981-2008) are available for this study. Figure 10.1.2-1 shows location of these rainfall stations and of projects location.

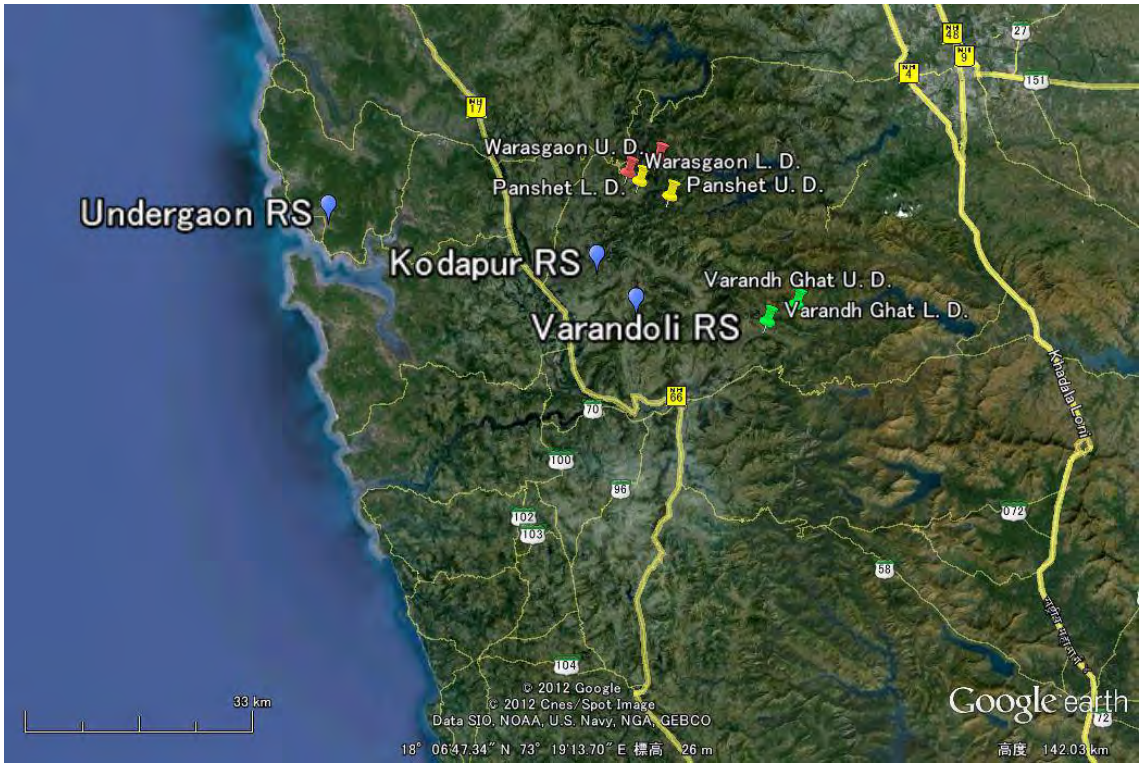


Figure 10.1.2-1 Location of Rainfall Station and Projects

Maximum rainfall (mm/day) in each year is summarized in Table 10.1.2-1 to Table 10.1.2-3.

Maximum rainfall was 490.20mm at Kodapur RS, 377.80mm at Undergaon RS, and 340.00mm at Varandoli RS respectively. In addition, corresponding return period T (i) calculated by Plotting

Position Formula is also shown in every table. Plotting Position Formula as shown below is used.

$$T(i) = \frac{N + 0.2}{i - \alpha}$$

Where,

N : Total number of data

i : Number in descending order

α : Parameter, in Cunnane plot, α=0.4

Table 10.1.2-1 Maximum Rainfall at Kodapur RS

measured		descending order		
	Rainfall	N	Rainfall	T(i)
year	mm	-	mm	year
1980	103.00	1	490.20	40.33
1981	209.10	2	407.60	15.13
1982	106.20	3	305.00	9.31
1983	305.00	4	233.30	6.72
1984	161.40	5	215.50	5.26
1985	157.00	6	209.10	4.32
1986	133.00	7	168.00	3.67
1987	96.50	8	161.40	3.18
1988	155.00	9	158.00	2.81
1989	69.00	10	157.00	2.52
1990	490.20	11	155.00	2.28
1991	158.00	12	140.60	2.09
1992	140.60	13	133.00	1.92
1993	107.50	14	130.00	1.78
1994	407.60	15	121.66	1.66
1995	168.00	16	119.70	1.55
1996	233.30	17	110.66	1.46
1997	215.50	18	107.50	1.38
1998	130.00	19	106.20	1.30
1999	119.70	20	103.00	1.23
2000	102.40	21	102.40	1.17
2001	100.54	22	100.54	1.12
2002	110.66	23	96.50	1.07
2003	121.66	24	69.00	1.03

Table 10.1.2-2 Maximum Rainfall at Undergaon RS

measured		descending order		
	Rainfall	N	Rainfall	T(i)
year	mm	-	mm	year
1981	263.60	1	377.80	45.33
1982	182.70	2	350.00	17.00
1983	274.90	3	325.10	10.46
1984	308.00	4	310.20	7.56
1985	325.10	5	308.00	5.91
1986	288.10	6	288.10	4.86
1987	196.00	7	274.90	4.12
1988	191.30	8	263.60	3.58
1989	201.80	9	250.00	3.16
1990	246.30	10	246.30	2.83
1991	377.80	11	227.50	2.57
1992	168.80	12	205.50	2.34
1993	227.50	13	203.10	2.16
1994	158.00	14	201.80	2.00
1995	97.80	15	201.00	1.86
1996	165.70	16	200.20	1.74
1997	205.50	17	196.00	1.64
1998	250.00	18	191.30	1.55
1999	200.20	19	182.70	1.46
2000	201.00	20	168.80	1.39
2001	140.00	21	168.40	1.32
2002	162.00	22	165.70	1.26
2003	203.10	23	162.00	1.20
2004	350.00	24	158.00	1.15
2006	168.40	25	140.00	1.11
2007	310.20	26	102.00	1.06
2008	102.00	27	97.80	1.02

Table 10.1.2-3 Maximum Rainfall at Varandoli RS.

measured		descending order		
	Rainfall	N	Rainfall	T(i)
year	mm	-	mm	year
1981	236.4	1	340.00	45.33
1982	245.3	2	294.80	17.00
1983	270.2	3	286.40	10.46
1984	272	4	278.40	7.56
1985	267.6	5	272.00	5.91
1986	190.2	6	270.20	4.86
1987	205	7	267.60	4.12
1988	190.4	8	262.80	3.58
1989	262.8	9	260.80	3.16
1990	223.4	10	250.20	2.83
1991	286.4	11	245.30	2.57
1992	220.6	12	245.00	2.34
1993	236.7	13	243.60	2.16
1994	260.8	14	236.70	2.00
1995	133.2	15	236.40	1.86
1996	294.8	16	227.00	1.74
1997	340	17	225.00	1.64
1998	214.8	18	223.40	1.55
1999	227	19	220.60	1.46
2000	225	20	214.80	1.39
2001	212	21	212.00	1.32
2002	190	22	205.00	1.26
2003	169.4	23	190.40	1.20
2004	243.6	24	190.20	1.15
2006	250.2	25	190.00	1.11
2007	278.4	26	169.40	1.06
2008	245	27	133.20	1.02

10.1.3 Probable Rainfall

Probable rainfall is analyzed with rainfall data shown in Table 10.1.2-1 to Table 10.1.2-3. In the analysis, four probability distribution functions are adopted, which are as listed up below. Analyzed results are shown in Table 10.1.3-1 and Table 10.1.3-2**.**

1) Exponential distribution
2) Gumbel distribution
3) SQRT-wxponential type maximum distribution
4) Genelarized extreme value distribution

Table 10.1.3-1 Probable Rainfall Analysis Results (1)

Return Period (yrs)	Kodapur RS				Undergaon RS			
	Exp	Gumbel	SqrtEt	Gev	Exp	Gumbel	SqrtEt	Gev
2	140.8	156.0	146.5	136.9	195.7	208.4	205.8	211.7
3	180.5	193.8	175.5	165.4	229.1	240.3	241.7	244.1
5	230.5	236.0	210.5	205.3	271.1	275.7	284.7	278.7
10	298.3	289.0	258.4	270.9	328.2	320.3	343.2	319.9
20	366.1	339.8	308.4	355.2	385.2	363.0	403.9	357.4
30	405.8	369.0	339.0	415.8	418.6	387.6	440.8	378.0
50	455.8	405.5	379.0	507.1	460.6	418.4	489.0	402.8
80	501.8	439.0	417.5	608.8	499.3	446.5	535.2	424.7
100	523.6	454.8	436.3	664.1	517.7	459.8	557.7	434.8
150	563.3	483.5	471.3	778.0	551.1	484.0	599.7	452.7
200	591.4	503.9	497.0	870.7	574.7	501.1	630.3	465.1
400	659.3	552.9	561.2	1142.5	631.8	542.3	706.8	493.7
500	681.1	568.7	582.6	1247.2	650.2	555.6	732.2	502.6
1,000	748.9	617.7	651.5	1638.5	707.2	596.8	814.0	529.3
SLSC	0.050	0.081	0.083	0.036	0.060	0.033	0.047	0.028
JK's error	183.8	146.4	157.2	735.6	74.0	59.0	113.0	101.2

Table 10.1.3-2 Probable Rainfall Analysis Results (2)

Return Period (yrs)	Varandoli RS			
	Exp	Gumbel	SqrtEt	Gev
2	221.9	229.4	230.1	237.6
3	241.5	248.1	255.7	256.6
5	266.2	268.9	285.6	274.2
10	299.7	295.0	325.4	292.0
20	333.2	320.1	365.8	305.4
30	352.7	334.6	390.0	311.8
50	377.4	352.6	421.3	318.7
80	400.1	369.1	451.0	324.0
100	410.9	376.9	465.3	326.3
150	430.5	391.1	492.0	330.0
200	444.4	401.2	511.2	332.3
400	477.9	425.4	559.1	337.1
500	488.7	433.2	574.9	338.4
1,000	522.2	457.4	625.3	342.0
SLSC	0.082	0.050	0.072	0.088
JK's error	47.0	36.6	119.5	46.7

In the above tables, two indexes are also shown; such as SLSC and JK's error. SLSC express fitness between data and adopted distribution function and lower SLSC gives more fitness. On the other hand, JK's error means Jackknife's method error which express stability of analyzed results and lower JK's error gives more stability. Judging from these two indexes, the result by Exponential distribution is chosen for Kodapur rainfall data, as well as those by Gumbel are chosen for Undegaon rainfall data and Varandoli rainfall data. Figure 10.1.3-1 to Figure 10.1.3-3 shows rainfall data by plotting position formula and analyzed distribution at every rainfall station.

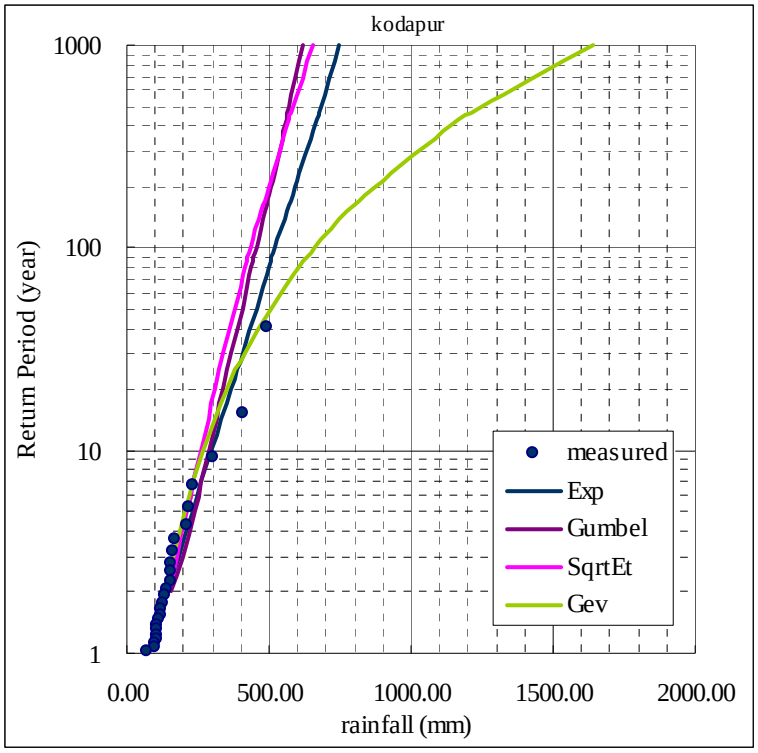


Figure 10.1.3-1 Rainfall Data and Analyzed Probable Rainfall at Kodapur RS

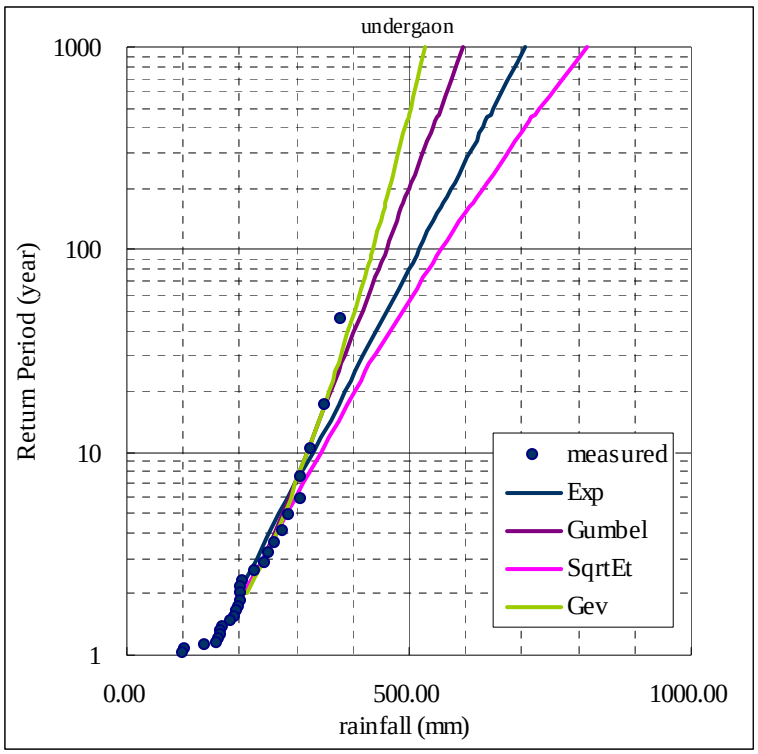


Figure 10.1.3-2 Rainfall Data and Analyzed Probable Rainfall at Undergaon RS

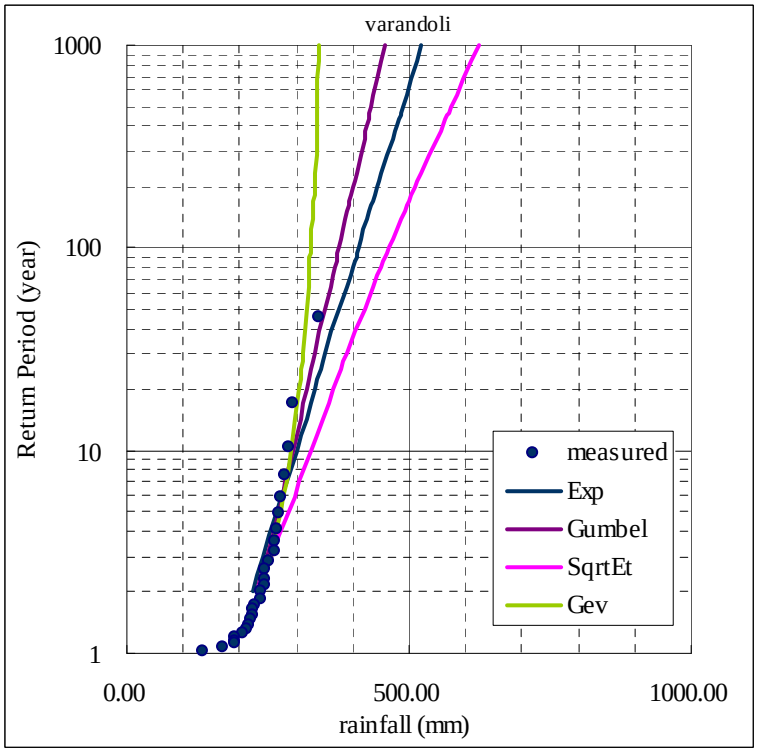


Figure 10.1.3-3 Rainfall Data and Analyzed Probable Rainfall at Varandoli RS

10.1.4 Peak Flood Discharge

1) Probable rainfall (daily rainfall: R_{24})

Probable daily rainfall is calculated by stochastic method. Definite calculation is as shown in the sub-chapter 10.1.3. In order to estimate peak discharge in 1,000 years return period, analyzed probable rainfall in 1,000 years return period shown in Table 10.1.2-1 to Table10.1.2-3 are taken and average of those is adopted to the estimation. As shown in Table 10.1.4-1, 601 m3/s of daily rainfall is applied to peak flood discharge estimation.

Table 10.1.4-1 Probable Rainfall in 1,000 Years Return Period (mm/day)

Kodapur	Undergaon	Varandoli	Average
748.9	596.8	457.4	601

2) Time of concentration: Ta

Time of concentration is calculated by the formula shown below. Table 10.1.4-2 shows calculated time of concentration.

$$Ta = \left(\frac{l}{\omega_1}\right) = l/20\left(\frac{h}{l}\right)^{0.6} \quad (m/\sec)$$

$$Ta = \left(\frac{l}{\omega_2}\right) = l/72\left(\frac{h}{l}\right)^{0.6} \quad (km/hr)$$

where,

L	:	Horizontal distance from upstream end to down stream end in the catchment area (m, km)
h	:	Vertical difference between upstream end to down stream end in the catchment area (m, km)
ω_1, ω_2	:	Propagation velocity (m/s, km/hr)

Table 10.1.4-2 Calculated Time of Concentration

		l (km)	h (km)	ω1 (km/hr)	Ta (hr)
Panshet	Upper Dam	1.79	0.05	8.41	0.21
	Lower Dam	1.63	0.05	8.90	0.18
Warasgaon	Upper Dam	1.26	0.03	7.65	0.16
	Lower Dam	2.69	0.04	5.76	0.47
Varandh Ghat	Upper Dam	10.6	0.05	2.89	3.67
	Lower Dam	7.8	0.085	4.78	1.63

3) Rain intensity in T hours (r_T; mm/hr)

Rainfall intensity duration T is converted from daily rainfall R24 with following formula. Generally, since peak discharge becomes maximum, when rainfall duration equal to time of concentration; T = Ta, daily rainfall; R24, is converted to rainfall intensity during Ta. Furthermore, due to rather narrow catchment area, time of concentration less than 1 hour is calculated in some cases as shown in Table 10.1.4-2. However, for same rainfall duration T, discharge with Ta =T is obviously larger than discharge with Ta < T as shown in Figure 10.1.4-1. Therefore, Ta is set as 1 hour when Ta less than 1 hour is calculated. Calculated rain intensity is shown in Table 10.1.4-3.

$$r_T = \frac{R_{24}}{24}\left(\frac{24}{T}\right)^{2/3} \quad (mm/hr)$$

where,

T : Duration for r_T (hours)

R_{24} : Daily rainfall (mm)

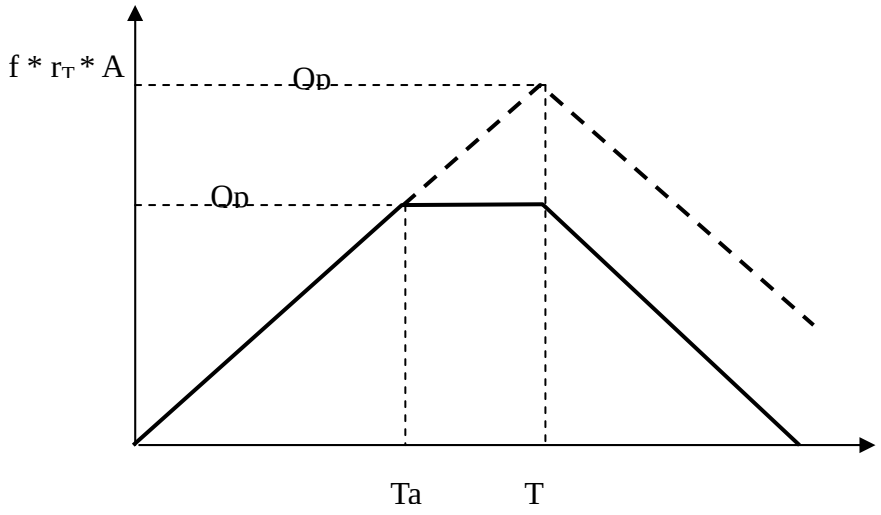


Figure 10.1.4-1 Relation Peak discharge, Time of Concentration Ta and Rainfall Duration T

Table 10.1.4-3 Calculated Rainfall Intensity

		R_{24} mm/day	T hr	r_T mm/hr
Panshet	Upper Dam	601	1	208
	Lower Dam	601	1	208
Warasgaon	Upper Dam	601	1	208
	Lower Dam	601	1	208
Varandh Ghat	Upper Dam	601	3.67	88
	Lower Dam	601	1.63	150

4) Runoff coefficient

In steep mountain zone, runoff coefficient is generally set as 0.90. In this study, 0.90 of runoff coefficient is adopted considering topographic condition of every dam site.

5) Probable Peak discharge Qp

Peak discharge Qp is calculated with following formula. Since rainfall intensity rT is converted from probable daily rainfall corresponding to 1,000 years return period, peak flood discharge corresponding to 1,000 years return period is calculated. Calculation result is shown in Table 10.1.4-4.

$$Qp = \frac{1}{3.6} \cdot f \cdot r_T \cdot A \ (m/\sec)$$

where,

A : Catchment area (km^2)

Table 10.1.4-4 Calculated Peak Discharge

		C.A km^2	f -	r_T mm/hr	Qp m^3/s	applied Qp (m^3/s)
Panshet	Upper Dam	6.99	0.90	208	363	370
	Lower Dam	8.92	0.90	208	464	470
Warasgaon	Upper Dam	2.43	0.90	208	126	130
	Lower Dam	19.66	0.90	208	1,022	1,100
Varandh Ghat	Upper Dam	22.99	0.90	88	506	510
	Lower Dam	54.01	0.90	150	2,025	2,030

6) Peak Discharge by Inglis Formula

Peak flood discharge calculated by Inglis Formula is shown in Table 10.1.4-5. Inglis formula is one of empirical formulae to estimate flood discharge, which is introduced in "Manual of Minor Irrigation Works".

Table 10.1.4-5 Peak Flood Discharge with Inglis Formula

		C.A (km^2)	C (-)	Qp (m^3/s)
Panshet	Upper Dam	6.99	51.96	137
	Lower Dam	8.92	59.68	178
Warasgaon	Upper Dam	2.43	31.44	49
	Lower Dam	19.66	85.25	378
Varandh Ghat	Upper Dam	22.99	89.29	428
	Lower Dam	54.01	115.01	845

$Q = C\sqrt{C.A}$ (in metric units)

C	:	Coefficient (depending on CA)
C.A	:	Catchment area (km^2)

Compared with peak discharge by rational formula, those by Inglis formula are smaller in all sites, so that those by rational formula are used in the later study.

10.2 Civil Structure

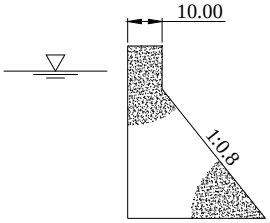
10.2.1 General

In this chapter, in order to make construction costs estimated in Chapter 8 more precise, study on plant layout and main civil structure are carried out for selected three candidate sites, which are Panshet (1,400 MW), Warasgaon (1,000 MW), and Varandh Ghat (1,100 MW). The study is carried out on available topographical map scale 1//25,000 for Panshet and Warasgaon, and scale 1/50,000 for Varandh Ghat. Studied contents are as described below.

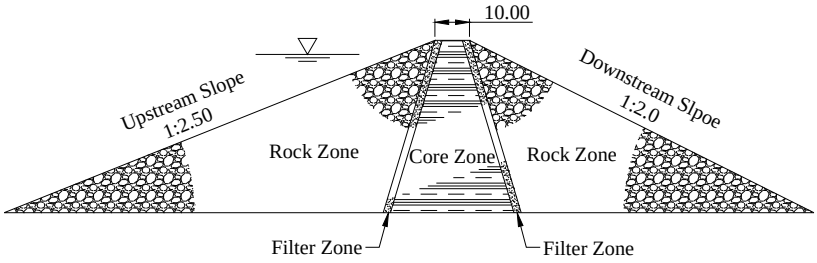
Construction quantities of main items are calculated based on "Guideline and Manual for Hydropower Development Vol. 1 Conventional Hydropower and Pumped Storage Hydropower, March 2011, JICA" (hereafter Guide Line).

10.2.2 Dam and Spillway

Roller Compacted Concrete (RCC) Type dam and Rockfill Type dam are compared in terms of the construction cost for every project. In the study, following typical sections shown in Figure 10.2.2-1 are applied to each dam.



RCC Type



Rockfill Type

Figure 10.2.2-1 Typical Section of Dam

As for Spillway, necessary width of spillway is calculated for assumed peak flood discharge in the sub-chapter 10.1.4. Table 10.2.2-1 shows calculation results under condition that overflow depth equals to 3.0 m, which is one of condition to set dam height. It is understood that necessary spillway widths in all dam sites are within the allowable length taking account of actual topographic conditions.

Table 10.2.2-1 Necessary Spillway Width under Overflow depth 3.0 m

		W M	Hd m	Cd	Qd m3/s	B m
Panshet	Upper Dam	60	3.0	2.199248	370	32.38
	Lower Dam	43	3.0	2.198954	470	41.13
Warasgaon	Upper Dam	48	3.0	2.199062	130	11.38
	Lower Dam	36.5	3.0	2.19877	1,100	96.28
Varandh Ghat	Upper Dam	37.9	3.0	2.198815	510	44.64
	Lower Dam	37.2	3.0	2.198793	2,030	177.68

$$Q = CBH^{3/2}$$

$$C = 1.60 \cdot \frac{1 + 2a\left(\frac{H}{Hd}\right)}{1 + a\left(\frac{H}{Hd}\right)}$$

$$Cd = 2.200 - 0.0146\left(\frac{Hd}{W}\right)^{0.990}$$

$$a = \frac{Cd - 1.60}{3.20 - Cd}$$

Where,

C	:	Flow coefficient
B	:	Width of Spillway
H	:	Overflow depth (m)
Hd	:	Design overflow depth (m)
Cd	:	Flow coefficient (at H=Hd)
W	:	Dam height (m)

From the above study, since it is understood that spillway of sufficient scale can be arranged in all sites, the construction costs of RCC type and Rockfill type are calculated as shown Table 10.2.2-2 for comparative study.

Table 10.2.2-2 Comparative Study of Dam Types

(million INR)

	Panshet		Warasgaon		Varandh Ghat	
	RCC	Rockfill	RCC	Rockfill	RCC	Rockfill
Upper Dam	5,480	5,101	3,847	3,626	2,395	2,538
Lower Dam	7,514	7,064	5,546	5,052	2,106	2,610

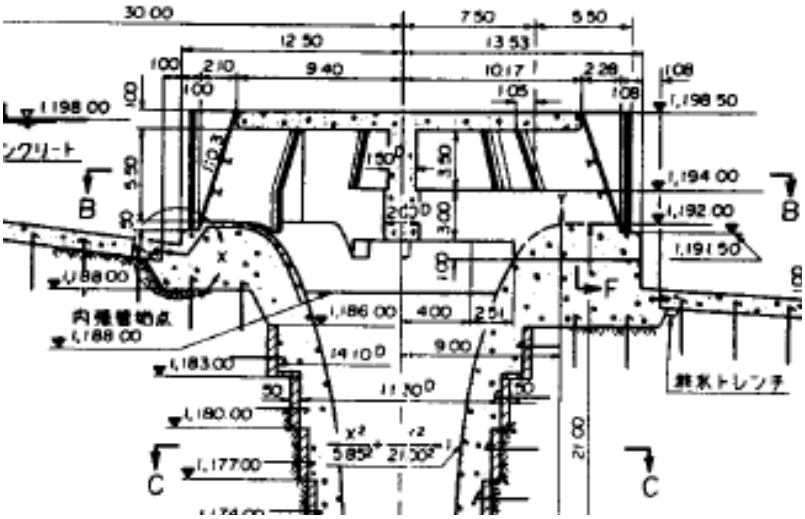
Considering the above results, Rockfill type dam is to be selected to Upper and Lower Dam both for Panshet and for Warasgaon in cosat estimation in this chapter as well as RCC type dam is to be selected to Upper and Lower Dam for Varandh Ghat.

10.2.3 Intake and Outlet Structure

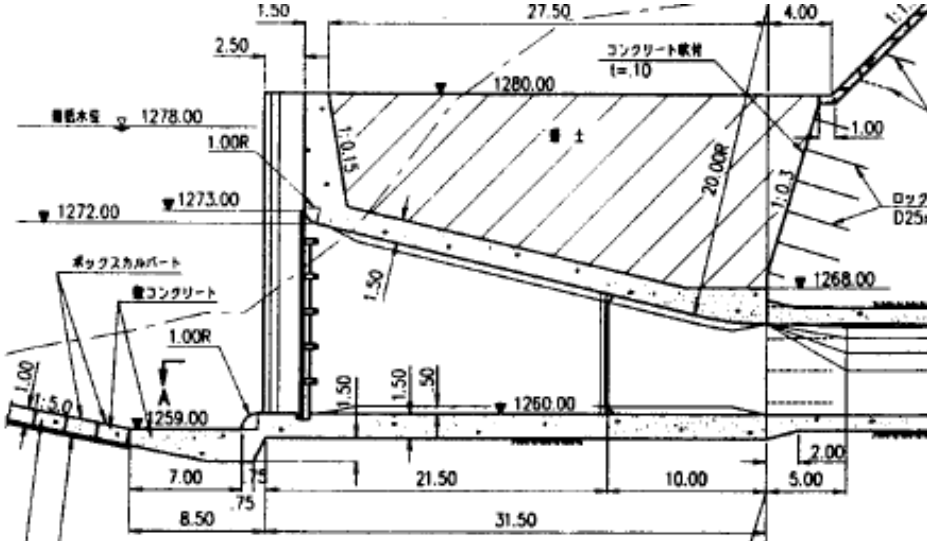
Typical intake and outlet structure adopted to pumped storage power plant is shown in Figure 10.2.3-1. In every selected three project, b. Lateral intake type is suitable because intake and outlet structures will be laid on reservoir slope. In case of b. Lateral type, relation intake water depth and setting elevation is as shown in Figure 10.2.3-2. Sedimentation level is determined first by sediment yield and configuration in the reservoir automatically. Minimum draw-down level (MDDL) is set above sedimentation level keeping a water depth which assures sound water taking without any air babbles.

In Figure 10.2.3-2, a water depth to be kept in front of the structure is defined as more than 2 times of a diameter of headrace or of tailrace tunnel. This concept is applied to project planning.

If larger reservoir capacity can be made available, it is advantageous in terms of project economy, so that intake and outlet structures are to be studied in detail in later stage with hydraulic model test or so on. Structures shown in Figure 10.2.3-1 are what have been improved and renovated through experiences in past projects.



a. Morning Glory Type



b. Lateral Intake Type

Figure 10.2.3-1 Type of Intake and Outlet Structure

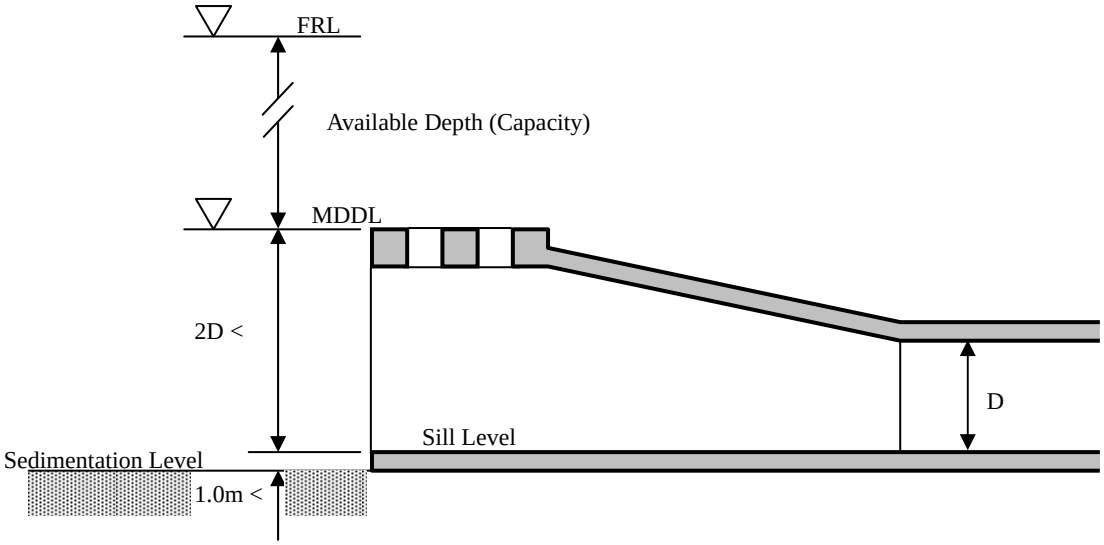


Figure 10.2.3-2 Structure Setting Elevation and Water Depth

10.2.4 Waterway

2-Line of main water way is to be provided and those are to be divided to 4-Line around Powerhouse cavern, because of four number of main pump-turbine generator units.

(1) Headrace Tunnel

To prevent internal pressure from being negative, tunnel alignment is set not so as to be beyond hydraulic gradient line which is defined by frictional loss due to water flow. In this study, water velocity inside headrace tunnel is set as 6.0 m/s based on the past experience; consequently tunnel diameter is in the extent from 3.50 m to 6.0 m.

Table 10.2.4-1 shows calculation result of hydraulic gradient; according the result, it is understood that tunnel alignment is not beyond hydraulic gradient line if the tunnel gradient is kept more than 1/138 in any cases. Therefore, tunnel gradient is set as more than 1/100 in any projects.

In the cost estimation, concrete lining is totally assumed.

Table 10.2.4-1 Calculation Result of Hydraulic Gradient

tunnel diameter	D	m	3.5	4	4.5	5	5.5	6
Roughness coefficient	n	-	0.013	0.013	0.013	0.013	0.013	0.013
Tunnel length	L	m	1000	1000	1000	1000	1000	1000
Frictional loss	hf	m	7.27	6.08	5.2	4.52	3.98	3.54
Hydraulic gradinent	hf/L	-	1/138	1/164	1/192	1/221	1/251	1/282

where,

In case of circular internal section,

$$h_f = f \cdot \frac{1}{D} \cdot \frac{v^2}{2g}$$

$$f = \frac{12.7 \cdot g \cdot n^2}{D^{\frac{1}{3}}}$$

(2) Penstock Tunnel

Based on past experiences of similar projects, the inclined tunnel type is applied in the study. Inclined angle is set around 45 degree which is to be adjusted to the ground surface profile and two horizontal sections are to be also provided; one is upper horizontal sections, which is laid around intermediate height of penstock tunnel so that two work fronts can be installed per 1-line, and the other is lower horizontal to be laid at pump-turbine setting elevation. Tunnel diameter is determined so that water velocity inside is around 10.0 m/s in 2-Line portion.

In the cost estimation, total steel lining is assumed.

(3) Tailrace Tunnel

Alignment of Tailrace Tunnel is set so as to connect outlet structure and exit of draft-tube. One horizontal sections is to be provided around Powerhouse, in which 4-line of the tunnel is conjoin to 2-line. Tunnel diameter is determined so that water velocity inside is around 5.0 m/s in 2-Line portion.

In the cost estimation, total concrete lining is assumed.

(4) Surge Tank

In Headrace and Penstock sections, Surge Tank is provided around downstream end of Headrace Tunnel. Main purpose of Surge Tank is to reduce steel liner installation releasing water hammer pressure in case of load rejection in generating mode. In addition, occurrence of negative pressure can be prevented to supply water from Surge Tank to Headrace Tunnel inside in case of rapid load increase in generating mode and of sudden load rejection in pumping mode. This is another function of Surge Tank provided Headrace Tunnel.

In Tailrace Tunnel side, Surge Tank is sometimes provided at around upstream side. Reason to provide Surge Tank to Tailrace Tunnel is to release water hammer pressure in case of sudden load rejection in pumping mode, which would be advantageous to limit heavily lined sections, and to prevent negative pressure to supply water to Tailrace Tunnel inside from Surge Tank in case of sudden load rejection in generating mode and of rapid load increase in pumping mode.

As one of empirical indexes judging whether Surge Tank is needed or not, LV is often used. L is tunnel length and V is water velocity tunnel inside. When LV is more than 4,500, surge tank is to be provided in many cases. However, detailed study stage, necessity of Surge Tank is examined analytical method as well as its structural features is to be examined.

In the study, Surge Tank is provided in both Headrace side and Tailrace side, and totally, concrete lining is adopted in the cost estimation.

10.2.5 Powerhouse

(1) Powerhouse

Setting elevation of pump-turbine is decided so as to ensure suction head; Hs to MDDL of Lower Reservoir. According to the Figure 8.2.3-2, required suction head is set as 65 m in all three project. Subsequently, elevation of Pump-Turbine, Erection bay, and Cable Tunnel are determined. Figure 10.2.5-1 shows conception of Powerhouse cavern section, and Table 10.2.5-1 shows determined elevation of pump-turbine, Erection Bay and Cable Tunnel.

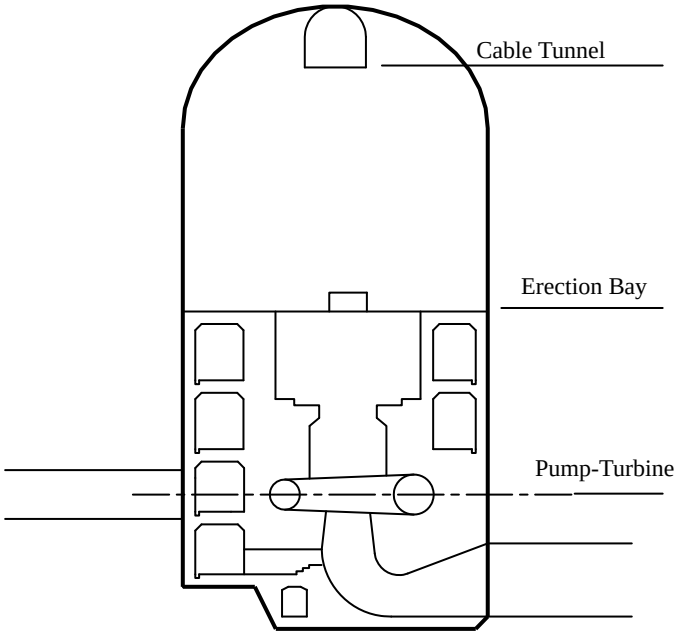


Figure 10.2.5-1 Typical Section of Powerhouse Cavern

Table 10.2.5-1 Setting Elevation in Powerhouse Cavern

	Lower Reservoir MDDL	Pump-Turbine	Erection Bay	Cable Tunnel Floor
Panshet	E.L.152.00m	E.L.87.00m	E.L.102.00m	E.L.122.00m
Warasgaon	E.L.134.00m	E.L.69.00m	E.L.84.00m	E.L.104.00m
Varandh Ghat	E.L.100.00m	E.L.35.00m	E.L.50.00m	E.L.70.00m

(2) Access Tunnel to Powerhouse

Access Tunnel to Powerhouse is to be arranged so that the length of the tunnel is within 1,000m in this study. In case of underground powerhouse, all construction activity in powerhouse cavern cannot be commenced till access tunnel is competed. In case of long access tunnel, total construction period is likely to be also long. Therefore, as typical layout of pumped storage power project, the length within 1,000m is adopted. In addition, tunnel floor inclination is made less than 10 %, taking into account that transportation of construction materials, electrical equipment and hydro mechanical equipment to Powerhouse.

In the cost estimation, it is assumed that tunnel sectional area is 45 m2 and concrete lined to total length.

Table 10.2.5-2 shows structural features of arranged Access Tunnel to Powerhouse

Table 10.2.5-2 Structural Feature of Access Tunnel to Powerhouse

Project	Portal (E.L.-m)	Powerhouse (E.L.-m)	Horizontal Length (m)
Panshet	185.00	102.00	880.00
Warasgaon	160.00	84.00	850.00
Varandh Ghat	120.00	50.00	830.00

(2) Cable Tunnel

Cable Tunnel is arranged from Powerhouse to Switchyard in which main power-cable is to be accommodated. In general, the length of cable tunnel is also limited to around 1,000 m because of transport limitation of single cable-dram; otherwise, more than two drams cables are to be connected in the tunnel.

Table 10.2.5-3 shows structural features of arranged Cable Tunnel

Table 10.2.5-3 Structural Feature of Cable Tunnel

Project	Switchyard (E.L.-m)	Powerhouse (E.L.-m)	Horizontal Length (m)
Panshet	200.00	122.00	850.00
Warasgaon	160.00	104.00	850.00
Varandh Ghat	360.00	70.00	340.00

In Varandh Ghat, profile of Cable Tunnel alignment is to be inclined tunnel as shown in Figure 10.2.5-2.

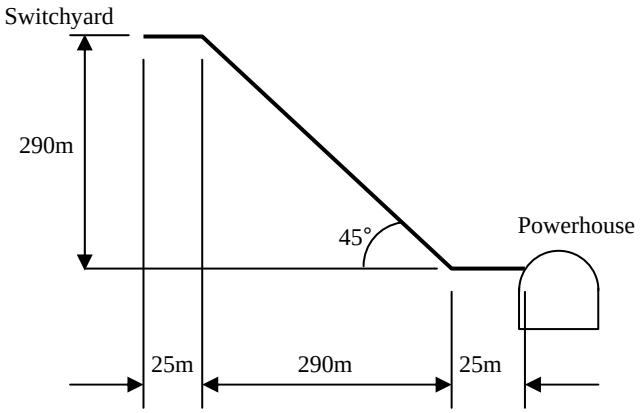


Figure 10.2.5-2 Alignment of Cable Tunnel in Varandh Ghat

10.3 Transmission and Electro-Mechanical equipment

10.3.1 Basic Design Conditions

The basic design conditions for this study, pumped storage power generation projects, were determined by J-Power and GOMWRD. The three sites were selected as candidate sites.

(1) Candidate Sites

Panshet
Warasgaon
Varandh Ghat

(2) Water Level and Generation plan

The water level and generation plans are shown in Table 10.3.1-1.

Table 10.3.1-1 Water Level and Generation plan

Item		Unit	1	2	3
			Panshet	Warasgaon	Varandh Ghat
		MW	1,400	1,000	1,100
	Unit		4	4	4
			4*350MW	4*250MW	4*275MW
Upper Reservoir					
	F.R.L	m	734	692	658
	M.D.D.L	m	707	663	652
	Nominal.W.L	m	725.0	682.3	656.0
Lower Reservoir					
	F.R.L	m	167	140	105
	M.D.D.L	m	153	134	100
	Nominal.W.L	m	162.3	138.0	103.3
	Generatiing Discharge	$m^{3/}s$	331.64	247.67	259.26
	Gross Head	m	562.7	544.3	552.7
	Head Loss 8%	m	45.0	43.5	44.2
	He	m	517.65	500.79	508.45

(Source:: JICA Study Team)

10.3.2 Basic Design of Electric-Mechanical Equipment

(1) General

All candidates are of a reservoir type with upper and lower dams and have a maximum output from 1,000MW to 1,400MW, using an effective head of approximate 500m and the maximum discharge from 250 m^3/s to 340 m^3/s.

Electric-mechanical equipment of PSPP consists of the following main equipment.

a) Pump-Turbine

b) Generator-Motor

c) Main Transformer

d) High Voltage Switching Gear

e) Pump Starting System

(2) Unit Capacity

Generally, for a turbine-generator, a larger unit capacity is said to be more economical in terms of economic of scale. However, optimum unit capacity of the turbine-generator is determined in

consideration of the following subjects.

a) Influence of the unit capacity to the power system

b) Transportation route and limit of the heavy and large equipment

c) The level of current manufacturing technology

d) The reliability and flexibility of maintenance and operation

Regarding item a) of the influence of the unit capacity to the power system, the units can be generally applicable in the power system. However, in case of tripping of the turbine-generator from power system, it will cause a huge impact on the power system stability and it is necessary to choose the unit capacity which will not cause a great instability in the power system.

In addition, it is necessary to take into account the operation flexibility, such as alternative for outage work and so on. In this study, all candidates will adopt 4 units.

In this case, as per item c) of the level of current manufacturing technology, the unit capacity ranges from approximate 250MW to 350MW as generator-motor, and that is available in the international market.

10.3.3 Pump Turbine

(1) Type

The reversible pump turbines recently have been used for pumped-storage power plants. The pump turbines are classified to the three types as shown below (Table 10.3.3-1) based on their configurations, and the maximum pump head applicable shows a increasing trend with advances made in its technology.

The type of pump-turbine will be determined by the effective head and output, but in this study the Francis type reversible pump-turbine with vertical shaft, single runner and spiral case will be adopted.

Table 10.3.3-1 Type of Pump-turbine

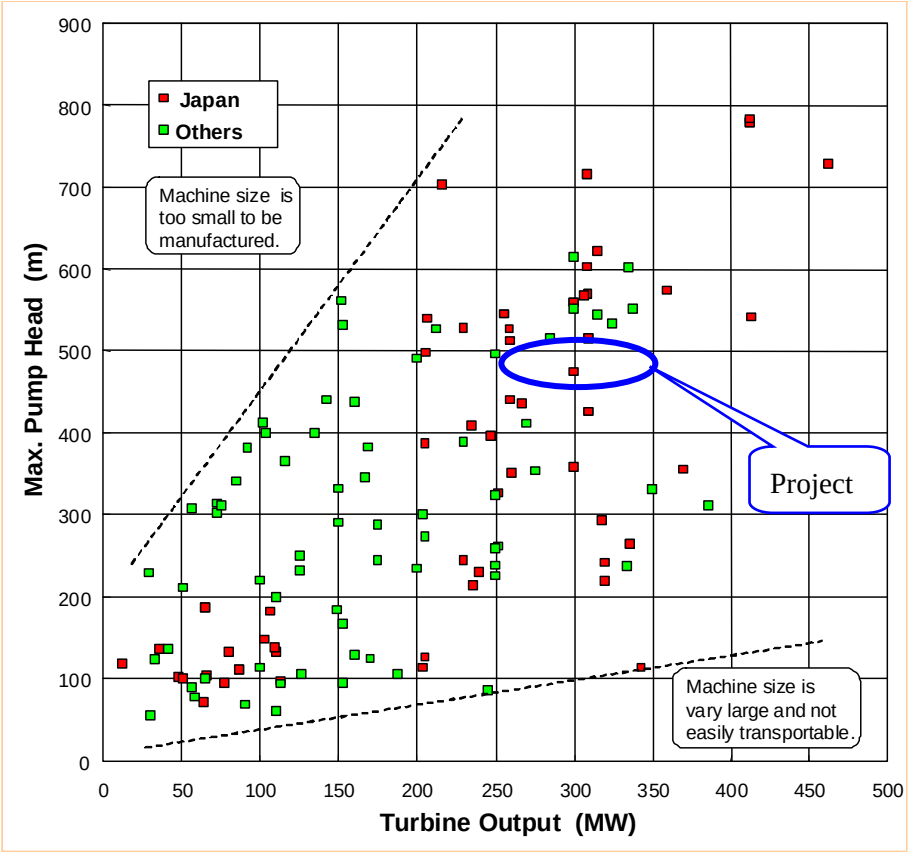
Type	Runner	Applicable Pump Head
Francis	Single Stage Multi Stage	30m – 800m Over 800m
Diagonal Flow	Single Stage	20m – 200m
Propeller	Single Stage	20m and under

(Source : Hydro Turbine)

(2) Pump Head and Turbine Output

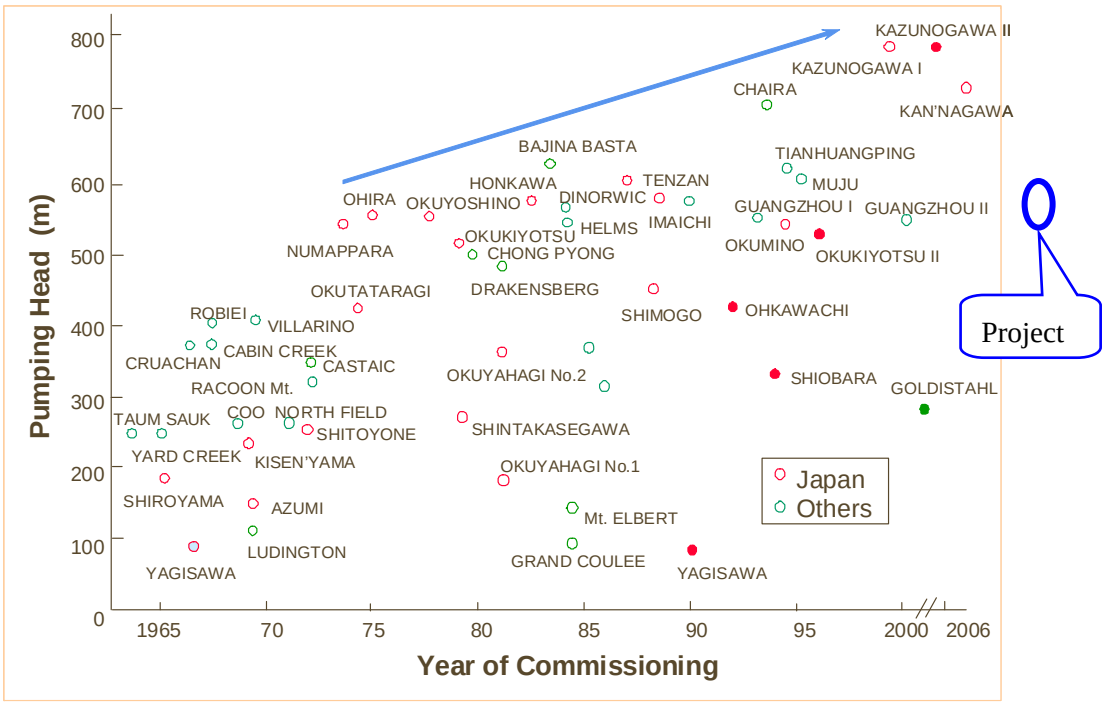
The pump turbine has limits of production and transportation as shown in Figure 10.3.3-1 from the manufacture records, and a newly planned plant needs attention so that it may be within these limits.

In addition, as shown in Figure 10.3.3-2, there is a tendency to make a pump-turbine for higher pumping head recently.



(Source : JICA Study Team)

Figure 10.3.3-1 Manufacture Records of Francis Type Reversible Pump Turbine



(Source: JICA Study Team)

Figure 10.3.3-2 Record of High Pumping Head of Francis Type Reversible Pump Turbine

(3) Subjects to be considered at the next stage

The basic concept of the number of unit, capacity and type are mentioned in this study.

At the next stage, it is necessary to consider the validity of pump turbine, pump turbine efficiency, maximum output, maximum input, pump specific speed, rotating speed, Hs (i.e. Suction head) and impact to the power system.

10.3.4 Generator Motor

(1) Type

The three-phase, alternating current synchronous generator-motor, vertical shaft, rotating field, semi-umbrella type, will be adopted in this study. The power factor will be selected as 90% for generating mode , 95% for pumping mode.

It is necessary to determine the power factor according to the network needs, norm, and so on at the next stage.

(2) Subjects to be considered at the next stage

At the next stage, it is necessary to consider generator-motor efficiency, power factor, a capacity, rated voltage, short circuit ratio, an insulation class and so on.

10.3.5 Main Transformer

(1) Type

Three phase transformer will be adopted for this study. Regarding transportation condition and space for installation, three single phase transformers can be considered as.

The split-winding type, one (1) main transformer is used for two (2) generator-motor units, also can be considered from the perspective on cost reduction.

In this study, each generator has its main transformer.

(2) Outline of Transformer

The transformer capacity should be decided taking into account of generator maximum output, motor maximum input, station service transformer capacity, excitation transformer capacity and SFC transformer capacity.

Primary voltage should be same value as the rated voltage of generator/motor. Secondary voltage should be stepped up to 400 kV, the same voltage of transmission lines in the power system.

For the pumping operation, on-load tap changer (OLTC) should be equipped. Taking into account of an underground transformer cavern, oil-immersed, forced-oil-cooled with forced-water cooler type (class OFWF) should be adopted.

The main transformers are located inside the transformer room which is designed on the same floor level as an erection bay in the powerhouse cavern at the powerhouse.

The high voltage side of the transformer is of oil-gas bushing for connection with 400 kV GIS line with a surge arrester in the indoor GIS room.

The low voltage side is of oil-air bushing for connection with isolated phase metal-enclosed busses (IPB) of each generator-motor.

10.3.6 High Voltage Switching Gear

(1) GIS

GIS will be adopted as high voltage switching gear to connect to the transmission line. Due to the long length of XLPE cable, surge arresters should be required on the high voltage side of the transformer. GIS will be located at each side of XLPE cable. i.e. indoor and outdoor.

At the next stage, the necessity of the indoor GIS should be considered in detail.

(2) GMCS

Circuit Breaker for generator will be adopted in the lower voltage side of the main transformer.

(3) Switchyard Equipment and Switchyard System

The switchyard system is recommended to apply the “Double-system” for this project.

At the next stage, it is necessary to define the switchyard system and to consider the characteristics of switchyard system such as reliability and maintainability, number of transmission line, grid system, and so on.

(4) XLPE Cable

The 400 kV single copper conductor, cross-linked polyethylene (XLPE) insulated will be adopted between outdoor switchyard and indoor equipment.

Due to the power house conditions and limitation of transportation, the length of XLPE cable has some limitations. Based on our experience, the around 1,500m length cable is considered to be acceptable with no connection point.

10.3.7 Pump Starting System

(1) Pump Starting System

Although there are several methods for pump starting system, the followings are only available for the project, taking into consideration that unit capacity of the generator-motor and its impact to the power system such as voltage drop.

- Induction motor starting
- Static Frequency Converter starting (SFC)
- Back-to-back starting

Among them, back-to-back starting system itself cannot be a main system for the project, as there is no generator which is exclusively provided for starting the pump-turbine units. Therefore, back-to-back system should be equipped as "back-up" system when the main starting system is in trouble.

SFC has the following advantages compared with induction motor starting method.

- Better efficiency is obtained during normal operation as it does not produce losses such as windage loss, etc.
- More stable operation against the shaft vibration is obtained as the shaft becomes shorter and the height of generator-motor is reduced.

- Easier maintenance and higher reliability is expected, as SFC does not have any moving and wearing parts.
- SFC becomes more economical when the number of main unit increases.
- SFC has the capability of technological improvement, which results in the compact installation, efficiency improvement, etc.

Therefore, SFC system with back-to-back system combined is the most recommendable starting system for the project. In the case of back-to-back starting, Unit 1 or Unit 2 will be starting generator for Unit 3 and Unit 4, and vice versa Unit 3 or Unit 4 will be starting generator for Unit 1 and Unit 2. The capacity of SFC is estimated approximately 10% of Generator capacity.

In addition, an adjustable speed pumped storage power generation system can start to pump up with its excitation system. Therefore, pump starting system can be omitted.

10.3.8 Single Line Diagram and Powerhouse Layout

(1) Single Line Diagram

At the next stage, it is necessary to make the single line diagram and to consider the type of transformer, equipment location, GIS system, type of pump starting system, and so on.

(2) Powerhouse Layout

At the next stage, it is necessary to consider the powerhouse layout based on the single line diagram.

Generally, pumped storage power plant needs large space compare for installation as compared with the conventional plant because of many auxiliary equipment.

Regarding powerhouse layout consideration, it is necessary to take into account that transformer room, GIS room, starting system room, main circuit route, control cable route, ventilation system, piping route, overhaul working space, maintenance working space, access route, and so on.

10.3.9 Possibility of Adjustable Speed Pumped Storage Power system

(1) Designing point of concern

To design an adjustable speed pumped storage power system, it is necessary to recognize the benefit of its characteristics. The basic design should be defined based on the important design condition. It is difficult to obtain all merits at the same time.

(2) Adoption point of concern

As described in chapter 5, an adjustable speed pumped storage power system has superior

merits. On the other hand, it needs many additional costs, such as large installation space and civil excavation increase and so on.

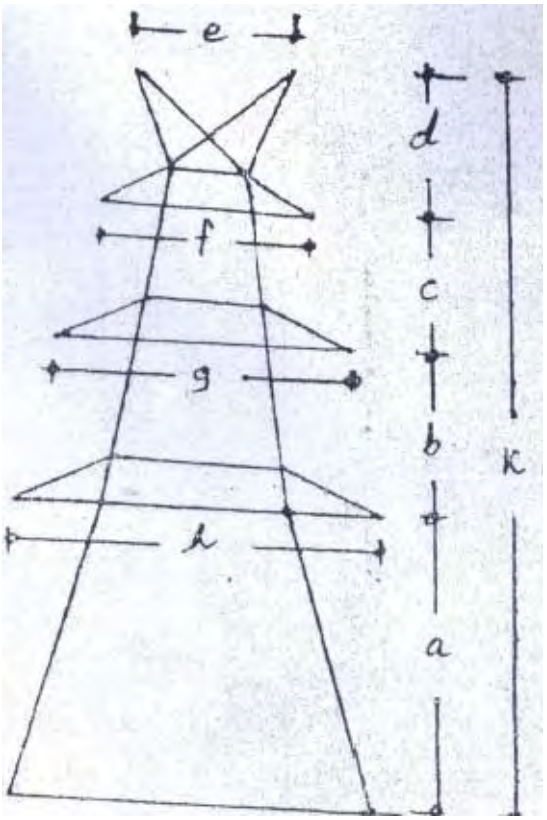
In considering the adoption of an adjustable speed pumped storage power system, it is necessary to take it into account.

10.3.10 Transmission Line

(1) Transmission Tower

The line should be constructed on double circuit type designed to carry the line conductors with the necessary insulators, ground wires and fittings under loading conditions. The three phases of each circuit should be in vertical formation in both sides of the tower. Each phase should be constituted with a bundle of two or four sub-conductors. Two continuous ground wires should be provided over the each circuit offering effective shielding against lighting.

A typical 400kV transmission tower on double circuit is shown in Figure 10.3.10-1. The measurement of the transmission line is shown in Table 10.3.10-1



(Source: MAHATRANSCO)

Figure 10.3.10-1 400kV transmission line at double circuit.

Table 10.3.10-1 The measurement of 400kV transmission line on double circuit

Type of Tower	a	b	c	d	e	f	g	h	k
Normal	25.92	7.9	7.85	3.05	7.99	12.46	13.20	14.95	44.70
15º	21.50	7.7	7.60	6.77	7.95	12.46	13.20	14.95	43.57
30º	21.70	7.85	7.85	6.77	7.99	12.46	13.20	14.95	44.17
60º	21.70	7.95	7.95	6.77	7.99	12.46	13.20	14.95	44.41

(Source: MAHATRANSCO)

(2) Conductor

Conductor is defined as Moose from 9.5. Specification of conductor is shown in Table 10.3.10-2.

Table 10.3.10-2 Specification of conductor

Conductor(Code word)	Moose
Stranding	Al: 54/3.53mm St: 7/3.53mm
Size of conductor	528.7mm^2
Outside diameter	31.77mm
Weight	1.999kg/m
Minimum tension load	16783kgf

(Source:: JICA study team)

(3) Rough Cost Estimation of Transmission Line Construction

The construction cost of 400kV line on double circuit by unit length is shown in Table 10.3.10-3. But these costs are that of material and labor. The costs of survey and compensation aren't included.

Table 10.3.10-3 Unit Construction Cost of 400kV Double Circuit Transmission Line

Conductor	Unit Cost(INR/km)
Quad Moose	19,600,000
Twin Moose	15,000,000

(Source: JICA study team)

Table 10.3.10-4 shows the cost of the each case calculated from table above.

Capacity of Panshet is 1,400MW. So the case of Quad Moose should be selected because capacity of conductor is exceeded in the case of Twin Moose. However Warasgaon and Varandh Ghat should be considered by detail power system analysis in the future study.

Hinjewadi is nearer to the candidate site than Lonikand. Therefore it is hopeful that connecting substation is Hinjewadi.

Also, the cost can be reduced in addition if the transmission line from the candidate site is

connected to Hinjewadi – Jejuri line or Lonikand – Vile line.

Table 10.3.10-4 Rough Construction Cost of 400kV Double Circuit Transmission Line

No.	P/S	S/S	Conductor	Distance (km)	Rough Construction Cost (INR)
1	Warasgaon	Lonikand	Twin Moose	138	2,074,000,000
2	Warasgaon	Lonikand	Quad Moose	138	2,704,800,000
3	Warasgaon	Hinjewadi	Twin Moose	100	1,500,000,000
4	Warasgaon	Hinjewadi	Quad Moose	100	1,960,000,000
5	Varandh Ghat	Lonikand	Twin Moose	139	2,085,000,000
6	Varandh Ghat	Lonikand	Quad Moose	139	2,724,000,000
7	Varandh Ghat	Hinjewadi	Twin Moose	128	1,920,000,000
8	Varandh Ghat	Hinjewadi	Quad Moose	128	2,508,800,000
9	Panshet	Lonikand	Quad Moose	137	2,685,200,000
10	Panshet	Hinjewadi	Quad Moose	99.4	1,948,240,000

(Source: JICA study team)

10.4 Construction Plan

Based on revised layout and structural studies as mentioned in this chapter, construction schedule of each project is roughly estimated. Construction periods of all projects are estimated within 6 years.

10.4.1 Panshet

Figure 10.4.1-1 shows the construction schedule of Panshet Pumped Storage Power Project. Because of rather larger embankment volume of Lower Dam, which is assumed as approximately 6.0 million cubic meters, Lower Dam construction becomes one of critical paths as well as underground Powerhouse construction and main electrical equipment installation. In order to catch up planned schedule, embankment work have to be maintained as 200,000 cubic meters per a month.

Embankment work is not allocated to rainy season which is assumed to start from April and to end to September in this study. In addition, the impounding is to be competed before commissioning test, which is stared at end of 5^{th} year, so that dam embankment is needed to be completed before rainy season in 5^{th} year. Consequently, duration allocated to Lower Dam construction is only around 4 years except impounding.

As for construction of inclined penstock, simultaneous two work faces as per 1-line are envisaged. One of those is work face from Headrace Tunnel downstream end to work in upper inclined section and the other is from Upper Horizontal Penstock to work in lower inclines section. In the construction schedule estimation, only lower inclined penstock, which is longer than upper inclined, is considered. In this regard, two work adits are required to be arranged; that is, one is to Headrace downstream end, and the other is to upper horizontal penstock; however, although work adit to upper horizontal

penstock is incorporated both in the schedule study and cost estimation, work adit to Headrace downstream end is not incorporated in the schedule study as well as in cost estimation, because it is likely to be a rather shorter tunnel due to sallow cover.

10.4.2 Warasgaon

Figure 10.4.2-1 shows the construction schedule of Warasgaon Pumped Storage Power Project. Because of rather larger embankment volume of Lower Dam, which is assumed as approximately 4.1 million cubic meters, Lower Dam construction becomes one of critical paths as well as underground Powerhouse construction and main electrical equipment installation. In order to catch up planned schedule, embankment work has to be maintained as 150,000 cubic meters per a month.

Embankment work is not allocated in rainy season which is assumed to start from April and to end to September in this study. In addition, the impounding is to be competed before commissioning test, which is stared at end of 5th year, so that dam embankment is needed to be completed before rainy season in 5th year. Consequently, duration allocated to Lower Dam construction is only around 4 years except impounding.

As for construction of inclined penstock, simultaneous two work faces as per 1-line are envisaged. One of those is work face from Headrace Tunnel downstream end to work in upper inclined section and the other is from Upper Horizontal Penstock to work in lower inclines section. In the construction schedule estimation, only lower inclined penstock, which is longer than upper inclined, is considered. In this regard, two work adits are required to be arranged; that is, one is to Headrace downstream end, and the other is to upper horizontal penstock; however, although work adit to upper horizontal penstock is incorporated both in the schedule study and cost estimation, work adit to Headrace downstream end is not incorporated in the schedule study as well as in cost estimation, because it is likely to be a rather shorter tunnel due to sallow cover.

10.4.3 Varandh Ghat

Figure 10.4.3-1 shows the construction schedule of Varandh Ghat Pumped Storage Power Project. Unlike Panshet and Warasgaon, a critical path is obviously construction of underground Powerhouse and electrical equipment installation. This is due to rather small concrete volumes both for Upper Dam and Lower Dam, which are estimated as 0.7 million and 0.6 million cubic meters, respectively. Other structures, except Upper Dam and Lower Dam, have allowance more than 1 year to schedule in underground Powerhouse.

As for construction of inclined penstock, simultaneous two work faces as per 1-line are envisaged. One of those is work face from Headrace Tunnel downstream end to work in upper inclined section and the other is from Upper Horizontal Penstock to work in lower inclines section. In the construction

schedule estimation, only lower inclined penstock, which is longer than upper inclined, is considered. In this regard, two work adits are required to be arranged; that is, one is to Headrace downstream end, and the other is to upper horizontal penstock; however, although work adit to upper horizontal penstock is incorporated both in the schedule study and cost estimation, work adit to Headrace downstream end is not incorporated in the schedule study as well as in cost estimation, because it is likely to be a rather shorter tunnel due to sallow cover.

Work Items	unit	Quantities	per month	months
1. Preparation Works				6.0
2. Civil Works				
2.1 Upper Dam				
Common Excavation	m3	133,560	200,000	0.7
Rock Excavation	m3	311,640	150,000	2.1
Embankment (Rock)	m3	853,440	150,000	5.7
Impounding				
2.2 Lower Dam				
Common Excavation	m3	247,860	200,000	1.3
Rock Excavation	m3	578,340	150,000	3.9
Embankment (Rock)	m3	4,767,633	200,000	23.9
Impounding				
2.3 Power Intake				
Excavation	m3	79,762	100,000	0.8
Concrete	m3	28,483	1,000	28.5
2.4 Headrace Tunnel				
Tunnel Excavation	m3	1,510	80	18.9
Concrete	m3	1,510	40	37.8
2.5 Penstock Tunnel				
Work Adit (Excavation)	m	530	80	6.7
(Concrete)	m	530	200	2.7
Tunnel Excavation	m	700	80	8.8
Steel Liner and Concrete	m	700	40	17.5
2.6 Surge Tank				
Shaft Excavation	m3	86,992	3,500	24.9
Lining Work	m3	25,182	1,000	25.2
2.8 Tailrace Tunnel				
Tunnel Excavation	m	1,000	80	12.5
Concrete	m	1,000	40	25.0
2.9 Tailrace Surge Tank				
Shaft Excavation	m3	39,207	3,500	11.3
Lining Work	m3	11,349	1,000	11.4
2.10 Tailrace Outlet				
Excavation	m3	59,363	100,000	0.6
Concrete	m3	21,397	1,000	21.4
2.7 Powerhouse				
Access Tunnel (Excavation)	m	960	80	12.0
(Concrete)	m	960	300	3.2
Cavern Excavation	m3	190,426	10,000	19.1
Concrete	m3	34,153	2,000	17.1
2.11 Cable Tunnel				
Excavation	m	930	80	11.7
Concerete	m	930	40	23.3
Installation	RS			12.0
3. Electro-mechanical Equipment				
Installation				
Commsionning Test				
4. Transmission Line				

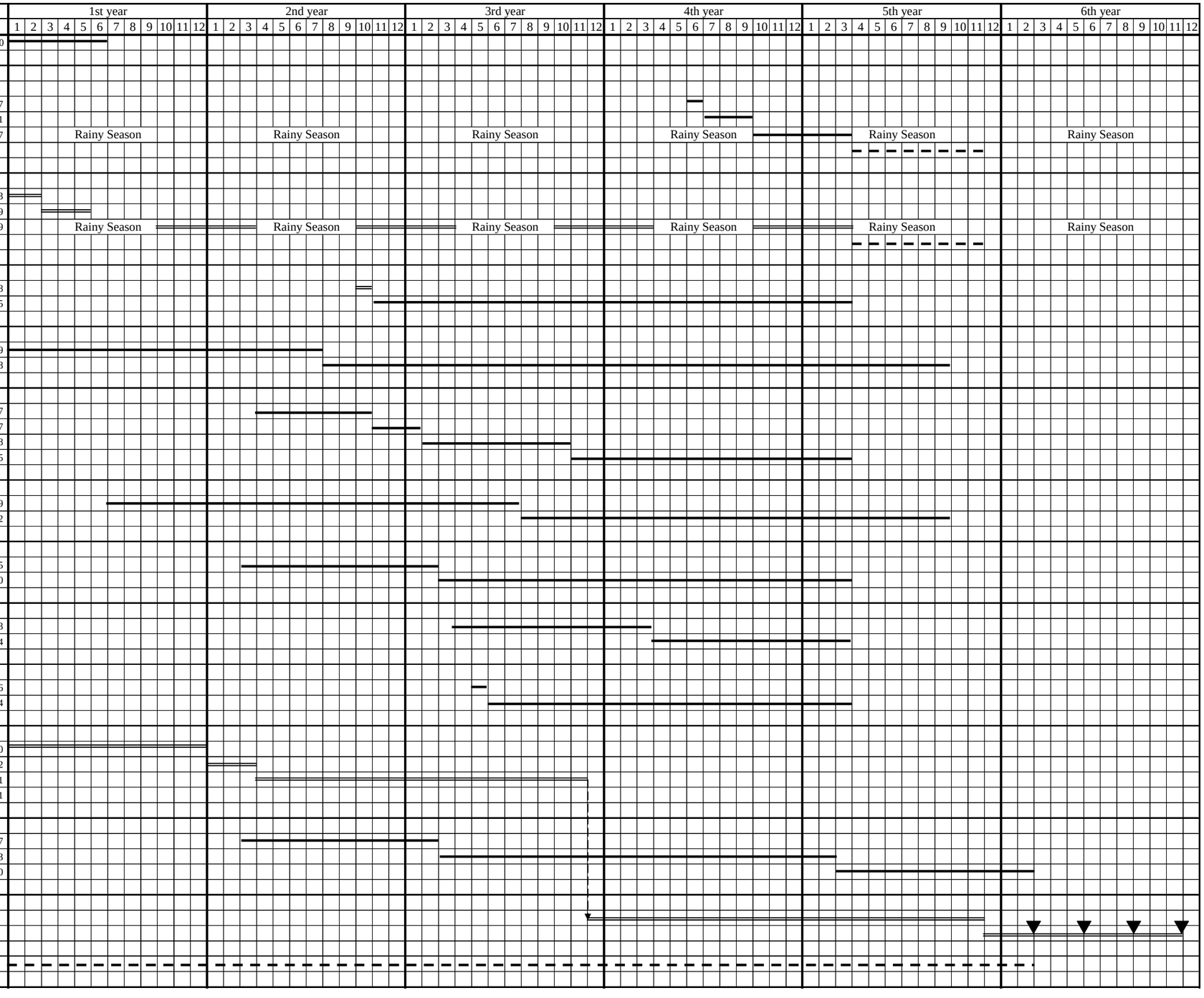


Figure 10.4.1-1 Construction Schedule of Panshet Pumped Storage Project

Work Items	unit	Quantities	per month	months
1. Preparation Works				6.0
2. Civil Works				
2.1 Upper Dam				
Common Excavation	m3	110,448	200,000	0.6
Rock Excavation	m3	257,712	150,000	1.8
Embankment (Rock)	m3	639,182	150,000	4.3
Impounding				
2.2 Lower Dam				
Common Excavation	m3	238,392	200,000	1.2
Rock Excavation	m3	556,248	150,000	3.8
Embankment (Rock)	m3	3,144,742	150,000	21.0
Impounding				
2.3 Power Intake				
Excavation	m3	65,152	100,000	0.7
Concrete	m3	23,415	1,000	23.5
2.4 Headrace Tunnel				
Tunnel Excavation	m3	1,050	80	13.2
Concrete	m3	1,050	40	26.3
2.5 Penstock Tunnel				
Work Adit (Excavation)	m	540	80	6.8
(Concrete)	m	540	200	2.7
Tunnel Excavation	m	600	80	7.5
Steel Liner and Concrete	m	600	40	15.0
2.6 Surge Tank				
Shaft Excavation	m3	57,649	3,500	16.5
Lining Work	m3	16,688	1,000	16.7
2.8 Tailrace Tunnel				
Tunnel Excavation	m	1,330	80	16.7
Concrete	m	1,330	40	33.3
2.9 Tailrace Surge Tank				
Shaft Excavation	m3	30,407	3,500	8.7
Lining Work	m3	8,802	1,000	8.9
2.10 Tailrace Outlet				
Excavation	m3	33,993	100,000	0.4
Concrete	m3	12,470	1,000	12.5
2.7 Powerhouse				
Access Tunnel (Excavation)	m	940	80	11.8
(Concrete)	m	940	300	3.2
Cavern Excavation	m3	160,224	10,000	16.1
Concrete	m3	28,736	2,000	14.4
2.11 Cable Tunnel				
Excavation	m	930	80	11.7
Concerete	m	930	40	23.3
Installation	RS			
3. Electro-mechanical Equipment				
Installation				
Commsionning Test				
4. Transmission Line				

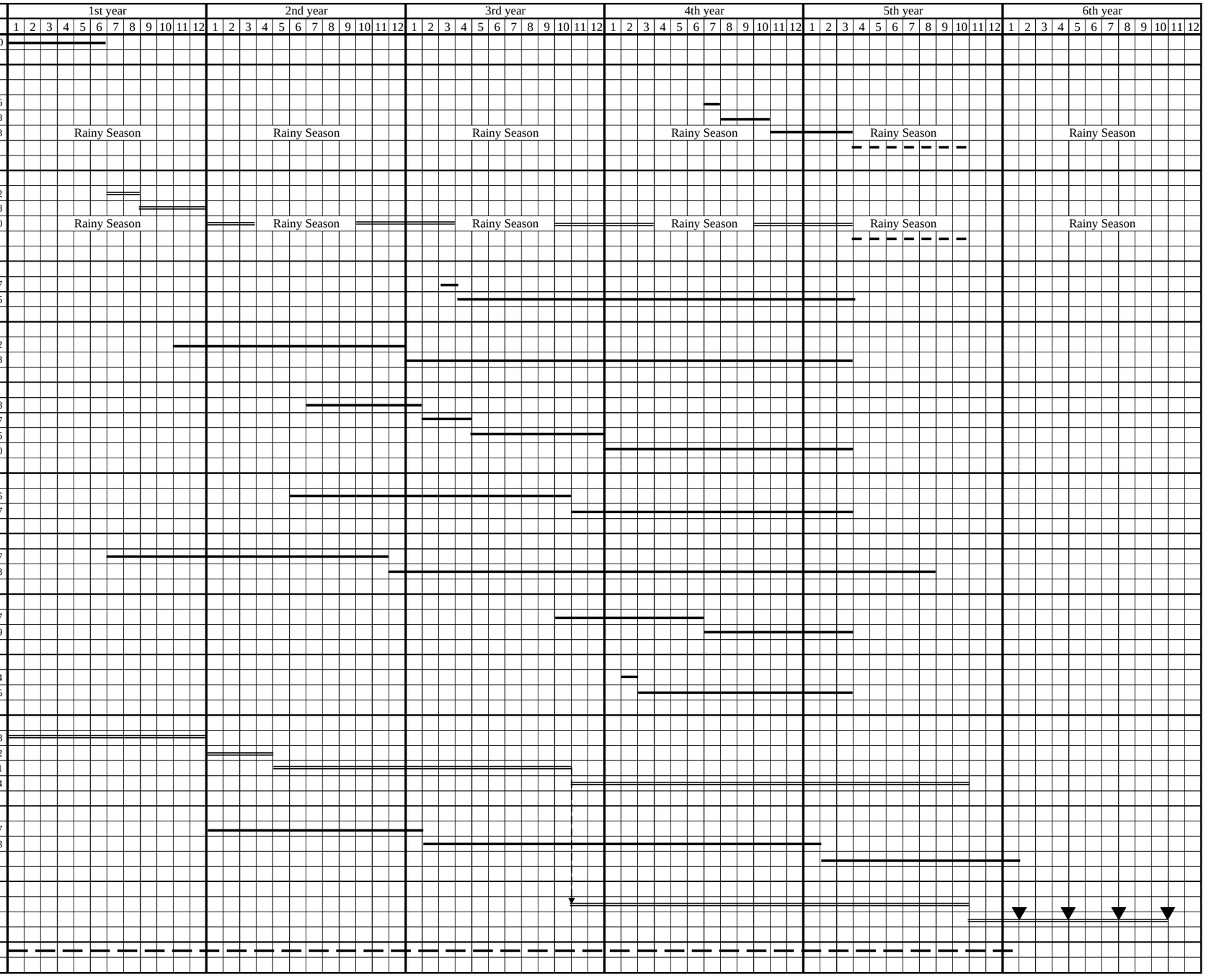


Figure 10.4.2-1 Construction Schedule of Warasgaon Pumped Storage Project

Work Items	Duration unit	Quantities	per month	months
1. Preparation Works				6.0
2. Civil Works				
2.1 Upper Dam				
Common Excavation	m3	100,217	200,000	0.6
Rock Excavation	m3	233,839	150,000	1.6
Concrete (RCC)	m3	449,973	25,000	18.0
Impounding				
2.2 Lower Dam				
Common Excavation	m3	98,654	200,000	0.5
Rock Excavation	m3	230,194	150,000	1.6
Concrete (RCC)	m3	392,447	25,000	15.7
Impounding				
2.3 Power Intake				
Excavation	m3	37,334	100,000	0.4
Concrete	m3	13,655	1,000	13.7
2.4 Headrace Tunnel				
Tunnel Excavation	m3	790	80	9.9
Concrete	m3	790	40	19.8
2.5 Penstock Tunnel				
Work Adit (Excavation)	m	520	80	6.5
(Concrete)	m	520	200	2.6
Tunnel Excavation	m	650	80	8.2
Steel Liner and Concrete	m	650	40	16.3
2.6 Surge Tank				
Shaft Excavation	m3	59,583	3,500	17.1
Lining Work	m3	17,248	1,000	17.3
2.8 Tailrace Tunnel				
Tunnel Excavation	m	950	80	11.9
Concrete	m	950	40	23.8
2.9 Tailrace Surge Tank				
Shaft Excavation	m3	30,407	3,500	8.7
Lining Work	m3	8,802	1,000	8.9
2.10 Tailrace Outlet				
Excavation	m3	34,180	100,000	0.4
Concrete	m3	12,536	1,000	12.6
2.7 Powerhouse				
Access Tunnel (Excavation)	m	910	80	11.4
(Concrete)	m	910	300	3.1
Cavern Excavation	m3	170,010	10,000	17.1
Concrete	m3	30,491	2,000	15.3
2.11 Cable Tunnel				
Excavation	m	450	80	5.7
Concerete	m	450	40	11.3
Installation	RS			
3. Electro-mechanical Equipment				
Installation				
Commsionning Test				
4. Transmission Line				

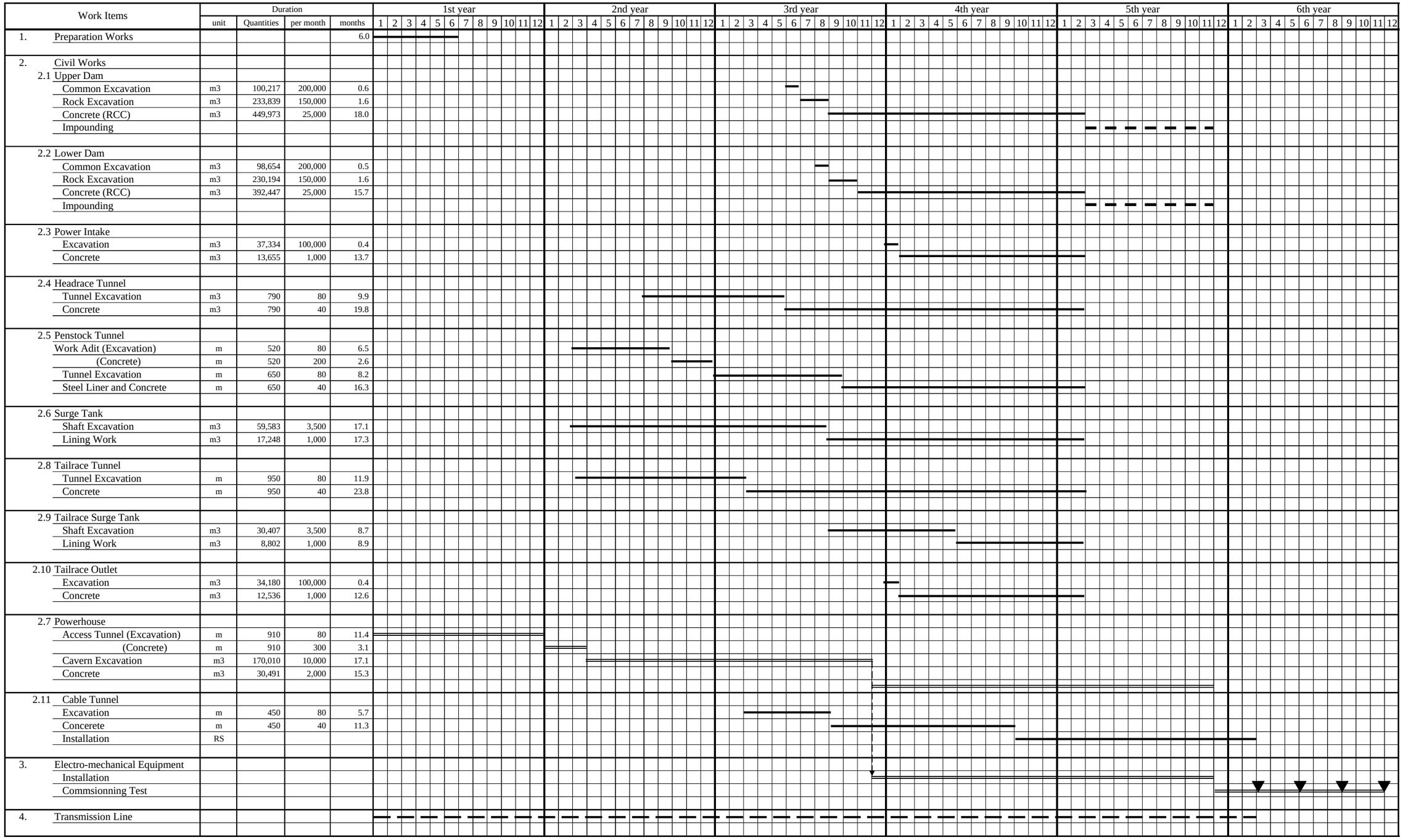


Figure 10.4.3-1 Construction Schedule of Varandh Ghat Pumped Storage Project

10.5 Construction Cost

Based on revised layout and structural studies as mentioned in this chapter, construction cost of each project is also estimated. Table 10.5-1 shows revised general feature of Projects. Furthermore, Table 10.5-2 and Table 10.5-3 shows summary of project cost, and break down of project cost, respectively. In addition, Table 10.5-4 shows summary of project cost in case that the adjustable speed pumped storage system is introduced with 4 units in each projects.

Table 10.5-1 Revised General Feature of Project

No.		1	2	3
	Unit	Panshet	Warasgaon	Varandh Ghat
General Feature				
Installed Capacity	MW	1,400	1,000	1,100
Unit Capacity	MW/unit	350	250	275
Number of Units	unit	4	4	4
Generating Dischrge	m^3/s	332.27	240.58	268.20
Effective Head	m	517.65	500.48	507.96
Generating Hours	hours/day	7.00	7.00	7.00
Upper Reservoir				
FRL	EL.-m	735.00	693.00	658.90
MDDL	EL.-m	706.00	663.00	651.00
Effective Depth	m	29.00	30.00	7.90
R.I.W.L	EL.-m	725.00	683.00	656.00
Gross Capacity	MCM	17.17	12.90	37.67
Effective Capacity	MCM	13.95	10.10	11.26
Dam Type	-	Rockfill	Rockfill	RCC
Dam Height	m	70.00	59.00	44.90
Crest Length	m	530.00	520.00	620.00
Lower Reservoir				
FRL	EL.-m	168.00	141.50	106.20
MDDL	EL.-m	152.00	134.00	100.00
Effective Depth	m	16.00	7.50	6.20
R.T.W.L	EL.-m	163.00	139.00	104.00
Gross Capacity	MCM	21.71	28.83	26.67
Effective Capacity	MCM	14.00	10.75	11.31
Dam Type	-	Rockfill	Rockfill	RCC
Dam Height	m	51.00	38.50	44.20
Crest Length	m	1350.00	1720.00	620.00
Waterways				
Headrace Length	m	1510.00	1050.00	790.00
Headrace Dia.	m	5.95	5.10	5.20
Penstock Length	m	1100.00	1120.00	1160.00
Penstock Dia.	m	4.60	3.95	4.05
Tailrace Length	m	1000.00	1330.00	950.00
Tailrace Dia.	m	6.50	5.60	5.70

Table 10.5-2 Summary of Project Cost

	Item/Project	Panshet	Warasgaon	Varandh G.	Remarks
		(INR)	(INR)	(INR)	
1.	Preparation and Land Acquisition	350,337,225	257,270,950	163,515,978	3. Civil Works * 2%
	(1) Access Roads				
	(2) Compensation & Resettlement				
	(3) Camp & Facilities				
2.	Environmental Mitigation Cost	525,505,837	385,906,425	245,273,968	3. Civil Works * 3%
3.	Civil Works	17,516,861,235	12,863,547,512	8,175,798,920	
4.	Hydromechanical Works	6,153,890,400	4,514,788,800	4,981,624,560	
5.	Electro-Mechanical Equipment	19,656,000,000	16,484,000,000	17,056,000,000	
6.	Transmission Line	1,948,240,000	1,960,000,000	2,508,800,000	
	Direct Cost	46,150,834,697	36,465,513,687	33,131,013,426	
7.	Administration and Engineering Service	6,922,625,205	5,469,827,053	4,969,652,014	Direct Cost * 15%
8.	Contingency	4,615,083,470	3,646,551,369	3,313,101,343	Direct Cost * 10%
9.	Interest during Construction	12,460,725,368	9,845,688,696	8,945,373,625	(1~7)*0.4*9%*6yrs
	Total Cost	70,149,268,740	55,427,580,805	50,359,140,408	
	Power Output	1,400	1,000	1,100	
	INR per kW	50,107	55,428	45,781	

Table 10.5-3 Breakdown of Project Cost

Work Items		unit	unit rate	1. Panshet		2. Warasgaon		3. Varandh Ghat		Remarks
				Quantity	Cost	Quantity	Cost	Quantity	Cost	
A. Civil Works										
1. Upper Dam (Rockfill)					5,100,750,115		3,625,944,858		(2,537,679,561)	
1.1	Care of River	LS			981,757,350		706,005,900		(478,627,635)	(1.2+1.3+1.3+1.4+1.5)*0.25
1.2	Common Excavation	m3	100	133,560	13,356,000	110,448	11,044,800	(100,217)	(10,021,700)	Ve*30%
1.3	Rock Excavation	m3	500	311,640	155,820,000	257,712	128,856,000	(233,839)	(116,919,500)	Ve*70%
	Core Embankment	m3	825	853,440	704,088,000	639,182	527,325,150	(467,668)	(385,826,100)	
1.4	Rock Embankment	m3	675	3,554,460	2,399,260,500	2,497,966	1,686,127,050	(1,603,938	(1,082,658,150)	
1.5	Others	LS			654,504,900		470,670,600		(319,085,090)	(1.2+1.3+1.4)*20%
1.6 Spillway					191,963,365		95,915,358		(144,541,386)	
1.6.1	Common Excavation	m3	100	40,718	4,071,800	20,343	2,034,300	(30,663)	(3,066,300)	
1.6.2	Rock Excavation	m3	500	95,008	47,504,000	47,466	23,733,000	(71,547)	(35,773,500)	
1.6.3	Concrete	m3	4,670	21,005	98,093,350	10,494	49,006,980	(15,818)	(73,870,060)	
1.6.4	Reinforcement	t	59,150	420	24,843,000	210	12,421,500	(316)	(18,691,400)	
1.6.5	Others	LS			17,451,215		8,719,578		(13,140,126)	(1.6.1-1.6.4)*0.10
1. Upper Dam (RCC)					(5,480,352,307)		(3,846,737,890)		2,394,794,456	
1.1	Care of River	LS			(107,457,888)		(75,426,233)		46,956,754	(1.2+1.3+1.3+1.4+1.5)*0.02
1.2	Common Excavation	m3	100	(133,560)	(13,356,000)	(110,448)	(11,044,800)	100,217	10,021,700	
1.3	Rock Excavation	m3	500	(311,640)	(155,820,000)	(257,712)	(128,856,000)	233,839	116,919,500	
1.4	Concrete	m3	4,066	(1,059,576)	(4,308,236,016)	(738,529)	(3,002,858,914)	449,973	1,829,590,218	
1.5	Others	LS			(895,482,403)		(628,551,943)		391,306,284	
2. Lower Dam (Rockfill)					7,064,031,639		5,052,347,100		(2,610,123,989)	
2.1	Care of River	LS			1,381,279,028		974,064,150		(465,243,735)	(1.2+1.3+1.3+1.4+1.5)*0.02
2.2	Common Excavation	m3	100	247,860	24,786,000	238,392	23,839,200	(98,654)	(9,865,400)	Ve*30%
2.3	Rock Excavation	m3	500	578,340	289,170,000	556,248	278,124,000	(230,194)	(115,097,000)	Ve*70%
	Core Embankment	m3	825	1,299,582	1,072,155,150	996,626	822,216,450	(456,590)	(376,686,750)	
2.4	Rock Embankment	m3	675	4,767,633	3,218,152,275	3,144,742	2,122,700,850	(1,554,316	(1,049,163,300)	
2.5	Others	LS			920,852,685		649,376,100		(310,162,490)	(1.2+1.3+1.4)*20%
2.6 Spillway					157,636,501		182,026,350		(283,905,314)	
2.6.1	Common Excavation	m3	100	33,435	3,343,500	38,614	3,861,400	(60,222)	(6,022,200)	
2.6.2	Rock Excavation	m3	500	78,015	39,007,500	90,098	45,049,000	(140,517)	(70,258,500)	
2.6.3	Concrete	m3	4,670	17,248	80,548,160	19,920	93,026,400	(31,067)	(145,082,890)	
2.6.4	Reinforcemnt	t	59,150	345	20,406,750	398	23,541,700	(621)	(36,732,150)	
2.6.5	Others	LS			14,330,591		16,547,850		(25,809,574)	
2. Lower Dam (RCC)					(7,514,177,183)		(5,546,374,045)		2,106,077,928	
2.1	Care of River	LS			(147,336,808)		(108,752,432)		41,295,646	(1.2+1.3+1.3+1.4+1.5)*0.02
2.2	Common Excavation	m3	100	(247,860)	(24,786,000)	(238,392)	(23,839,200)	98,654	9,865,400	
2.3	Rock Excavation	m3	500	(578,340)	(289,170,000)	(556,248)	(278,124,000)	230,194	115,097,000	
2.4	Concrete	m3	4,066	(1,432,631)	(5,825,077,646)	(1,040,184)	(4,229,388,144)	392,447	1,595,689,502	
2.5	Others	LS			(1,227,806,729)		(906,270,269)		344,130,380	
3. Power Intake					288,371,075		236,911,500		137,814,688	
3.1	Common Excavation	m3	100	23,929	2,392,900	19,546	1,954,600	11,200	1,120,000	Ve*30%
3.2	Rock Excavation	m3	500	55,833	27,916,500	45,606	22,803,000	26,134	13,067,000	Ve*70%
3.3	Concrete	m3	4,670	28,483	133,015,610	23,415	109,348,050	13,655	63,768,850	
3.4	Reinforcement	tons	59,150	1,139.00	67,371,850	937.00	55,423,550	546.00	32,295,900	
3.5	Others	LS			57,674,215		47,382,300		27,562,938	(3.1+3.2+3.3+3.4+3.5)*25%
4. Headrace Tunnel (v=6.0m/s)					699,327,003		373,785,637		288,522,326	
4.1	Excavation	m3	2,671	123,512	329,900,552	64,579	172,490,509	50,168	133,998,728	
4.2	Conrete	m3	4,670	39,541	184,656,470	21,680	101,245,600	16,613	77,582,710	
4.3	Reinforcement	tons	59,150	1,581.63	93,553,415	867.20	51,294,880	664.54	39,307,541	
4.4	Others	LS			91,216,566		48,754,648		37,633,347	(4.1+4.2+4.3)*15%
5. Surge Tank (L>= 500m)					762,897,895		505,537,321		522,500,056	
5.1	Excavation	m3	3,450	86,992	300,122,400	57,649	198,889,050	59,583	205,561,350	
5.2	Concrete	m3	4,670	25,182	117,599,940	16,688	77,932,960	17,248	80,548,160	
5.3	Reinforcement	tons	59,150	1,259.00	74,469,850	834.00	49,331,100	862.00	50,987,300	
5.4	Others	LS			270,705,705		179,384,211		185,403,246	(5.1+5.2+5.3)*55%
6. Penstock (v=10.0m/s)					365,104,015		304,058,389		325,287,820	
6.1	Excavation	m3	3,450	58,126	200,534,700	46,661	160,980,450	50,222	173,265,900	
6.2	Concrete	m3	4,100	21,564	88,412,400	19,211	78,765,100	20,335	83,373,500	
6.3	Reinforcement	tons	59,150	258.77	15,306,246	230.54	13,636,441	244.02	14,433,783	
6.4	Others	LS			60,850,669		50,676,398		54,214,637	(6.1+6.2+6.3)*20%
7. Powerhouse					1,010,397,945		850,114,170		902,106,825	
7.1	Excavation	m3	1930	209,469	404,275,170	176,247	340,156,710	187,011	360,931,230	
7.2	Concrete	m3	5,520	34,153	188,524,560	28,736	158,622,720	30,491	168,310,320	
7.3	Reinforcement	tons	59150	1,366.00	80,798,900	1,149.00	67,963,350	1,220.00	72,163,000	
7.4	Others	LS			336,799,315		283,371,390		300,702,275	(7.1+7.2+7.3)*50%
8. Tailrace (v=5.0m/s)					523,538,356		535,215,184		392,215,927	
8.1	Excavation	m3	2,671	81,796	218,477,116	81,800	218,487,800	60,329	161,138,759	
8.2	Concrete	m3	4,670	26,186	122,288,620	27,461	128,242,870	19,978	93,297,260	
8.3	Reinforcement	tons	59,150	1,047.44	61,956,076	1,098.45	64,973,318	799.13	47,268,540	
8.4	Others	LS			120,816,544		123,511,196		90,511,368	(7.1+7.2+7.3)*30%
9. Tailrace Surge Tank (L=500m)					266,162,436		206,442,588		211,620,672	
9.1	Excavation	m3	3,450	39,207	135,264,150	30,407	104,904,150	31,170	107,536,500	
9.2	Concrete	m3	4,670	11,349	52,999,830	8,802	41,105,340	9,023	42,137,410	
9.3	Reinforcement	tons	59,150	567.00	33,538,050	440.00	26,026,000	451.00	26,676,650	
9.4	Others	LS			44,360,406		34,407,098		35,270,112	(9.1+9.2+9.3)*20%

Table 10.5-3 Breakdown of Project Cost (continued)

Work Items		unit	unit rate	1. Panshet		2. Warasgaon		3. Varandh Ghat		Remarks
				Quantity	Cost	Quantity	Cost	Quantity	Cost	
10. Outlet					216,392,863		125,835,063		126,457,088	
10.1	Common Excavation	m3	100	17,809	1,780,900	10,198	1,019,800	10,254	1,025,400	Ve*30%
10.2	Rock Excavation	m3	500	41,554	20,777,000	23,795	11,897,500	23,926	11,963,000	Ve*70%
10.3	Concrete	m3	4,670	21,397	99,923,990	12,470	58,234,900	12,536	58,543,120	
10.4	Reinforcement	tons	59,150	856.00	50,632,400	499.00	29,515,850	501.00	29,634,150	
10.5	Others	LS			43,278,573		25,167,013		25,291,418	(10.1+10.2+10.3+10.4)*25%
11. Cable Tunnel					106,885,180		106,885,180		62,235,136	
11.1	Excavation	m3	2,671	23,250	62,100,750	23,250	62,100,750			
11.1	Excavation (inclined)	m3	3,450		0			11,250	38,812,500	
11.2	Conrete	m3	4,670	4,185	19,543,950	4,185	19,543,950	2,025	9,456,750	
11.3	Reinforcement	t	59,150	126	7,426,283	126	7,426,283	61	3,593,363	
11.4	Others	LS			17,814,197		17,814,197		10,372,523	(11.1+11.2+11.3)*20%
12. Access Tunnel					212,705,280		208,273,920		201,626,880	
12.1	Excavation	m3	2,671	43,200	115,387,200	42,300	112,983,300	40,950	109,377,450	
12.2	Concrete	m3	4,670	9,600	44,832,000	9,400	43,898,000	9,100	42,497,000	
12.3	Reinforcement	t	59,150	288	17,035,200	282	16,680,300	273	16,147,950	
12.4	Others	LS			35,450,880		34,712,320		33,604,480	(12.1+12.2+12.3)*20%
13. Access Tunnel to Upper Horizontal Penstock					66,161,184		119,646,720		115,215,360	
13.1	Excavation	m3	2,671	16,101	43,005,771	24,300	64,905,300	23,400	62,501,400	
13.2	Concrete	m3	4,670	1,882	8,788,940	5,400	25,218,000	5,200	24,284,000	
13.3	Reinforcement	t	59,150	56	3,339,609	162	9,582,300	156	9,227,400	
13.4	Others	LS			11,026,864		19,941,120		19,202,560	(13.1+13.2+13.3)*20%
12. Miscellaneous					834,136,249		612,549,882		389,323,758	(1 to 11)*5%
A. Civil Works Total					17,516,861,235		12,863,547,512		8,175,798,920	
B. Hydromechanical Works										
			unit rate	Quantity		Quantity		Quantity		
1. Upper Dam										
	Gate	t	126,000	58	7,308,000	20	2,520,000	80	10,080,000	
2. Lower Dam										
	Gate	t	126,000	124	15,624,000	290	36,540,000	317	39,942,000	
2. Power Intake										
	Gate	t	126,000	533	67,158,000	386	48,636,000	385	48,510,000	
	Trashrack	t	105,000	296	31,080,000	214	22,470,000	214	22,470,000	
3. Penstock										
	Steel Lining	t	270,000	18,199.30	4,913,811,000	13,291.70	3,588,759,000	14,667.84	3,960,316,800	
4. Outlet										
	Gate	t	126,000	506	63,756,000	344	43,344,000	380	47,880,000	
	Trashrack	t	105,000	281	29,505,000	191	20,055,000	211	22,155,000	
5. Others		LS			1,025,648,400		752,464,800		830,270,760	(1+2+3+4)*20%
B. Hydromechanical Works Total					6,153,890,400		4,514,788,800		4,981,624,560	

Table 10.5-4 Summary of Project Cost (Adjustable Speed System; 4 Units)

	Item/Project	Panshet (INR)	Warasgaon (INR)	Varandh G. (INR)	Remarks
1.	Preparation and Land Acquisition	354,194,303	260,517,002	166,958,893	3. Civil Works * 2%
	(1) Access Roads				
	(2) Compensation & Resettlement				
	(3) Camp & Facilities				
2.	Environmental Mitigation Cost	531,291,455	390,775,503	250,438,340	3. Civil Works * 3%
3.	Civil Works	17,709,715,150	13,025,850,112	8,347,944,672	
4.	Hydro-mechanical Works	6,153,890,400	4,514,788,800	4,981,624,560	
5.	Electro-Mechanical Equipment	22,880,000,000	19,188,000,000	19,864,000,000	Adjustable Speed System
6.	Transmission Line	1,948,240,000	1,960,000,000	2,508,800,000	
	Direct Cost	49,577,331,308	39,339,931,417	36,119,766,465	
7.	Administration and Engineering Service	7,436,599,696	5,900,989,713	5,417,964,970	Direct Cost * 15%
8.	Contingency	4,957,733,131	3,933,993,142	3,611,976,647	Direct Cost * 10%
9.	Interest during Construction	13,385,879,453	10,621,781,483	9,752,336,946	(1~7)*0.4*9%*6yrs
	Total Cost	75,357,543,588	59,796,695,755	54,902,045,028	
	Power Output	1,400	1,000	1,100	
	INR per kW	53,827	59,797	49,911	

10.6 Proposal on Investigation in Later Stage

10.6.1 Geological Investigation

According to the study so far, the three sites (Panshet, Warasgaon, and Varandh Ghat) are geologically very similar and in equally good conditions. The rocks are generally hard and fundamentally impermeable. No serious geological problem is foreseen, and the sites are geologically feasible of dam construction.

Further geological investigations are considered as follows.

- To determine the geological superiority of one site to the others (Further comparison of the three possible sites)
- To obtain geological information necessary for design and construction at the finally determined site (Detailed survey of the actual construction site)

Further comparison of the three sites intends to take subsurface conditions into account, by conducting drilling and else as little as necessary, and finally determine the actual construction site. If there are more important issues than geology to determine the actual construction site, further comparison of the three sites may not be necessary.

Table 10.6.1-1 Further geological investigations

	Comparison (of 3 possible sites)	Detailed survey (of the actual site)	Note
Purposes	To obtain sub-surface geological conditions in order to determine the most favorable site (actual site) out of all the candidate sites	To obtain detailed geo-technical data for the actual site in order to design the dam	Comparison can be omitted if actual site is determined by non-geological criteria
Concerns	Rock types, properties Rock head (excavation line) Permeability distribution, tendency	Foundation strength, deformability, permeability Construction material availability Powerhouse and tunnel geology	
Methods	Large-scale topographic map Surface exploration Drilling along dam axis at 100～200m intervals depth same as height permeability test Seismic survey along dam axis	Drilling in foundation area on the grid at intervals less than 100m depth same as height lab rock tests permeability test Seismic survey in u/d direction In-situ rock tests Drilling and lab rock tests for powerhouse, tunnel, quarry	If comparison is omitted, the methods for it are to be included in detailed survey.

- Large-scale topographic map

  Topographic maps based on aerial photograph and survey with a scale larger than 1/2,000 are necessary. Detailed topographic maps are a priority because they are important for both planning and field works.

- Surface Exploration

  Geological conditions such as rock types, distribution, weathering and so on are to be examined through observations of outcrops.

- Drilling

  Subsurface conditions are to be examined through drilling. Rock classifications are to be made according to the observation of the core samples.

  The size of drill will be, unless otherwise any particular reason, 66 mm in diameter, which is very common. The depth will be equal to the proposed height of the dam as a rule.

- Permeability Test (Lugeon Test)

  The permeability of dam axis will be examined by Lugeon test. Since the rocks are expected to be sound, the test may employ a double packer for efficiency, but a single packer is more reliable.

- Seismic Survey

  Seismic refraction survey will be conducted to examine the thickness of covering layers and condition of weathering and cracks etc.

- In-situ Rock Tests

  Shear strength and deformation properties are to be examined by various tests using boreholes, and trial pits or shafts if necessary. All that involved or certain rock types and classes are to be dealt with.

- Laboratory Tests

  Core samples will be used for the following tests to examine physical and kinematical properties of all rock types and classes involved.

  1) Uniaxial compression strength test
  2) Tension strength test
  3) Ultrasonic wave velocity measurement
  4) Specific Gravity, Water Absorption, Effective Porosity Test

  In consideration of fill-type dams, the following soil tests will be conducted. The materials will be obtained from test pits.

  1) Particle size distribution test
  2) Water content test
  3) Specific gravity of the particles
  4) Compaction test
  5) Triaxial compression strength test

10.6.2 Other Investigation

(1) Hydrological Data

In this study, peak discharge is estimated with available data as mentioned in the sub-chapter 10.1. Since peak flood discharge is one of most important factor governing dam safety design, more detailed study is required in the future study. In order to estimate design flood more accurate, it is necessary to collect sufficient number and period of rain data and/or discharge data in the vicinity of every dam site.

Sedimentation data would generally have impact on dam life span; therefore, in addition to empirical value such as used in this study, it is also necessary to collect and accumulate actual measurement to verify applied empirical value.

(2) Other Data

As mentioned in the sub-chapter 10.6.1, more detailed topographic map is considered as essential. In this study, scale 1/25,000 maps are used for Panshet and Warasgaon and scale 1/50,000 map for Varandh Ghat. Dam capacity curve has significant impact on project scheme such as maximum plant output, also, construction costs of dams occupy significant portion of project cost in all candidate projects. Therefore, projects scheme and the costs revealed in this study is to be verified with more detailed topographic information in later stage.

In addition, available quantities of dam embankment, and those properties are also important data. In Panshet and Warasgaon, selection of rockfill type dam makes costs considerably advantageous. compared with RCC dam. However, if sufficient embankment material is not available in the vicinities of both sites, those have to be transported from long distance, which would make rockfill dam option disadvantageous. And, if only poor materials in terms of strength and impermeability are available, embankment volume have to be large, which would also affect construction cost.

Chapter 11

Preliminary Economic and Financial Evaluation

Chapter 11 Preliminary Economic and Financial Evaluation

11.1 Preliminary Economic Evaluation

Based on the rough construction cost, preliminary economic evaluation was carried out. The purpose of this preliminary evaluation is to know the rough economy of the project, and, preliminary assumptions were adopted for calculation.

11.1.1 Methodology

(1) Methodology

Economic evaluation aims at measuring the "economic" impact brought about to a country by implementing a project from a viewpoint of national economy. Here, a comparison of costs and benefits expressed in terms of economic prices will be made by applying the Discount Cash Flow Method, which is widely adopted for such purposes.

The basic approach for this method is as follows: First, the cash outflow (costs) and inflow (benefits) are developed on an annual basis over the project life. Secondly the amount generated during different years will be discounted to the start year of the project and expressed as an accumulated present value at the same standard year. Then a comparison will be made between the costs and benefits.

Evaluation indices to be obtained will be the Net Present Value, the Benefit/Cost Ratio, and the Economic Internal Rate of Return (EIRR). The EIRR is a discount rate at which the present values of the two cash flows become equal. This rate shows the return to be expected from the project. EIRR is expressed in the following equation:

$$\sum_{t=0}^{n} C_t / (1+r)^t - \sum_{t=0}^{n} B_t / (1+r)^t = 0$$

Where,

C_t : Cost

B_t : Benefit

t : Year

n : Project life (year)

r : Discount rate (= EIRR)

(2) Basic Conditions

According to the discussions with GOM WRD, as well as in line with the existing reports for other projects in Maharashtra or India, the following basic conditions were adopted:

- Opportunity Cost of Capital

Opportunity cost of capital refers to an interest rate at which the appropriateness of investment can be justified. A rate of 12% was used in view of the rates used for other projects in India.

- Discount Rate
  A discount rate of 12% was used to obtain the present value.
- Conversion Factor
  Standard conversion factor of 0.9, used commonly in other projects, was used. This is a coefficient to calculate the economic price from the construction costs estimated at the market price. It is applied to the domestic currency portion.
- Economic Life
  Economic life of each facility, according to the experience of the Consultant, was determined as follows:
- 50 years for civil works
- 35 years for hydro-mechanical and electro-mechanical equipment and transmission line
- Project Life (Calculation Period)
  Calculation period for evaluation is 56 years: 50 years of service life of civil facilities and 6 years of construction works.
- Escalation
  No escalation was considered, therefore, a constant price will be used.

11.1.2 Economic Costs of the Project

The economic costs of the Project were calculated from the rough estimation as presented in Chapter 10. Construction cost, excluding interest during construction as well as Operation and Maintenance cost, replacement cost and pumping up cost, were included in the cost stream. Economic price was calculated by applying conversion factor to the local portion.

Pumping up cost is calculated with the following assumption: 800 hours/year of annual operation; 70% of pumping up efficiency; Rs.2.5/kWh of unit cost for pumping up. Pumping up cost corresponds to the additional fuel cost for energy generation at coal-fired thermal power plant and the unit rate presented by GOM WRD is used.

Initial investment costs, annual investment cost, Operation & Maintenance cost by major items, as well as pumping up cost are shown in Table 11.1.2-1.

Replacement cost of equipment and transmission line after fulfilling the service life will be separately considered, referring to the initial investment cost.

Table 11.1.2-1 (1) Economic Cost of the Project (Panshet)

1) Construction Cost (unit: Rs)

	Total	Foreign Portion	Local Portion
Preparation and Land Acquisition Cost	350,337,225		350,337,225
Environmental Mitigation Cost	525,505,837		525,505,837
Civil Works	17,516,861,235	7,006,744,494	10,510,116,741
Hydromechanical Works	6,153,890,400	4,307,723,280	1,846,167,120
Electro-Mechanical Equipment	19,656,000,000	17,690,400,000	1,965,600,000
Transmission Line	1,948,240,000	779,296,000	1,168,944,000
Direct Cost	46,150,834,697	29,784,163,774	16,366,670,923
Administration and Engineering Services	6,922,625,204	4,467,624,566	2,455,000,638
Contingency	4,615,083,469	2,978,416,377	1,636,667,092
Interest during Construction	12,460,725,368	8,041,724,219	4,419,001,149
TOTAL	70,149,268,738	45,271,928,936	24,877,339,802

2) Construction cost with Admin/Eng. Services and Contingency (unit: Crore Rs)

Preparation and Land Acquisition Cost	43.79	0.00	43.79
Environmental Mitigation Cost	65.69	0.00	65.69
Civil Works	2,189.60	875.84	1,313.76
Hydromechanical Works	769.24	538.47	230.77
Electro-Mechanical Equipment	2,457.00	2,211.30	245.70
Transmission Line	243.53	97.41	146.12
TOTAL	5,768.85	3,723.02	2,045.83

3) Economic Cost Conversion factor: 0.9 (unit: Crore Rs)

Preparation and Land Acquisition Cost	39.41	0.00	39.41
Environmental Mitigation Cost	59.12	0.00	59.12
Civil Works	2,058.22	875.84	1,182.38
Hydromechanical Works	746.16	538.47	207.69
Electro-Mechanical Equipment	2,432.43	2,211.30	221.13
Transmission Line	228.92	97.41	131.51
TOTAL	5,564.26	3,723.02	1,841.24

4) Annual Disbursement (unit: Crore Rs)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Preparation and Land Acquisition Cost	1.97	3.94	7.88	11.82	7.88	5.91
Environmental Mitigation Cost	2.96	5.91	11.82	17.74	11.82	8.87
Civil Works	102.91	205.82	411.64	617.47	411.64	308.73
Hydromechanical Works	37.31	74.62	149.23	223.85	149.23	111.92
Electro-Mechanical Equipment	121.62	243.24	486.49	729.73	486.49	364.86
Transmission Line	11.45	22.89	45.78	68.68	45.78	34.34
TOTAL	278.22	556.42	1112.84	1669.29	1112.84	834.63
	5%	10%	20%	30%	20%	15%

5) Total cost for equipment and transmission line (unit: Crore Rs)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Replacement cost for equipment	170.38	340.75	681.50	1022.26	681.50	511.12

6) Annual O&M cost 5564.26 1.0% 55.64 Crore Rs/year

7) Annual Cost for Pumping up Energy

Duration of annual plant operation	800	hours
Firm peak output	1,400	MW
Annual energy generation	1,120,000	MWh
Pumping efficiency	70	%
Annual pumping energy	1,600,000	MWh
Unit cost of fuel	2.50	Rs/kWh
Annual pumping cost	400.00	Crore Rs

Source: JICA Study Team

Table 11.1.2-1 (2) Economic Cost of the Project (Warasgaon)

1) Construction Cost (unit: Rs)

	Total	Foreign Portion	Local Portion
Preparation and Land Acquisition Cost	257,270,950		257,270,950
Environmental Mitigation Cost	385,906,425		385,906,425
Civil Works	12,863,547,512	5,145,419,005	7,718,128,507
Hydromechanical Works	4,514,788,800	3,160,352,160	1,354,436,640
Electro-Mechanical Equipment	16,484,000,000	14,835,600,000	1,648,400,000
Transmission Line	1,960,000,000	784,000,000	1,176,000,000
Direct Cost	36,465,513,687	23,925,371,165	12,540,142,522
Administration and Engineering Services	5,469,827,053	3,588,805,675	1,881,021,378
Contingency	3,646,551,369	2,392,537,117	1,254,014,252
Interest during Construction	9,845,688,696	6,459,850,215	3,385,838,481
TOTAL	55,427,580,805	36,366,564,172	19,061,016,633

2) Construction cost with Admin/Eng. Services and Contingency (unit: Crore Rs)

Preparation and Land Acquisition Cost	32.16	0.00	32.16
Environmental Mitigation Cost	48.24	0.00	48.24
Civil Works	1,607.95	643.18	964.77
Hydromechanical Works	564.34	395.04	169.30
Electro-Mechanical Equipment	2,060.50	1,854.45	206.05
Transmission Line	245.00	98.00	147.00
TOTAL	4,558.19	2,990.67	1,567.52

3) Economic Cost Conversion factor: 0.9 (unit: Crore Rs)

Preparation and Land Acquisition Cost	28.94	0.00	28.94
Environmental Mitigation Cost	43.42	0.00	43.42
Civil Works	1,511.47	643.18	868.29
Hydromechanical Works	547.41	395.04	152.37
Electro-Mechanical Equipment	2,039.90	1,854.45	185.45
Transmission Line	230.30	98.00	132.30
TOTAL	4,401.44	2,990.67	1,410.77

4) Annual Disbursement (unit: Crore Rs)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Preparation and Land Acquisition Cost	1.45	2.89	5.79	8.68	5.79	4.34
Environmental Mitigation Cost	2.17	4.34	8.68	13.03	8.68	6.51
Civil Works	75.57	151.15	302.29	453.44	302.29	226.72
Hydromechanical Works	27.37	54.74	109.48	164.22	109.48	82.11
Electro-Mechanical Equipment	102.00	203.99	407.98	611.97	407.98	305.99
Transmission Line	11.52	23.03	46.06	69.09	46.06	34.55
TOTAL	220.08	440.14	880.28	1320.43	880.28	660.22
	5%	10%	20%	30%	20%	15%

5) Total cost for equipment and transmission line (unit: Crore Rs)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Replacement cost for equipment	140.89	281.76	563.52	845.28	563.52	422.65

6) Annual O&M cost 4401.44 1.0% 44.01 Crore Rs/year

7) Annual Cost for Pumping up Energy

Duration of annual plant operation	800	hours
Firm peak output	1,000	MW
Annual energy generation	800,000	MWh
Pumping efficiency	70	%
Annual pumping energy	1,142,857	MWh
Unit cost of fuel	2.5	Rs/kWh
Annual pumping cost	285.71	Crore Rs

Source: JICA Study Team

Table 11.1.2-1 (3) Economic Cost of the Project (Varandh Ghat)

1) Construction Cost (unit: Rs)

	Total	Foreign Portion	Local Portion
Preparation and Land Acquisition Cost	163,515,978	0	163,515,978
Environmental Mitigation Cost	245,273,968	0	245,273,968
Civil Works	8,175,798,920	3,270,319,568	4,905,479,352
Hydromechanical Works	4,981,624,560	3,487,137,192	1,494,487,368
Electro-Mechanical Equipment	17,056,000,000	15,350,400,000	1,705,600,000
Transmission Line	2,508,800,000	1,003,520,000	1,505,280,000
Direct Cost	33,131,013,426	23,111,376,760	10,019,636,666
Administration and Engineering Services	4,969,652,014	3,466,706,514	1,502,945,500
Contingency	3,313,101,343	2,311,137,676	1,001,963,667
Interest during Construction	8,945,373,625	6,240,071,725	2,705,301,900
TOTAL	50,359,140,408	35,129,292,675	15,229,847,733

2) Construction cost with Admin/Eng. Services and Contingency (unit: Crore Rs)

Preparation and Land Acquisition Cost	20.44	0.00	20.44
Environmental Mitigation Cost	30.66	0.00	30.66
Civil Works	1,021.97	408.79	613.18
Hydromechanical Works	622.70	435.89	186.81
Electro-Mechanical Equipment	2,132.00	1,918.80	213.20
Transmission Line	313.60	125.44	188.16
TOTAL	4,141.37	2,888.92	1,252.45

3) Economic Cost Conversion factor: 0.9 (unit: Crore Rs)

Preparation and Land Acquisition Cost	18.40	0.00	18.40
Environmental Mitigation Cost	27.59	0.00	27.59
Civil Works	960.65	408.79	551.86
Hydromechanical Works	604.02	435.89	168.13
Electro-Mechanical Equipment	2,110.68	1,918.80	191.88
Transmission Line	294.78	125.44	169.34
TOTAL	4,016.12	2,888.92	1,127.20

4) Annual Disbursement (unit: Crore Rs)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Preparation and Land Acquisition Cost	0.92	1.84	3.68	5.52	3.68	2.76
Environmental Mitigation Cost	1.38	2.76	5.52	8.28	5.52	4.14
Civil Works	48.03	96.07	192.13	288.20	192.13	144.10
Hydromechanical Works	30.20	60.40	120.80	181.21	120.80	90.60
Electro-Mechanical Equipment	105.53	211.07	422.14	633.20	422.14	316.60
Transmission Line	14.74	29.48	58.96	88.43	58.96	44.22
TOTAL	200.80	401.62	803.23	1,204.84	803.23	602.42
	5%	10%	20%	30%	20%	15%

5) Total cost for equipment and transmission line (unit: Crore Rs)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Replacement cost for equipment	150.47	300.95	601.90	902.84	601.90	451.42

6) Annual O&M cost 4016.12 1.0% 40.16 Crore Rs/year

7) Annual Cost for Pumping up Energy

Duration of annual plant operation	800	hours
Firm peak output	1,100	MW
Annual energy generation	880,000	MWh
Pumping efficiency	70	%
Annual pumping energy	1,257,143	MWh
Unit cost of fuel	2.5	Rs/kWh
Annual pumping cost	314.29	Crore Rs

Source: JICA Study Team

11.1.3 Economic Benefit of the Project

For the purpose of the study, construction cost and operation & maintenance cost of an alternative power plant, which can supply equivalent power and energy to the pumped storage plant, are considered as economic benefit of the project. A power plant fueled by gas is selected as the alternative power plant.

(1) Adjustment Factor

In order to estimate the economic benefit in terms of alternative thermal power plant, firstly an adjustment factor to adjust the difference of loss rate between hydropower plant and thermal power plant is calculated. With such adjustment factor, basic characteristics of alternative thermal power plant will be obtained. Then economic benefit will be calculated using such basic characteristics. Adjustment Factor is shown in Table 11.1.3-1.

Table 11.1.3-1 Adjustment Factors for Power (kW) and Energy (kWh)

Item	Pumped Storage Power Plant		Alternative Thermal Plant	
Station Use	0.30%	①	2.09%	⑤
Forced Outage	0.50%	②	5.25%	⑥
Planned Outage	1.00%	③	2.32%	⑦
Transmission Loss	3.00%	④	3.00%	⑧
kW-Adjustment Factor	-		1.08378	⑨
kWh-Adjustment Factor	-		1.01828	⑩

(Note) 1. ⑨ =(1−①)∗(1−②)∗(1−③)∗(1−④)/(1−⑤)∗(1−⑥)∗(1−⑦)∗(1−⑧)

2. ⑩ =(1−①)∗(1−④)/(1−⑤)∗(1−⑧)

(Source: JICA Study Team Estimation)

(2) Cost of Alternative Thermal Power Plant

Basis characteristics of alternative thermal power plant are shown in Table 11.1.3-2.

Table 11.1.3-2 Basic Features of Alternative Thermal Power Plant

Item	Unit	Panshet	Warasgaon	Varandh Ghat
Installed capacity	MW	1,517	1,084	1,192
Energy generation	GWh	1,140.5	814.6	896.1
Plant Life	Years	20		

(Source: JICA Study Team Estimation)

Construction cost, annual O&M cost, and annual O&M cost for alternative thermal power plant is summarized in Table 11.1.3-3.

Table 11.1.3-3 Economic Benefit of the Project

	Unit	Panshet	Warasgaon	Varandha Ghat
1. Pumped Storage Power Plant				
Installed Capacity	MW	1,400	1,000	1,100
Annual hour of operation	hour	800	800	800
2. Alternative Thermal Power Plant				
Adjustment Factor (kW)		1.08378	1.08378	1.08378
Installed Capacity	MW	1,517	1,084	1,192
Adjustment Factor (kWh)		1.01828	1.01828	1.01828
Annual Energy Generation	MWh	1,140,476	814,626	896,088
1) Construction Cost				
Unit Construction Cost	Rs/kW	37,500.00	37,500.00	37,500.00
Construction Cost	Crore Rs	5,688.75	4,065.00	4,470.00
First year (40%)	Crore Rs	2,275.50	1,626.00	1,788.00
Second year (60%)	Crore Rs	3,413.25	2,439.00	2,682.00
2) Fuel Cost				
Unit Fuel Cost	Rs/kWh	3.517	3.517	3.517
Annual Fuel Cost	Crore Rs/year	401.11	286.50	315.15
3) O&M Cost				
Fixed O&M Cost				
Construction Cost	Crore Rs	5,688.75	4,065.00	4,470.00
OM Cost Rate		4.5%	4.5%	4.5%
Fixed O&M Cost	Crore Rs/year	255.99	182.93	201.15
Variable Unit O&M Cost	Rs/kWh	0.21	0.21	0.21
Variable O&M Cost	Crore Rs/year	23.95	17.11	18.82
Annual O&M Cost	Crore Rs/year	279.94	200.04	219.97

Source: JICA Study Team based on data from GOM WRD

11.1.4 Economic Evaluation

Evaluation indices like the Net Present Value (B-C) and Benefit Cost Ratio (B/C), as well as EIRR are summarized in Table 11.1.4-1 Cash flow is presented in Table 11.1.4-2.

Table 11.1.4-1 Result of Economic Evaluation

	Evaluation Index	Evaluation Criteria	Evaluation
Panshet Project (1400MW)			
NPV	713	> 0	
B/C	1.13	> 1	Acceptable
EIRR	16.4 %	> Opportunity cost of capital (12 %)	
Warasgaon Project (1000MW)			
NPV	212	> 0	
B/C	1.05	> 1	Acceptable
EIRR	13.6 %	> Opportunity cost of capital (12 %)	
Varandh Ghat Project (1100MW)			
NPV	802	> 0	
B/C	1.19	> 1	Acceptable
EIRR	192. %	> Opportunity cost of capital (12 %)	

(Note: Discount rate of 12% was used for calculating NPV and B/C.)

As a result, NPV results in positive (over zero) and EIRR exceeds 12% which corresponds to the opportunity cost of capital for all Projects. Therefore these are judged as economically feasible at a preliminary study level.

Table 11.1.4-2 (1) Economic Evaluation (Panshet)

(Unit: Crore Rs)

Year	Cost				Benefit				Balance
	Construction and Replacement	Operation and Maintenance	Pumping Energy	Total	Construction and Replacement	Operation and Maintenance	Fuel Cost	Total	
1	278.2			278.2				0.0	-278.2
2	556.4			556.4				0.0	-556.4
3	1,112.8			1,112.8				0.0	-1,112.8
4	1,669.3			1,669.3				0.0	-1,669.3
5	1,112.8			1,112.8	2,275.5			2,275.5	1,162.7
6	834.6			834.6	3,413.3			3,413.3	2,578.6
7	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
8	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
9	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
10	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
11	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
12	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
13	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
14	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
15	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
16	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
17	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
18	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
19	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
20	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
21	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
22	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
23	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
24	0.0	55.6	400.0	455.6	2,275.5	279.9	401.1	2,956.6	2,500.9
25	0.0	55.6	400.0	455.6	3,413.3	279.9	401.1	4,094.3	3,638.7
26	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
27	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
28	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
29	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
30	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
31	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
32	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
33	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
34	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
35	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
36	170.4	55.6	400.0	626.0		279.9	401.1	681.1	55.0
37	340.8	55.6	400.0	796.4		279.9	401.1	681.1	-115.3
38	681.5	55.6	400.0	1,137.1		279.9	401.1	681.1	-456.1
39	1,022.3	55.6	400.0	1,477.9		279.9	401.1	681.1	-796.9
40	681.5	55.6	400.0	1,137.1		279.9	401.1	681.1	-456.1
41	511.1	55.6	400.0	966.8		279.9	401.1	681.1	-285.7
42	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
43	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
44	0.0	55.6	400.0	455.6	2,275.5	279.9	401.1	2,956.6	2,500.9
45	0.0	55.6	400.0	455.6	3,413.3	279.9	401.1	4,094.3	3,638.7
46	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
47	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
48	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
49	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
50	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
51	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
52	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
53	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
54	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
55	0.0	55.6	400.0	455.6		279.9	401.1	681.1	225.4
56	-1,849.8	55.6	400.0	-1,394.1	-2,844.4	279.9	401.1	-2,163.3	-769.2
Total	7,122.0	2,782.0	20,000.0	29,904.0	14,221.9	13,997.0	20,055.5	48,274.4	18,370.4
Discount rate:	12%								
		PV (Cost):		5,555			PV (Benefit):	6,268	713
								EIRR:	**16.4%**
								NPV:	**713**
								B/C:	**1.13**

Table 11.1.4-2 (2) Economic Evaluation (Warasgaon)

(Unit: Crore Rs)

Year	Cost				Benefit				Balance
	Construction and Replacement	Operation and Maintenance	Pumping Energy	Total	Construction and Replacement	Operation and Maintenance	Fuel Cost	Total	
1	220.1			220.1				0.0	-220.1
2	440.1			440.1				0.0	-440.1
3	880.3			880.3				0.0	-880.3
4	1,320.4			1,320.4				0.0	-1,320.4
5	880.3			880.3	1,626.0			1,626.0	745.7
6	660.2			660.2	2,439.0			2,439.0	1,778.8
7	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
8	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
9	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
10	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
11	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
12	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
13	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
14	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
15	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
16	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
17	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
18	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
19	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
20	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
21	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
22	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
23	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
24	0.0	44.0	285.7	329.7	1,626.0	200.0	286.5	2,112.5	1,782.8
25	0.0	44.0	285.7	329.7	2,439.0	200.0	286.5	2,925.5	2,595.8
26	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
27	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
28	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
29	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
30	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
31	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
32	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
33	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
34	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
35	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
36	140.9	44.0	285.7	470.6		200.0	286.5	486.5	15.9
37	281.8	44.0	285.7	611.5		200.0	286.5	486.5	-124.9
38	563.5	44.0	285.7	893.2		200.0	286.5	486.5	-406.7
39	845.3	44.0	285.7	1,175.0		200.0	286.5	486.5	-688.5
40	563.5	44.0	285.7	893.2		200.0	286.5	486.5	-406.7
41	422.7	44.0	285.7	752.4		200.0	286.5	486.5	-265.8
42	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
43	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
44	0.0	44.0	285.7	329.7	1,626.0	200.0	286.5	2,112.5	1,782.8
45	0.0	44.0	285.7	329.7	2,439.0	200.0	286.5	2,925.5	2,595.8
46	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
47	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
48	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
49	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
50	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
51	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
52	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
53	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
54	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
55	0.0	44.0	285.7	329.7		200.0	286.5	486.5	156.8
56	-1,529.6	44.0	285.7	-1,199.8	-2,032.5	200.0	286.5	-1,546.0	-346.1
Total	5,689.5	2,200.5	14,285.5	22,175.5	10,162.5	10,002.0	14,325.0	34,489.5	12,314.0
Discount rate:	12%								
		PV (Cost):		4,266			PV (Benefit):	4,478	212
								EIRR:	**13.6%**
								NPV:	**212**
								B/C:	**1.05**

Table 11.1.4-2 (3) Economic Evaluation (Varandh Ghat)

(Unit: Crore Rs)

Year	Cost				Benefit				Balance
	Construction and Replacement	Operation and Maintenance	Pumping Energy	Total	Construction and Replacement	Operation and Maintenance	Fuel Cost	Total	
1	200.8			200.8				0.0	-200.8
2	401.6			401.6				0.0	-401.6
3	803.2			803.2				0.0	-803.2
4	1,204.8			1,204.8				0.0	-1,204.8
5	803.2			803.2	1,788.0			1,788.0	984.8
6	602.4			602.4	2,682.0			2,682.0	2,079.6
7	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
8	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
9	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
10	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
11	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
12	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
13	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
14	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
15	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
16	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
17	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
18	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
19	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
20	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
21	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
22	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
23	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
24	0.0	40.2	314.3	354.5	1,788.0	220.0	315.2	2,323.1	1,968.7
25	0.0	40.2	314.3	354.5	2,682.0	220.0	315.2	3,217.1	2,862.7
26	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
27	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
28	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
29	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
30	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
31	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
32	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
33	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
34	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
35	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
36	150.5	40.2	314.3	504.9		220.0	315.2	535.1	30.2
37	301.0	40.2	314.3	655.4		220.0	315.2	535.1	-120.3
38	601.9	40.2	314.3	956.4		220.0	315.2	535.1	-421.2
39	902.8	40.2	314.3	1,257.3		220.0	315.2	535.1	-722.2
40	601.9	40.2	314.3	956.4		220.0	315.2	535.1	-421.2
41	451.4	40.2	314.3	805.9		220.0	315.2	535.1	-270.8
42	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
43	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
44	0.0	40.2	314.3	354.5	1,788.0	220.0	315.2	2,323.1	1,968.7
45	0.0	40.2	314.3	354.5	2,682.0	220.0	315.2	3,217.1	2,862.7
46	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
47	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
48	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
49	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
50	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
51	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
52	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
53	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
54	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
55	0.0	40.2	314.3	354.5		220.0	315.2	535.1	180.7
56	-1,633.7	40.2	314.3	-1,279.3	-2,235.0	220.0	315.2	-1,699.9	-420.6
Total	5,391.9	2,008.0	15,714.5	23,114.4	11,175.0	10,998.5	15,757.5	37,931.0	14,816.6

Discount rate:	12%				
	PV (Cost):	4,123	PV (Benefit):	4,925	802
				EIRR:	**19.2%**
				NPV:	**802**
				B/C:	**1.19**

11.2 Preliminary Financial Evaluation

11.2.1 Methodology

(1) Evaluation Method

Financial analysis aims at measuring the expected return on investment from a viewpoint of an implementing agency. Here, the Discounted Cash Flow method was adopted. The basic approach for this method is as follows: First, the cash outflow (construction cost and O&M cost estimated at market price, i.e. financial costs) and inflow (benefits as electricity sale revenue) are developed on an annual basis over the project life. Secondly the amount generated each year will be discounted to the start year of the project and expressed it as an accumulated present value at the same standard year. Then a comparison will be made between the costs and benefits. The evaluation index to be obtained is the Financial Internal Rate of Return (FIRR) on investment. FIRR on investment is not affected by financing conditions; therefore, it is appropriate to evaluate the profitability of the project itself.

(2) Basic Conditions

According to the discussions with GOM WRD, as well as in line with the existing reports for other projects in India, the following basic conditions were adopted:

- Economic Life
  Economic life of each facility, according to the experience of the Consultant, was determined as follows:
- 50 years for civil works
- 35 years for hydro-mechanical and electro-mechanical equipment and transmission line
- Project life (Calculation Period)
  Calculation period for evaluation is 56 years: 50 years of service life of civil facilities and 6 years of construction works.
- Escalation
  No escalation was considered, therefore, a constant price will be used.

11.2.2 Financial Cost and Benefit of the Project

(1) Financial Cost

The financial cost of the Project includes the initial investment cost, the cost for replacement of equipment, operation & maintenance cost, and pumping cost. The operation and maintenance cost was calculated by multiplying the construction cost of each work item by a certain rate, which was determined based on the experiences with similar projects by the

Consultant. Pumping up cost is calculated with a unit cost of Rs.2.5/kWh, corresponding to the additional fuel cost for energy generation at coal-fired thermal power plant, presented by GOM WRD. Initial investment cost, O&M cost and pumping up cost of the Project are shown in Table 11.2.2-1..

Table 11.2.2-1 (1) Financial Cost of the Project (Panshet)

1) Construction Cost (unit: Rs)

	Total	Foreign Portion	Local Portion
Preparation and Land Acquisition Cost	350,337,225		350,337,225
Environmental Mitigation Cost	525,505,837		525,505,837
Civil Works	17,516,861,235	7,006,744,494	10,510,116,741
Hydromechanical Works	6,153,890,400	4,307,723,280	1,846,167,120
Electro-Mechanical Equipment	19,656,000,000	17,690,400,000	1,965,600,000
Transmission Line	1,948,240,000	779,296,000	1,168,944,000
Direct Cost	46,150,834,697	29,784,163,774	16,366,670,923
Administration and Engineering Services	6,922,625,204	4,467,624,566	2,455,000,638
Contingency	4,615,083,469	2,978,416,377	1,636,667,092
Interest during Construction	12,460,725,368	8,041,724,219	4,419,001,149
TOTAL	70,149,268,738	45,271,928,936	24,877,339,802

2) Construction cost with Admin/Eng. Services and Contingency (unit: Crore)

Preparation and Land Acquisition Cost	43.79	0.00	43.79
Environmental Mitigation Cost	65.69	0.00	65.69
Civil Works	2,189.60	875.84	1,313.76
Hydromechanical Works	769.24	538.47	230.77
Electro-Mechanical Equipment	2,457.00	2,211.30	245.70
Transmission Line	243.53	97.41	146.12
TOTAL	5,768.85	3,723.02	2,045.83

3) Annual Disbursement (unit: Crore Rs)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Preparation and Land Acquisition Cost	2.19	4.38	8.76	13.14	8.76	6.57
Environmental Mitigation Cost	3.28	6.57	13.14	19.71	13.14	9.85
Civil Works	109.48	218.96	437.92	656.88	437.92	328.44
Hydromechanical Works	38.46	76.92	153.85	230.77	153.85	115.39
Electro-Mechanical Equipment	122.85	245.70	491.40	737.10	491.40	368.55
Transmission Line	12.18	24.35	48.71	73.06	48.71	36.53
TOTAL	288.44	576.89	1,153.77	1,730.66	1,153.77	865.33
	5%	10%	20%	30%	20%	15%

4) Total cost for equipment and transmission line (unit: Crore Rs)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Replacement cost for equipment	173.49	346.98	693.95	1,040.93	693.95	520.47

5) Annual O&M cost	5768.85	1.0%	57.69	Crore Rs/year

6) Annual Cost for Pumping up Energy

Duration of annual plant operation	hours	800	1,500	1,800
Firm peak output	MW	1,400	1,400	1,400
Annual energy generation	MWh	1,120,000	2,100,000	2,520,000
Pumping efficiency	%	70	70	70
Annual pumping energy	MWh	1,600,000	3,000,000	3,600,000
Unit cost of fuel	Rs/kWh	2.5	2.5	2.5
Annual pumping cost	Crore Rs	400.00	750.00	900.00

Source: JICA Study Team

Table 11.2.2-1 (2) Financial Cost of the Project (Warasgaon)

1) Construction Cost (unit: Rs)

	Total	Foreign Portion	Local Portion
Preparation and Land Acquisition Cost	257,270,950	0	257,270,950
Environmental Mitigation Cost	385,906,425	0	385,906,425
Civil Works	12,863,547,512	5,145,419,005	7,718,128,507
Hydromechanical Works	4,514,788,800	3,160,352,160	1,354,436,640
Electro-Mechanical Equipment	16,484,000,000	14,835,600,000	1,648,400,000
Transmission Line	1,960,000,000	784,000,000	1,176,000,000
Direct Cost	36,465,513,687	23,925,371,165	12,540,142,522
Administration and Engineering Services	5,469,827,053	3,588,805,675	1,881,021,378
Contingency	3,646,551,369	2,392,537,117	1,254,014,252
Interest during Construction	9,845,688,696	6,459,850,215	3,385,838,481
TOTAL	55,427,580,805	36,366,564,172	19,061,016,633

2) Construction cost with Admin/Eng. Services and Contingency (unit: Crore)

Preparation and Land Acquisition Cost	32.16	0.00	32.16
Environmental Mitigation Cost	48.24	0.00	48.24
Civil Works	1,607.95	643.18	964.77
Hydromechanical Works	564.34	395.04	169.30
Electro-Mechanical Equipment	2,060.50	1,854.45	206.05
Transmission Line	245.00	98.00	147.00
TOTAL	4,558.19	2,990.67	1,567.52

3) Annual Disbursement (unit: Crore)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Preparation and Land Acquisition Cost	1.61	3.22	6.43	9.65	6.43	4.82
Environmental Mitigation Cost	2.41	4.82	9.65	14.47	9.65	7.24
Civil Works	80.40	160.80	321.59	482.39	321.59	241.19
Hydromechanical Works	28.22	56.43	112.87	169.30	112.87	84.65
Electro-Mechanical Equipment	103.03	206.05	412.10	618.15	412.10	309.08
Transmission Line	12.25	24.50	49.00	73.50	49.00	36.75
TOTAL	227.91	455.82	911.64	1,367.46	911.64	683.73
	5%	10%	20%	30%	20%	15%

4) Total cost for equipment and transmission line (unit: Crore)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Replacement cost for equipment	143.49	286.98	573.97	860.95	573.97	430.48

5) Annual O&M cost 4558.19 1.0% 45.58 Crore/year

6) Annual Cost for Pumping up Energy

Duration of annual plant operation	hours	800	1,500	1,800
Firm peak output	MW	1,000	1,000	1,000
Annual energy generation	MWh	800,000	1,500,000	1,800,000
Pumping efficiency	%	70	70	70
Annual pumping energy	MWh	1,142,857	2,142,857	2,571,429
Unit cost of fuel	Rs/kWh	2.5	2.5	2.5
Annual pumping cost	Crore Rs	285.71	535.71	642.86

Source: JICA Study Team

Table 11.2.2-1 (3) Financial Cost of the Project (Varandh Ghat)

1) Construction Cost (unit: Rs)

	Total	Foreign Portion	Local Portion
Preparation and Land Acquisition Cost	163,515,978	0	163,515,978
Environmental Mitigation Cost	245,273,968	0	245,273,968
Civil Works	8,175,798,920	3,270,319,568	4,905,479,352
Hydromechanical Works	4,981,624,560	3,487,137,192	1,494,487,368
Electro-Mechanical Equipment	17,056,000,000	15,350,400,000	1,705,600,000
Transmission Line	2,508,800,000	1,003,520,000	1,505,280,000
Direct Cost	33,131,013,426	23,111,376,760	10,019,636,666
Administration and Engineering Services	4,969,652,014	3,466,706,514	1,502,945,500
Contingency	3,313,101,343	2,311,137,676	1,001,963,667
Interest during Construction	8,945,373,625	6,240,071,725	2,705,301,900
TOTAL	50,359,140,408	35,129,292,675	15,229,847,733

2) Construction cost with Admin/Eng. Services and Contingency (unit: Crore Rs)

Preparation and Land Acquisition Cost	20.44	0.00	20.44
Environmental Mitigation Cost	30.66	0.00	30.66
Civil Works	1,021.97	408.79	613.18
Hydromechanical Works	622.70	435.89	186.81
Electro-Mechanical Equipment	2,132.00	1,918.80	213.20
Transmission Line	313.60	125.44	188.16
TOTAL	4,141.37	2,888.92	1,252.45

3) Annual Disbursement (unit: Crore Rs)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Preparation and Land Acquisition Cost	1.02	2.04	4.09	6.13	4.09	3.07
Environmental Mitigation Cost	1.53	3.07	6.13	9.20	6.13	4.60
Civil Works	51.10	102.20	204.39	306.59	204.39	153.30
Hydromechanical Works	31.14	62.27	124.54	186.81	124.54	93.41
Electro-Mechanical Equipment	106.60	213.20	426.40	639.60	426.40	319.80
Transmission Line	15.68	31.36	62.72	94.08	62.72	47.04
TOTAL	207.07	414.14	828.27	1,242.41	828.27	621.21
	5%	10%	20%	30%	20%	15%

4) Total cost for equipment and transmission line (unit: Crore Rs)

	1st year	2nd year	3rd year	4th year	5th year	6th year
Replacement cost for equipment	153.42	306.83	613.66	920.49	613.66	460.25

5) Annual O&M cost	4,141.37	1.0%	41.41	Crore Rs/year

6) Annual Cost for Pumping up Energy

Duration of annual plant operation	hours	800	1,500	1,800
Firm peak output	MW	1,100	1,100	1,100
Annual energy generation	MWh	880,000	1,650,000	1,980,000
Pumping efficiency	%	70	70	70
Annual pumping energy	MWh	1,257,143	2,357,143	2,828,571
Unit cost of fuel	Rs/kWh	2.5	2.5	2.5
Annual pumping cost	Crore Rs	314.29	589.29	707.14

Source: JICA Study Team

(2) Financial Benefit

The financial benefit of the Project is the revenue to be earned by the electricity sale. Here the electricity sale revenue was obtained from an average unit rate (USc12.157/kWh), multiplied by salable energy volume, as shown in Table 11.2.2-2.

Table 11.2.2-2 Financial Benefit

Project	Capacity (MW)	Operation (hour)	Energy Generation (GWh)	Gross Loss	Unit Price (Rs/kWh)	Annual Revenue (Crore Rs)
Panshet	1,400	800	1,120	5%	5.27	560.73
		1,500	2,100			1,051.37
		1,800	2,520			1,261.64
Warasgaon	1,000	800	800	5%	5.27	400.52
		1,500	1,500			750.96
		1,800	1,800			901.17
Varandh Ghat	1,100	800	880	5%	5.27	440.57
		1,500	1,650			826.07
		1,800	1,980			991.29

(Source: JICA Study Team Estimation)

11.2.3 Financial Evaluation

The Financial Internal Rate of Return (FIRR) on investment was calculated based on the financial revenue. The result is summarized in Table 11.2.3-1.

Table 11.2.3-1 Result of Financial Evaluation

	Operation	Panshet	Warasgaon	Varandh Ghat
FIRR	800 hours	--	--	---
	1,500 hours	2.4 %	1.7 %	2.8 %
	1,800 hours	3.6 %	2.9 %	4.1 %

This result shows that use of concessional loan would make the project financially feasible. On the other hand, considering the fact that this is a preliminary level study, it is not appropriate to define the financial feasibility only from this result. Scrutiny on assumption is necessary for further study.

Chapter 12

Conclusions and Recommendations on Environmental and Social Considerations

Chapter 12 Conclusions and Recommendations on Environmental and Social Considerations

12.1 Preliminary scoping of three candidate sites

12.1.1 Identification of affected areas

A detailed social and environmental survey has not been conducted at each site and it is difficult to identify the affected areas in a precise manner. Affected areas, therefore, are tentatively identified as the following and a preliminary scoping for environmental and social considerations is conducted at each site. The exact affected area of each site is subject to a further study.

(1) Directly affected villages (including dam and reservoir areas):

Panshet: Dasper (upper), and Sakalyachiwadi (lower)

Warasgaon: Dhamanhol (upper), and Umbardi (lower)

Varandh Ghat: Nigademose and Kelad (upper), and Ranawadi, Kumbheshivtar and Ambeshivtar (lower)

(2) Upstream areas

The entire catchment areas of both upper and lower sites, and the area between upper and lower sites.

Regarding the Warasgaon upper alternative site, there is no catchment area.

(3) Downstream areas

Upper sites: There is another reservoir downstream of each upper site, and it is appropriate that those reservoirs are regarded as their downstream areas.

Regarding the Warasgaon upper alternative site, there is no downstream area.

Lower sites: The downstream area of each site can be tentatively identified as the area from the dam site to the next confluence point with another river, especially for the considerations of the social environments. Figure 12.1.1-1 and Figure 12.1.1-2 show the downstream areas of Panshet and Warasgaon sites, and of Varandh Ghat site. The direct distance from Panshet site to the confluence point is about 7 km, and from Warasgaon site is about 5km. The one from Varandh Ghat is about 7 km.

(4) Quarry

Although location of quarry has not been identified, impacts of development of the quarry are briefly explained in the scoping table of each site.

(5) Transmission lines

Although route of transmission lines have not been identified, impacts of development of the transmission lines are briefly explained in the scoping table at each site.

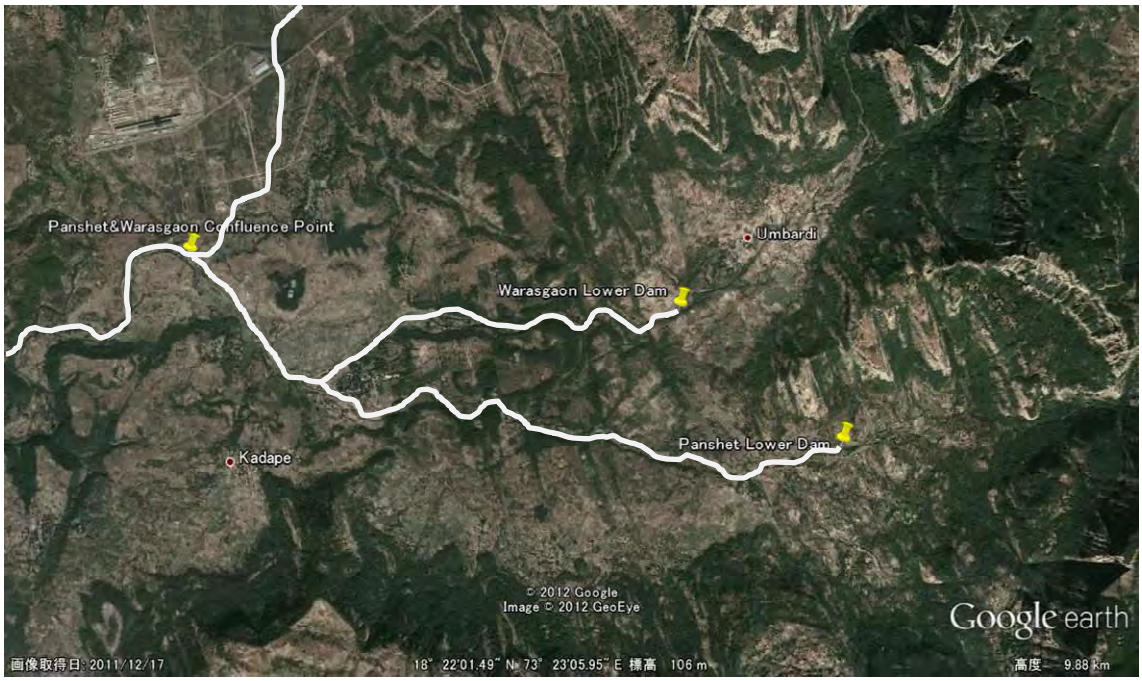


Figure 12.1.1-1 Panshet and Warasgaon Lower dams and confluence point (downstream areas)

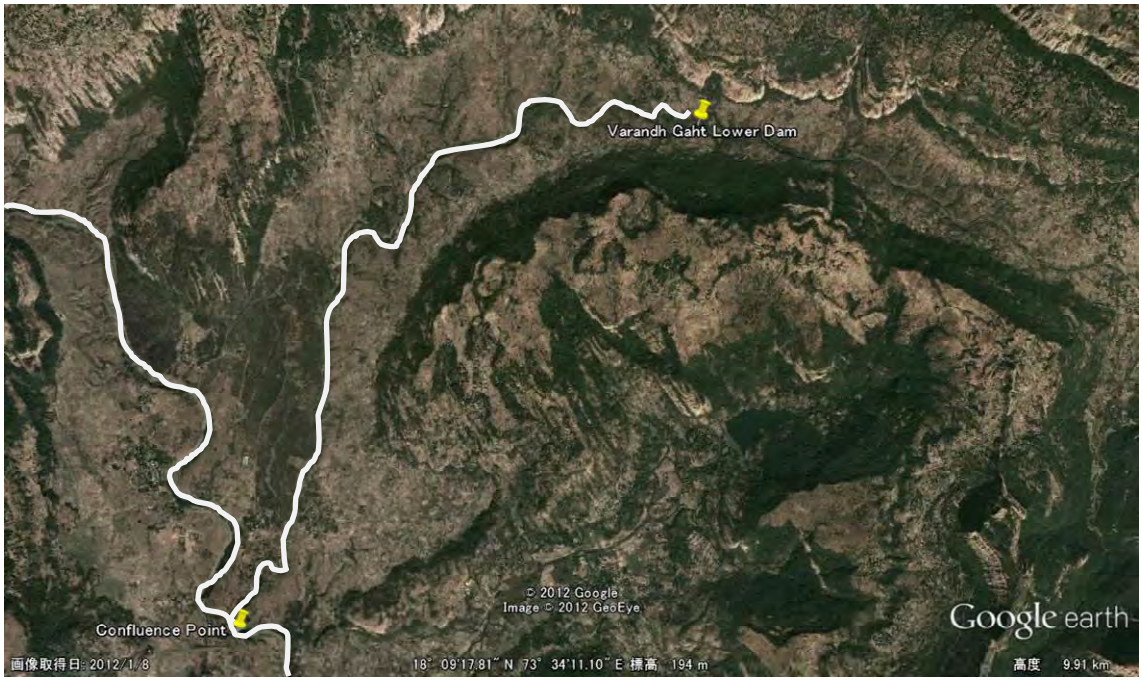


Figure 12.1.1-2 Varandh Ghat lower dams and confluence point (downstream area)

12.1.2 Preliminary scoping for the three candidate sites

A preliminary scoping is conducted for each of the three (3) candidate sites based on collected information and observations during the Study. It covers 31 items for the environmental and social considerations stipulated in "JICA Guidelines for Environmental and Social Considerations (2010)". The form of the scoping table is shown in Table 12.1.2-1. "Model TOR for Hydropower Projects (MOEF)[1]" is also referred to fill out the table.

Table 12.1.2-1 Scoping table

Category	No.	Expected impact	Evaluation		Explanation on the evaluation	
			Construction stage	Operation /maintenance stage	Construction state	Operation /maintenance stage
Pollution	1	Air pollution				
	2	Water pollution				
	3	Waste				
	4	Soil pollution				
	5	Noise / vibration				
	6	Ground subsidence				
	7	Offensive odors				
	8	Bottom sediments				
Natural environment	9	Protected areas				
	10	Ecosystems				
	11	Hydrology				
	12	Geography				
Social environment	13	Involuntary resettlement				
	14	Poor people				
	15	Indigenous or ethnic minority				
	16	Local economies, such as employment, livelihood				
	17	Land use and utilization of local resources				
	18	Water usage				
	19	Existing social infrastructures and services				
	20	Social institutions such as				

[1] Downloaded on 03 August 2012 from MoEF Website: http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/Model.htm

Category	No.	Expected impact	Evaluation		Explanation on the evaluation	
			Construction stage	Operation /maintenance stage	Construction state	Operation /maintenance stage
		social infrastructure and local decision-making institutions				
	21	Misdistribution of benefits and damages				
	22	Local conflicts of interest				
	23	Cultural heritages				
	24	Landscape				
	25	Gender				
	26	Children's rights				
	27	Infectious diseases such as HIV/AIDS				
	28	Labor conditions				
Others	29	Accidents				
	30	Trans-boundary impacts / global warming				
	31	Transmission lines				

A: Adverse impact is expected. B: Beneficial impact is expected. NE: Impact is not expected. Nk: Impact is not known yet.

Preliminary Scoping tables for three (3) candidate sites – Panshet, Warasgaon and Varandh Ghat – are shown in Table 12.1.2-2, 12.1.2-3 and 12.1.3-4.

Because of the similar nature of each site, the scoping tables are similar to each other. Texts underlined in each table are the important and different points from other sites.

Table 12.1.2-2 Preliminary Scoping for Panshet site

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Panshet site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
Pollution	1	Air pollution	A	NE	Pollutants from construction machines and heavy transportation vehicles, dust from the earth works are expected. Air pollution (dust) is expected at quarry site.	There are no works and activities which may cause air pollution.
	2	Water pollution	A	A	The turbidity of river during the rainy season is expected. Cleaning water for machines and vehicles, drainage water with soil and sewage from construction site and camp are expected.	The water levels of the reservoirs change every day because of its operation pattern of a pumped storage power station, and it is expected that the reservoirs do not eutrophicate so much. It is thought that the level of water contamination in the downstream area is limited during the rainy season if any. Since the sludge in the bottom of the reservoirs are not released to the downstream, water pollution in the downstream area is not expected.
	3	Waste	A	A	Industrial solid wastes and domestic wastes (camp) are expected.	Industrial solid wastes and domestic wastes (management quarter) are expected.
	4	Soil pollution	A	NE	Oil and other chemicals from construction machines and vehicles may contaminate soil.	There are no works and activities which may contaminate soil.
	5	Noise / vibration	A	NE	Noise and vibration from construction machines / vehicles, and blasting works are expected. Blasting works are also expected at quarry site.	Turbines are the main source of the noise and vibration. They are located underground and no negative impact is expected.
	6	Ground subsidence	NE	NE	There are no works and activities which may cause ground subsidence. Geological formation is solid and it is not expected any ground subsidence.	Geological formation is solid and it is not expected any ground subsidence.
	7	Offensive odors	NE	NE	There are no works and activities which may	There are no works and activities which may

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Panshet site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					produce offensive odors.	produce offensive odors.
	8	Bottom sediments	NE	NE	There are no works and activities which may cause contamination of bottom sediments.	There are no works and activities which may cause contamination of bottom sediments.
Natural environment	9	Protected areas	NE	NE	There are not National Parks, Wildlife Sanctuaries, Biosphere Reserves and World Natural Heritage Sites in and around the site.	There are no works and activities which may cause negative impacts on protected areas.
	10	Ecosystems	NE A Nk	NE A Nk	The project site is not within Important Bird Areas. The Talula − Mangaon − where the lower dam and reservoir are located is recommended as ESZ 3 by WGEEP. Regarding their recommended regulations within ESZ 3, refer to Table 7.3.2-1 and 7.3.2-2. The existing reserved forests are not directly affected by the project including tunnel works. Since the project sites are located in Western Ghats (a biodiversity hot spot), there is a possibility that endemic and endangered species of fauna and flora (including aquatic species such as fish) may occur in and around the project area There is also a possibility that there are migratory path / route of terrestrial animals and birds. It is necessary to conduct a detailed survey on fauna and flora, and to confirm the scale and nature of impacts. Since both dams are located at the upstream of the rivers, impacts on anadromous fishes are limited if any.	There are no works and activities which may cause negative impacts on the ecosystem. Only first infilling to the reservoir is necessary, and after the first filling, the water overflows to the downstream during the rainy season. It is therefore expected that negative impact is limited. Since both dams are located at the upstream of the rivers, impacts on anadromous fishes are limited if any. There may be negative impacts caused by alien species. Impacts caused by domestic animals including cats and dogs, and poaching are unknown.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Panshet site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					Since the downstream of the upper dam is a reservoir of other dam, it is expected that negative impacts on ecosystem are limited. There is neither Ramsar site nor other important wetlands in the Savitri River basin (the downstream of the lower dam and reservoir). There may be negative impacts caused by alien species. Impacts caused by domestic animals including cats and dogs, and poaching are unknown. It is expected there is no impact on vegetation cover by tunnel construction works. Since geological formation is mainly of basaltic lava flow, there is no fossil of fauna and flora.	
	11	Hydrology	A	A	If the tunnels go through aquifers, ground water level may come down.	Ground water level may change because of the reservoir at each site.
	12	Geology / geography	A	NE A	If the dam construction works requires huge amount of aggregates, negative impacts on geographical features at quarry are expected. Risk of earthquakes is moderately high (refer to 9.2 Landform and Geology).	There are no works and activities which may cause negative impacts on geology / geography. The catchment area does not produce lots of earth and sand because of its geological formation. It is therefore expected that impact on downstream riverbed caused by sedimentation in the reservoir is limited.
Social environment	13	Involuntary resettlement	A Nk	NE	**Before construction:** Involuntary resettlement is expected at the upper	There are no works and activities which cause resettlement.

<table>
<tr><th rowspan="2">Category</th><th rowspan="2">No.</th><th rowspan="2">Expected impact</th><th colspan="2">Evaluation</th><th colspan="2">Explanation on the evaluation for Panshet site</th></tr>
<tr><th>Con.</th><th>O&M</th><th>Construction (Con.) Stage
(If impacts are expected before this stage, explanations are given.)</th><th>Operation and Maintenance (O&M) Stage</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>reservoir’ site. The scale is expected to be small but the exact scale is not known.

At the lower reservoir site, it seems that no residential house exists in the site. The site is mainly used for agricultural practices. However, since some people may lose their main source of their livelihood, it is required to conduct a survey on social environment to confirm the scale and nature of impacts.

Although routes and site of access roads and quarry are planned to avoid resettlement as much as possible, they may cause resettlements.

Although there is low possibility of squatters in the area and it is expected no impact on them, a detailed survey on social environment is required to confirm their existence and impacts if any.

Construction stage:
There are no works and activities which may cause resettlement.</td><td></td></tr>
<tr><td></td><td>14</td><td>Poor people</td><td>Nk</td><td>B</td><td>Before construction:
Since there may be poor people within the PAPs, a detailed survey on social environment is required to confirm their existence and the scale and nature of impacts if any.</td><td>The poor people may obtain more opportunities to access to social services and markets because of the new access road.</td></tr>
<tr><td></td><td>15</td><td>Indigenous or ethnic minority</td><td>Nk</td><td>NE</td><td>It is required to conduct a survey on social environment to confirm the existence of indigenous and ethnic minorities in the area and the scale and nature of impacts if any.</td><td>There are no works and activities which may cause negative impacts on indigenous and ethnic minorities, even if there are these people in the area.</td></tr>
</table>

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Panshet site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
	16	Local economies, such as employment, livelihood	A B	B	**Before construction:** There are changes in the local economies because of resettlement. **Construction stage:** There are beneficial impacts on the local economies because of employment of unskilled labors and procurement of minor materials.	There are beneficial impacts on the local economies because of employment of unskilled labors and procurement of minor materials.
	17	Land use and utilization of local resources	A	NE Nk	**Before construction:** There are changes in the land use and utilization of local resources because of resettlement.	Since water flow during the rainy season does not change a lot, impacts are limited if any. It may become difficult for the local people to harvest non-timber forest products such as fire woods and medicinal plants if any.
	18	Water usage	A NE	Nk	If there are water utilization activities in the downstream area, muddy waters during the rainy season may cause impacts in the downstream. It is necessary to conduct a survey to confirm the scale and nature of impacts in the downstream area. Regarding the interstate water utilization right, it is recognized that there is no issue based on the results of KWDT I.	Upper reservoir: Although there is another reservoir just downstream of the upper reservoir, the catchment area of the upper reservoir is small and it is expected that impact is limited if any. Lower reservoir: Only first infilling to the reservoir is necessary, and after the first filling, the water overflows to the downstream during the rainy season. It is therefore expected that impact is limited if any.
	19	Existing social infrastructures and services	A	NE	There is a possibility that roads and bridges maybe damaged because of heavy transportation vehicles. Traffic jams and accidents are expected. It is necessary to conduct a social survey to	There are no works and activities which may cause impacts on the existing social infrastructures and services.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Panshet site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					confirm the scale and nature of impacts on schools and hospitals.	
	20	Social institutions such as social infrastructure and local decision making institutions	A	NE	There are impacts on the social institutions because of resettlement.	There are no works and activities which may cause impacts on the social institutions.
	21	Uneven distribution of benefits and damages	A	NE	**Before construction:** Uneven distribution of benefits and damages may happen among the PAPs. **Construction stage:** Without appropriate and acceptable guidelines of employment qualification and procurement of minor materials, it may give unfair impression to the local people and may cause social conflict among them.	There are no works and activities which may cause uneven distribution of benefits and damages.
	22	Local conflicts of interest	A	NE	**Before construction:** Because of resettlement, social conflict may happen among the PAPs. **Construction stage:** Without appropriate and acceptable guidelines of employment qualification and procurement of minor materials, it may give unfair impression to the local people and may cause social conflict among them.	There are no works and activities which may cause local conflicts of interest.
	23	Cultural heritages	NE	NE	There is neither World Cultural Heritage Site nor other cultural heritage in and around the project site.	There are no works and activities which may cause negative impacts on cultural or religious heritages.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Panshet site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					In the upper reservoir site, there is a small temple within the reservoir site, and it needs to be relocated.	
	24	Landscape	A	A	There is a change in the landscape because of dam and reservoir construction.	There are no works and activities which may cause negative impacts on landscape.
	25	Gender	Nk	Nk	Although it is not expected negative impacts on gender issues, it is required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.	Although it is not expected negative impacts on gender issues, it is required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.
	26	Children's rights	Nk	Nk	It is not expected negative impacts on children's rights gender issues. For example, child labor is prohibited by an act. It is, however, required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.	Although it is not expected negative impacts on children's rights gender issues, it is required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.
	27	Infectious diseases such as HIV/AIDS	A	A	Infectious diseases may be spread because of the inflow of labor from outside.	Water-borne and / or mosquito-borne diseases may occur but the impacts are expected to be limited.
	28	Labor conditions	A	NE	It is necessary to give sufficient consideration to labor conditions of construct workers.	There are no works and activities which may cause negative impacts on labor conditions.
Others	29	Accidents	A	A	It is necessary to give sufficient consideration to accidents during the construction works.	Traffic accidents may increase because of new access road.
	30	Trans-boundary impacts / global warming	NE A	B A	No trans-boundary impacts are expected. CO_2 is released because of tree felling in the reservoir area and it gives negative impact on global warming, but the impact is limited.	The project contributes reduction of CO_2 emissions from other power generation development. Greenhouse gases are released from the reservoirs, but limited.
	31	Transmission lines	A Nk	NE	**Before construction:** Transmission lines need to be extended to the planned line, and land acquisition and involuntary resettlement may occur.	There are no works and activities which may cause negative impacts on surrounding environments.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Panshet site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					Route of the new transmission lines is not decided, and impacts on protected areas are not confirmed yet. Although migratory routes of birds are not reported, it is necessary to conduct a survey when the route is planned.	

A: Adverse impact is expected. B: Beneficial impact is expected. NE: Impact is not expected. Nk: Impact is not known yet.

Table 12.1.2-3 Preliminary Scoping for Warasgaon site

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Warasgaon site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
Pollution	1	Air pollution	A	NE	Pollutants from construction machines and heavy transportation vehicles, dust from the earth works are expected. Air pollution (dust) is expected at quarry site.	There are no works and activities which may cause air pollution.
	2	Water pollution	A	A	The turbidity of river during the rainy season is expected. Cleaning water for machines and vehicles, drainage water with soil and sewage from construction site and camp are expected.	The water levels of the reservoirs change every day because of its operation pattern of a pumped storage power station, and it is expected that the reservoirs do not eutrophicate so much. It is thought that the level of water contamination in the downstream area is limited during the rainy season if any. Since the sludge in the bottom of the reservoirs are not released to the downstream, water pollution in the downstream area is not expected.
	3	Waste	A	A	Industrial solid wastes and domestic wastes (camp) are expected.	Industrial solid wastes and domestic wastes (management quarter) are expected.
	4	Soil pollution	A	NE	Oil and other chemicals from construction machines and vehicles may contaminate soil.	There are no works and activities which may contaminate soil.
	5	Noise / vibration	A	NE	Noise and vibration from construction machines / vehicles, and blasting works are expected. Blasting works are also expected at quarry site.	Turbines are the main source of the noise and vibration. They are located underground and no negative impact is expected.
	6	Ground subsidence	NE	NE	There are no works and activities which may cause ground subsidence. Geological formation is solid and it is not expected any ground subsidence.	Geological formation is solid and it is not expected any ground subsidence.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Warasgaon site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
	7	Offensive odors	NE	NE	There are no works and activities which may produce offensive odors.	There are no works and activities which may produce offensive odors.
	8	Bottom sediments	NE	NE	There are no works and activities which may cause contamination of bottom sediments.	There are no works and activities which may cause contamination of bottom sediments.
Natural environment	9	Protected areas	NE	NE	There are not National Parks, Wildlife Sanctuaries, Biosphere Reserves and World Natural Heritage Sites in and around the site.	There are no works and activities which may cause negative impacts on protected areas.
	10	Ecosystems	NE A Nk	NE A Nk	The project site is not within Important Bird Areas. The Talula − Mangaon − where the lower dam and reservoir are located is recommended as ESZ 3 by WGEEP. Regarding their recommended regulations within ESZ 3, refer to Table 7.3.2-1 and 7.3.2-2. The existing reserved forests are not directly affected by the project including tunnel works. Since the project sites are located in Western Ghats (a biodiversity hot spot), there is a possibility that endemic and endangered species of fauna and flora (including aquatic species such as fish) may occur in and around the project area There is also a possibility that there are migratory path / route of terrestrial animals and birds. It is necessary to conduct a detailed survey on fauna and flora, and to confirm the scale and nature of impacts. Since both dams are located at the upstream of the rivers, impacts on anadromous fishes are	There are no works and activities which may cause negative impacts on the ecosystem. Only first infilling to the reservoir is necessary, and after the first filling, the water overflows to the downstream during the rainy season. It is therefore expected that negative impact is limited. Since both dams are located at the upstream of the rivers, impacts on anadromous fishes are limited if any. There may be negative impacts caused by alien species. Impacts caused by domestic animals including cats and dogs, and poaching are unknown.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Warasgaon site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					limited if any. Since the downstream of the upper dam is a reservoir of other dam, it is expected that negative impacts on ecosystem are limited. There is neither Ramsar site nor other important wetlands in the Savitri River basin (the downstream of the lower dam and reservoir). There may be negative impacts caused by alien species. Impacts caused by domestic animals including cats and dogs, and poaching are unknown. It is expected there is no impact on vegetation cover by tunnel construction works. Since geological formation is mainly of basaltic lava flow, there is no fossil of fauna and flora. <u>Regarding the upper dam/reservoir (alternative site), a new access road from the existing road needs to be constructed.</u>	
	11	Hydrology	A	A	If the tunnels go through aquifers, ground water level may come down.	Ground water level may change because of the reservoir at each site.
	12	Geology / geography	A	NEA	If the dam construction works requires huge amount of aggregates, negative impacts on geographical features at quarry are expected. Risk of earthquakes is moderately high (refer to	There are no works and activities which may cause negative impacts on geology / geography. The catchment area does not produce lots of earth and sand because of its geological

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Warasgaon site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					9.2 Landform and Geology).	formation. It is therefore expected that impact on downstream riverbed caused by sedimentation in the reservoir is limited.
Social environment	13	Involuntary resettlement	A Nk	NE	**Before construction:** In the upper reservoir site, it seems that no residential house exists in the site. The site is mainly used for agricultural practices. However, since some people may lose their main source of their livelihood, it is required to conduct a survey on social environment to confirm the scale and nature of impacts. In the lower reservoir site, an entire village may need to be resettled, and huge negative impacts are expected. In the upper alternative site, although no resettlement is expected, there is a possibility that it may make some people lose the source of their livelihood. A survey needs to be conducted. Although routes and site of access roads and quarry are planned to avoid resettlement as much as possible, they may cause resettlements. Although there is low possibility of squatters in the area and it is expected no impact on them, a detailed survey on social environment is required to confirm their existence and impacts if any. **Construction stage:** There are no works and activities which may	There are no works and activities which cause resettlement.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Warasgaon site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					cause resettlement.	
	14	Poor people	Nk	B	**Before construction:** Since there may be poor people within the PAPs, a detailed survey on social environment is required to confirm their existence and the scale and nature of impacts if any.	The poor people may obtain more opportunities to access to social services and markets because of the new access road.
	15	Indigenous or ethnic minority	Nk	NE	It is required to conduct a survey on social environment to confirm the existence of indigenous and ethnic minorities in the area and the scale and nature of impacts if any.	There are no works and activities which may cause negative impacts on indigenous and ethnic minorities, even if there are these people in the area.
	16	Local economies, such as employment, livelihood	A B	B	**Before construction:** There are changes in the local economies because of resettlement. **Construction stage:** There are beneficial impacts on the local economies because of employment of unskilled labors and procurement of minor materials.	There are beneficial impacts on the local economies because of employment of unskilled labors and procurement of minor materials.
	17	Land use and utilization of local resources	A	NE Nk	**Before construction:** There are changes in the land use and utilization of local resources because of resettlement. There is no mining concession in the area.	Since water flow during the rainy season does not change a lot, impacts are limited if any. It may become difficult for the local people to harvest non-timber forest products such as fire woods and medicinal plants.
	18	Water usage	A NE	Nk	If there are water utilization activities in the downstream area, muddy waters during the rainy season may cause impacts in the downstream. However, it is necessary to conduct a survey to confirm the scale and nature of impacts in the downstream area. Regarding the interstate water utilization right, it	Upper reservoir: Although there is another reservoir just downstream of the upper reservoir, the catchment area of the upper reservoir is small and it is expected that impact is limited if any. Lower reservoir: Only first infilling to the reservoir is necessary, and after the first filling,

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Warasgaon site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					is recognized that there is no issue based on the results of KWDT I.	the water overflows to the downstream during the rainy season. It is therefore expected that impact is limited if any.
	19	Existing social infrastructures and services	A	NE	There is a possibility that roads and bridges maybe damaged because of heavy transportation vehicles. Traffic jams and accidents are expected. It is necessary to conduct a social survey to confirm the scale and nature of impacts on schools and hospitals.	There are no works and activities which may cause impacts on the existing social infrastructures and services.
	20	Social institutions such as social infrastructure and local decision making institutions	A	NE	There are impacts on the social institutions because of resettlement.	There are no works and activities which may cause impacts on the social institutions.
	21	Uneven distribution of benefits and damages	A	NE	**Before construction:** Uneven distribution of benefits and damages may happen among the PAPs. **Construction stage:** Without appropriate and acceptable guidelines of employment qualification and procurement of minor materials, it may give unfair impression to the local people and may cause social conflict among them.	There are no works and activities which may cause uneven distribution of benefits and damages.
	22	Local conflicts of interest	A	NE	**Before construction:** Because of resettlement, social conflict may happen among the PAPs.	There are no works and activities which may cause local conflicts of interest.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Warasgaon site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					Construction stage: Without appropriate and acceptable guidelines of employment qualification and procurement of minor materials, it may give unfair impression to the local people and may cause social conflict among them.	
	23	Cultural heritages	NE	NE	There is neither World Cultural Heritage Site nor other cultural heritage in and around the project site. There is one temple in the middle of the village in the lower reservoir site. It needs to be relocated.	There are no works and activities which may cause negative impacts on cultural or religious heritages.
	24	Landscape	A	A	There is a change in the landscape because of dam and reservoir construction.	There are no works and activities which may cause negative impacts on landscape.
	25	Gender	Nk	Nk	Although it is not expected negative impacts on gender issues, it is required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.	Although it is not expected negative impacts on gender issues, it is required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.
	26	Children's rights	Nk	Nk	It is not expected negative impacts on children's rights gender issues. For example, child labor is prohibited by an act. It is, however, required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.	Although it is not expected negative impacts on children's rights gender issues, it is required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.
	27	Infectious diseases such as HIV/AIDS	A	A	Infectious diseases may be spread because of the inflow of labor from outside.	Water-borne and / or mosquito-borne diseases may occur but the impacts are expected to be limited.
	28	Labor conditions	A	NE	It is necessary to give sufficient consideration to labor conditions of construct workers.	There are no works and activities which may cause negative impacts on labor conditions.
Others	29	Accidents	A	A	It is necessary to give sufficient consideration to accidents during the construction works.	Traffic accidents may increase because of new access road.
	30	Trans-boundary	NE	B	No trans-boundary impacts are expected.	The project contributes reduction of CO_2

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Warasgaon site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
		impacts / global warming	A	A	CO_2 is released because of tree felling in the reservoir area and it gives negative impact on global warming, but the impact is limited.	emissions from other power generation development. Greenhouse gases are released from the reservoirs, but limited.
	31	Transmission lines	A Nk	NE	**Before construction:** Transmission lines need to be extended to the planned line, and land acquisition and involuntary resettlement may occur. Route of the new transmission lines is not decided, and impacts on protected areas are not confirmed yet. Although migratory routes of birds are not reported, it is necessary to conduct a survey when the route is planned.	There are no works and activities which may cause negative impacts on surrounding environments.

A: Adverse impact is expected. B: Beneficial impact is expected. NE: Impact is not expected. Nk: Impact is not known yet.

Table 12.1.2-4 Preliminary Scoping for Varandh Ghat site

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Varandh Ghat site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
Pollution	1	Air pollution	A	NE	Pollutants from construction machines and heavy transportation vehicles, dust from the earth works are expected. Air pollution (dust) is expected at quarry site.	There are no works and activities which may cause air pollution.
	2	Water pollution	A	A	The turbidity of river during the rainy season is expected. Cleaning water for machines and vehicles, drainage water with soil and sewage from construction site and camp are expected.	The water levels of the reservoirs change every day because of its operation pattern of a pumped storage power station, and it is expected that the reservoirs do not eutrophicate so much. It is thought that the level of water contamination in the downstream area is limited during the rainy season if any. Since the sludge in the bottom of the reservoirs are not released to the downstream, water pollution in the downstream area is not expected.
	3	Waste	A	A	Industrial solid wastes and domestic wastes (camp) are expected.	Industrial solid wastes and domestic wastes (management quarter) are expected.
	4	Soil pollution	A	NE	Oil and other chemicals from construction machines and vehicles may contaminate soil.	There are no works and activities which may contaminate soil.
	5	Noise / vibration	A	NE	Noise and vibration from construction machines / vehicles, and blasting works are expected. Blasting works are also expected at quarry site.	Turbines are the main source of the noise and vibration. They are located underground and no negative impact is expected.
	6	Ground subsidence	NE	NE	There are no works and activities which may cause ground subsidence. Geological formation is solid and it is not expected any ground subsidence.	Geological formation is solid and it is not expected any ground subsidence.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Varandh Ghat site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
	7	Offensive odors	NE	NE	There are no works and activities which may produce offensive odors.	There are no works and activities which may produce offensive odors.
	8	Bottom sediments	NE	NE	There are no works and activities which may cause contamination of bottom sediments.	There are no works and activities which may cause contamination of bottom sediments.
Natural environment	9	Protected areas	NE	NE	There are not National Parks, Wildlife Sanctuaries, Biosphere Reserves and World Natural Heritage Sites in and around the site.	There are no works and activities which may cause negative impacts on protected areas.
	10	Ecosystems	NE A Nk	NE A Nk	The project site is not within Important Bird Areas. The Taluka − Mahad - where the lower dam and reservoir are located is recommended as ESZ 1 by WGEEP. Regarding their recommended regulations within ESZ 1, refer to Table 7.3.2-1 and 7.3.2-2. The existing reserved forests are not directly affected by the project including tunnel works. Since the project sites are located in Western Ghats (a biodiversity hot spot), there is a possibility that endemic and endangered species of fauna and flora (including aquatic species such as fish) may occur in and around the project area There is also a possibility that there are migratory path / route of terrestrial animals and birds. It is necessary to conduct a detailed survey on fauna and flora, and to confirm the scale and nature of impacts. Since both dams are located at the upstream of the rivers, impacts on anadromous fishes are	There are no works and activities which may cause negative impacts on the ecosystem. Only first infilling to the reservoir is necessary, and after the first filling, the water overflows to the downstream during the rainy season. It is therefore expected that negative impact is limited. Since both dams are located at the upstream of the rivers, impacts on anadromous fishes are limited if any. There may be negative impacts caused by alien species. Impacts caused by domestic animals including cats and dogs, and poaching are unknown.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Varandh Ghat site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					limited if any. Since the downstream of the upper dam is a reservoir of other dam, it is expected that negative impacts on ecosystem are limited. There is neither Ramsar site nor other important wetlands in the Savitri River basin (the downstream of the lower dam and reservoir). There may be negative impacts caused by alien species Impacts caused by domestic animals including cats and dogs, and poaching are unknown. It is expected there is no impact on vegetation cover by tunnel construction works. Since geological formation is mainly of basaltic lava flow, there is no fossil of fauna and flora.	
	11	Hydrology	A	A	If the tunnels go through aquifers, ground water level may come down.	Ground water level may change because of the reservoir at each site.
	12	Geology / geography	A	NE A	If the dam construction works requires huge amount of aggregates, negative impacts on geographical features at quarry are expected. Risk of earthquakes is moderately high (refer to 9.2 Landform and Geology).	There are no works and activities which may cause negative impacts on geology / geography. The catchment area does not produce lots of earth and sand because of its geological formation. It is therefore expected that impact on downstream riverbed caused by sedimentation in the reservoir is limited.
Social	13	Involuntary	A	NE	**Before construction:**	There are no works and activities which cause

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Varandh Ghat site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
environment		resettlement	Nk		In the upper and lower reservoirs' sites, it seems that there is no residential house in the sites. The sites are mainly used for agricultural practices. However, since some people may lose their main source of their livelihood, it is required to conduct a survey on social environment to confirm the scale and nature of impacts. Although routes and site of access roads and quarry are planned to avoid resettlement as much as possible, they may cause resettlements. Although there is low possibility of squatters in the area and it is expected no impact on them, a detailed survey on social environment is required to confirm their existence and impacts if any. **Construction stage:** There are no works and activities which may cause resettlement.	resettlement.
	14	Poor people	Nk	B	**Before construction:** Since there may be poor people within the PAPs, a detailed survey on social environment is required to confirm their existence and the scale and nature of impacts if any.	The poor people may obtain more opportunities to access to social services and markets because of the new access road.
	15	Indigenous or ethnic minority	Nk	NE	It is required to conduct a survey on social environment to confirm the existence of indigenous and ethnic minorities in the area and the scale and nature of impacts if any.	There are no works and activities which may cause negative impacts on indigenous and ethnic minorities, even if there are these people in the area.
	16	Local economies, such as employment,	A B	B	**Before construction:** There are changes in the local economies because of resettlement.	There are beneficial impacts on the local economies because of employment of unskilled labors and procurement of minor materials.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Varandh Ghat site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
		livelihood			**Construction stage:** There are beneficial impacts on the local economies because of employment of unskilled labors and procurement of minor materials.	
	17	Land use and utilization of local resources	A	NE Nk	**Before construction:** There are changes in the land use and utilization of local resources because of resettlement. There is no mining concession in the area.	Since water flow during the rainy season does not change a lot, impacts are limited if any. It may become difficult for the local people to harvest non-timber forest products such as fire woods and medicinal plants.
	18	Water usage	A NE	Nk	If there are water utilization activities in the downstream area, muddy waters during the rainy season may cause impacts in the downstream. However, it is necessary to conduct a survey to confirm the scale and nature of impacts in the downstream area. Regarding the interstate water utilization right, it is recognized that there is no issue based on the results of KWDT I.	Upper reservoir: Although there is another reservoir just downstream of the upper reservoir, the catchment area of the upper reservoir is small and it is expected that impact is limited if any. Lower reservoir: Only first infilling to the reservoir is necessary, and after the first filling, the water overflows to the downstream during the rainy season. It is therefore expected that impact is limited if any.
	19	Existing social infrastructures and services	A	NE	There is a possibility that roads and bridges maybe damaged because of heavy transportation vehicles. Traffic jams and accidents are expected. It is necessary to conduct a social survey to confirm the scale and nature of impacts on schools and hospitals.	There are no works and activities which may cause impacts on the existing social infrastructures and services.
	20	Social	A	NE	There are impacts on the social institutions	There are no works and activities which may

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Varandh Ghat site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
		institutions such as social infrastructure and local decision making institutions			because of resettlement.	cause impacts on the social institutions.
	21	Uneven distribution of benefits and damages	A	NE	**Before construction:** Uneven distribution of benefits and damages may happen among the PAPs. **Construction stage:** Without appropriate and acceptable guidelines of employment qualification and procurement of minor materials, it may give unfair impression to the local people and may cause social conflict among them.	There are no works and activities which may cause uneven distribution of benefits and damages.
	22	Local conflicts of interest	A	NE	**Before construction:** Because of resettlement, social conflict may happen among the PAPs. **Construction stage:** Without appropriate and acceptable guidelines of employment qualification and procurement of minor materials, it may give unfair impression to the local people and may cause social conflict among them.	There are no works and activities which may cause local conflicts of interest.
	23	Cultural heritages	NE	NE	There is neither World Cultural Heritage Site nor other cultural heritage in and around the project site. Although there is a famous religious cave in Shivathar Ghat near the lower reservoir site	There are no works and activities which may cause negative impacts on cultural or religious heritages.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Varandh Ghat site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					(upstream area), it is not affected by the project.	
	24	Landscape	A	A	There is a change in the landscape because of dam and reservoir construction.	There are no works and activities which may cause negative impacts on landscape.
	25	Gender	Nk	Nk	Although it is not expected negative impacts on gender issues, it is required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.	Although it is not expected negative impacts on gender issues, it is required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.
	26	Children's rights	Nk	Nk	It is not expected negative impacts on children's rights gender issues. For example, child labor is prohibited by an act. It is, however, required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.	Although it is not expected negative impacts on children's rights gender issues, it is required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.
	27	Infectious diseases such as HIV/AIDS	A	A	Infectious diseases may be spread because of the inflow of labor from outside.	Water-borne and / or mosquito-borne diseases may occur but the impacts are expected to be limited.
	28	Labor conditions	A	NE	It is necessary to give sufficient consideration to labor conditions of construct workers.	There are no works and activities which may cause negative impacts on labor conditions.
Others	29	Accidents	A	A	It is necessary to give sufficient consideration to accidents during the construction works.	Traffic accidents may increase because of new access road.
	30	Trans-boundary impacts / global warming	NE A	B A	No trans-boundary impacts are expected. CO_2 is released because of tree felling in the reservoir area and it gives negative impact on global warming, but the impact is limited.	The project contributes reduction of CO_2 emissions from other power generation development. Greenhouse gases are released from the reservoirs, but limited.
	31	Transmission lines	A Nk	NE	**Before construction:** Transmission lines need to be extended to the planned line, and land acquisition and involuntary resettlement may occur. Route of the new transmission lines is not decided, and impacts on protected areas are not	There are no works and activities which may cause negative impacts on surrounding environments.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation for Varandh Ghat site	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					confirmed yet. Although migratory routes of birds are not reported, it is necessary to conduct a survey when the route is planned.	

A: Adverse impact is expected. B: Beneficial impact is expected. NE: Impact is not expected. Nk: Impact is not known yet.

12.2 Conclusions and Recommendations

12.2.1 Natural Environment

All project sites do not overlap or are not within the protected areas of India (e.g. National Parks, Wildlife Sanctuaries and Biosphere Reserves), World Natural Heritage Sites, and other internationally recognized biologically important sites (e.g. Important Bird Areas). There is neither Ramsar site nor other important wetlands in the Savitri River basin (the downstream of the lower dams and reservoirs).

The WGEEP recommends Mahad Taluka (Varandh Ghat lower site) as ESZ 1, and Mangaon Taluka (Panshet and Warasgaon lower sites) as ESZ 3 in their report. According to their recommendations, the construction of a large dam is not allowed in ESZ 1, and it is allowed in ESZ 3 subject to strict environmental regulations (refer to Table 7.3.2-1). Velhe (Panshet and Varandh Gaht upper sites) and Mulshi (Watasgaon upper site) Talukas are not identified as Talkas which are assigned to ESZs.

It is not clear how the Government of India uses the WGEEP report and its recommendations in the future based on the feedbacks from the stakeholders. However all sites are within the Western Ghats – an internationally recognized Biodiversity Hot Spot, it is likely that MOEF requires the implementation of strict EIA study whichever site is selected in the future. It will be required to implement detailed survey on fauna and flora and ecosystems in and around the project sites (both upper and lower sites) when one of the recommended sites is selected.

12.2.2 Social Environment

Regarding resettlement, at the Warasgaon lower site, a village (population: 1,000 - 1,200) may needs to be resettled and significant negative impacts are expected. At the Panshet upper site, small scale resettlement is expected (exact number of PAPs are subject to further survey).

At other sites, it seems that there are no residential houses in the sites and direct impacts are not expected. However, since these sites are mainly agricultural lands, some people may depend on their main sources of livelihood from the products of the lands. In this case, rehabilitation and resettlement exercise is required (it may also have to include the Panshet upper site).

The State of Maharashtra has its own R&R act and has been implementing R&R for many PAPs. However, since the Government of India submitted Draft National Land Acquisition and R&R Bill in 2011, the situation of land acquisition and R&R is particularly fluid. It is recommended to carefully observe the development of the situation.

Chapter 13

Operator of Pumped Storage Hydropower Scheme

Chapter 13 Operator of Pumped Storage Hydropower Scheme

13.1 Operation by Mahagenco

GOMWRD is the entity responsible and entrusted in the planning, design and development of hydropower schemes in Maharashtra state. After the completion and commencement of operation, the project is normally leased to Mahagenco, which is the entrusted entity in charge of commercial operation and maintenance. The ownership of the plant usually remains on the GOM.

GOMWRD has been playing the core roles since the former entity GOMID (Government of Maharashtra, Irrigation Department) in materializing various hydropower projects into the stream line, also has been engaged in the foreign doners' funded projects like Ghadghar PSPP (2*125MW, Japanese ODA), Paithon PSPP (1*12MW, Japanese ODA), Ujjani PSPP (1*12MW, Japanese ODA) or Koyna IV hydropower system (4*250MW, World Bank) etc. In order to proceed the project, the funding is essential issue. Considering the required cost, the soft loans bearing low interest ratios such as ODA are the recommended option to utilize. From this perspective too, GOMWRD is the best qualified entity in the project having sufficient experiences in ODA utilization that it has plenty capabilities and experiences in technical issues as wells as administrative management issues involved. It is also advised, reflecting the increase of the need on adjustable speed pumped storage power system in to the grid, for GOMWRD to take leading role in the development work assisted by a consultant company who experiences in both construction and operation of adjustable speed pumped storage system.

Mahagenco, as the state owned power generating company operates around a half of power output in Maharashtra state (namely 7 coal thermal powers plants, 2 gas thermal power plants, 12 hydropower plants (except small hydro)). It operates Ghadghar PSPP with a constant condition contributing as the peaking power source in Maharashtra. The financial condition of the company shows the stable commercial sales and profitability, with slight lower ratio than expected for the present CPI or interest ratio. The accumulation of the debt asset inevitably stocked by the outcome of recent acceleration of the power plants constructions needs to be watched closely from the financial accounting views.

Generally speaking, not only the security of construction cost but the security of pumping energy is essential for a company to develop and operate PSPPs. From such observations the role taken by Maharashtra state – the GOMWRD in charge of development including funding to the construction, the Mahagenco in charge of operation using its base load thermal powers as the pumping energy, is a realistic effective choice.

The outcome of the 11th power generation plan and the draft 12th power generation plan indicate that Maharashtra state intentionally or inevitably heavily focuses on the base load coal thermal power projects only. Nonetheless the private projects are apparently increasing in numbers. The private plants have a strong inclination to generate as much power as possible with high PLF and with maximum output so as to pursuit the maximum benefit. Therefore, it is not advisable for them to be in

consultation and offering of ancillary service but advisable for a state owned company like Mahagenco to take a part in such business including the services of load demand control and frequency adjustment function.

13.2 Issues on Mahadiscom

A state company Mahagenco, as a principle, sells 100% power to a state distributor Mahadiscom.

Naturally, Mahagenco always bears the risks of payment by Mahadiscom (on the contrary a private vehicle is authorized to sell 40% power to market if it likes from hydro powers of its owned).

So far Mahadiscom is managed without a significant unpayment issues. But as is the case in other states it is being operated constantly financially deficit condition historically, so unless problems causing such structural deficit is overcome, anytime payment risk maybe materialized.

For this, a recent incident is noted that Multi Year Tariff regulation 2011 once authorized by MERC had been planned to effect from April 2011. But on the opposition by Mahadiscom MERC accepted it and postponed the introduction of the regulation until April 2013. In the meantime the tariff regulation 2005 still has its effect that Mahagenco's expected return of operation from PPA remains ROE 14% instead of new schemes's ROE 15.5%.

Since the fixed debt of Mahagenco has currently been increasing, it is of vital importance for Mahagenco to keep the authorized PPA renewals revised in no time delays thus maintaining its financial health unaffected.

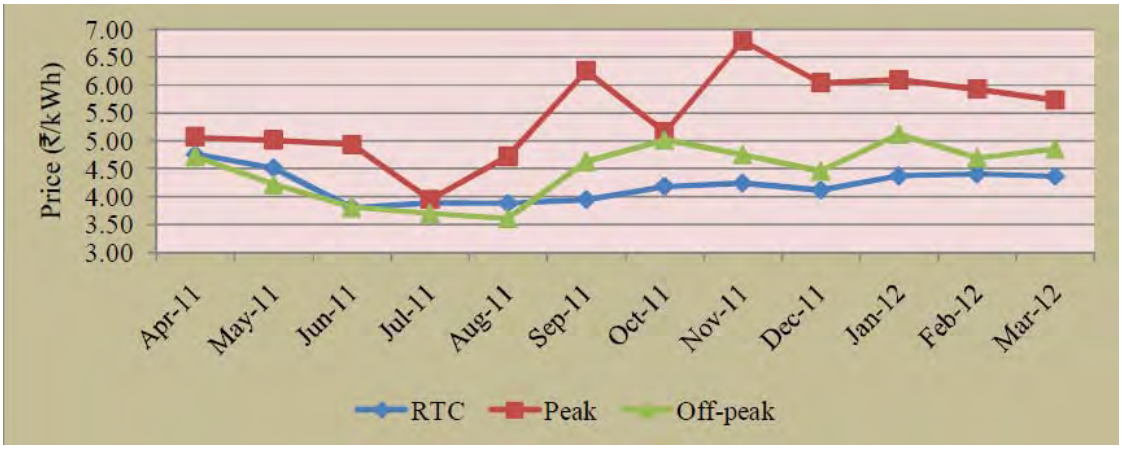
Further, it is essential to recover the financial conditions of Mahadiscom. They know the revision of distribution tariffs with surplus over the PPA purchase cost is fundamental solution. However it is also known for a political incentive are lain in all states to keep the tariff low on the agricultural category, with revision not to be easily made historically. There are enough reason not to change it so soon.

Yet MERC recently authorized the revision of its power tariff except in Mumbai by 5 – 11% above (average 6.9%) from August 2012. There may lie a hope compared to other states.

13.3 Power Trade Market

It must be admitted that the power shortage in the Maharashtra state is the severest among all states in India with 20% deficit. It necessitates urgent installation of base load power plants. The requirement of peak power installation is also high as the Ghadghar PSPP operated with a very high PLF of 6 hours daily (on week days operation basis).

The Figure 13.3-1 shows the recent price of power traded through the Traders in short term market.



（Source: Report on Short-term Power Market in India: 2011-12, July,2012, CERC）

Figure 13.3-1 Price of Electricity through Traders in Short Term Market

The power trading in the market has commenced in India for some years now and it is recognized the price of peak time power is traded with “premium value” compared to that of off-peak time. But, looking at the price history, it is noted the premium remains as much as 1 -2 Rupee/kWh, except in the startup time of the market. This is partly because the scale of the power market has grown as much as 11% of the total power transaction yet and most of the transaction still links itself to LT (Long Term) bilateral transaction. Also it is suggested that major buyers (those are state distributing companies) hate to purchase high priced peak power from the market and tend to take “load shedding” methodology. This is to avoid worsening the financial deficit.

PTC India recently commented to JICA study team that no companies so far have traded their power from PSPP in the short term market (personal communication, July 2012).

However, the future power trend must be projected. The peak demand no doubt steepens. The peaking power will be purchased for its full capacity in the future and transaction in the trade market may become the effective choice for selling and purchase. With reasonable price it gives the opportunity to private players to take part in market to sell peaking power, from their own PSPPs, by developing and investing themselves.

It is risky from the present market circumstances though to have 100% PSPP by private investors, attaining the full economic operation of PSPP (ie.purchase cheap power for pumping and generate to sell it in higher priced market for profit). The more realistic scheme by a private company to have PSPP is “captive operation” like Tata Power. (Bhira PSPP is to generate power to its own factory consumer, by purchasing pumping energy from it own thermal power).

In the future JV scheme (JV of a state company and private company) to own and operate PSPP when a reasonable peaking power price is made in the market, and traded with sufficient volume at steady condition, with growth of power trade market. At such occasion the participants have to get the conclusive ideas for priority how they pursue the profits focusing selling at high price market as “private company”, and their obligation as “state company” providing power for grid frequency

adjustment and stable grid maintenance. The regulatory authorization may be required by ERC or LDC.

13.4 Project Implementation Plan

Table 13.4-1 shows project implementation Plan, which is as per conventional "Bill of Quantities" basis. Content of each item is as described below.

Table 13.4-1 Project Implementation Plan

	2012		2013				2014				2015				2016				2017				2018				···	2024			
	1	2	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		1	2	3	4
Investigation																															
Feasibility Study																															
EIA																															
Project Funding																															
Selection of Consultants																															
Detailed Design & Tendor Document																															
Tendor Negociation																															
Construction																															

(1) Investigation

As mentioned in the sub-chapter 10.7, further investigations are to be executed. Many of those are to be executed before and/or during the feasibility study and the results are to be reflected to the feasibility study. Investigations are to be continued before the detailed design. It is desirable that topographic map more than 1/5,000 is prepared before the feasibility study at least.

(2) Feasibility Study & EIA

The feasibility study is expected to take 18 months, which is commenced at the beginning of FY 2013. EIA is also expected to take 1 year for actual survey and 6 months for obtaining required permission such as EC, FC and so on.

(3) Project Funding

In case that Japanese ODA Loan is applied, being parallel to activities for obtaining EIA permission, negotiation with JICA is to be conducted, which is expected to take 6 months. After the negotiation is finished, the loan agreement is to be made.

(4) Selection of Consultants

After the loan agreement is made, consultants, who conduct the detailed design, preparation of tender documents and so on, are to be selected by the project implementation organization. It is

expected that the procedure of consultants' selection takes 6 months. Engineering service, such as detailed design and preparation of tender documents provided by selected consultants is covered by the ODA loan.

(5) Detailed Design and Tender Documents

It is expected that the detailed design and preparation of tender documents takes 27 months.

(6) Tender Negotiation

The tender negotiation, herein, includes the submission, the evaluation, and the negotiation, which is expected to take 12 month. The tender is conducted by lot by lot basis in series, such as preparation works, civil works, hydro-mechanical works, electro-mechanical works, power cable works, and transmission line works, and so on.

(7) Construction

As mentioned in the sub-chapter 10.4, the construction works is expected to take 6 years.

13.5 Adjustable Speed Pumped Storage Power System

Since the economic development in Maharashtra state is very rapid, the necessity of the high response speed power generation such as spinning reserve will increase as like old Japan.

Therefore, against the frequency fractuation and increasing power demand, the character of an adjustable speed pumped storage power system will be expected more important.

An adjustable speed pumped storage power system needs large space due to installing the winding type rotor, converter system and so on. Because of that reason, it is difficult to install that system as a renewal of conventional plant.

In considering a construction of a pumped storage power plant, it is important to consider the possibility and necessity of an adjustable speed pumped storage power system from many and long-term points of view, i.e. the network system, the network condition, peak power supply, network stability, maintain frequency and so on.

For the economic development, the high quality electric power, stable voltage and frequency, is necessary as well as stable power supply.

Especially, the quality of frequency is essential for the manufacturing equipment to work adequately.

In addition, an adjustable speed pumped storage power system has an excellent characteristics from the increasing output (kW, kWH), such as expansion of dam effective depth, turbine efficiency

increase.

At the present moment, the operation ratio of Ghatghar PSP is going well. Therefore, the possibility of an adjustable speed pumped storage power system is worthwhile to consider.

In India, Tehri Hydro Development Corporation proceeds an adjustable speed pumped storage power project (1,000MW).

Thus, the technology of an adjustable speed pumped storage power system also should be considered at this moment in Maharashtra state.

The merit of an adoption of that system seems to promise sufficiently.

Recently, R.P.O (Renewable Purchase Obligation) was determined in Maharashtra state. According to the annual report of MNRE (Government of India Ministry of New and Renewable Energy), it aims 1% increase every year from 6% of 2010-11, and finally achieve 9% at 2013-14. (Table 13.5-1)

Maharashtra state aims the positive implementation of renewable energy, it seems that the function of the adjustable pumped storage power generation will be more valuable for the stability of India network in the future.

Table 13.5-1 R.P.O (Renewable Purchase Obligation) in India

	State	RPO
1	Andhra Pradesh	5.0%
2	Haryana	09-10 _10%
3	Karnataka	7% - 10% Captive & Open Access_5%
4	West Bengal	10-11-2.00%, 11-12-3.00%, 12-13-4.00%
5	Madhya Pradesh	10-11-0.80%, 11-12-2.50%, 12-13-4.00% 13-14-5.50%, 14-15-7.00%
6	**Maharashtra**	**10-11-6.00%, 11-12-7.00%, 12-13-8.00%** **13-14-9.00%, 14-15-9.00%,15-16-9.00%**
7	Rajasthan	
8	Tamil Nadu	9.00%
9	Gujarat	10-11-5.00%, 11-12-6.00%, 12-13-7.00%
10	Kerala	3.00% from 2010 with annual increase of 10% of 3% per year upto a max. RPO of 10%
11	Punjab	08-09-6.25%, 09-10-7.45%, 10-11-8.50% 11-12-9.50%
12	Odisha	

(Source: MNRE WEB）

Chapter 14

Conclusion

Chapter 14 Conclusion

14.1 Power Scenario of Maharashtra State

At present India, and Maharashtra state as well, are in the situation causing frequent routine load shedding from the shortage of power supply. Thus both are requesting more power for base supply than the powers in demand supply control or the powers with frequency adjustment function (Volume of Power has priority to the Quality of Power).

The planned outage (load shedding) for long hours has already begun in Maharashtra state due to the power shortage. So far Mumbai enjoys privileges being exception. The damage to state economy is large if Mumbai be forced to face sudden frequent “blackouts”. Mumbai area has gathered nearly one third of FDIs (Foreign Direct Investments), and a number of companies in automotive industry put its base on Maharashtra state (100s of SEZ sites have been registered and some 200 Japanese companies in the state, which is outstanding in India).

Here and after from now it is certain that Mumbai area with Maharashtra state as well will escalate their power demand without stagnation, that the needs on the quality of power is being put more emphasis, thus that the capability of power source for demand supply control with frequency adjustment function is cast a spotlight.

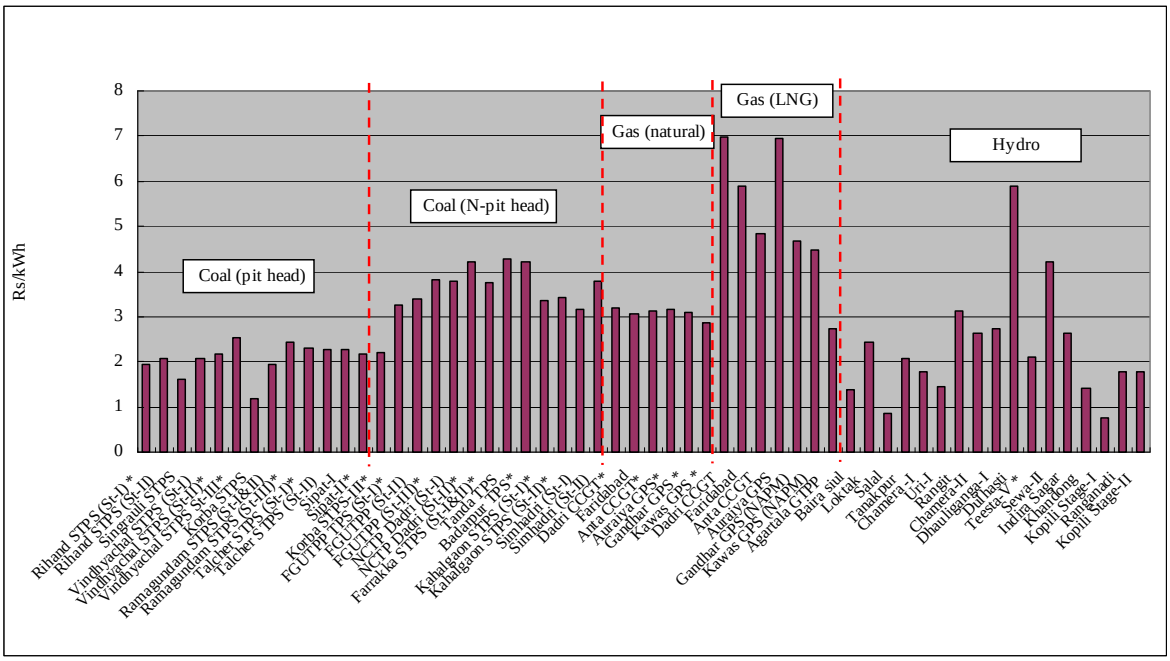
In short, Maharashtra state will in the near future needs

1) Base load power source for power shortage
2) Peaking power source for meeting steeping peak power
3) Power source supplying frequency adjustment functions

The present Indian power generation plan focuses on further introduction of coal thermal power plants, not to mention to Maharashtra state itself. At the same time with uncertainty of coal supply alternative fuel source (hydro, gas, nuclear, or renewable energy) is encouraged by central and state government.

The state Maharashtra is rich in wind power resource (the 3rd largest power capacity at present with 260 MW and 5,273MW is on the track). The wind power in its nature is unstable source for grid stabilization. This size of wind power utilization needs the equivalent size of spinning reserve of power to keep necessary frequency adjustment.

Regarding peaking power, gas thermal power plant and pumped storage power system can be athe promising candidates. In case of gas thermal power plant, the cost of fuel is one of the uncontrollable risk factors that must be taken care of. The reference of gas thermal power cost is shown in the figure below. It shows the LT (long term) price of power trade market.



(Source: Report on Short-term Power Market in India: 2011-12, CERC, 2012/3)

Figure 14.1-1 Long Term contract price by the power sources

It is highly likely that the gas procurement price goes high by LNG market unless cheaper domestic gas supplies meet sufficient demands. In this sense, PSPP system has its competitiveness and advantage in Maharashtra state.

Moreover, adjustable speed pumped storage power system has further advantages as more and more renewable sources of energy are promised to enter into the power grid. Such power requires the spinning reserve as well that adjustable speed pumped storage power system offers effective load and control and frequency adjustment function during low demand hours in nighttime.

14.2 Recommendation to Maharashtra State government

So far GOMWRD (Water Resource Dept., Government of Maharashtra) has expressed and confirmed the plan to proceed the site surveys in all three promising sites. GOMWRD got an approval to go forward in 1 site (Varandh Ghad) on August 2012 by the GOM (Government of Maharashtra). GOMWRD plans to conduct surveys after the 2 remaining sites (Panshet and Warasgaon) are approved.

GOMWRD also considers commencing the study on replacement of Koyna Hydro Power System (I&II) including the utilization of PSPP. GOMWRD wishes to apply to JICA study scheme. The study is still in its early stage of conceptual design that no concrete direction are determined. If PSPP is selected then earlier development may be probable as it uses the existing reservoirs for both new upper and lower reservoir than those 3 candidate sites.

GOMWRD has its own engineers and staffs in planning, designing and developing irrigation systems and hydropower systems. As the budget of WRD as well as other departments has its certain limit, the hydropower projects such as PSPP needs to introduce other private investment fund, Indian governmental fund such as PFC, or ODA soft loan like JICA.

It is considered realistic to utilize ODA soft loan as PSPP project cannot afford sufficient return for the time being requested by private funds, with taking into account of the discrepancy of peak power price and off peak power price traded at the present market.

In order to apply for the ODA loan like Japanese ODA loan, it is required to follow the prefixed procedure of 1) taking the approval of state government, 2) applying to Central government route (CEA, Planning Commission), and 3) having it approved by the Central government.

Also concrete procedure includes the site survey, followed by DPR (Detailed Project Report), EC (Environmental Clearance), FC (Forest Clearance) and TEC (Techno Economic Clearance). It is advised to include consultant from earlier stage experienced in introducing and operating adjustable speed pumped storage power systems in Japan like J-POWER, as such system is necessary in the system.

Environmental Impact Assessment Study must be carried out by expertise of neutrality in transparent and reliable manner.

14.3 Recommendation to Central Government

The large scale grid failures “The Great Indian Outage” on the whole India (3 grid outages out of 5) occurred on 30th and 31st July, 2012, were considered due to the over drawl by the northern states utilities from power line, initiating heavy power flow in the line, resulting in the cascade frequency drops, power shutdown, thus successive grid collapses (the preliminary report from the expert committee, 16th Aug., 2012).. Indian continent geographically consists of wide in East-West wise and North-South wise land areas spotting fuel sources as coals very locally, with inevitably necessitating very long distant transmission lines connecting power supply regions and power consuming regions. Such circumstances make the steady and stable grid discipline and operation vital important.

In order for this purpose, for India being away from the outages of power plants from frequency drops, it is worth to note that the value of having adjustable speed pumped storage hydropower system increases for its merit and importance of frequency adjustment capability in lowest load demand hours, as well as of its demand supply control capability by initiating or stopping pumping mode or generation mode in real time for the load requirement thus eliminating excessive power flow on power lines.

The large scale blackout this time, the emergence of the unavailability of the minimum power infrastructure, is one of the biggest hurdles for FDI into Indian economy. There is no doubt that it

should be critical for India to provide such power infrastructure for preparing and meeting its economic growth.

In the 12th National Electricity Plan (2012 - 2017), Indian government has determined and announced to encourage such power sources as hydropower and renewable energy other than coal thermal powers (admitting and recognizing which are mentioned as the ever more required sources), since it is well aware the ever increasing scarcity of coal supply sources. The lack of, and the difficulty of securing fuel coal is the consensus among all parties involved. It has become very much obvious hardly any more coal is secured for new projects, even procurement of import coals are harder than ever like from Indonesian coals (both purchased and invested coals). Furthermore recently the domestic natural gas is getting harder and harder for new gas power projects to secure.

We admit understand the present outline that government prioritizes the coal thermal power projects. However, we also suggest that India pay attention to the necessity for preparing the certain amount of "Peaking Power Sources", in the recognition that the peak shortage already becomes sharpener year on year in the scope of the urbanization of Indian states. For the prospective sources of such peaking powers, it is encouraged to consider the potential competitive sources like such Pumped Storage Hydropower sites in Maharashtra which have sufficient MW potentials from geographical background as well as cost advantages compared against gas thermal powers. In this meaning, Indian government is recommended to take necessary steps to make use of these sources as much as possible for the energy conservation and security.

The Economic Benefit of the Pumped Storage Hydropower Projects in this study (EIRR) is proven to have much larger advantages than that of comparative gas thermal power projects. In other words, it is concluded all the projects herein mentioned in this study are "superior" candidate sites which can restrain the generation costs.

At the same time, at the present financial conditions of the state still being in the budget deficit, it is not encouraged for proceeding the projects by solely depending on the State's own budget or by solely the promotion of the private funds or capital markets, although the certain obligation is required. By contrast, it can provide the global benefits when it utilizes such soft loans as Japanese Yen Loans such as with low interest 1.4%, grace period of 10 years or repayment period of 30 years.

We well acknowledge the "financial principle" of Indian government on each state must be appreciated and that "a certain external debt sustainability" of each state should be kept in principle. The Utilization of private funds must be promoted for the healthy growths of each state economy. However, it is also a great concern such principle might slow down the urgent provision of electric power infrastructures by escalating the poor financial situations of state power industries, and it may be a practical method to make full use of ODA, Japanese Yen Loans as they have effective reductions or moratorium on interest payment functions.

The former existing "Master Plan Study on Pumped Power Storage Hydroelectric `Power

Development in Maharashtra State (Mar., 1998)" did choose the promising sites without eliminating the Reserved Forests so that the relevant governmental divisions since then might have been taking the misguided ideas that "Environmental hurdles on Maharashtra for Pumped Storage Power Projects are very high". However the truth is, in the present study, as many as 3 (three) promising sites have been selected out of even outside of the Reserved Forest areas. The conclusion is that the development of Pumped Storage Power Projects is quite possible with the adequate consideration on the environment.

The growth of the renewable sources of power is highly inevitable and also indispensable for Indian power sector's future. Such powers are in nature unstable sources of generation, and require at the same time the stabilizing function of load and grid frequency. The Adjustable Speed Pumped Storage Power System is recommended to introduce at the earlier stages of National and State Electricity Plan. Such technology is Japanese industries' and consultants' home fields of expertise. It is also advisable to consider Tied Loans (such as STEP (Special Terms for Economic Partnership)) of Japan at earlier stage of project formulation.

It is necessary, upon the application by the Maharashtra Government for Japanese Yen Loan, for Indian Government to enlist this Pumped Storage Power Project on the "Long List" so as for the dialogues between the two countries can be initiated.

14.4 Specific issues for consideration

The PSPP project must be pursuit by Maharashtra state as it specifically will need the peaking power sources soon as well as power sources with frequency adjustment capability.

The three sites selected by the study team are feasible although preliminary in technically, economically and environmental and social perspectives. It is prudent to propose the system can contribute to the grid stability as well as a source of valuable peaking power.

The value of PSPP largely depends on the coming power demand and supply balance, so further constant collection and evaluation of the state (and the western regional) power data. The progressed study in phased manner is recommended.

The issues to be studied are:

14.4.1 Issues on Power Sector

- Projection of power demand supply
- Projection of sharpening peaking power demand
- Trend of base thermal power development (especially coal thermal power, with its PPA price)
- Development of competitive alternative source of peaking power, ie. Gas thermal power trend,

with its PPA or market price)

- Development of renewable energy sources (wind, solar) including enhancement of its incentives.
- Trend of power trade market with its price movement

14.4.2 Issues on Survey, Design, Construction

- Conduction of the next stage pre-FS Study at the sites
- Topographical survey (to acquire accurate finer scaled map for study)
- Confirmation of geological issues (Although preliminary observation indicates good geological conditions, it is advisable to conduct survey including drillings to confirm there is no such issues affecting project economy, with surface surveys for possible dam construction materials)

14.4.3 Issues on Environmental and Social Aspects

- Integration (conformity) with JICA "Guidelines for Environmental and Social Considerations". When the projects are progressed by JICA's funding, it is necessary for EIA to satisfy not only Prior Environmental Clearance – Notification, 2006) but also the JICA's guideline. Among all, the following 2 aspects shall be taken care of:
  - Conformity of the project schedule with JICA's work. Preparation of scoping and TOR of EIA within certain (60) days by MOEF shall allow the JICA entrusted Preparatory Study performed.
  - Stakeholders' meeting. EC Notification requires 1 stakeholders' meeting at the time of draft EIA report. JICA's guideline provides 2 meetings for consultation at the preparation of scoping of EIA and at the time of draft EIA report.
- The Western Ghats Ecology Expert Panel (WGEEP). The fact that taluka (Mahad) where Varandh Ghat lower reservoir locates is assigned to ESZ1, and that taluka (Mangaon) Panshet and Warasgaon lower reservoirs locate is assigned to ESZ3, requires attentions.
- The latest Village maps must be obtained to confirm the distribution of the reserved forests around the project sites.
- Approval of Draft National Land Acquisition and Rehabilitation & Resettlement Bill, 2011. It is necessary to pay attentions to how the existing laws coordinate themselves to the new law (especially the Maharashtra Project Affected Persons Rehabilitation Act, 1999) and how the compensation to the livelihood losers (non-land owners) are revised.
- The outcome of KWTD II. The Tribunal may allow the extra water utilization to the Maharashtra government.

14.4.4 Issues on Financial Aspects

- Estimation of economical advantages from the PSPP. This should be done from time to time in accordance with the status of power sector to find the values of the project. It is worth mention that the economic value and monetary worth of the realized merits of adjustable speed pumped storage power system must be evaluated, as these have not been made yet in cash terms.
- The close observation on how the peaking power is being, and will be valued in power trade market, PPA terms, and in the regulatory schemes identified by SERC. Such values must be reflected into the financial evaluation in phased manners.

14.4.5 Issues on Surrounding Environment

- Movement of coal thermal power projects and coal procurement. The 12th power development plan in India assumes or necessitates 800 – 900 Mtpa of coal to be secured at 2016/17 timing and being discussed as problematic in the report. The actual progress of coal thermal plant developments in 12th plan influence the motives on development of peaking power, thus the project schedule shall be arranged in line with such movement.
- Full dissemination of the values of adjustable speed pumped storage power system to those governmental sections in charge.

14.5 Replacement of Koyna Hydro Power System

Koyna Hydropower System is located in the upperstream of Koyna river, which is one of the main branches of Krishna river. The total output capacity ranks 1,920MW or more is being the core of hydropower in Maharashtra state. The system now generates peaking power to the whole grid. Table 14.5-1 shows the features of the whole system.

Table 14.5-1 Features of the Koyna Hydropower System

	Power House (Stage)	Type	Reservoir	Head (m)	Downstream	Output (MW)	Commissioning
①	Koyna PH I& II	Underground (U/G)	Koyna	475-490	Arabian Sea	4*65+4*75	1963
②	Koyna PH III	Underground (U/G)	Kolkewadi	110	Arabian Sea	4*80	1976
③	Koyna PH IV	Underground (U/G)	Koyna	496	Arabian Sea	4*250	1999
④	Koyna DPH	Damfoot	Koyna	80	Indian Sea	2*20	1980
⑤	Koyna DPH II	Underground (U/G)	Koyna	110	Indian Sea	4*40	(planning)

Koyna I & II, Koyna III, Koyna DPH, Koyna IV have been in line. As Koyna I&II were nearly over 50 years in operation, it is necessary sooner or later to be rehabilitated or replaced. The GOMWRD considers replacement as the viable option, and also indicates the installation of PSPP as a further alternative. This option has a lesser environmental impact as it uses Koyna and Kolkewadi reservoirs

as the upper and lower reservoir, thus restricts the project cost, making the option competitive.

Furthermore, the water utilization right allotted to Maharashtra government from the Koyna river allows 67.5TMC (thousand mil. cubic meter). According to GOMWRD it is probable to have the volume increased in further 20TMC. If this is realized much better utilization of the river system can be made both in replacement or PSPP options.

This project must be further studied in conjunction with the three candidate sites.

14.6 Plans ahead

GOMWRD wishes further study by JICA Study Team both on three candidate sites in this study and on Koyna replacement project. It is necessary to continue discussions with GOMWRD for further smooth progress of the projects including the security of funding, and the advices on necessary actions to be taken towards governmental sections such as but not limited to the Maharashtra state government.