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CHAPTER 6 TOPOGRAPHICAL SURVEY

6.1 Preparation of Topographical Map

6.1.1 General

The objectives of the topographical survey (hereinafter referred as the "Survey") are to take aerial photographs at a scale of 1:20,000 covering the three surveys areas of approximately 145km in total and prepare topographical maps at a scale of 1:10,000 covering the same area of approximately 285sq.km with intermediate contour of 5m, as shown on the planning map.
The Survey area covers three proposed areas (Jalond, Marleshwar, Hevale) in Maharashtra state. Survey areas of three sites are as follows:

(1) Jalond 95sq.km
(2) Marleshwar 110sq.km
(3) Hevare 80sq.km

Actual survey works will be carried out by JICA Survey Team in collaboration with a Indian Survey Team.

6.1.2 Scope of Work

In order to achieve the objectives mentioned above, the Survey covers the following work items and quantities;

Items and Volume of the Work

Work Items	Volume	Remarks
Signalization	22 points	
Monumentation	22 points	
Aerial Photography	145 km	Scale 1:20,000
Ground Control Survey	22 points	GPS survey
Leveling & Pricking	230 km	Direct leveling
Field Verification	285 sq. km	
Aerial Triangulation	75 models	
Plotting, Editing and Drawing	285 sq. km	Scale 1:10,000

6.1.3 Operational Standards of the Survey

Survey standards and map accuracy are as follows;

(1)	Geodetic reference ellipsoid	:	Everest 1830
(2)	Datum of height	:	National Bench Marks of INDIA
(3)	Map projection	:	Lambert
(4)	Map scale and Contour interval	:	Map scale 1:10,000 Intermediate contour 5 m
(5)	Map style and application rule	:	Those adopted by the Survey of India
(6)	Maplaccuracy		
	(a) Planimetry of conspicuous ground features	:	Not more 1.0 mm on the map
	(b) Spot height	:	Note more than 2/3 of the contour interval
	(c) Contour Line	:	Not more than 1/1 of the contour interval
	(d) Grid tick	:	Lambert grid lines shall be drawn every 10 cm on the map

6.1.4 Work Plan

The Survey shall be carried out under a three-phase program starting from March,1995, and accomplishing in July,1996. It shall consist of the following three phases in accordance with the time schedule.

The Survey of phase 1 shall be exclusively executed by the Team.

Those of phase 2 and phase 3 shall be carried out by the Survey of India who shall be entrusted and supervised by the Team.

Phase 1. (March, 1995)
Planning and Preparation of the Survey (Including the drawing up of P/O)
Field Reconnaissance

Phase 2. (From October, 1995 to March, 1996)
Signalization on control points
Monumentation of control points
Aerial Photography
Leveling

Pricking
Geodetic Control Point Survey
Field Identification
Aerial Triangulation

Phase 3. (From May, 1996 to July, 1996)
Stereo Plotting
Compilation
Drawing

6.2 Modification of Scope of Work

Accordingly to the original work plan the aerial photography covering Jalond, Marleswar and Hevale was scheduled to be conducted and thereafter a topographic maps of a scale of 1:10,000 would be made on the basis of those aerial photos. However it was found that the Survey of India had already done the aerial photography. The team therefore decided to cancelle the aerial photography and carried out technical support and management for preparation of topographical maps by Survey of India.

GOMID made application to Ministry of Defence regarding taking out of topographic maps. Ministry of Defence did not permit it.

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CHAPTER 7 GEOLOGY

7.1 Jalond Site

(1) Upper Dam Site

(a) Condition of Rock Mass

The subground is divided into 2 velocity zones of surface layer and bedrock. The velocity of bedrock is 4.5 km/sec at the left bank of the river and 4.0 km/sec at the right bank. It is considered that these velocities represent the hard fine basalt (Compact Basalt). The sonic velocity of intact core is 5.4 to 6.0 km/sec.

The velocity at the left bank is similar to the velocity of 4.9 to 5.0 km/sec at the upper reservoir of Hevale where the Compact Porphyritic Basalt and Amygdaloidal Basalt are present, while the velocity at the right bank is similar to the velocity of 4.0 km/sec at the lower reservoir of Marleshwar where the Amygdaloidal Basalt is present. Therefore, the left bank of the river is expected to be underlain by the Compacted Porphyritic Basalt and Amygdaloidal Basalt and the right bank be underlain by the Amygdaloidal Basalt.

(b) Rock Mass Evaluation at Dam Site

Based on the site reconnaissance and seismic velocity, a gravity dam is expected to be feasible. However, if the Compact Basalt is present at the dam site, the Compact Basalt causes water seepage although the coefficient of permeability (Lugeon value) is low. There is a report that cement grouting is not effective in the Compact Basalt. The water seepage is expected through the joints and at the boundary between the Compact and Amygdaloidal Basalts. If the Compact Basalt has such problem, blanket or facing to prevent water seepage needs to be considered both at the dam site and reservoir area after the economic evaluation.

(2) Lower Dam Site

(a) Condition of Rock Mass

The lower reservoir site is formed also by 2 zones of surface layer and bedrock. The velocity of the bedrock of basalt is 4.5 to 4.6 km/sec at the both sides of the river. The high velocity (4.6 km/sec) was obtained at the riverbed, too. There is no low velocity zone in the bedrock. The surface layer is expected to consist of talus deposits based on the recorded velocity of 0.35 to 0.4 km/sec. The thickness of talus deposits is 7 to 10m on the slope of the right bank of the river and about 1m on an average on the slope of the left bank. The maximum thickness of the talus deposits at the left bank is 5m. It was anticipated, at the initial stage of the study, that the rocks at the ridge of right abutment of the dam site were heavily weathered. However, the high seismic velocity of 4.5 km/sec was obtained. On the ridge, an about 10m thick weathered zone with open joints is expected to be present.

(b) Rock Mass Evaluation at Dam Site

The basalt at the riverbed and both abutments is good in rock quality and as a foundation of the dam. In terms of permeability, the weathered portion indicates less than 4 Lugeon and there are no problems. Furthermore, there are no problems in terms of strength either. Considering availability of aggregate, a masonry type dam is feasible at this site. For a fill type dam, laterite and lateritic basalt are to be used for the fill materials. However, the volume of the laterite may be insufficient. The river deposits are also insufficient and contain a small amount of sand particles and large gravel or boulders which need to be fragmented for use.

7.2 Marleshwar Site

(1) Upper Dam Site

(a) Condition of Rock Mass

The subground is divided into 3 layers with the different seismic velocities. The 3 layers consist of surface layer, laterite and bedrock basalt. The bedrock with the velocity of 4.6 km/sec exposes on the riverbed. The laterite with the velocity of 0.7 to 1.5 km/sec covers the bedrock with the thickness of 32 to 33m at both banks of the river. Since the laterite is thick at the right bank, the depth to the bedrock is not clear. The bedrock may not raise its elevation towards the ridge as drawn in the seismic profile. The thickness of the laterite of about 30m is estimated based on the borehole result at UM1. The seismic survey line was set on the foot of right bank of the river in parallel with the river flow and the survey detected 5 to 10m talus deposits with the velocity of 0.4 to 0.5 km/sec. Beneath the talus deposits, there is 18 to 20m thick laterite with 0.7 to 1.2 km/sec velocity. The 4.6 km/sec velocity layer lies underneath the laterite (the layer has no low velocity zone).

Two saddle dam sites are underlain by about 20m thick laterite with 1.1 to 1.5 km/sec in velocity, and the bedrock of weathered Porphyritic Basalt with 4.0 km/sec velocity underlies the laterite.

(b) Rock Mass Evaluation at Dam Site

At the dam site, the basalt is located deep and is overlain by 30m thick laterite. It can be said that this dam site is unsuitable for construction of any type of dam from an aspect of permeability. A man-made reservoir could be a possible alternative, however, excavatability of laterite nees to be studied in detail because the laterite contains a lot of boulders at the deeper portion than 23 to 24 and its strength has a wide range.

(2) Lower Dam Site

(a) Condition of Rock Mass

[Downstream dam site (Dam Axis I)]

The subground is divided into two zones of surface layer and bedrock. The velocity of the bedrock is 4.0 km/sec at the riverbed and the both abutments. There is no low velocity zone in the bedrock. Talus deposits or colluvial debris cover slopes of the both abutments and have the velocity of 0.35 to 0.4 km/sec and the thickness of 5 to 10m.

The slopes at both sides of the river are formed by primary gentle slope at the high level and secondary steep slope at the low level. The boundary of the two slopes is located at the elevation of about 230m at the left bank of the river. The colluvial debris was found on the primary slope and the thin talus deposits were found on the secondary slope. The boundary of the two slopes at the right bank of the river is located at the elevation of about 240m. The surface layer is thin at the borehole LM1 which is located on the secondary slope.

[Upstream dam site (Dam Axis II)]

There are two zones of surface layer and bedrock. The bedrock has the velocity of 4.0 km/sec and no low velocity zone was found. The slopes at both banks of the river consist of primary and secondary slopes at high and low elevations, respectively. The boundary of the two slopes is located at the elevation of about 230m. The talus deposits cover the secondary slope with a thickness of about 5m on the both banks. There are some rock exposures at the right bank of the river. The primary slope at the left bank is covered by colluvial debris with a velocity of 0.4 km/sec. The primary slope at the right bank is covered by a layer with a velocity of 0.35 to 0.4 km/sec. This layer is assumed to be talus deposits and may be landslide mass. The detail study using aerial photographs should be carried out.

(b) Rock Mass Evaluation at Dam Site

Based on alteration, fissure, strength and presence of Tachylytic Basalt, the rock mass quality is classified as moderately poor. Landslide masses found at the reservoir and dam site are expected to be unstable when the dam is constructed. The landslide mass may have been formed in such a way that talus deposits were firstly derived from alteration of rocks and presence of Tachylytic Basalt, the deposits were then developed on the primary slope, and the deposits finally became unstable together with the development of secondary slope at the lower portion of the slope. The secondary slope has been formed by erosion in Quaternary, thus the landslide mass is expected still active. There is an active landslide located downstream of the downstream dam site. Detailed study on the landslide by analyzing aerial photographs shall be carried out.

7.3 Hevale Site

(1) Upper Dam Site

(a) Condition of Rock Mass

The subground is divided into two layers of laterite and bedrock. The laterite has a velocity of 0.45 to 0.5 km/sec and a thickness of 6 to 13m. The bedrock has the velocity of 4.0 to 5.0 km/sec and consists mainly of the Compact Porphyritic Basalt with columnar joints. The bedrock contains two layers of 3 to 5m thick blackish Tachylytic Basalt. These layers are not detectable by the seismic survey.

(b) Rock Mass Evaluation at Dam Site

The bedrock quality is good. The Tachylytic Basalt is thin and is present at the shallow depth. Therefore, it can be removed without difficulties. Geologically, there is little problem at this site.

(2) Lower Dam Site

(a) Condition of Rock Mass

The subground is divided into two zones of bedrock and surface layer consisting of talus deposits. The bedrock consists of the strong Pre-Cambrian Crystalline Schist with the velocity of 4.8 to 5.0 km/sec.

The talus deposits has velocity of 0.4 to 0.5 km/sec and a thickness of about 10m. There is a gravel layer with the velocity of 1.5 km/sec at the riverbed and there is a topographic depression beneath the gravel layer. This depression is considered to be the old riverbed. The foundation of the dam needs to be designed taking the old riverbed into account.

(b) Rock Mass Evaluation at Dam Site

Basically, the rock quality at the dam site is good. However, the dip and strike of schistocity and lineament may influence on the stability of the dam. Furthermore, there is a variation in the strength of rocks. These matters should be considered in the dam design.

The talus deposits which may have been formed by mud flow are present along the river. The talus deposits exist on the gentle slope upstream of the dam site or at the mouths of small valleys. Therefore, the transportation and deposition of the soils into the reservoir need to be examined.

7.4 Engineering Consideration

The geological features of each project site from an engineering point of view is summarized as follows:

a) Jalond site has no major geological problem. The dam height needs to be adjusted based on the actual topography. The presence of Sanctuary area needs to be considered in the design. A masonry type dam is suitable considering availability of the construction materials.

b) Marleshwar dam site is covered by 30m thick laterite and the bedrock for dam foundation lies deep. Therefore, a man-made type reservoir seems better. As for the two alternative lower dam sites, there are landslide masses in the reservoir areas and partially at the dam locations. The landslide needs to be studied in detail using aerial photographs, etc. The rock mass quality is classified as moderately poor because of the presence of altered basalt, Volcanic Breccia and Tachylytic Basalt.

c) At Hevale site, poor Volcanic Breccia and Tachylytic Basalt are present in the bedrock at the upper reservoir. Their occurrence is shallow and limited to the small extent and thus, these materials can be treated properly by removal or replacement. The lower reservoir is underlain by the strong Pre-Cambrian Crystalline Schist. Generally, the schist has no problem as a foundation of dam. However, the schistocity or lineament in the schist shall be taken into account for the design. The presence of talus deposits derived from mud flow implies transportation and deposition of soils into the proposed reservoirs.

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CHAPTER 8 HYDRO-METEOROLOGICAL STUDY

8.1 Hydro-meteorological Conditions of the Konkan Region

The proposed dam sites are located in and near the Sahyadri range and they have an altitude from about EL+100 to 900 m. Climatically, there are three seasons as below:

(1) Summer from March to the middle of June

The average atmospheric temperature in May is about 30°C and the average relative humidity is about 68% in the coastal area.

(2) Rainy season from the middle of June to the middle of October

The average atmospheric temperature in this season is about 27.5°C and the relative humidity is about 85% on average.

(3) Winter from the middle of October to February

The average atmospheric temperature in January is about 24°C and the relative is about 65% on average.

The Konkan Region lies in the high rainfall zone having annual rainfall exceeding 1,905 mm. The precipitation is generally brought by the south-west monsoon currents and about 90% of annual rainfall is received in the rainy season. The rainfall is heaviest on the Sahyadri edge, where the rainfall is over 6,000 mm, and it reduces towards the sea.

8.2 Monthly Rainfall

(1) Jalond

For the study, 4 raingauge stations - Kundachiwadi, Moroshi, Phangloshi and Waliware - were selected. These are located very close to the site.

(2) Marleshwar

For the study, 2 raingauge stations - Pastewadi and Sangave - were selected.

(3) Hevale (lower dam site)

Data at the Kodali station located in the catchment area of the site was adopted.

8.3 Low Flow Analysis

(1) Annual Inflow used for the Initial Site Selection

(a) Run-off coefficient

The following run-off coefficients were used for the preliminary flow and flood estimation:

(i) For the calculation of design floods : <u>0.9</u>
(ii) For the calculation of annual yield : <u>0.85</u>

(b) Annual inflow

For the initial site selection, annual inflows to the proposed sites were estimated by using the annual rainfall data (the second lowest annual rainfall) observed in the vicinities of the sites and the run-off coefficient of 0.85. The total loss due to evaporation and infiltration is assumed as being 3,000 mm per annum.

(2) Low Flow Analyses for 3 Selected Sites

The Tank Model was used for the analysis.

First, the run-off characteristics were examined by using the monthly rainfall data and the monthly flow data at the following stations:

(a) Near the Jalond site : Sajgaon (about 15 km south of the site)
(b) Near the Marleshwar site : Pastewadi (about 10 km south-west of the site)
(c) Near the Hevale site : Shirshingi (about 35 km north-west of the site)

It was finally decided to adopt the run-off characteristics obtained for Shirshingi considering the overall similarity of the simulated flow to the actual one and reliability of the results (sample sizes, correlation coefficients).

By using the above run-off characteristics and the monthly areal rainfall obtained in Section 8.2, the monthly flows at the Jalond, Marleshwar and Hevale sites were derived as summarized in **Tables 8.3-1 through 8.3-5**.

8.4 Flood Estimation

(1) Rainfall Intensity

It is necessary, first of all, to determine the rainfall intensity to be used in the Rational Formula. For this purpose, the rainfall data (the hourly distribution of rainfall at more than 250 mm/day) observed in the Konkan Region was examined and the highest percentage of one-hour rainfall to the daily rainfall is found to be 19.32%. In this study, we adopted 25 % to be on the safe side.

(2) Preliminary Flood Estimation

Raingauge stations which are located near each proposed site and have rainfall data over a longer period than 10 years were selected. The maximum daily rainfall of each year at each station was extracted and statistically analyzed by using the Hazen Plot for obtaining probable daily rainfall.

(3) Flood Estimation for the 3 Selected Sites

Probable rainfall was obtained by statistically analyzing a series of the annual maximum daily rainfall at each station described in Section 8.3. The data was statistically analyzed using the Hazen Plot, the Thomas Plot, the Gumbel's Method and the Iwai's Method for the return periods of 10, 30, 100, 200 and 1,000 years, and the Hershfield's Method for the probable maximum precipitation (PMP). For the return periods of 10, 30, 100, 200 or 1,000 years, the maximum one among the probable rainfalls obtained by the 4 methods was adopted.

The one-hour rainfall intensity for flood estimation was derived by multiplying the above probable daily rainfall by 0.25 according to the study in Section 8.4-(1). The run-off coefficient of 0.95 was used. The probable floods for the proposed sites were obtained as summarized in **Table 8.4-1**.

8.5 Evaporation and Infiltration Losses

The evaporation loss of 5.56 mm/day was adopted in the preliminary study stage (for the initial site selection). Further study was conducted after obtaining the evaporation data at the Khapri, Pastewadi and Tillariwadi meteorological stations. Since it is well known that the evaporation loss from ponds is much less than from evaporation pans, it was assumed that the evaporation loss to be used for the optimization study is 75% of the loss observed at each station. Regarding the infiltration loss, it was assumed that the infiltration loss from ponds is 50 % of the evaporation loss.

Jalond			Marleshwar			Hevale		
Evapo. (mm/yr)	Infilt. (mm/yr)	Total (mm/yr)	Evapo. (mm/yr)	Infilt. (mm/yr)	Total (mm/yr)	Evapo. (mm/yr)	Infilt. (mm/yr)	Total (mm/yr)
1,470	744	2,214	1,178	601	1,779	1,266	641	1,907

8.6 Sedimentation

Sedimentation data of the existing 76 reservoirs in Maharashtra State was examined and the sediment yield rates at the proposed sites were obtained as shown in the table below.

Site	Upper Dam Sediment yield rate ($m^3/km^2/year$)	Lower Dam Sediment yield rate ($m^3/km^2/year$)
Jalond	645.0	593.4
Marleshwar	590.1	620.6
Hevale	591.1	--

Table 8.3-1
Simulated Monthly Flow for the Upper Dam Site, Jalond

(m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1980	0.00	0.00	0.00	0.00	0.00	4.40	7.06	9.73	2.46	0.15	0.00	0.00	2.00
1981	0.00	0.00	0.00	0.00	0.00	1.65	10.77	5.84	2.11	0.44	0.00	0.00	1.76
1982	0.00	0.00	0.00	0.00	0.00	1.29	4.26	4.53	0.31	0.17	0.00	0.00	0.89
1983	0.00	0.00	0.00	0.00	0.00	2.13	6.61	8.23	3.99	0.37	0.00	0.00	1.79
1984	0.00	0.00	0.00	0.00	0.00	1.38	8.16	5.79	1.73	0.80	0.00	0.00	1.50
1985	0.00	0.00	0.00	0.00	0.00	0.87	8.02	5.39	0.76	0.20	0.00	0.00	1.29
1986	0.00	0.00	0.00	0.00	0.00	2.56	5.64	7.02	0.87	0.00	0.00	0.00	1.36
1987	0.00	0.00	0.00	0.00	0.00	0.26	3.32	5.66	0.64	0.22	0.00	0.00	0.86
1988	0.00	0.00	0.00	0.00	0.00	0.35	10.96	2.80	2.10	0.28	0.00	0.00	1.39
1989	0.00	0.00	0.00	0.00	0.00	1.92	6.75	7.81	2.07	0.01	0.00	0.00	1.57
1990	0.00	0.00	0.00	0.00	0.00	4.62	6.43	7.12	2.72	1.55	0.00	0.00	1.89
1991	0.00	0.00	0.00	0.00	0.00	4.27	9.58	8.26	0.89	0.00	0.00	0.00	1.94
1992	0.00	0.00	0.00	0.00	0.00	0.01	1.83	5.47	2.60	0.23	0.00	0.00	0.85
Mean	0.00	0.00	0.00	0.00	0.00	1.98	6.88	6.44	1.79	0.34	0.00	0.00	1.47

Table 8.3-2
Simulated Monthly Flow for the Lower Dam Site, Jalond

(m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1980	0.00	0.00	0.00	0.00	0.00	0.73	1.17	1.61	0.41	0.02	0.00	0.00	0.33
1981	0.00	0.00	0.00	0.00	0.00	0.27	1.79	0.97	0.35	0.07	0.00	0.00	0.29
1982	0.00	0.00	0.00	0.00	0.00	0.21	0.71	0.75	0.05	0.03	0.00	0.00	0.15
1983	0.00	0.00	0.00	0.00	0.00	0.35	1.10	1.37	0.66	0.06	0.00	0.00	0.30
1984	0.00	0.00	0.00	0.00	0.00	0.23	1.35	0.96	0.29	0.13	0.00	0.00	0.25
1985	0.00	0.00	0.00	0.00	0.00	0.14	1.33	0.89	0.13	0.03	0.00	0.00	0.21
1986	0.00	0.00	0.00	0.00	0.00	0.43	0.94	1.16	0.14	0.00	0.00	0.00	0.23
1987	0.00	0.00	0.00	0.00	0.00	0.04	0.55	0.94	0.11	0.04	0.00	0.00	0.14
1988	0.00	0.00	0.00	0.00	0.00	0.06	1.82	0.46	0.35	0.05	0.00	0.00	0.23
1989	0.00	0.00	0.00	0.00	0.00	0.32	1.12	1.30	0.34	0.00	0.00	0.00	0.26
1990	0.00	0.00	0.00	0.00	0.00	0.77	1.07	1.18	0.45	0.26	0.00	0.00	0.31
1991	0.00	0.00	0.00	0.00	0.00	0.71	1.59	1.37	0.15	0.00	0.00	0.00	0.32
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.91	0.43	0.04	0.00	0.00	0.14
Mean	0.00	0.00	0.00	0.00	0.00	0.33	1.14	1.07	0.30	0.06	0.00	0.00	0.24

Table 8.3-3

Simulated Monthly Flow for the Upper Dam Site, Marleshwar

(m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1982	0.00	0.00	0.00	0.00	0.00	1.86	4.80	4.00	0.99	0.30	0.18	0.00	1.02
1983	0.00	0.00	0.00	0.00	0.00	4.46	4.35	5.47	2.88	0.24	0.01	0.00	1.46
1984	0.00	0.00	0.00	0.00	0.00	2.59	4.86	2.11	0.89	0.41	0.01	0.00	0.91
1985	0.00	0.00	0.00	0.00	0.00	3.86	4.17	3.26	0.60	0.97	0.04	0.00	1.08
1986	0.00	0.00	0.00	0.00	0.00	3.02	2.50	3.45	0.31	0.08	0.01	0.00	0.79
1987	0.00	0.00	0.00	0.00	0.00	1.60	4.06	3.52	0.78	0.71	0.03	0.00	0.90
1988	0.00	0.00	0.00	0.00	0.00	2.45	6.73	3.33	2.14	0.14	0.00	0.00	1.24
1989	0.00	0.00	0.00	0.00	0.00	3.47	4.66	2.57	0.94	0.13	0.00	0.00	0.99
1990	0.00	0.00	0.00	0.00	0.07	2.41	4.38	4.99	1.24	0.51	0.09	0.00	1.15
1991	0.00	0.00	0.00	0.00	0.00	2.54	7.03	3.11	0.66	0.14	0.00	0.00	1.14
1992	0.00	0.00	0.00	0.00	0.00	1.51	4.34	3.80	1.55	0.52	0.00	0.00	0.98
Mean	0.00	0.00	0.00	0.00	0.01	2.71	4.72	3.60	1.18	0.38	0.03	0.00	1.06

Table 8.3-4

Simulated Monthly Flow for the Lower Dam Site, Marleshwar

(m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1982	0.00	0.00	0.00	0.00	0.00	4.26	11.52	9.59	2.34	0.68	0.42	0.00	2.43
1983	0.00	0.00	0.00	0.00	0.00	9.35	9.37	11.81	6.18	0.46	0.01	0.00	3.11
1984	0.00	0.00	0.00	0.00	0.00	5.29	10.49	4.51	1.85	0.82	0.02	0.00	1.93
1985	0.00	0.00	0.00	0.00	0.00	8.05	8.97	7.02	1.23	2.02	0.09	0.00	2.30
1986	0.00	0.00	0.00	0.00	0.00	6.21	5.35	7.42	0.59	0.21	0.00	0.00	1.66
1987	0.00	0.00	0.00	0.00	0.00	3.14	8.73	7.57	1.62	1.46	0.06	0.00	1.90
1988	0.00	0.00	0.00	0.00	0.00	4.99	14.53	7.17	4.57	0.33	0.00	0.00	2.65
1989	0.00	0.00	0.00	0.00	0.00	7.21	10.04	5.50	1.96	0.32	0.00	0.00	2.10
1990	0.00	0.00	0.00	0.00	0.06	4.83	9.44	10.78	2.63	1.04	0.20	0.00	2.44
1991	0.00	0.00	0.00	0.00	0.00	5.19	15.19	6.68	1.36	0.34	0.00	0.00	2.42
1992	0.00	0.00	0.00	0.00	0.00	2.94	9.34	8.17	3.29	1.05	0.00	0.00	2.08
Mean	0.00	0.00	0.00	0.00	0.01	5.59	10.27	7.84	2.51	0.79	0.07	0.00	2.28

Table 8.3-5
Simulated Monthly Flow for the Lower Dam Site, Hevale

(m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1980	0.00	0.00	0.00	0.00	0.00	14.04	18.48	15.57	2.29	0.26	0.00	0.00	4.24
1981	0.00	0.00	0.00	0.00	0.00	6.23	16.65	20.35	5.30	0.04	0.00	0.00	4.09
1982	0.00	0.00	0.00	0.00	0.03	5.02	18.05	19.46	2.01	0.97	0.07	0.00	3.85
1983	0.00	0.00	0.00	0.00	0.00	11.60	18.26	15.85	7.97	1.08	0.16	0.00	4.61
1984	0.00	0.00	0.00	0.00	0.00	10.48	18.61	12.29	3.31	0.95	0.09	0.00	3.84
1985	0.00	0.00	0.00	0.00	0.00	10.68	12.37	12.76	2.46	1.87	0.00	0.00	3.37
1986	0.00	0.00	0.00	0.00	0.00	11.16	10.43	9.71	1.11	0.23	0.38	0.00	2.77
1987	0.00	0.00	0.00	0.00	0.00	4.18	14.97	8.45	3.30	1.23	0.06	0.00	2.71
1988	0.00	0.00	0.00	0.00	0.00	7.89	26.86	12.66	7.91	0.41	0.00	0.00	4.68
1989	0.00	0.00	0.00	0.00	0.00	17.16	13.87	8.97	3.32	0.38	0.00	0.00	3.66
1990	0.00	0.00	0.00	0.00	0.12	11.43	18.64	14.98	5.59	1.00	0.10	0.00	4.36
1991	0.00	0.00	0.00	0.00	0.32	6.99	23.87	13.55	1.90	0.67	0.02	0.00	4.00
1992	0.00	0.00	0.00	0.00	0.00	9.22	14.23	13.44	3.16	1.03	0.17	0.00	3.46
Mean	0.00	0.00	0.00	0.00	0.04	9.70	17.33	13.70	3.82	0.78	0.08	0.00	3.82

Table 8.4-1 Probable Floods

Site			Return Periods					
			10-yr	30-yr	100-yr	200-yr	1,000-yr	PMF
Jalond	L.D (CA = 3.43 km^2)	Rainfall intensity (mm/hr)	67.5	84.1	103.2	115.5	146.6	233.8
		Flood (m^3/s)	**61.1**	**76.1**	**93.4**	**104.5**	**132.7**	**211.6**
	U.D (CA = 20.68 km^2)	Rainfall intensity (mm/hr)	67.5	84.1	103.2	115.5	146.6	233.8
		Flood (m^3/s)	**368.1**	**459.1**	**562.9**	**630.2**	**800.0**	**1,275.8**
Marleshwar	L.D (CA = 23.20 km^2)	Rainfall intensity (mm/hr)	96.2	119.5	144.4	158.7	201.6	259.9
		Flood (m^3/s)	**589.0**	**731.5**	**884.0**	**971.5**	**1,234.2**	**1,590.9**
	U.D (CA = 8.15 km^2)	Rainfall intensity (mm/hr)	96.2	119.5	144.4	158.7	201.6	259.9
		Flood (m^3/s)	**206.9**	**257.0**	**310.6**	**341.3**	**433.6**	**558.9**
Hevale	L.D (CA = 22.46 km^2)	Rainfall intensity (mm/hr)	89.0	103.7	119.4	128.4	149.3	237.0
		Flood (m^3/s)	**527.2**	**614.3**	**707.7**	**761.2**	**885.1**	**1,404.7**

CONTENTS

CHAPTER 9 ENVIRONMENTAL IMPACT SURVEY

The State of Maharashtra, which is located in the western part of India, is inhabited by approximately 80 million people or 9% of the total population of India. Mumbai, formally called Bombay, is the capital of the State, and the largest economic center of the country. The State accounts for nearly a quarter of the country's total industrial output.

The economy of the State is growing fast, fuelled by both domestic and foreign investment. This economic growth has inevitably invited increase in power and energy demand. In particular, the peak-hour power demand is growing substantially, as it is projected to increase annually by 7% between 1995 and 2001, and 6% between 2002 and 2007. In order to cope effectively with the growing peak demand, a proposal has been made to build pumped-storage hydro power plants in the State. This preliminary environmental assessment (Pre-EIA) report is a part of the preliminary feasibility study report for the implementation of this proposed action, and is concerned with the environmental aspect of the action for the project.

Three potential sites have been identified for the project, namely Hevale, Jalond, and Marleshwar; and conceptual development plans have been drawn for respective sites. The installed capacity intended for each site is around 1,000 MW to 1,200 MW, as compared with the average capacity of some 200 MW among the existing 6 plants in India with the same scheme.

Indian environmental policies are concerned mainly with the following two issues: pollution control (air and water) and conservation of biological resources (forests and wildlife). Two of the proposed sites, Jalond and Marleshwar, are located within the boundaries of proposed sanctuaries. Alteration of the boundaries to exclude the sites from the sanctuaries, as par the Wildlife (Protection) Act, 1972, is essential for the implementation of the project at these two sites. For this purpose, a resolution has to be approved by the State Legislation. Other environmental permits required for the project are as follows:

1) Site clearance from the Ministry of Environment and Forests (MOEF) of the central government,
2) No-objection certificate (NOC) from the Maharashtra State Pollution Control Board (MSPCB)
3) Environmental clearance from MOEF as per the Environmental (Protection) Act, 1986, and
4) Forest clearance as per the Forest (Conservation) Act, 1980.

The proposed three sites are located in the mountain side of the Konkan region. The region has three distinctive seasons, namely, Summer, Monsoon, and Winter, and the annual rainfall exceeding 2,000 mm. Geologically, the region is formed mainly by layers of basaltic lava. The upper reservoir sites are situated at the elevation of around 700-900 meters from the mean sea level, and the lower reservoir sites around 200-300 meters. The Hevale site comes entirely under semi-green reserved forest, whereas the Jalond and Marleshwar sites comprise both forest and non-forest land including some agricultural land. Forest in Maharashtra is known to be rich in biological diversity.

During the survey carried out in the post-monsoon winter season, two endangered avifauna species were observed at the Hevale site, namely, Peafowl and Pied Indian Hornbill. The former was observed at the Jalond site as well. Although no endangered species listed in Schedule I of the Wildlife Act were found, information derived from local residents indicated the presence of the following mammals at the Hevale site: Tiger, Leopard, Leopard Cat, and Sloth Bear. Similar information was obtained at the other two sites. Important flora species found at the sites are as shown below.

Important flora species found at the project sites

Project Site	Hevale	Jalond	Marleshwar
1	Pittosoprum florinundum	Brideliaretusa	Engenia jambolana
2	Holigarna arnoltiana	Cassia fistula	Glochydeonlanceolariumn
3	Elaeagnus latitolis	Mangifera indica	Mangitera iadica
4	Terminalia arjuna	Saccopetalum tomentosum	Semecarpus anacardium
5	Terminalia chebula	Terminalia tomentosa	
6	Phyllanthus imblica	Biuhinia gacamosa	
7	Terminalia bellirica	Vanguria spinosa	
8	Terminalia crenulata		
9	Erirocarpus nimmonii		
10	Terminalia tomentosa		
11	Diospyros montana		
12	Bridellia rotusa		
13	Steculia guttata		
14	Xylia xylocarpa		
15	Sapium insigne		

Source: Hevale: BNHS Report, 1996.
Jalond and Marleshwar: GOMID Reports, 1996.
Wild Institution of India Derrandum.

No villages will be directly affected by the project at any of the three sites, although a few villages are located in the immediate vicinity of the Jalond and Marleshwar sites. Villagers lead a self-sufficient life, cultivating non-irrigated and less fertile land and grazing cattle in stony waste land. They grow rice, bajari, nagli and other crops. Some villagers work in Mumbai during the off-season. Villages have no public facilities, except primary schools with one or two classrooms. Electricity is available, but not all the households are under contract to receive power service. Water source is usually wells and occasionally river water. During the dry season, some villages are provided with tanker water.

Being a site specific hydro project, the project will inevitably generate adverse impacts on the environment. Potential significant impacts are as follows:

1) loss of forest (including loss of flora, fauna, and wildlife habitat),
2) loss of agricultural land,
3) possible onset of epidemics or water-borne diseases, and
4) deterioration (deoxygenation) of water quality during the construction and post-construction periods and possible depletion of the ground water during the construction period.

With respect to the loss of forest and agricultural land, the degree of impact at each site, measured by area to be inundated, is expected to be as follows: (Submerged land areas must be reassessed, when detailed topographic maps become available.)

Site	Hevale	Jalond	Marleshwar (ha)
1. Loss of Forest Land	82	280	200
(Reserved forest)	(82)	(190)	
(Non-reserved forest)		(90)	(200)
2. Loss of Agricultural Land	0	50	32

Biologically or ecologically, the Hevale site may have the most serious impact, as it is covered entirely by a high-quality reserved forest which harbours a variety of fauna and flora species. However, thick forest is also observed in the upper reservoir area of the Jalond site and the lower reservoir area of the Marleshwar site. Villages located in the immediate vicinity of the Jalond and Marleshwar sites will have the most significant social and cultural impacts including some loss of agricultural land.

Minor and modest impacts will include decrease in fish catch, traffic safety problems, and air pollution. The table entitled Environmental Impact Matrix summarises the impacts anticipated at different sites.

Because the project is site specific, loss of forest and agricultural land can not be avoided. For those negative impacts, compensatory afforestation has to be implemented as per the Forest Act, and alternative land or monetary compensation has to be offered to affected villagers as per the Maharashtra State Act for Rehabilitation of the Project Affected Persons. Compensatory afforestation assumes that creating alternative forest will balance the negative impact resulting from the loss of forest. Potential mitigation measures are summarised in the table entitled Mitigation Measures.

Monitoring is an integral part of environmental impact management, and is required during the construction and post-construction periods to ensure that actual impacts are within the environmentally acceptable level, and that no impacts are occurring other than those previously anticipated. Environmental elements needed to be monitored include the following:

(1) Watershed protection:

Catchment area has to be managed and protected to minimise the occurrence of land slides and soil erosion and thus to assure a maximum life of a reservoir. Periodical monitoring will be required to ensure that no disturbance is made by residents in the area resulting in land slides and soil erosion, and that mitigation measures employed including reforestation of the area are adequately functioning.

(2) Public health protection:

Through a dispensary to be established on the project site, monitoring of public health should be conducted. Monitoring activities will include periodical health check for both project workers and local residents, and project area reconnaissance to investigate possible causes for outbreak of an epidemic or a water-related disease. Water analysis should be carried out regularly.

(3) Wildlife protection:

The monitoring work should include educating project workers about the importance of wildlife conservation. To minimise the disturbance of the surrounding environment by project workers and to observe the change in habitat, an independent monitoring unit needs to be organised.

Estimated costs for the implementation of major mitigation measures and monitoring plan is exhibited in the table of the same name. The costs for watershed protection and compensatory domestic water supply are expected to constitute relatively high proportions of the total cost. (Detailed investigation into all the wells in the general area of the project and more accurate assessment of compensatory water requirements will be required.)

In conclusion, it can be said that the three potential sites are not likely to make much difference in terms of adverse environmental impacts involved. The mitigation measures and monitoring plan discussed above should be implemented in a strict and satisfactory manner with sufficient funds provided. It is required that contractors have stringent employment provisions with workers that prevent disturbance of the surrounding environment by them, and provide adequate housing, safe water supply, sanitation, and fuel for them. If those requirements are fulfilled, a substantial portion of the negative impacts can be mitigated.

Table 9-1 Environmental Impact Matrix

Environmental component affected	Phase	Impact	Project site	Area affected	Significance	Duration
1. Village/inhabitants to be displaced	Pre-Con. & Con	Nil. No houses or no major infrastructure facilities of villages will be inundated or lost.	Hevale	n.a.		
			Jalond			
			Marleshwar			
2. Agriculture	Con. & Post-Con.	Loss of agricultural land. The total agricultural land to be inundated or lost will be: none (or negligible) at Hevale, 50 ha at Jalond, and 32 ha at Marleshwar. Little impact is expected on agricultural activities attributable to changes in ground water	Hevale	1	1	3
			Jalond	2	3	3
			Marleshwar	2	3	3
3. Forestry	Con. & Post-Con.	Loss of forest. The total forest land to be lost will be: 82 ha of reserved forest at Hevale, 190 ha of reserved and 90 ha of non-reserved forest at Jalond, and 200 ha of non-reserved forest at Marleshwar.	Hevale	2	3	2
			Jalond	2	3	2
			Marleshwar	2	3	2
4. Fishery	Con. & Post-Con.	Decrease in fish catch. However, fishery is practiced only on negligible scale.	Hevale	3	1	2
			Jalond	3	1	2
			Marleshwar	3	1	2
5. Land transportation		Traffic blockage and traffic safety problems. Existing roads will serve as the access to the construction sites, while they will be improved and extended. Those roads currently have little traffic, and basically, construction-related vehicles will remain on site and rarely go outside the project sites. Unless aggregates (concrete materials) are imported from outside the project sites, impact will be limited. Improvement and extension of the existing roads would have little benefit for the regional transportation network as a whole	Hevale	3	2	2
			Jalond	3	2	2
			Marleshwar	3	2	2
6. River transportation	Con.	Nil. Rivers are not used for transportation.	Hevale	n.a.		
			Jalond			
			Marleshwar			
7. Public health	Con. & Post-Con.	Possible onset of epidemics or water-borne diseases. In the absence of infrastructure facilities for project workers, such as housing, safe water supply and sewage, there is a possibility of outbreak of epidemics. The risk of water-related diseases will be high, without proper management of the catchment area and reservoirs.	Hevale	3	3	3
			Jalond	3	3	3
			Marleshwar	3	3	3

Table 9-1 Environmental Impact Matrix (Continued)

Environmental component affected	Impact: Phase	Impact	Project site	Area affected	Significance	Duration
8. Aesthetics	Con. & Post-Con.	Enhancement of the beauty of the location due to the creation of reservoirs as water masses (positive impact). This benefit can be valued at the Jalond and Marleshwar sites, because they are located in sanctuaries as sight-seeing resources. (Negative impact is perceived to be negligible.)	Hevale	2	1	3
			Jalond	2	2	3
			Marleshwar	2	2	3
9. Cultural assets	Con. & Post-Con.	There is a small, local temple in the vicinity of the upper reservoir site of Hevale, which however will not be affected. Below the upper dam site of Marleshwar, there is a famous temple called Marleshwar Temple. Without a proper measure, the falls belonging to the temple will be affected. There are no other cultural assets in or around the project site areas.	Hevale	n.a.		
			Jalond			
			Marleshwar	1	3	3
10. River/ground/ reservoir water	Con. & Post-Con.	Water pollution caused by turbid water, alkaline water by concreting, eutrophic reservoir water, etc. Problems resulting from decrease in water flow. Possible change in ground water level.	Hevale	3	3	3
			Jalond	3	3	3
			Marleshwar	3	3	3
11. Flora/fauna	Pre-Con & Con.	Loss of flora and fauna in the forest to be acquired, and disturbance of habitat in surrounding areas, due to noise, air pollution, etc.	Hevale	3	3	2
			Jalond	3	3	2
			Marleshwar	3	3	2
12. Air	Con. & Post-Con.	Air pollution caused by operation of construction equipment and construction-related vehicles. Odor caused by eutrophic reservoir water.	Hevale	2	2	3
			Jalond	2	2	3
			Marleshwar	2	2	3

Note: 1. n.a. : Not applicable Con: Construction

2. Affected area:
   1. Small (Limited to particular sites)
   2. Medium (Project site and its close vicinity)
   3. Large (Neighboring area)
3. Significance:
   1. Insignificant
   2. Moderately significant
   3. Significant
4. Duration::
   1. Short (Very limited duration)
   2. Medium (Basically, construction period)
   3. Long (Construction and post-construction periods)

Table 9-2 Summary of Mitigation Measures for Major Impacts

Component of Environment	Impact	Mitigation Measure
1 Agriculture	- Loss of agricultural land	- Alternative land/monetary compensation.
2 Forestry	- Loss of forest	- Compensatory afforestation. - No effective measures except scaling-down the reservoir size (including adoption of pondage-type reservoir).
3 Fishery	- Decrease in fish catch	- Adequate treatment of construction-related waste water/monetary compensation.
4 Land transportation	- Traffic blockage and safety problems	- Improvement of bottleneck. - Safe driving instructions. - Placing persons who control the traffic at appropriate spots.
5 Public health	- Possible onset of epidemics or water-borne diseases	- Medical screening in hiring project workers - Provision of adequate housing, sanitation (toilets, drainage, septic tanks, etc.) safe water, and dispensaries (with qualified doctors and paramedical staff) for workers. - Provision of safe water (tanker water) for villagers. - Periodical medical check for workers and villagers. - Education campaign to raise awareness on public health issues. - Malaria abatement (by spraying DDT). - Project area reconnaissance to investigate possible causes for outbreak. - Proper management of catchment areas and reservoirs. - Reservoir water analysis.
6 River/ground/reservoir water	- Deterioration of the quality of river/ground water	- Complete clearing of reservoir areas (prior to flooding). - Adequate treatment of construction-related waste water.
	- Possible depletion of water at village wells	- Water supply by tankers (for villagers). - Alternative source of water for the project.
	- Deterioration of the quality of reservoir water	- Complete clearing of reservoir areas (prior to flooding). - Proper management of catchment areas and reservoirs
7 Flora/fauna	- Loss of flora/fauna/habitat at project sites	- No effective measures except scaling-down reservoir size (including adoption of pondage-type reservoir).
	- Loss of flora/fauna/habitat in surrounding areas	- Education of project workers for wildlife conservation. - Provision of sufficient fuel for workers.

Table 9-3 Estimated Costs for the Implementation of Mitigation Measures and Monitoring Plan

Mitigation measure/monitoring item	Unit Cost	Hevale		Jalond		Marleshwar	
		Quantity	Cost (mil. Rs.)	Quantity	Cost (mil. Rs.)	Quantity	Cost (mil. Rs.)
1. Clearance of woody vegetation[1] (including salvage logging)	15,000 Rs./ha	90 ha	1.4	181 ha	2.7	204 ha	3.1
2. Compensatory afforestation[2]	30,000 Rs./ha	90 ha	2.7	253 ha	7.6	220 ha	6.6
3. Compensation for loss of agricultural land	25,000 Rs./ha	0	0	50 ha	1.3	32 ha	0.8
4. Watershed protection							
(1) Reforestation[3]	20,000 Rs./ha	12 ha	2.3	24 ha	4.8	62 ha	12.4
(2) Periodical monitoring[4]	3,000 Rs./ha/year	12 ha 8 years	2.9	24 ha 8 years	5.8	62 ha 8 years	14.5
5. Domestic water supply for villagers[5]	320 Rs./person/year	1,500 persons 8 years	3.8	1,200 persons 8 years	3.1	3,000 persons 8 years	7.7
6. Public heath protection							
(1) Dispensary[6]	1,000,000 Rs.	1	1	1	1	1	1
(2) Periodical monitoring including water analysis[7]	90,000 Rs./year	8 years	0.7	8 years	0.7	8 years	0.7
7 Wildlife protection (monitoring)	50,000 Rs./year	8 years	0.4	8 years	0.4	8 years	0.4
8. Landscaping	700,000 Rs.	Lump Sum	0.7	Lump Sum	0.7	Lump Sum	0.7
	Total Costs (mil. Rs.)		15.9		28.1		47.9

Notes:

1. Clearance area : Inundated area x 1.10% x vegetation area ratio (VAR)
   VAR: Hevale 100%, Jalond 70%, Marleshwar 80%
2. Compensatory afforestation area: Inundated forest area x 110%
3. Reforestation includes tree planting, provision of drainage system and other capital investments for watershed management and control.
   Reforestation area: Catchment area x 0.5 - 2%
   Hevale 0.5%, Jalond 1%, Marleshwar 2%
4. Reforestation work will be implemented at an early stage of construction, say, during the first two years. Monitoring work will focus on the reforestation area. The cost estimate for the monitoring work takes account of the work during the construction period and the first three years of operation.
5. Tanker water cost is assumed at 400 Rs. per 10,000 litters. Water requirement per person is estimated at 40 litters a day. It is assumed that the tanker water supply is required for 200 days a year during the entire construction period and the first year of operation. The water supply cost is estimated at 320 Rs/person/year.
6. Costs to set up a dispensary. (During the peak construction period, two dispensaries may be required, since there are two separate construction sites (i.e., upper and lower dam sites)).
7. Costs to operate a dispensary and to carry out monitoring work including periodical medical check for local inhabitants and water analysis.

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CHAPTER 10 STUDY IN THE FUTURE

10.1 General

This Study was started in September, 1994 to establish a pumped storage hydroelectric power development program which will be subjective to the feasibility study in the future for Maharashtra State, India. The objectives of the Study were to produce a Master Plan for pumped storage hydroelectric power development and to conduct a Pre-feasibility Study accordingly regarding the several candidate sites.

Ministry of Environment and Forests (MOEF), Maharashtra State, advised that two of the three sites subjected to the Pre-feasibility Study were situated in environmental protection areas. The Ministry also instructed the suspension of the geological site investigation at these sites (December, 1995). Although aerial photography surveys were made at the three sites in question, the Indian Government did not provide permission for the taking out the resulting topographic maps from the country. The pre-feasibility study could not be conducted in Japan as per the agreement between JICA and GOMID.

The Pre-feasibility Study shall be carried out in the next step based on the results of master plan and detailed site investigation which are compiled in this report.

General contents and approach of the Pre-feasibility Study are described in this Chapter.

10.2 Geology

The first priority of investigation is to make a 1/1,000 scale geological map of the project area.

For Jalond and Hevale the investigation for the preliminary design is needed. For Marleshwar, the investigation at places in question is needed because the rock mass condition is not good. The proposed geological investigation plan is as follows:

(1) Jalond Site

(a) Upper Dam Site

(i) Dam Site — Drilling: 80m x 5 locations
(including 3 drilling not yet started)

(ii)	Rock Test	5 samples x 5 location (kinds of test is proportionated to this investigation)
(iii)	Lugeon Test	26 x 5 locations
(iv)	Underground Power Station Site	450m x 1 location (Rock test: 10 samples)
(v)	Surge-tank Site	100m x 1 location (Rock test: 10 samples)
(vi)	Water-conveyance Conduit Site	100m x 3 locations (Rock test: 4 samples x 3 locations)
(vii)	Seismic Survey at Water-conveyance Conduit	1 km
(viii)	Quarry Site	100m x 3 locations (Rock test: 5 samples x 3 locations, Slaking test: 3 samples)
(ix)	Seismic Survey at Quarry	1.5 km

(b) Lower Dam Site

(i)	Dam Site	Drilling: 70m x 4 locations (100m grid)
(ii)	Rock Test	5 samples x 4 location (kinds of test is proportionated to this investigation)
(iii)	Lugeon Test	23 x 4 locations
(iv)	Adit	Dam site 1.5 x 2.0 x 30m x 2 locations, Sketching
(v)	In-situ Shear Test	1 x 2 locations x 2 sites
(vi)	Plate Load Test	1 x 2 locations x 2 sites
(vii)	Outlet	Drilling: 50m x 1 location
(viii)	Seismic Survey at Outlet	1 km
(ix)	Quarry Site	100m x 3 locations (Rock test: 5 samples x 3 locations, Slaking test: 3 samples)
(x)	Seismic Survey at Quarry	1.5 km
(xi)	Survey for Soil Material	Reconnaissance, Drilling: 3 locations (sampling and compaction test: 5 samples)

(2) Hevale Site

(a) Upper Dam Site

(i)	Dam Site	Drilling: 30m x 7 locations
(ii)	Rock Test	5 samples x 7 location (kinds of test is proportionated to this investigation)
(iii)	Lugeon Test	9 x 7 locations
(iv)	Underground Power Station Site	550m x 1 location (Rock test: 10 samples)
(v)	Surge-tank Site	100m x 1 location (Rock test: 5 samples)
(vi)	Water-conveyance	100m x 3 locations (Rock test: 4 samples x 3 locations) Conduit Site
(vii)	Seismic Survey at Water-conveyance Conduit	1 km
(viii)	Quarry Site	100m x 2 locations (Rock test: 5 samples x 3 locations, Slaking test: 3 samples)
(ix)	Survey for Soil Material	Reconnaissance, Drilling: 3 locations (sampling and compaction test: 5 samples)
(x)	In-situ Permeability Test	Vertical shaft ϕ 1.8m x 10m

(b) Lower Dam Site

(i)	Dam Site	Drilling: 70m x 4 locations
(ii)	Rock Test	5 samples x 4 location (kinds of test is proportionated to this investigation)
(iii)	Lugeon Test	23 x 4 locations
(iv)	Adit	Dam site 1.5 x 2.0 x 30m x 2 locations, Sketching
(v)	In-situ Shear Test	1 x 2 locations x 2 sites
(vi)	Plate Load Test	1 x 2 locations x 2 sites
(vii)	Outlet	Drilling: 50m x 1 location
(viii)	Seismic Survey at Outlet	1 km
(ix)	Quarry Site	100m x 3 locations (Rock test: 5 samples x 3 locations, Slaking test: 3 samples)

(x)	Seismic Survey at Quarry	1.5 km
(xi)	Survey for Soil Material	Reconnaissance, Drilling: 3 locations (sampling and compaction test: 5 samples)

(3) Marleshwar Site

(a) Upper Dam Site

(i)	Pond	Drilling: 45m x 5 locations
(ii)	Laterite Sampling	Triple tube sampler ϕ 120mm x 3 x 5 locations
(iii)	Laboratory Permeability Test	Laterite: 3 samples x 5 locations
(iv)	Laboratory Soil Test	Laterite: Index test, Unconfined and triaxial compression tests
(v)	In-situ Permeability	Laterite: Vertical shaft ϕ 1.8m x 10m, 3 tests
(vi)	Lugeon Test	3 x 5 locations (Basalt)
(vii)	Underground Power Station Site	600m x 1 location (Rock test: 10 samples)
(viii)	Surge-tank Site	100m x 1 location (Rock test: 5 samples)
(ix)	Water-conveyance Conduit Site	100m x 3 locations (Rock test: 4 samples x 3 locations)
(x)	Seismic Survey at Water-conveyance Conduit	1 km
(xi)	Quarry Site	100m x 3 locations (Rock test: 5 samples x 3 locations, Slaking test: 3 samples)

(b) Lower Dam Site

(i)	Dam Site	Drilling: 70m x 4 locations
(ii)	Survey for Ponding Area	Drilling: 70m x 6 locations
(iii)	Survey for Landslide	Drilling: 35m x 2 locations x 4 sites
(iv)	Soil Test	Index test
(v)	Stability Analysis	2 sections
(vi)	Monitoring	Pipe strain gauge 35m x 4 locations
(vii)	Rock Test	5 samples x 6 locations (kinds of test is proportional to this investigation)
(viii)	Lugeon Test	23 x 4 locations

(ix)	Galley	Dam site 1.5 x 2.0 x 30m x 2 locations, Sketching
(x)	In-situ Shear Test	1 x 2 locations x 2 sites
(xi)	Plate Load Test	1 x 2 locations x 2 sites
(xii)	Outlet	Drilling: 50m x 1 location
(xiii)	Seismic Survey for Outlet	1 km
(xiv)	Quarry Site	100m x 3 locations (Rock test: 5 samples x 3 locations, Slaking test: 3 samples)
(xv)	Seismic Survey for Quarry	1.5 km
(xvi)	Survey for Soil Material	Reconnaissance, Drilling: 3 locations (sampling and compaction test: 5 samples)

10.3 Hydrology

The hydrological parameters were analyzed by using the available data as summarized in Chapter 11. However, in fact, there is limitation in the data availability and the study results are not at a satisfactory level. It is to be noted that a further study is to be conducted to obtain more accurate hydrological parameters and utilize them for the subsequent detailed planning of the project. For these purposes, it is suggested to carry out the following surveys:

(1) Rainfall, river flow and sediment load shall be measured at the proposed sites.

(2) The monthly and daily rainfall data recorded at some stations which have been operated over a long period of time (30 years or more) by other organizations shall also be collected, if available.

(3) Hourly meteorological data such as vapor pressure, dry and wet temperature and so forth shall also be measured. These will be useful for PMP estimation.

10.4 Environmental Impact Survey

The major aim of this pre-EIA study is to conduct the environmental survey, assess the environmental impacts, identify mitigating measures and formulate an environmental management plan, comparatively for the three proposed sites of Hevale, Jalond and Marleswar.

However, further studies for the following issues are required because of the insufficient data obtained in this pre-EIA study.

(1) To conduct environmental survey, assess the environmental impacts, identify mitigating measures and formulate an environmental management plan based on the detailed topographic maps and land-use maps obtained from the aerial survey.

(2) To collect and survey examples relating to monetary compensation or alternative land for affected persons in other hydro-electric projects.

(3) To conduct additional environmental surveys along the transmission lines which were not performed by this pre-EIA study in spite of being essential facilities for hydro-electric power projects.

(4) To conduct a detailed survey relating to the distribution of wells, current use and water table, etc. around the proposed sites.

(5) To study the issues on the agreement process between the project proponent and the local inhabitants during construction (A community consisting of the worker's residence, schools and other relevant infrastructure will be generated around the proposed sites).

(6) To study the possibilities of committees relating to the preservation of Marleswar temple in Marleswar site.

(7) To study the adaptation of tree species to the existing vegetation of the proposed site for the case of transplantation or afforestation.

(8) To conduct a detailed survey on the latest legislation.

10.5 Power Survey

An extensive survey must be conducted concerning the power demand/supply projection of the power systems and all other relevant factors before introducing a pumped-storage power plant. The power supply plan survey contains a variety of particularly important study items, and this survey serves as the basic information for the plant planning. Following items should be studied and revised to develop the pumped storage hydropower project.

10.5.1 Power Supply Plan

(1) Survey of present power supply/demand conditions (re-examination)

(2) Power source composition survey and electric power development plan survey (re-examination)
(3) Study of load curves (re-examination)
(4) Study of pumping potential (re-examination)
(5) Studies of optimal capacity and commissioning sequence/time
(6) Power system analysis calculation
(7) Study of operation plan

10.5.2 Power Transmission Plan

(1) Survey of current status of transmission facilities (re-examination)
(2) Transmission facility expansion plan (re-examination)
(3) Determination of transmission line route appropriate to each project
(4) Feasibility study design of transmission lines for each project
(5) Cost estimation

10.5.3 Power Plant Design

(1) Preliminary designs of power plant layout and equipment
(2) Preliminary design of outdoor switchyard
(3) Preliminary design of related substations
(4) Cost estimation

10.6 Major Civil Works

(1) General

According to the results of power survey to set up the operation mode of pumped storage power plan (maximum output, duration of maximum output), the capacity of reservoir and dimension of civil structure will be determined.

First, the concept design of project planned at the master plan stage will be reviewed. The layout of project will be studied again in the next stage taking into consideration results of detailed site investigations whether the design concept at the master plan stage should be changed or not.

An optimum development scheme will be determined to study the project layout and structure in detailed.

(2) Schematic Design for Major Structures

The civil structures such as upper and lower dams, water way, power house and layout of generator, transformer and switch gear will be studied and determined. The above study will be conducted based on 1:10,000 scale topographical map and the results of all detailed site investigations.

(a) Dam and Reservoir

(i) Upper and lower dam

The major content for the schematic design of dams are the selection of the dam axis, selection of the dam type, selection of the spillway location, and the calculation of an approximate quantity of the work.

The type of dam employed is determined by the prevailing topography such as valley configurations, geology, construction materials, location of spillway and economic performance.

As for the hill-top type reservoir, an optimum earth moving plan should be determined taking into consideration a balance of excavation and embankment since excavated material will be utilized for embankment. The concrete facing with steel reinforcement will be 50 cm in thickness generally.

(ii) Spillway

The capacity of spillway and structure will be determined based on the design flood studied in Chapter 8.

(b) Water Way

(i) Headrace and tailrace tunnels

The final water conducting route will be finalized by considering the plane route and topography between the upper dam, lower dam and power house site, and also utilizing the geological data from the detailed site investigation.

And also a sufficient overburden above the tunnel should be checked for the stability of the tunnel.

The optimum tunnel section will be determined based on the generating energy and pumping up energy which are calculated from the loss head of water way and the construction cost.

(ii) Surge tunk

A surge tank will be provided at the before the penstock for the headrace tunnel and after the draft gate shaft for the tailrace tunnel, if the tunnel length exceeds 500 m to 1,000 m.

(iii) Steel penstock

The economical design point of view, the diameter of penstock shall be gradually reduced due to increasing the design head. 10 m/sec. In velocity will be applied at the end of penstock in generally.

(c) Powerhouse

An underground powerhouse will be expected in this project. The location of powerhouse will be determined by an integrated study of underground stability, engineering geological surrounding rockbed.

The location will be also taken into consideration lengths of headrace, penstock and tailrace tunnels as well as layout of access tunnel to powerhouse cable tunnel and construction method. Also dimension of powerhouse and elevation of turbine center will be determined based on the design of hydromechanical equipment.

10.7 Project Cost

Construction cost at pre-feasibility stage includes following items.

- Preparatory work
- Civil work
- Hydromechanical equipment
- Electromechanical equipment

- Transmission line
- Compensation
- Contingency
- Administration fee including engineering services

10.8 Construction Schedule

A construction schedule will be made taking into consideration the scale of project, construction method, locations of the structures and the hydrological/meteorological conditions. The conditions that cause critical pass for the schedule will be studied and the construction method will be studied and then the appropriate construction schedule will be planned accordingly.

10.9 Economic and Financial Framework

Difficulties are encountered by the mission to further specify the project parameters to proceed with financial analysis and evaluation due to the delay in processing of the JICA study. With this, this report provides an outline framework for financial and economic analyses with the associated parameters therein to the extent possible. Specifically, the financial and economic analyses on the prospective pumped storage hydropower project have been confined to the following scope; (i) analytical framework, (ii) analytical processing, (iii) model configuration and parameters, (iv) financial analysis, and (v) economic analysis. With this, no numerical analyses as reflected in financial internal rate of return (FIRR) and Equalizing discount rate (EDR) are presented in this report.

10.9.1 Analytical Framework

(1) Outline View

Economic analysis of the prospective investment project will be undertaken while using benefits and costs as measured in terms of scarcity of resources and allocative efficiency. In the meantime, financial analysis comes in place to measure profitability for project entity, while considering costs and benefit in terms of market value. Economic analysis will be undertaken on the same basic data as financial analysis with the modifications to covert from market value to border prices, notably CIF prices for importables and FOB prices for exportables. Conversion factors will be applied in valuation of non-tradable goods and services, while transfer payments which is a shift of claims on real resources from one member or sector of society to another without any change in the national income being excluded from financial costs.

(2) Least Cost Analysis

It is presumably considered that the prospective pumped-storage hydraulic power scheme would be the least-cost means of supplying peak load and also an integral part of the power system expansion program of MSEB.

(3) Benefits and Costs

Assuming that the expected demand for power must be met regardless of which sector investment in the economy be prioritized, an EDR analysis will be carried out in the feasibility study while explicit technical specification of the investment alternative under consideration being defined. An EDR estimate which equalizes the economic cost flows of the two alternatives, vis-à-vis, the prospective pumped storage hydropower plant and a peak adjustment coal thermal plant that deliver the same benefit will be compared with the opportunity cost of capital to confirm numerical superiority.

In the case of pumped-storage power projects, the variable recurrent costs and fuel costs accruable to base-load coal thermal/nuclear power supply for the project at night are to be incrementally added.

10.9.2 Analytical Processing

In carrying out the study, the following financial and economic analyses on the prospective pumped storage hydropower project would possibly be undertaken during the study period ahead:

(1) Estimation of EDR to determine which type of power investment (the prospective project and the alternative power generation) represents the best use of scarce resources given the decision to invest in power,

(2) FIRR calculation to forecast financial viability,

(3) Formation of Indicative Financial and Repayment Plans,

(4) Sensitivity analysis for variation in relevant parameters, vis-à-vis, (i) tariff, (ii) capital cost , and (iii) delay in project commissioning, and

(5) Financial and economic evaluation of the Project based on the numerical superiority as reflected in FIRR and EDR (alternative EIRR).

10.9.3 Model Configuration and Parameters

(1) Project Life

Currently, the total project life will be set at 30-40 years inclusive of loan periods.

(2) Tariff (Revenue)

Taking into account that major consumers for GOMID include farmers and agro-business entities, it would be possible to accept apply 50.0 paisa/kWh in the analysis due to the firm commitment of State government to raise electricity prices for farmers as per the long-run marginal cost of electricity supply.

(3) Sales Volume

In carrying out the analysis, sales volume of electricity would be postulated as per the following formula, while taking MSEB and GOMID revenue projections into consideration.

Q = Average power generation x (1-Transmission loss) x (1-Auxiliary use)

(4) Foreign Exchange Quotation

Conversions of the Indian Rupees to the US dollar, unless otherwise noted, in early 1997 was Rs.35.43 to one dollar. This rate is presumably assumed to represent the maximum value that the domestic currency would be worth under the market conditions for the time being.

(5) Financial Cost Estimation

The financial costs comprise base cost (capital cost) inclusive of taxes and duties, physical contingencies, price contingency, and interest during construction as measured in constant prices. The capital costs will be reconcilable with the base costs and physical contingencies, but with the exclusion of price contingencies and interest during construction in FIRR calculation.

(6) Physical Contingencies

Reflecting expected increases in the base cost estimates of a project due to changes in quantities and methods of implementation, physical contingency allowances will be set at 5-10% of the base cost of the Project.

(7) Price Contingencies

Price contingency allowances will in most cases be set at 5-10 % of initial investment. This margin may be subject to further review.

(8) Recurrent (O/M) Costs

Annual O/M costs associated with the project in operation is apt to set at 3-5 % of the initial investment.

(9) Financial Terms

The Japanese aide agency currently assumes 30 years of repayment inclusive of 10 years of grace at the interest rate around 2.6 percent, whereas international lending agencies assume 20 years of repayment including five years of grace period with around 6-7 % of interest rate.

(10) Interest During Construction (IDC)

It is to be noted that IDC does not accrue to yen-credit because of its lending policy of interest payment during construction due to debt service covenant. It neither be included in FIRR calculation.

(11) Discount Rate

Discount rate would be assumed to be around 10 % while taking into account the real term capital cost as of the end of 1996 in India. This figure may be subject to further review.

10.9.4 Financial Analysis (Project sustainability)

Profitability associated with the project will be measured by financial internal rate of return (FIRR). Nonetheless, project accounting analysis was not fully be prepared at the time of fielding in 1994 due to lack of best relevant accounting information/data of GOMID.

(1) Tariff

The current electricity price for the agriculture sector is 27.0 paisa/kWh. While taking into account that major consumers for GOMID include farmers and agro-business entities, it would be possible to apply 50.0 paisa/kWh in the analysis due to the firm commitment of the state government to raise electricity prices for farmers as per the long-run marginal cost of electricity supply.

(2) Financial Internal Rate of Return (FIRR)

Financial viability of the project will be measured by FIRR in the time-discount cash-flow method. With a view to self-financing future investment costs at the maximum currently in place. GOMID will be expected to generate FIRR reasonably equivalent or close to the current opportunity cost of capital of about 10 percent.

(3) Sensitivity Analysis

Sensitivity analysis for variation in relevant parameters, vis-à-vis, (i) lower tariff by 10 percent, (ii) capital cost over-run by 10 percent, and (iii) one year delay in project commissioning will take place to indicate resiliency against the risks as specified above.

10.9.3 Economic Analysis

Economic analysis will be undertaken on the same basic data as financial analysis with the major modifications that follow.

(1) Transfer Payment

Transfer payment which is a shift of claims on real resources from one member or sector of society to another without any change in the national income will be excluded in the EDR estimation.

(2) Conversion Factors for Economic Costs

To date, Standard Conversion Factor (SCF) and conversion factor for unskilled labor in use by World Bank and the Study team are 0.8 and 0.52, respectively.

(3) Equalizing Discount Rate (EDR, Alternative EIRR)

An EDR estimate equalizes the economic cost flows of the two alternatives, vis-à-vis, the prospective hydropower plant and a peak adjustment coal thermal plant (or gas-turbine power plant) that deliver the same benefit. EDR will be compared with the opportunity cost of capital to reveal its numerical superiority.

(4) Sensitivity Analysis

As is the case of financial analysis, sensitivity analysis for variation in relevant parameters, vis-à-vis, (i) lower tariff by 10 percent, (ii) capital cost over-run by 10 percent, and (iii) one year delay in project commissioning will take place to indicate resiliency against the risks as specified above.

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