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BALANTHODU
MINI HYDROELECTRIC PROJECT
2 x 125 kW

DETAILED PROJECT REPORT

for

UNIDO Regional Centre for Small Hydropower

JANUARY 2007

CONTENTS

PREFACE

UNIDO (United Nations Industrial Development Organisation), through its project No.US/IND/03/002 has established a Regional Centre for Small Hydro Power in Thiruvananthapuram, Kerala, India, on 4 April 2003. at the Energy Management Centre, under Department of Power, Government of Kerala, UNIDO Regional Centre (RC) would like to ensure that this project, initially designed for a period of three years, paves the way for several micro, mini and small hydro projects to be implemented in Kerala, rest of India and in the South Asia region.

The aims and objectives of establishing this project is to further strengthen the Small Hydro Power related activities of the Energy Management Centre. With the establishment of the Centre, several renewable energy related awareness building and training programmes were conducted, to promote and accelerate sustainable development. It will facilitate the design of cost effective Renewable Energy Technologies using locally manufactured equipment, materials, labour, and organizing consultancy services on comprehensive aspects of renewable energy systems and small hydropower development.

One of the planned activities of the UNIDO Regional Centre project is to develop bankable Detailed Project Reports during the initial duration of the project.

One of the envisaged specific activities of the Regional Centre is developing programmes and projects related to the development of SHP for promoting and accelerating sustainable development through creating replicable income generating activity models and Community Development Centres (CDC) for remote rural areas. The RC kicked-off such an endeavour in Mankulam, an un-electrified Panchayath in Kerala, which is an agricultural resource rich village in the Idukki district, devoid of communication facilities. This is done in association with the local self Government of this Panchayath.

During 2001, with the objective of generating power for the lighting needs of the local community, the Panchayath initiated implementation of a 100 kW micro hydropower scheme at Pampumkayam, with a catchment area of 8 sq. km. The Honourable Minister for Power, Govt. of Kerala, inaugurated the project for power supply in October 2004.

Also, the investigation team of EMC has made reconnaissance site visits to various potential mini hydropower project sites within the Mankulam Grama Panchayath area during the first week of November 2004 along with the representatives of the Panchayath. The total population of the Panchayath is around 15,000 out of which 25% of the population belongs to scheduled tribe category.

The initiative of the Regional centre, with the help of Energy Management Centre the Investigation for reconnaissance and site visits to various mini hydropower projects have been made. The following potential sites have been further identified and detailed investigation completed. The schemes developed are

1. Kozhiyilakuthu - Mankulam Grama Panchayath (DPR Completed)
2. Kilikkaithodu - Mankulam Grama Panchayath (DPR Completed)
3. Padivathil - Naranammozhi Panchayath (Ranni Block) (DPR Completed)
4. Panamkudantha - Naranammozhi Panchayath (Ranni Block) (DPR Completed)
5. Rasathikuthu - Mannamkandam Panchayath (Adimaly Block) (DPR Completed)
6. Rajamudy - Pallivasal Panchayath (DPR Completed)
7. Balanthodu - Vannapuram Panchayath
8. Peechad - Vannapuram Panchayath

The Balanthodu Mini Hydro Electric Project is proposed in Balanthodu stream in Muvattupuzha basin and is located in Thodupuzha Block. The installed capacity of the scheme is 250 kW with an annual energy generation of 1.198 Mu.

The KSEB grid is yet to reach the village and the only power grid available is the 11kV evacuation line of KSEB available at a distance of about 3.5km away from Balanthodu. Another project can be envisaged at Edathanalkuthu a tributary of Kotamangalam Ar, which gets joined with waters of Balanthodu to form Kotamangalam Ar. The power generated from the different schemes of the Panchayath can be connected together to form a local grid serving the whole population in the Panchayath, and excess power sold off to KSEB.

After making site visits, reconnaissance studies and conducting topographical investigation works it is seen that the scheme is technically feasible. Thereafter, detailed study has been made and report prepared. As per the report the cost of generation from this project is Rs2.24/Unit. Therefore this project is deemed financially viable.

BALANTHODU MHP

PART – I
GENERAL REPORT

CHAPTER - I

SALIENT FEATURES

1. Location		
1.1	***State***	Kerala
1.2	***District***	Idukki
1.3	***Thaluk***	Thodupuzha
1.4	***Panchayath***	Vannapuram
1.5	***Access***	
	a. Road	30 km to Mullaringkadu from Thodupuzha, then 3 km jeep road to PH site
	b. Rail	Kochi
	c. Airport	Kochi
	d. Harbour	Kochi
1.6	***Geographical Co-ordinates***	
	Latitude	9°59.5' N
	Longitude	76°49.5' E
2. River		
2.1	*River*	Balanthodu, a tributary of Kotamangalam Ar.
2.2	*Basin*	Muvattupuzha
3. Hydrology		
3.1	*Catchment Area*	3.5 sq. km.
3.2	*Mean annual rainfall*	4163 mm
3.3	*Nearest rain gauge station*	Thodupuzha (Malankara Plantations)
3.4	*Nearest river gauging station*	Karimanal
4. Component Structures		
4.1	***Diversion Structure***	
	i. Type	Gravity Weir with un-gated overflow portion
	ii. Length of weir	30m
	(a) Overflow portion	15m
	(b) Non Overflow portion	10m length on Left side and 5m on right side of overflow portion
	iii. Deepest Bed Level	193.00
	iv. Excavated level	192.50
	v. Top width of non -overflow portion	1.00 m
	vi. Shape of the overflow	Ogee (Parabolic with vertical u/s face)

	portion	
	vii. FSL	+195.00
	viii. Energy Dissipaters	Type II Stilling basin (IS)
	ix. Height of Weir at deepest bed level at overflow portion	2.00 m
	x. Top level of Non-overflow portion	+196.30
	xi. Size of river sluices and gate	0.5m dia, on right bank, with 1.00 x 1.00 m gate
4.2	***Intake***	
	i. Location	On Left bank non overflow portion of weir
	ii. Type	With concrete column support and steel racks
	iii. Sill level at intake	+193.50
	iv. Size of Intake gate	1 x 1 m
	v. Control of gate	Manually operated vertical lift gates.
	vi. Floor level at Intake	+193.00
4.3	***Low pressure Pipe***	
	i. Shape and width	Circular, 0.60m dia
	ii. Size	150 m (Length)
	iii. Bed slope	1 in 500
	iv. Design discharge	0.299 m^3/sec
	v. Inlet bed level	+193.50
	vi. Outlet bed level	+193.20
	vii. Velocity	1.06 m/s
	viii. FSL	+195.00
4.4	***Forebay***	
	i. Type	R.C.C rectangular tank with compartments
	ii. Size	8 x 4 x 4.50 (L x B x D)
	iii. Wall Thickness	50 cm
	iv. F. S. L	+195.00
	vi. M. D. D. L.	+193.00
	vii. Top of Tank	+195.50
	viii. Bottom level of tank	+191.11
	ix. Control gate	Electrically operated vertical lift gate (1.5x1.5)
	x. C/L of penstock intake	80.00

4.5	*Penstock Pipe-(Steel Pipe)*	
	i. Number	1 No.
	ii. Diameter & Length	0.50m dia & 600 m long
	iii. Thickness of pipe	8 mm uniform
	iv. Design discharge	0.299 m^3/s
	v. No of feeder lines	Main penstock line bifurcating at PH end to feed 2 turbines (2 Nos. 40cm dia)
	vi. Max. velocity	1.52m/sec
4.6	*Power House*	
	i. Type	Over Ground
	ii. Head (Net Head)	107.00 m
	iii. Elevation of C/L of turbine	+80.00
	iv. Floor level of M/C hall	+79.34
	v. Tail water level (*normal*)	+78.84
	vi. Size	
	i. Length	7.0 m
	ii. Width	6.0 m
	iii. *Height*	8.0 m
	iv. Installed Capacity	250 kW
	v. Turbine type	Horizontal Pelton turbine
	vi. No. of units & capacity	2 x 125kW
4.7	*Tail Race Channel*	
	i. Shape	Rectangular with rubble masonry sidewalls
	ii. Length	15 m
	iii. Size	1m x 1m
	iv. Sill level of channel at exit	+78.84
4.8	*Power Evacuation*	
	i. Transmission lines	Power Generated will be transmitted through 11kV line for 2 km length
	ii. Local distribution	Approximately 2km of L T line
5. Power Benefits		
5.1	*Annual Energy generation*	1.198 Mu
6. Financial		
6.1	Total Cost of project	Rs. 194.40 Lakhs (incl. of distribution lines)
6.2	Cost per kW installed	Rs. 77760 /-
6.3	Cost of generation/ unit	Rs. 2.24 (incl. of local distribution lines)

CHAPTER - II
INTRODUCTION

Balanthodu waterfall is located in Balanthodu stream originating from Suraikattu Mudi at an altitude of 811 m. The stream drains into one of the main tributary of Muvattupuzha River. The Project site is located in Vannapuram Panchayath near Thodupuzha town - about 33 kms. The site is characterised with its high head and reasonably good summer discharge of approximately 0.08 m^3/s. The gross head of this site is estimated to be about 115m. The design head after deducting the losses comes to 107m. Further an additional head of about 20m is also available down stream portion of the present powerhouse site. This area is in forestland. To protect the thick growth of forest-land and to get easier environmental clearance the present site is selected for this project.

The Panchayath is electrified leaving apart from a few locations similar to the one near Mullaringkadu where this project is located. In addition there are a few Pico hydro equipments by individuals run on motorbike dynamos with batteries. The total population of the Panchayath is around 15,000 out of which 20% of the population belongs to scheduled tribe category.

Exposed rock available is through out the stream. An overflow type weir is proposed to be located in the stream at about 50m away from the bridge near the jeep track from Mullaringkadu to Pattayakudi a tribal settlement. The spilled water will not make any problem because the water emerges after energy dissipation. The project will not cause any forest submergence with the proposed weir having a height of 4 m from the river bed level. The Intake position is fixed at left bank in the Non-overflow block. A. Scour sluice is also provided to remove silt accumulated in the reservoir. Regarding the water conductor system, a Low pressure pipe is proposed to carry water in to the forebay. The alignment of this Low pressure pipe is located in the left bank of the stream over the rock out crop. The forebay of the project and part of the penstock are also aligned along the route mentioned above. The power house location is fully in private land. The tail water is let in to the existing valley stream, which is in forest land. This project envisages 11kV power evacuation line with around 2 km to distribution locations.

The capacity of the scheme is 2 x125 kW. The capacity is selected after detailed study of the availability of water in the stream by correlating the discharge readings obtained from the nearest catchment of the Lower Periyar Hydroelectric project.

Investigation of the site has been done and many alternatives have been studied for fixing the weir location. The weir is fixed at a suitable location 50 mts away from the present jeep track which is presently used for transport from Mullaringkadu to Pattayakkudi. The project area is selected in such a way to avoid forest completely. On detailed study it is seen that another fall is also available after the powerhouse location. But for this project this head cannot be utilized due to the special nature of the terrain. This fall can be considered as a second stage in a later stage if necessary.

From the forebay a penstock having a length of about 600m, 50cm dia have to be installed for the generation of power. The turbine selected is Hori: Pelton turbine to suit the available head and discharge. The machines selected are with denomination of 2 x 125kW, as this is the optimum size, which can cater to a lean flow in the dry seasons as well.

The total estimated cost of the project is 1.944 Crores and cost per kWh is Rs. 2.24 with a pay back period of 11 years. This is economically viable and better to implement at the earliest. There is no eviction and 0.50 Ha of private land is involved in the power house and water conductor system. A simple intake with vertical lift gate is proposed on the left bank of the river through the non-overflow portion of the weir. An LPP (hdpe pipe) having a length of 150m is proposed for carrying water to the forebay from the intake. A scour sluice is also provided in the left bank of the river adjacent to the intake structure to remove the silt, which may be deposited near the intake. Three minutes storage is proposed in the forebay considering the high head of the stream. The main attraction in the scheme is the availability of head of about 100m. The hydrology of the scheme is worked out based on the rainfall records and also by comparing the inflow available from the nearest catchment of Lower Periyar HEP. The total catchment area of the stream is 3.5 km^2 and average annual rainfall is 4063 mm. The hydrological calculations are made based on the data availed Karimanal Gauging station owned by KSEB and that of the rainfall details availed from Malankara Plantations, Thodupuzha. For computing the summer discharge attempt has been made to correlate the measured lean period discharge at Mullaringkadu.

An approach road up to the powerhouse site and about 50m away from the weir site are available.

The main components of the structures of the project are

1. Concrete weir of length 30m. The overflow portion is 15m and Non-overflow portion of 10m on left and 5m on right bank.
2. A gated intake having an opening of 1.00x1.00m is provided at the Left bank, through the non-overflow portion.
3. A gated out let arrangement having 50cm diameter is also provided to remove silt accumulated in the reservoir portion.
4. The main water conductor system is a Low pressure pipe having a length of 150 m and having a diameter of size of 60 cm is proposed to carry water up to forebay
5. A forebay with 3 min storage having a size of 8 x 4 x 4.5 m is provided in order to get sufficient quantity of water during the full load and overloaded periods of the machine.
6. A surplus channel having size 2.5m x 0.5m is to be provided to take away the water during sudden load rejèction near the forebay.
7. A penstock having a dia of 50cm and thickness 10mm having a length of 600 m is to be provided and bifurcated near to the powerhouse.
8. A powerhouse having a size of 9 x 7x 8 m is to be provided
9. A tailrace channel of length 15 m have to be cut and lined for the safe flow of water back to the river without being affected by the high flood conditions.

CHAPTER - III
SURVEY AND INVESTIGATION

Reconnaissance survey was first conducted along the course of Balanthodu stream. This survey revealed that the stream upstream of the weir site is passing through moderate slope to steep slope terrain. The contribution of the high head potential due to this waterfall in the stream is the unique advantage for selecting this portion of the stream for hydropower generation.

The idea behind the field investigation was to utilise the water availability and the head potential to the optimum extent possible, after taking into consideration of all factors affecting the project, such as engineering, environmental, social, economical and especially forest. The position of powerhouse selected in such a way to avoid forestland completely. The additional head available has been sacrificed in order to avoid thick forestland

A detailed investigation was carried out independently for this project after conducting preliminary field investigation and environmental studies. Taking into account of possible impact on the forest, it was decided to carry out construction activities in private land.

The land lying on the right bank of the stream is private land. A portion of the land has been kept unutilised, since the area is lying near the boundary of Thodupuzha Reserve forest. The private area is owned by the people in and around Mullaringkadu. This land is being used for cultivating pepper, rubber, areca nut and other cash crops and other agricultural produces by farmers. Data collected through reconnaissance study, reveals that the water conductor system, and powerhouse etc can be located on the Left bank of the stream, without having any impact on the forest, the tribal people and settlement system. The water conducting system is a Low pressure pipe (HDPE pipe) which can be laid over exposed rock near the weir site.

Since no level benchmark is established at this site, an arbitrary benchmark value assigned at the top of the waterfall by using digital altimeter. This value confers with the spot level value shown in the Survey of India topo sheets as well as the reading taken at the weir site. A preliminary topography survey is carried out covering the project area which is purely on the right bank of the stream. The level difference of the ground at the top of the waterfall and the powerhouse site comes to 115 meters, i.e., (195.00 – 80.00). Alternate proposals with weir site and P.H site at various levels were studied and it is concluded that the present proposal is the best without disturbance of forest.

Topography survey covering the whole project area was completed. A copy of the survey drawing is enclosed. Survey conducted along the alignment of water conductor system in the right bank. Alternate routes for the water conductor system were studied and a combination of Low Pressure pipe and penstock is proposed.

Cross section of the stream at weir site, and powerhouse sites are taken. A survey of the penstock route is also conducted. The powerhouse site is easily approachable with pedestrian track of 50m from tarred road. The site for LPP, forebay tank, and penstock pipe are also selected on the Left bank of stream.

Preliminary property survey conducted revealed that there is no necessity of eviction and also no resettlement requirement due to the project. The project area is partly in private land and vested riverine forests.

CHAPTER – IV

HYDROLOGY

Mullaringadu is located in Vannapuram Panchayat in Idukki District. This place is about 33 km distant from the Thodupuzha and approachable by good tarred road. Mullaringadu stream is a tributary of Muvattupuzha river. The stream is formed by two other streams called Edathanalthodu and Balanaduthodu.

Balanthodu Mini Hydro electric Scheme envisages the utilisation of water from Balanthodu stream, the primary tributary of Muvattupuzha River originating from Suraikattu mudi at an altitude of 811 m. The Balanthodu stream flows in the north-west direction before joining to Edathanalkuthu (kotamangalam thodu) and thereafter flow westwards. A temporary river gauging was established in the in the stream after its confluence with Kotamangalam thodu. The rain gauge readings available are, rain gauge station maintained by Malankara Plantation at Thodupuzha. The monthly rainfall readings of rain gauge station at Malankara Plantations, Thodupuzha from 1995 to 2003 were collected & attached in Table-1.

The Hydrology of the project has been arrived after considering the hydrology of Malankara Mini hydro project which is at Thodupuzha sanctioned by Kerala Government recently for implementation by private owner for captive use, for detailed study in correlation with data availed from Lower Periyar Hydel project of KSEB. A rainfall run-off correlation was arrived based on the rainfall data at Malankara and that at Lower Periyar and thereafter the regression equations were compared with the gauge data at Mullaringkadu downstream of Balanthodu. Based on these comparisons the gauge data collected were roughly matching with that of the 50% dependable year. Hence the gauge data at site of year 2000 was used for the power potential studies.

Project site is located very near to Mullaringkau by about 4 km. The site is characterised with its high head and reasonably good summer discharge of approximately 0.08m^3/s.

The discharge in the stream has been computed proportional to the catchment areas based on the inflow readings as explained above is tabulated in Table-II. On computation from the monthly discharge it can be seen that

The average discharge of six months (monsoon period) is

1. For 10 years (1997 to 2006) = 0.41 m^3/s
2. 50% dependable year (2000) = 0.39 m^3/s

Considering the lean period discharge and the a factor for evaporation losses and other utilisations, the power potential study has been conducted for 50% dependable year and the installed capacity is fixed as 250kW. Considering 10% overloading of turbine & generator the required discharge will be 0.299m^3/s.

Maximum flood estimation

Flood estimation is done using Ryve's formula, $Q_{max} = C(A)^{2/3}$.
This project site is at about 80km from the seacoast. Hence the coefficient is taken as 8.45. Therefore $Q_{max} = 8.45 \times (3.5)^{2/3} = 19.48\ m^3/s$. This discharge is considered for the design of overflow portion of the weir.

Water utilisation

On observing the present condition of the river it is seen that water is available in good quantity during monsoon period and very small quantity during summer months. The average discharge during summer month is 0.08m^3/s. The water after power generation is let into the same stream. No hindrance will be brought down on the inhabitants after commissioning of the scheme.

Water quality and sedimentation

Since the project is designed as a run of the river scheme no problem due to siltation will be expected. However silt exclusion arrangements have been made in the dam body near the intake portion. Water is of good quality and people are using this water for drinking purposes directly.

Climatological parameters

The climate is generally moderate, with normal temperature of 28°C. The average annual rainfall is 4163 mm. Good Rainfall is available from May to November. This scheme is a run of the river scheme and power generation is intended during monsoon season only.

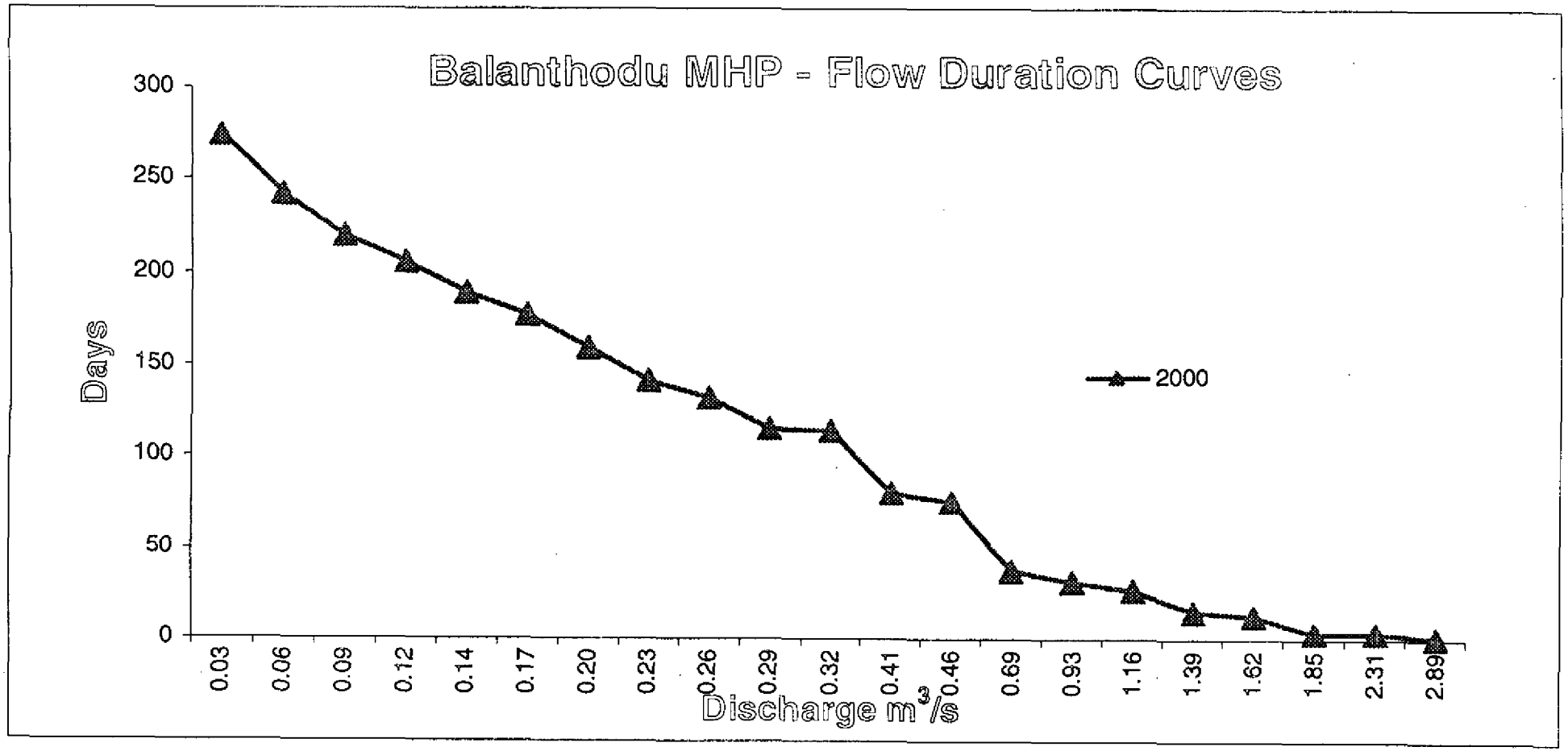
Table – I → Monthly rain fall data from Malankara Plantations, Thodupuzha in mm

Year / Month	1995	1996	1997	1998	1999	2000	2001	2002	2003
January	0	19.558	8.382	58.674	0	22.86	0	0	0
February	0	18.542	0	15.748	13.716	110.236	92.71	21.844	27.94
March	0	14.986	112.522	82.55	110.998	42.164	110.49	136.906	361.696
April	313.182	515.366	177.038	295.656	254	166.37	318.262	261.874	96.52
May	611.886	114.046	445.77	460.502	797.56	133.858	226.568	440.69	194.818
June	709.422	682.752	500.126	902.462	579.882	884.174	1081.278	586.232	557.022
July	757.936	962.66	1157.732	615.696	845.312	355.854	892.302	507.238	667.512
August	763.778	560.578	562.864	702.31	250.952	1046.988	300.482	649.478	609.346
September	336.804	566.42	275.082	801.624	247.65	351.282	280.416	110.998	128.524
October	284.988	618.49	549.91	716.534	989.33	213.106	434.848	593.344	812.8
November	237.236	248.666	477.774	0	71.374	56.134	261.112	173.99	69.596
December	0	72.898	57.912	227.584	221.742	44.45	34.036	32.004	69.596
TOTAL	4015.232	4394.962	4325.112	4879.34	4382.516	3427.476	4032.504	3514.598	3595.37

Mean annual rain fall = 4063 mm

Table - III. Computed Monthly Inflow of Balanthodu Catchment (In Mm^3) Catchment Area 3.5 km^2

Year	January	February	March	April	May	June	July	August	Septembe	October	November	December	yearly total	
1997	0.077	0.054	0.145	0.597	0.826	3.511	3.986	1.622	0.872	0.513	0.298	0.168	12.668	
1998	0.054	0.034	0.102	0.410	0.570	3.003	2.116	1.414	0.512	0.229	0.210	0.117	8.770	
1999	0.053	0.034	0.098	0.386	0.536	2.168	2.929	0.881	0.443	0.341	0.255	0.109	8.231	
2000	0.037	0.218	0.090	0.583	0.449	3.566	1.830	0.201	0.469	1.621	1.000	0.021	10.085	*50% Dependable*
2001	0.075	0.053	0.150	0.593	0.818	2.640	3.158	3.023	0.848	0.788	0.278	0.165	12.585	
2002	0.050	0.034	0.097	0.396	0.547	1.540	3.467	0.896	0.324	0.829	0.122	0.109	8.411	
2003	0.063	0.042	0.125	0.512	0.700	1.975	1.714	2.362	1.515	1.055	0.648	0.146	10.858	
2004	0.061	0.039	0.116	0.474	0.656	1.323	2.475	2.255	1.781	0.303	0.480	0.132	10.093	
2005	0.084	0.054	0.161	0.643	0.887	2.930	3.420	1.331	1.752	2.027	0.207	0.176	13.671	
2006	0.080	0.048	0.151	0.613	0.844	3.789	2.738	1.735	1.138	1.504	0.223	0.167	13.029	


Balanthodu MHP - Flow Duration Curves
Days
300
250
200
150
100
50
0
2000
0.03
0.06
0.09
0.12
0.14
0.17
0.20
0.23
0.26
0.29
0.32
0.41
0.46
0.69
0.93
1.16
1.39
1.62
1.85
2.31
2.89
Discharge m³/s

CHAPTER - V
GEOLOGY

The project area belongs to the typical formation of Western Ghats. The rock type in these ranges belongs to metamorphic nature, with more presence of Granitic Gneiss & Charnokite.

The dominant rock type at the weir site is gneiss. Exposed rock is seen at weir site and also and also along the portion of LPP. The bed of the waterfall is solid rock with small potholes due to the effect of falling water. Hence no geological exploration by core boring is carried out at weir site. The powerhouse is proposed on the right bank of the stream. Here the stream flows through a moderately level bed. Hence the riverbank is formed by the accumulation of river cobbles and pebbles carried through the water in flood. In powerhouse area also rock is expected at a reasonable depth.

General geology is suitable for weir site, Fore-bay, powerhouse site and water conductor system. Borehole details have to be obtained before the construction of fore-bay, and Power house.

CHAPTER – VI

NEED & NECESSITY OF THE PROJECT

Idukki District in general and the project area in particular is one of the most exquisite ecological and natural resource regions in Kerala. It is one of the natural resource regions where hydrological, forest and agricultural resource systems symbiotically co-exist, providing an optimum and adequate opportunity for initiating comprehensive sustainable development initiatives. As far as the agricultural potential and bio-diversity is concerned, the project area presents a dynamic and encouraging scenario/picture. It is also encouraging to note that the agricultural and forest ecosystems of this area together provide an enduring support base for a variety of medicinal plant wealth. The agricultural cropping pattern is especially compatible with developing different value added micro/small industrial/ enterprise systems. However, the full developmental benefit/potential could not be realised due to the non-availability of electricity. The existing electricity distribution network which is six km away, in an extremely undulating topographical background, could not be extended to this project settlement region because of prohibitive infrastructural and investment cost.

Even though the project impact settlement system is a robust ecological region, in the summer months water scarcity is a serious problem. It is paradoxical that when water as a basic resource is physically available, it could not be made use of for agricultural operation because of the peculiar topographical formations. If electricity is made available, the locally available water resource could be systematically channelled towards agricultural and human welfare/development objectives.

It is most disturbing that a major part of agricultural produce (especially vegetables and fruits) and milk is destroyed due to the lack of opportunities for electricity-based preservation and value-addition.

In the context of health, education and cultural development, especially the project impact area suffers significantly as no electricity based support system could be developed. The main beneficiaries are tribal population (40%) who are below poverty line. Absence of electricity supported social, economic and infrastructure (like home and street lighting systems, milk, vegetable and fruit preservation systems, value added processing using locally available rubber, fruits and vegetables etc.) as such became a permanent bottleneck in the development of this region. The non-availability of electricity also became a barricade in people living in the settlement region getting the cultural, educational, health and psychological benefits of modern technology. If electricity is made available to this region it could lead to optimum sustainable utilisation of these resources through preservation and value added processing initiatives. Such value added programmes and production of new plant based medicines will also help to improve the nutritional and health status of the people.

The reconnaissance survey and personal discussion which the Engineers of EMC had with the local people also reveal that the availability of electricity will significantly help develop/initiate micro/small enterprises like rice mill, flour mill, oil mill etc. including facility for semen preservation and artificial insemination for veterinary development. Further, the availability of electricity could help/develop eco-tourism in this area, resulting in an overall and comprehensive socio-economic, cultural and educational development of population especially the poverty stricken tribal who are facing seasonal unemployment and perpetual under - employment.

EMC-UNIDO-RC team has also identified that the absence of electricity to a greater extent prevented the process of providing the people residing in this settlement with adequate health and educational facilities. The team further found that the non-availability of electricity became a limiting factor in deriving the full advantage of health and educational facilities to the people of the settlement region. Also the absence of electricity became a stumbling block in providing the benefits of information and entertainment to the people of the project impact-area, which ultimately turned out as a permanent bottleneck in the process of cultural and educational advancement of the people.

Therefore, the reconnaissance survey and social contact programme (socio-economic and ecological/environmental) organised by the EMC,UNIDO-RC categorically identify that the development of the two mini-hydel systems (Balanthodu and Edathanalkuthu) will result in comprehensive sustainable development of the project region.

This report is the result of a sparkling example of such an effort from UNIDO. The Balanthodu Mini Hydro Scheme is located In Vannapuram Panchayath, Thodupuzha Block, in Idukki District. The two streams Balanthodu and Kotamangalam join at Mullaringkau, and thereafter flows on to form the Kotamangalam Ar which merges with Muvattupuzha River as a tributary. The capacity of the scheme is 250KW with an energy generation of 1.198Mu. Considering the importance of energy especially in this region the project have to be implemented early.

CHAPTER - VII

CONSTRUCTION MATERIALS AND PROGRAMME

(a) Materials

For the construction of this project, the materials that are locally available as well as materials to be transported from elsewhere in the State can be utilised.

Source and availability

Rubble is available at the project site. An aggregate processing plant is proposed to be established near the Power House site. The coarse aggregates and fine aggregates can be produced at the plant using the rubble quarried here. Even though river sand is available in some part of the river, in the light of the environmental impact, as for as possible sand mining can be avoided. Hence crushed sand is proposed for construction purpose.

The project area is accessible through road and there will be no difficulty to convey Cement and Steel materials by Lorry. Tor-steel for reinforcement of concrete and steel plates for the fabrication of control gates, sluice gates, trash-racks and Penstock pipe and structural steel section for switchyard, etc can be brought from Kothamangalam or Kochi by lorry.

Turbines and generating equipments if to be imported, these can be shipped to Cochin Port. From there, these items can be brought to site by lorry.

(b) Programme of Construction

Balanthodu Mini Scheme is proposed to be constructed under the guidance of UNIDO-RC and the work can be executed on contract basis. The proposed execution will be either a turnkey contract or separate contract for civil work, penstock fabrication & Erection work, Fabrication of Gates and its erection, Purchase and erection of Hydro mechanical Equipment etc. The quality control and the supervision for the entire work will be under the guidance of UNIDO-RC.

A Bar chart showing the starting and completion of various activities connected with the implementation of this project is attached with this project report.

The main activities involved are

1. Project Sanction including Finance
2. Marking Project Profile and fixing boundaries

3. Detailed design of the component Structures
4. Land acquisition
5. Preparation of tender documents
6. Tendering and award of Contract
7. Preliminary works, Access roads and infrastructure facilities.
8. Procurement of construction materials
9. Excavation of weir and intake.
10. Excavation of Fore Bay and surplus channel
11. Excavation of Penstock and anchor block.
12. Excavation of Power House, Tail Race and Switch Yard etc.
13. Concreting of weir
14. 1st Stage Concreting and roofing of Power House
15. Concreting of Anchor block and Erection of Penstock
16. Supply and erection of HDP pipe including excavation
17. Concreting of Fore-Bay and surplus Channel
18. Concreting of Tail Race & Switch yard
19. Supply and erection of T & G equipments, substation equipments etc
20. Erection of Machinery 1st stage
21. PH second stage concreting
22. Supply and erection of Gates and valves.
23. Fabrication and erection of Penstock
24. Final Erection of Machines
25. Construction of 11 KV transmission line.
26. Testing, Balancing & Commissioning

It is targeted to complete the construction activities, erection of T & G equipments and conduct trial running of the generators within 18 months from the date of awarding contract.

Multi-face activities are proposed. All the civil construction works will be carried out simultaneously to achieve the target. The entire activities of the project implementation will have to be monitored by an expert team of engineers.

CHAPTER - VIII

ENVIRONMENT AND ECOLOGICAL ASPECTS

Balanthodu M H P is formulated as a run off the river scheme. As such no pondage (reservoir) is envisaged in this scheme. The minor storage proposed is to accommodate the power intake for taking water safely to the Channel.

The detailed engineering investigation of the project were carried out such that no submergence, no diversion, no disturbance for the public, will occur. Therefore no impact on environment and ecological aspects is expected due to this project. Also, no resettlement and rehabilitation is required for this project.

Total project area is in private land. The construction of the project will be in such a way, that the disturbance of forest due to this project is totally eliminated by selecting the position of the power station. This Project report is so formulated taking into account of all the aspects to avoid the impact on environment due to this project. The water after power generation is let into the same stream.

CHAPTER - IX

COST OF THE PROJECT

Abstract of Costs

		In Rs. Lakhs
I	Civil Works	
	A. Preliminary (Land, Building etc.)	3.88
	B. Civil Works – Diversion structures, Water conductor System, Forebay, Powerhouse and Tail Race etc.	91.52
II	Electrical Works	
	i. Power plant equipments, accessories switchyard equipment	75.00
	ii. Transmission lines	5.00
III	Establishment charges including Project Management, Audit and Accounts, Running cost of vehicles, Welfare to workers, Inspection of UNIDO and other Experts and Officials, Maintenance of roads during the construction period, Camp equipments, forest and other clearances etc.	7.00
IV	Contingencies, consultancy, quality control, etc.	12.00
	Total	194.40

9.2 Year wise planning

The project is proposed to be implemented within a span of 2 years.

Expenditure for 1st year	Rs. 94.40lakhs
Expenditure for 2nd year	Rs. 100.00 lakhs
Total	**Rs. 194.40 lakhs**

CHAPTER - X

BENEFITS AND FINANCIAL ASPECTS

Balanthodu Mini hydel Project proposed to be implemented under the guidance of UNIDO for the generation of energy to meet the power requirements of the local people in and around Mullaringkadu & Pattayakudi area.

Direct benefit of this project is the availability of 1.188 MU of hydropower after deducting auxiliary consumption.

For the analysis of the financial viability of this project the following calculations are made.

1. Deprecation of the component structures of project and average depreciation constant
2. Interest to be accrued on the capital during the period of construction. This amount is to be capitalised at the end of project construction.
3. Annual recurring expenses include (a) Interest 10% (b) Depreciation 2.3% (c) O&M charges 1.0% etc.
4. Dividend on Equity is 10%
5. Equity/ Loan ratio 25:75

The cost of Generation of energy is found to be Rs 2.24/kWh. A financial analysis statement showing the capital expenditure, phasing of expenditure, recurring expenditure, cost of generation etc prepared and attached.

FINANCIAL ANALYSIS STATEMENT

Name of Project: - Balanthodu MHP
INSTALLED CAPACITY - 0.25 MW
Total Cost of project = Rs. 194.4 Lakhs
Period of implementation of project: 2 years
Source of financing of project: 25% Equity, 75% loan
Equity = 48.6 say, Rs. 49.4 Lakhs Loan = 145.8 say, Rs. 145 Lakhs

Phasing of expenditure	25% Equity	75% loan	Total
1st Year	Rs. 49.4 Lakhs	Rs. 45 Lakhs	Rs. 94.4 Lakhs
2nd Year	Rs. 0 Lakhs	Rs. 100 Lakhs	Rs. 100 Lakhs

Interest on loan = 10%
Interest During Construction
1st Year = 45x(10%)/2 = 2.25 Lakhs
2nd Year = 100x(10%)/2+45x10% = 4.75 Lakhs
Total = 7.00 Lakhs
Interest during construction is capitalized. Hence total loan = Rs.152 Lakhs
Total cost of project on completion will be 49.4 + 152 = Rs. 201.4 Lakhs
i.e., Cost per M.W = Rs. 805.6 Lakhs

Annual recurring expenses
(a) Interest on loan @ 10% p.a = Rs. 15.2 Lakhs
(b) Operation and maintenance expenses @ 1% of Project cost = Rs. 1.944 Lakhs
(c) Depreciation @ 2.3% of project cost = Rs. 4.48 Lakhs
(d) Dividend on Equity at 10% = Rs. 4.94 Lakhs
(e) Total expenses = Rs. 26.56 Lakhs
Total power generated from the project = 1.198 Mu
Deducting
i. Power for auxiliary use @ 1% of generation = 0.01198 say, 0.01 Mu
ii. Transmission and wheeling
Net power available = 1.188 Mu
Cost of generation of power per unit = 26.56/[1.188x10] = Rs. 2.24
The repayment and interest are to be made at a flat rate of [15.2 + 7.6] = Rs. 22.8 Lakhs (every year for complete repayment of loan + interest by 11 years)

Presently incentives & Subsidies are available from MNES. But this has not been considered in the financial analysis, owing to the reason that this amount is a variable subject to availability of fund.

Balanthodu MHP (250kW)

Calculation of pay back period and cash flow statement.

Year from commencement of the project	Sum of expenditure (Loan) at the beginning of the year in Rs. Crores	Yearly capital expenditure through equity in Rs Crores.	Yearly capital expenditure through loan in Rs. Crores	Interest @10% of col{2} +interest @5% of col{4}	O/M cost +depreciated expenses in Rs. Crores	Net Power Available for the company in Mu	Gross revenue @ in Rs Crores	Return on Equity	Net revenue col{8} - col{6}- col{9}	Annual surplus +ve or -ve (col.{10}- col.{5})	Sum of expenditure (Loan) at the er of year col.{2} col.{4} -col.{11}
{1}	{2}	{3}	{4}	{5}	{6}	{7}	{8}	{9}	{10}	{11}	{12}
I	0.00	0.49	0.45	0.02						-0.02	0.47
II	0.47	0.00	1.00	0.10						-0.10	1.57
1	1.57	0.00	0.00	0.16	0.06	1.19	0.34	0.05	0.23	0.07	1.50
2	1.50	0.00	0.00	0.15	0.06	1.19	0.34	0.05	0.23	0.08	1.42
3	1.42	0.00	0.00	0.14	0.06	1.19	0.34	0.05	0.23	0.09	1.33
4	1.33	0.00	0.00	0.13	0.06	1.19	0.34	0.05	0.23	0.10	1.24
5	1.24	0.00	0.00	0.12	0.06	1.19	0.34	0.05	0.23	0.10	1.13
6	1.13	0.00	0.00	0.11	0.06	1.19	0.34	0.05	0.23	0.12	1.02
7	1.02	0.00	0.00	0.10	0.06	1.19	0.34	0.05	0.23	0.13	0.89
8	0.89	0.00	0.00	0.09	0.06	1.19	0.34	0.05	0.23	0.14	0.75
9	0.75	0.00	0.00	0.08	0.06	1.19	0.34	0.05	0.23	0.15	0.60
10	0.60	0.00	0.00	0.06	0.06	1.19	0.34	0.05	0.23	0.17	0.43
11	0.43	0.00	0.00	0.04	0.06	1.19	0.34	0.05	0.23	0.19	0.24
12	0.24	0.00	0.00	0.02	0.06	1.19	0.34	0.05	0.23	0.20	0.04
13	0.04	0.00	0.00	0.00	0.06	1.19	0.34	0.05	0.23	0.22	-0.19
14	-0.19	0.00	0.00	-0.02	0.09	1.19	0.14	0.05	0.00	0.02	-0.20
15	-0.20	0.00	0.00	-0.02	0.09	1.19	0.14	0.05	0.00	0.02	-0.23
16	-0.23	0.00	0.00	-0.02	0.09	1.19	0.14	0.05	0.00	0.02	-0.25
17	-0.25	0.00	0.00	-0.02	0.09	1.19	0.14	0.05	0.00	0.02	-0.27
18	-0.27	0.00	0.00	-0.03	0.09	1.19	0.14	0.05	0.00	0.03	-0.30
19	-0.30	0.00	0.00	-0.03	0.09	1.19	0.14	0.05	0.00	0.03	-0.33
20	-0.33	0.00	0.00	-0.03	0.09	1.19	0.14	0.05	0.00	0.03	-0.36
21	-0.36	0.00	0.00	-0.04	0.09	1.19	0.14	0.05	0.00	0.04	-0.40
22	-0.40	0.00	0.00	-0.04	0.09	1.19	0.14	0.05	0.00	0.04	-0.44
23	-0.44	0.00	0.00	-0.04	0.09	1.19	0.14	0.05	0.00	0.04	-0.48
24	-0.48	0.00	0.00	-0.05	0.09	1.19	0.14	0.05	0.00	0.05	-0.53
25	-0.53	0.00	0.00	-0.05	0.09	1.19	0.14	0.05	0.00	0.05	-0.58

BALANTHODU MHP

PART – II
DESIGN REPORT

CHAPTER - XI

WATER AVAILABILITY & POWER POTENTIAL STUDIES

Balanthodu MHP scheme envisages utilisation of water in the stream a tributary of Kotamangalam river in Muvattupuzha basin for power generation of 250 kW. The scheme is designed as a run of the river scheme with no storage provisions.

Average rainfall

The monthly rainfall readings of rain gauge station at Malankara Plantations, Thodupuzha from 1995 to 2003 were collected for the hydrological studies. The average annual rainfall in the rain gauge station is 4163 mm. A rainfall run-off correlation was arrived based on the rainfall data at Malankara and that at Lower Periyar and thereafter the regression equations were compared with the actual gauge data at Mullaringkadu downstream of Balanthodu. Based on these comparisons the gauge data collected were roughly matching with that of the 50% dependable year. Hence the gauge data at site of year 2000 (50% dependable year) was used for the power potential studies.

The catchment area of the stream at the weir location is about 3.5 km^2.

Rainfall Details in mm at Malankara Plantations Rain Gauge station 1995-2003

Year	Annual Rainfall
1995	4015.2
1996	4395
1997	4325.1
1998	4879.3
1999	4382.5
2000	3427.5
2001	4032.5
2002	3514.6
2003	3595.4
Average	*4163*

The net head available for power generation is worked out as below.

1.	Full reservoir level	-	+195.00
2.	Sill level of intake	-	+193.50
3.	Bed level of Intake	-	+193.00
4.	Bed slope of Low pressure pipe	-	1:500
5.	Bed level of LPP at fore bay end	-	+193.20
6.	F.S.L at Forebay	-	+195.00
7.	M.D.D.L at Forebay	-	+193.00
8.	Level of c/l of runner	-	+80.00
9.	Max Head available	-	115 m
10.	Net design head allowing a head loss of 8m	-	107 m

For a Power requirement of 1000 kW

Power, P = 8.Q.H

1000 = 8 x Q x H

H = 107 m

Then power draft, Q = 1000/8*107 = 1.087 m^3/s

Power draft for various capacities of turbines from 50kW to 275 kW are as follows

50 kW	0.054 m^3/s
100 kW	0.109 m^3/s
150 kW	0.163 m^3/s
200 kW	0.217 m^3/s
250 kW	0.272 m^3/s
275 kW	0.299 m^3/s

The power generation possible with turbines of capacity from 50kW to 275 kW (10% overload of 250 kW) are worked out and attached. For optimum power utility, it is proposed to have two generators of 125 kW each. The power potential study has been conducted and attached. The Annual energy generation will be 1.198 Mu.

Power potential calculation for Balanthodu MHP project for 50% dependable year – 2000

Catchment Area = 3.5km^2
Head = 107 m

Date	Computed Discharge at Balanthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x125	Mu/day
1-Jan-00	0.01	10.04	0.00	0.00
2-Jan-00	0.01	10.04	0.00	0.00
3-Jan-00	0.01	10.04	0.00	0.00
4-Jan-00	0.01	10.30	0.00	0.00
5-Jan-00	0.01	11.49	0.00	0.00
6-Jan-00	0.01	10.30	0.00	0.00
7-Jan-00	0.01	10.30	0.00	0.00
8-Jan-00	0.01	10.77	0.00	0.00
9-Jan-00	0.01	10.86	0.00	0.00
10-Jan-00	0.01	10.86	0.00	0.00
11-Jan-00	0.01	10.86	0.00	0.00
12-Jan-00	0.01	10.86	0.00	0.00
13-Jan-00	0.01	10.86	0.00	0.00
14-Jan-00	0.01	11.17	0.00	0.00
15-Jan-00	0.01	11.17	0.00	0.00
16-Jan-00	0.01	11.17	0.00	0.00
17-Jan-00	0.01	11.81	0.00	0.00
18-Jan-00	0.01	11.81	0.00	0.00
19-Jan-00	0.01	11.81	0.00	0.00
20-Jan-00	0.01	12.17	0.00	0.00
21-Jan-00	0.01	12.17	0.00	0.00
22-Jan-00	0.01	12.17	0.00	0.00
23-Jan-00	0.01	12.56	0.00	0.00
24-Jan-00	0.02	12.97	0.00	0.00
25-Jan-00	0.02	12.97	0.00	0.00
26-Jan-00	0.02	12.97	0.00	0.00
27-Jan-00	0.02	13.41	0.00	0.00
28-Jan-00	0.02	13.85	0.00	0.00
29-Jan-00	0.02	15.46	0.00	0.00
30-Jan-00	0.02	15.46	0.00	0.00
31-Jan-00	0.02	15.46	0.00	0.00
1-Feb-00	0.14	122.77	122.77	0.00
2-Feb-00	0.14	122.77	122.77	0.00
3-Feb-00	0.14	122.77	122.77	0.00
4-Feb-00	0.14	122.77	122.77	0.00
5-Feb-00	0.14	122.77	122.77	0.00
6-Feb-00	0.14	122.77	122.77	0.00
7-Feb-00	0.14	122.77	122.77	0.00
8-Feb-00	0.09	75.75	75.75	0.00
9-Feb-00	0.09	75.75	75.75	0.00
10-Feb-00	0.09	75.75	75.75	0.00
11-Feb-00	0.09	75.75	75.75	0.00
12-Feb-00	0.09	75.75	75.75	0.00
13-Feb-00	0.09	78.10	78.10	0.00

Date	Computed Discharge at Balanthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x125	Mu/day
14-Feb-00	0.09	75.75	75.75	0.00
15-Feb-00	0.07	64.78	64.78	0.00
16-Feb-00	0.07	64.78	64.78	0.00
17-Feb-00	0.07	64.78	64.78	0.00
18-Feb-00	0.07	64.78	64.78	0.00
19-Feb-00	0.07	64.78	64.78	0.00
20-Feb-00	0.07	64.78	64.78	0.00
21-Feb-00	0.07	64.78	64.78	0.00
22-Feb-00	0.07	64.78	64.78	0.00
23-Feb-00	0.07	64.78	64.78	0.00
24-Feb-00	0.07	64.78	64.78	0.00
25-Feb-00	0.07	64.78	64.78	0.00
26-Feb-00	0.03	24.32	0.00	0.00
27-Feb-00	0.03	24.32	0.00	0.00
28-Feb-00	0.03	24.32	0.00	0.00
29-Feb-00	0.00	0.37	0.00	0.00
1-Mar-00	0.04	38.12	0.00	0.00
2-Mar-00	0.04	38.12	0.00	0.00
3-Mar-00	0.04	38.12	0.00	0.00
4-Mar-00	0.04	38.12	0.00	0.00
5-Mar-00	0.01	6.30	0.00	0.00
6-Mar-00	0.00	0.39	0.00	0.00
7-Mar-00	0.02	20.50	0.00	0.00
8-Mar-00	0.00	0.41	0.00	0.00
9-Mar-00	0.12	107.86	107.86	0.00
10-Mar-00	0.04	38.12	0.00	0.00
11-Mar-00	0.03	23.00	0.00	0.00
12-Mar-00	0.00	0.44	0.00	0.00
13-Mar-00	0.00	0.44	0.00	0.00
14-Mar-00	0.00	0.44	0.00	0.00
15-Mar-00	0.00	0.41	0.00	0.00
16-Mar-00	0.00	2.62	0.00	0.00
17-Mar-00	0.00	2.62	0.00	0.00
18-Mar-00	0.02	13.05	0.00	0.00
19-Mar-00	0.02	13.05	0.00	0.00
20-Mar-00	0.02	13.05	0.00	0.00
21-Mar-00	0.01	10.45	0.00	0.00
22-Mar-00	0.01	11.01	0.00	0.00
23-Mar-00	0.01	11.63	0.00	0.00
24-Mar-00	0.02	13.05	0.00	0.00
25-Mar-00	0.04	31.62	0.00	0.00
26-Mar-00	0.04	31.62	0.00	0.00
27-Mar-00	0.05	43.37	0.00	0.00
28-Mar-00	0.05	43.37	0.00	0.00
29-Mar-00	0.05	43.37	0.00	0.00
30-Mar-00	0.01	5.48	0.00	0.00
31-Mar-00	0.30	260.18	260.18	0.01
1-Apr-00	0.29	249.20	249.20	0.01
2-Apr-00	0.29	249.20	249.20	0.01

Catchment Area = $3.5km^2$
Head = 107 m

Date	Computed Discharge at Balanthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x125	Mu/day
3-Apr-00	0.21	179.46	179.46	0.00
4-Apr-00	0.23	202.97	202.97	0.00
5-Apr-00	0.27	237.45	237.45	0.01
6-Apr-00	0.27	237.45	237.45	0.01
7-Apr-00	0.21	179.46	179.46	0.00
8-Apr-00	0.22	191.22	191.22	0.00
9-Apr-00	0.25	213.94	213.94	0.01
10-Apr-00	0.22	191.22	191.22	0.00
11-Apr-00	0.25	213.94	213.94	0.01
12-Apr-00	0.26	225.70	225.70	0.01
13-Apr-00	0.27	237.45	237.45	0.01
14-Apr-00	0.27	237.45	237.45	0.01
15-Apr-00	0.25	213.94	213.94	0.01
16-Apr-00	0.23	202.97	202.97	0.00
17-Apr-00	0.25	213.94	213.94	0.01
18-Apr-00	0.26	225.70	225.70	0.01
19-Apr-00	0.26	225.70	225.70	0.01
20-Apr-00	0.26	225.70	225.70	0.01
21-Apr-00	0.17	144.20	144.20	0.00
22-Apr-00	0.22	191.22	191.22	0.00
23-Apr-00	0.25	213.94	213.94	0.01
24-Apr-00	0.27	237.45	237.45	0.01
25-Apr-00	0.27	237.45	237.45	0.01
26-Apr-00	0.18	155.96	155.96	0.00
27-Apr-00	0.08	65.26	65.26	0.00
28-Apr-00	0.03	28.23	0.00	0.00
29-Apr-00	0.16	137.15	137.15	0.00
30-Apr-00	0.07	63.75	63.75	0.00
1-May-00	0.15	132.01	132.01	0.00
2-May-00	0.02	19.80	0.00	0.00
3-May-00	0.02	19.80	0.00	0.00
4-May-00	0.04	32.76	0.00	0.00
5-May-00	0.08	70.70	70.70	0.00
6-May-00	0.03	28.30	0.00	0.00
7-May-00	0.05	47.19	0.00	0.00
8-May-00	0.09	76.58	76.58	0.00
9-May-00	0.10	82.45	82.45	0.00
10-May-00	0.12	105.17	105.17	0.00
11-May-00	0.14	116.93	116.93	0.00
12-May-00	0.14	116.93	116.93	0.00
13-May-00	0.14	116.93	116.93	0.00
14-May-00	0.14	116.93	116.93	0.00
15-May-00	0.15	128.68	128.68	0.00
16-May-00	0.16	140.44	140.44	0.00
17-May-00	0.18	151.41	151.41	0.00
18-May-00	0.18	151.41	151.41	0.00
19-May-00	0.19	163.94	163.94	0.00
20-May-00	0.12	105.17	105.17	0.00
21-May-00	0.15	128.68	128.68	0.00

Catchment Area = $3.5km^2$
Head = 107 m

Date	Computed Discharge at Balanthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x125	Mu/day
22-May-00	0.18	151.41	151.41	0.00
23-May-00	0.16	140.44	140.44	0.00
24-May-00	0.18	151.41	151.41	0.00
25-May-00	0.19	163.94	163.94	0.00
26-May-00	0.20	174.92	174.92	0.00
27-May-00	0.20	174.92	174.92	0.00
28-May-00	0.20	174.92	174.92	0.00
29-May-00	0.22	186.67	186.67	0.00
30-May-00	0.22	186.67	186.67	0.00
31-May-00	1.08	933.43	275.00	0.01
1-Jun-00	1.21	1049.40	275.00	0.01
2-Jun-00	1.31	1130.89	275.00	0.01
3-Jun-00	1.34	1154.40	275.00	0.01
4-Jun-00	0.86	739.72	275.00	0.01
5-Jun-00	0.19	166.86	166.86	0.00
6-Jun-00	2.55	2206.83	275.00	0.01
7-Jun-00	1.54	1333.15	275.00	0.01
8-Jun-00	2.71	2344.64	275.00	0.01
9-Jun-00	2.92	2524.61	275.00	0.01
10-Jun-00	0.69	596.82	275.00	0.01
11-Jun-00	1.59	1370.29	275.00	0.01
12-Jun-00	1.67	1444.33	275.00	0.01
13-Jun-00	1.67	1444.33	275.00	0.01
14-Jun-00	1.67	1444.33	275.00	0.01
15-Jun-00	1.67	1444.33	275.00	0.01
16-Jun-00	1.67	1444.33	275.00	0.01
17-Jun-00	1.07	923.08	275.00	0.01
18-Jun-00	0.59	507.37	275.00	0.01
19-Jun-00	0.56	486.57	275.00	0.01
20-Jun-00	0.96	833.22	275.00	0.01
21-Jun-00	0.81	695.68	275.00	0.01
22-Jun-00	0.75	651.74	275.00	0.01
23-Jun-00	0.44	383.75	275.00	0.01
24-Jun-00	1.67	1444.33	275.00	0.01
25-Jun-00	1.12	965.93	275.00	0.01
26-Jun-00	1.67	1444.33	275.00	0.01
27-Jun-00	1.67	1444.33	275.00	0.01
28-Jun-00	1.67	1444.33	275.00	0.01
29-Jun-00	1.67	1444.33	275.00	0.01
30-Jun-00	1.34	1153.46	275.00	0.01
1-Jul-00	1.34	1153.46	275.00	0.01
2-Jul-00	1.34	1153.46	275.00	0.01
3-Jul-00	1.34	1153.46	275.00	0.01
4-Jul-00	1.34	1153.46	275.00	0.01
5-Jul-00	0.22	189.99	189.99	0.00
6-Jul-00	0.37	323.44	275.00	0.01
7-Jul-00	0.35	300.13	275.00	0.01
8-Jul-00	0.37	317.03	275.00	0.01
9-Jul-00	0.44	382.26	275.00	0.01

Catchment Area = 3.5km^2
Head = 107 *m*

Date	Computed Discharge at Balanthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x125	Mu/day
10-Jul-00	0.27	229.36	229.36	0.01
11-Jul-00	0.22	186.62	186.62	0.00
12-Jul-00	0.57	494.83	275.00	0.01
13-Jul-00	0.47	403.74	275.00	0.01
14-Jul-00	0.70	602.66	275.00	0.01
15-Jul-00	0.88	758.76	275.00	0.01
16-Jul-00	1.20	1035.49	275.00	0.01
17-Jul-00	1.34	1153.46	275.00	0.01
18-Jul-00	1.34	1153.46	275.00	0.01
19-Jul-00	1.34	1153.46	275.00	0.01
20-Jul-00	0.97	839.22	275.00	0.01
21-Jul-00	0.80	695.11	275.00	0.01
22-Jul-00	0.61	525.46	275.00	0.01
23-Jul-00	0.55	473.83	275.00	0.01
24-Jul-00	0.24	208.50	208.50	0.01
25-Jul-00	0.26	227.80	227.80	0.01
26-Jul-00	0.17	150.94	150.94	0.00
27-Jul-00	0.36	311.01	275.00	0.01
28-Jul-00	0.53	453.98	275.00	0.01
29-Jul-00	0.69	599.27	275.00	0.01
30-Jul-00	0.58	501.88	275.00	0.01
31-Jul-00	0.02	17.84	0.00	0.00
1-Aug-00	0.03	29.09	0.00	0.00
2-Aug-00	0.05	46.02	0.00	0.00
3-Aug-00	0.06	48.54	0.00	0.00
4-Aug-00	0.04	37.68	0.00	0.00
5-Aug-00	0.05	45.11	0.00	0.00
6-Aug-00	0.04	35.32	0.00	0.00
7-Aug-00	0.05	44.07	0.00	0.00
8-Aug-00	0.06	51.25	51.25	0.00
9-Aug-00	0.05	47.39	0.00	0.00
10-Aug-00	0.07	57.53	57.53	0.00
11-Aug-00	0.07	56.79	56.79	0.00
12-Aug-00	0.07	58.15	58.15	0.00
13-Aug-00	0.05	47.39	0.00	0.00
14-Aug-00	0.04	36.85	0.00	0.00
15-Aug-00	0.03	25.97	0.00	0.00
16-Aug-00	0.02	20.07	0.00	0.00
17-Aug-00	0.03	23.95	0.00	0.00
18-Aug-00	0.03	22.26	0.00	0.00
19-Aug-00	0.04	38.28	0.00	0.00
20-Aug-00	0.05	41.10	0.00	0.00
21-Aug-00	0.05	45.34	0.00	0.00
22-Aug-00	0.05	44.73	0.00	0.00
23-Aug-00	0.07	63.78	63.78	0.00
24-Aug-00	0.09	80.57	80.57	0.00
25-Aug-00	0.13	108.94	108.94	0.00
26-Aug-00	0.09	79.77	79.77	0.00
27-Aug-00	0.10	82.66	82.66	0.00

Catchment Area = 3.5km^2
Head = 107 m

Date	Computed Discharge at Balanthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x125	Mu/day
28-Aug-00	0.16	140.32	140.32	0.00
29-Aug-00	0.30	260.96	260.96	0.01
30-Aug-00	0.14	123.67	123.67	0.00
31-Aug-00	0.19	167.23	167.23	0.00
1-Sep-00	0.18	154.70	154.70	0.00
2-Sep-00	0.21	183.34	183.34	0.00
3-Sep-00	0.23	195.91	195.91	0.00
4-Sep-00	0.22	191.38	191.38	0.00
5-Sep-00	0.22	187.50	187.50	0.00
6-Sep-00	0.22	189.89	189.89	0.00
7-Sep-00	0.26	226.91	226.91	0.01
8-Sep-00	0.24	210.33	210.33	0.01
9-Sep-00	0.24	209.17	209.17	0.01
10-Sep-00	0.21	180.25	180.25	0.00
11-Sep-00	0.18	151.86	151.86	0.00
12-Sep-00	0.11	93.64	93.64	0.00
13-Sep-00	0.15	130.96	130.96	0.00
14-Sep-00	0.20	172.29	172.29	0.00
15-Sep-00	0.19	162.13	162.13	0.00
16-Sep-00	0.18	151.86	151.86	0.00
17-Sep-00	0.15	133.31	133.31	0.00
18-Sep-00	0.43	374.57	275.00	0.01
19-Sep-00	0.06	54.88	54.88	0.00
20-Sep-00	0.05	41.30	0.00	0.00
21-Sep-00	0.03	22.22	0.00	0.00
22-Sep-00	0.05	39.37	0.00	0.00
23-Sep-00	0.07	60.22	60.22	0.00
24-Sep-00	0.08	68.31	68.31	0.00
25-Sep-00	0.09	76.87	76.87	0.00
26-Sep-00	0.12	101.02	101.02	0.00
27-Sep-00	0.17	145.87	145.87	0.00
28-Sep-00	0.17	148.51	148.51	0.00
29-Sep-00	0.20	175.53	175.53	0.00
30-Sep-00	0.53	456.92	275.00	0.01
1-Oct-00	0.59	508.29	275.00	0.01
2-Oct-00	0.65	561.13	275.00	0.01
3-Oct-00	0.65	562.12	275.00	0.01
4-Oct-00	0.65	562.12	275.00	0.01
5-Oct-00	0.65	562.12	275.00	0.01
6-Oct-00	0.65	562.12	275.00	0.01
7-Oct-00	0.65	562.12	275.00	0.01
8-Oct-00	0.65	562.12	275.00	0.01
9-Oct-00	0.65	562.12	275.00	0.01
10-Oct-00	0.20	175.11	175.11	0.00
11-Oct-00	0.65	562.12	275.00	0.01
12-Oct-00	0.63	546.53	275.00	0.01
13-Oct-00	0.65	562.12	275.00	0.01
14-Oct-00	0.65	562.12	275.00	0.01
15-Oct-00	0.65	562.12	275.00	0.01

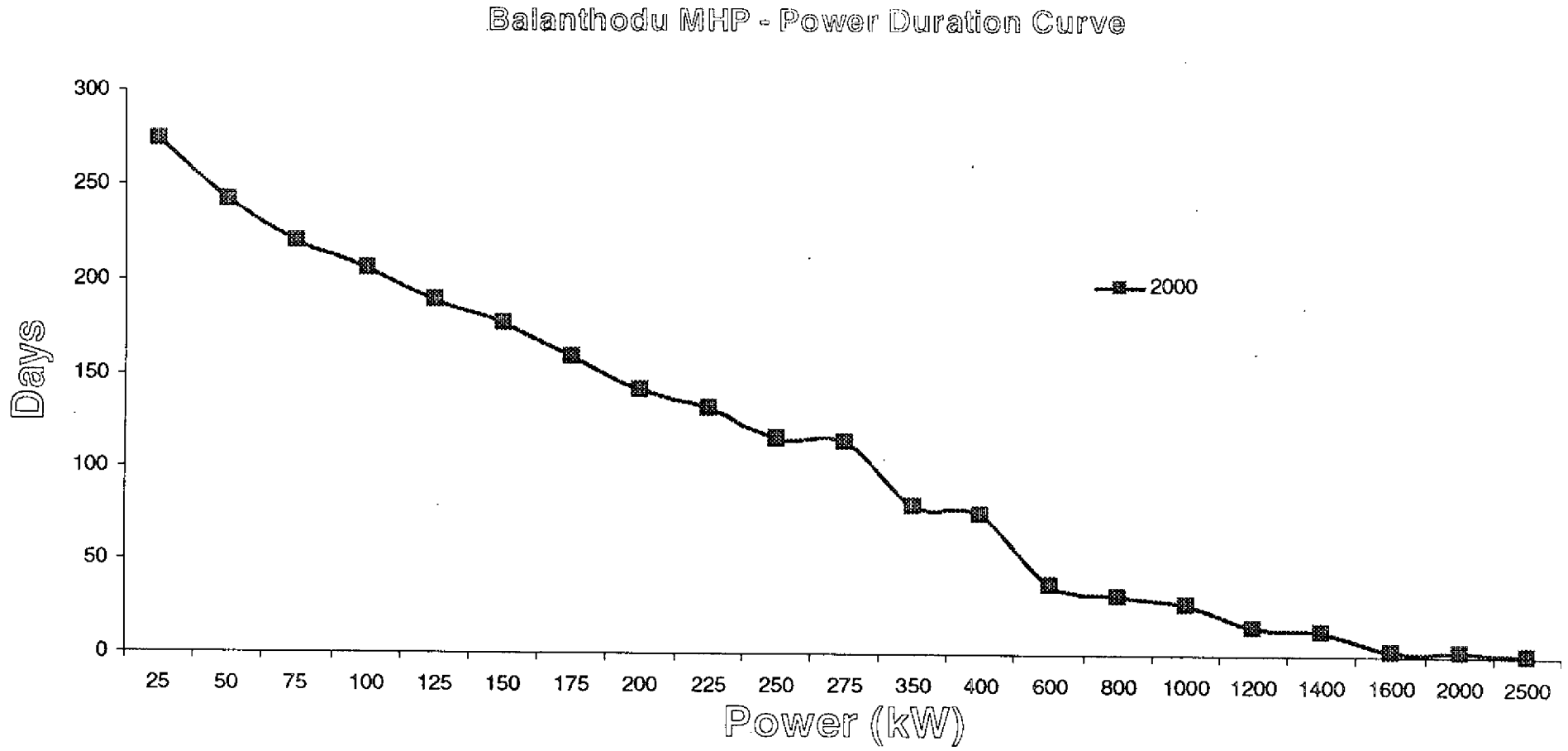
Catchment Area = 3.5km^2
Head = 107 m

Date	Computed Discharge at Balanthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x125	Mu/day
16-Oct-00	0.65	562.12	275.00	0.01
17-Oct-00	0.28	241.65	241.65	0.01
18-Oct-00	0.62	532.55	275.00	0.01
19-Oct-00	0.65	562.12	275.00	0.01
20-Oct-00	0.65	562.12	275.00	0.01
21-Oct-00	0.65	562.12	275.00	0.01
22-Oct-00	0.65	562.12	275.00	0.01
23-Oct-00	0.46	393.49	275.00	0.01
24-Oct-00	0.65	562.12	275.00	0.01
25-Oct-00	0.65	562.12	275.00	0.01
26-Oct-00	0.65	562.12	275.00	0.01
27-Oct-00	0.65	562.12	275.00	0.01
28-Oct-00	0.65	562.12	275.00	0.01
29-Oct-00	0.65	562.12	275.00	0.01
30-Oct-00	0.65	562.12	275.00	0.01
31-Oct-00	0.38	326.76	275.00	0.01
1-Nov-00	0.40	348.78	275.00	0.01
2-Nov-00	0.40	348.78	275.00	0.01
3-Nov-00	0.40	347.97	275.00	0.01
4-Nov-00	0.40	348.78	275.00	0.01
5-Nov-00	0.33	284.89	275.00	0.01
6-Nov-00	0.37	315.62	275.00	0.01
7-Nov-00	0.39	340.64	275.00	0.01
8-Nov-00	0.39	340.64	275.00	0.01
9-Nov-00	0.40	348.78	275.00	0.01
10-Nov-00	0.40	348.78	275.00	0.01
11-Nov-00	0.40	348.78	275.00	0.01
12-Nov-00	0.40	348.78	275.00	0.01
13-Nov-00	0.40	348.78	275.00	0.01
14-Nov-00	0.40	348.78	275.00	0.01
15-Nov-00	0.40	348.78	275.00	0.01
16-Nov-00	0.40	348.78	275.00	0.01
17-Nov-00	0.40	348.78	275.00	0.01
18-Nov-00	0.40	348.78	275.00	0.01
19-Nov-00	0.40	348.78	275.00	0.01
20-Nov-00	0.40	348.78	275.00	0.01
21-Nov-00	0.40	348.78	275.00	0.01
22-Nov-00	0.40	348.78	275.00	0.01
23-Nov-00	0.40	348.78	275.00	0.01
24-Nov-00	0.40	348.78	275.00	0.01
25-Nov-00	0.40	348.78	275.00	0.01
26-Nov-00	0.40	348.78	275.00	0.01
27-Nov-00	0.40	348.78	275.00	0.01
28-Nov-00	0.40	348.78	275.00	0.01
29-Nov-00	0.40	348.78	275.00	0.01
30-Nov-00	0.00	3.22	0.00	0.00
1-Dec-00	0.00	3.26	0.00	0.00
2-Dec-00	0.00	3.30	0.00	0.00
3-Dec-00	0.00	3.39	0.00	0.00

Catchment Area = $3.5km^2$
Head = 107 m

Date	Computed Discharge at Balanthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x125	Mu/day
4-Dec-00	0.00	3.49	0.00	0.00
5-Dec-00	0.00	3.69	0.00	0.00
6-Dec-00	0.00	3.99	0.00	0.00
7-Dec-00	0.00	3.99	0.00	0.00
8-Dec-00	0.00	4.11	0.00	0.00
9-Dec-00	0.01	4.42	0.00	0.00
10-Dec-00	0.01	12.00	0.00	0.00
11-Dec-00	0.01	4.65	0.00	0.00
12-Dec-00	0.01	4.74	0.00	0.00
13-Dec-00	0.01	4.96	0.00	0.00
14-Dec-00	0.01	5.12	0.00	0.00
15-Dec-00	0.01	5.12	0.00	0.00
16-Dec-00	0.01	5.58	0.00	0.00
17-Dec-00	0.01	5.12	0.00	0.00
18-Dec-00	0.01	5.16	0.00	0.00
19-Dec-00	0.01	5.12	0.00	0.00
20-Dec-00	0.01	5.23	0.00	0.00
21-Dec-00	0.01	5.23	0.00	0.00
22-Dec-00	0.01	5.34	0.00	0.00
23-Dec-00	0.01	5.46	0.00	0.00
24-Dec-00	0.01	5.46	0.00	0.00
25-Dec-00	0.01	5.70	0.00	0.00
26-Dec-00	0.01	5.84	0.00	0.00
27-Dec-00	0.01	5.84	0.00	0.00
28-Dec-00	0.01	5.98	0.00	0.00
29-Dec-00	0.01	6.13	0.00	0.00
30-Dec-00	0.01	6.13	0.00	0.00
31-Dec-00	0.05	47.21	0.00	0.00
			Yearly power generation Mu	**1.198**

Catchment Area = $3.5km^2$
Head = 107 m


Balanthodu MHP - Power Duration Curve
Days
300
250
200
150
100
50
0
2000
25
50
75
100
125
150
175
200
225
250
275
350
400
600
800
1000
1200
1400
1600
2000
2500
Power (kW)

CHAPTER – XII

DESIGN CRITERIA OF MAJOR COMPONENTS OF SCHEME

General

The river-bed is at primary stage. The flow in the river is very heavy during rainy seasons and as per hydrologic details available, there have been flash floods. During the monsoon seasons, heavy flow is available for about 5 months. In monsoon seasons in order to cater the flood with high velocities an overflow type diversion weir is adopted. The height of the weir is minimised in order to cater the intake provision to avoid cavitations, and to keep the maximum water level below the maximum flood level of the stream. The height of the weir at the overflow portion is thus kept as 2,0 m

The diversion weir of Ogee type is proposed with overflow portion having a length of 15m. The maximum flood discharge is 19.48 m^3/s. The lowest bed level of the stream at weir site is 193.

The Balanthodu mini hydel scheme is designed as a run of the river scheme with the following main project components.

1. Gravity weir

The weir is constructed across the river Balanthodu Stream, at about 4km from Mullaringkadu. Total length of the concrete weir is 30m and u/s side protected on either banks with DR masonry. This concrete weir will be having an ungated overflow section for a length of 15m and non-overflow sections of length 10m on left bank and 5m on right bank.

2. Water conductor system

a) A gated river sluice of dia 0.50 m to flush out the silt, settling down near the intake end.
b) An intake located at elevation +193.00 in the left bank non overflow portion of the weir.
c) A low pressure pipe of 150 m length and 0.60 m dia
d) A Fore-bay tank of 8 m × 4 m ×4.5 m
e) 1 No. Penstock pipes of diameter 0.50 m and length 600 m.

3. Power House

A surface powerhouse of size 7 m x 6 m to house two units of generating equipment of 125 kW capacity

4. Tailrace

A tailrace channel of length 15 m to discharge water back into stream (size 1m x 1m).

GRAVITY WEIR

The maximum height of weir at the overflow portion is 2.0 m.

According to Ryve's formula, Maximum flood discharge, $Q_{max} = C.A^{(2/3)}$

Catchment Area, A = 3.5 sq.km.

In Ghat region for area between 24 km to 161km from coast, C= 8.45

$Q_{max} = 8.45 \times (3.5)^{2/3} = 19.48\ m^3/s$, is adopted as the design flood discharge, Q.

Provide a of overflow section 15m length.

Taking C_d as 2.2, k_a=0.1, L=15 m and

$Q = C_d \times L \times (H_d)^{3/2}$

$H_d = 0.704$ m.

A design head of 0.7 m is adopted with level of non-overflow portion 1.3m above the overflow portion with free board of 0.6m. Top of Non over flow level 196.30

Effective length of spill way, $L_c = L\text{-}2\ (k_a \times H_d)$

$L_c = 14.86$m, with H_d= 0.7m

$Q = C_d \times L_c \times (H_d)^{3/2}$

$Q = 48.46\ m^3/sec$ ------- Hence okay

Therefore $H_d = 0.70$ m,

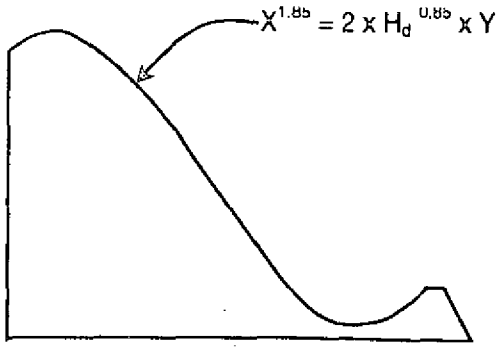
Hence a spillway length of 15 m and height of non-overflow portion above spillway crest of 1.3 m is adopted. The excavated bed level is taken as +192.50

Weir Profile

The upstream face of the weir is kept vertical.

Downstream Profile

$X_n = K\ H_d^{n-1}\ Y$



Equation for the Ogee profile for upstream face vertical → $X^{1.85} = 2 \times H_d^{0.85} \times Y$

$\frac{H_e}{H_d}$ is taken as 1

D/s slope of the weir below the point of tangency is given a slope of 0.75 H to 1 V.

Equating $\frac{dy}{dx} = \frac{1}{0.75}$ we get Co-ordinates of point of tangency → X = 1.06 and Y = 0.754

Co-ordinates of Ogee Profile:

X	0.106	0.530	0.742	0.848	0.954	1.060
Y	0.011	0.209	0.390	0.499	0.620	0.754

Upstream Profile

Equation for upstream profile

$$Y = \frac{0.724\,(X + 0.27H_d)^{1.85}}{H_d^{0.85}} + 0.126\,H_d - 0.4315H_d^{0.375}(X+0.27H_d)^{0.625}$$

$X_{max} = -0.27\,H_d = -0.189$ and corresponding $Y_{max} = 0.088$

River Sluice

A 0.50 m dia river sluice is provided at the right non-overflow portion of the diversion weir to pass through the silt, settling down near the intake end. The sluice is controlled by a manually operated gate arrangement of size 1m x 1m.

Intake

The intake is secured with a suitable trash rack arrangement in such a way that even at a clogging level of 50%, enough discharge will be available for power generation. The intake sill level of the water conductor after the trash rack chamber is at +193.50, which opens into the Low pressure pipe. The intake structure is arranged as a part of the main weir on the non-overflow portion with a single bayed gate arrangement of 1m x 1m. The gates are electrically/manually operated.

Low pressure Pipe

The low pressure pipe is used to carry water safely to Fore bay. Since the alignment of the water conductor system is through the boundary of the forest area, power channel may cause some disturbance to the forest boundary especially during construction. There fore high density PVC pipe having a length of 150m is proposed. The size of the pipe is 60 cm dia with a velocity of 1.06 m/sec.

Forebay and Penstock Bell mouth.

An RCC rectangular forebay tank 8m x 4m x 4.5m is proposed at the exit of the Low pressure pipe. The fore-bay will function as a balancing reservoir and will avoid vortex formation and air entry into the penstock.

Discharge required for an installed capacity of 250 kW with 10 % overload = 0.299m^3/s

A minimum of three minutes storage, i.e., 3 x 60 x 0.299= 53.80 m^3 is to be provided in the forebay tank. Depth of live storage is fixed as 2.0m.

The full supply level of the forebay will be kept as +195.00 with MDDL as +193.00 and a free board of 0.60m is to be provided.

Area of Forebay 53.80/2.0= 26.90m^2

The Size of tank 8m x 4m x 4.5m is proposed

The top of the bell mouth transition is to be at least 0.6H_e below MDDL.

Bell mouth design details

The penstock intake will have a transition from rectangular to circular using a bell mouth transition .The bell mouth is designed in such a way that the penstock takes off from the forebay horizontally. A penstock of 0.7m dia is adopted.

For θ = 0 - axis horizontal,

Width of transition = 1.43D = 0.72 m

Height of transition = 1.68D = 0.84 m

Size of intake opening – bell mouth = 0.84 m x 0.72m

Minimum water cover above bell mouth = 0.60H_e = 0.60 x 0.84 = 0.50m

Therefore top level of the penstock bell mouth will be = 195 – (2.0+0.50) = + 192.50

Level of centre line of bell mouth = +192.08

Bottom Level of Tank = +191.11

PENSTOCK PIPES

From the forebay the water is conveyed through penstock to the turbines. The length of penstock is 600m. It will be bifurcated near the Powerhouse to supply for two turbines of 125kW capacity each.

The penstock diameter from the forebay to the bifurcation points for feeder pipes is 0.40 m with a velocity of 1.52 m/s for the 110% load at the rated design head of 107m for a maximum output of 275 kW.

The maximum drop from the centre line of the intake bell mouth at the forebay to the machine centreline is 107 m. The penstock wall thickness arrived is 8mm after allowing for corrosion and handling allowances. There will be only two bends for the penstock line. A Stop log with electrically operated hoist is provided at the entry of the penstock for the maintenance of the penstock and valves.

Standard expansion joints will be provided for the penstock line at suitable intervals. Necessary anchor blocks are provided where there is a change in the direction of the pipelines along its alignment with suitable saddle supports in between.

Design of penstock pipe.

The rating of each of the two turbine generator set selected is 125kW at the generator terminals with a provision for 10% continuous overload.

Maximum design discharge per turbine for 100% load at a rated design head of 107 m, for obtaining a generator terminal output of 125kW, that is for a turbine output of 131.25 kW = 0.136 m^3/s. The maximum discharge for each turbine for obtaining 10% over load is 0.15 m^3/s.

Diameter of penstock:

A penstock dia of 0.50m is taken as design diameter.

Length of the penstock = 600 m

Velocity of flow through the penstock, v = Q/A

Where, Q = design draft of the penstock = 0.299 m^3/s.

A = area of the penstock = $(\Pi/4)d^2 = 0.196m^2$

The corresponding flow velocity is 1.52 m/s at maximum power draft, which is within acceptable limits as far as the losses are concerned.

The wall thickness is selected as 8mm.

Feeder Pipes

The main penstock will be bifurcated longitudinally to feed the two turbines. The diameter of the two feeder pipes supplying to the 125kW machines is fixed as 0.40m to with velocity of flow as 1.19 m/s.

Head loss in penstock

Dia of the penstock = 0.5 m, Length of the penstock = 600 m

Velocity of flow through the penstock, v = 1.52 m/s

Velocity head = $\frac{v^2}{2g}$ = 0.118

(a) Loss of head at bell mouth entry in forebay $h_e = k_e \frac{v^2}{2g}$

k_e = 0.16

$\therefore h_e = 0.16 \times 0.118 = 0.02$ m

(b) Loss of head due to friction, $h_f = \frac{f.l.v^2}{2gd}$

f= 0.0125 (for steel pipe with smooth surface)

$h_f = \frac{0.0125 \times 115 \times 1.52^2}{2 \times 9.81 \times 0.5} = 1.77$ m

(c) Loss of head due to bends (7nos in total)

Head loss due to, bends $h_b = \frac{v^2}{2g} \sum k_b$ = 0.118 x 0.751= 0.09m

(d) Loss of head due to gradual contraction at PH end.

$h_{gc} = 0.18 \frac{v^2}{2g}$ = 0.18 x 0.118 = 0.02 m

(e) Loss of head due to butterfly valve.

$h_{gc} = 0.2 \frac{v^2}{2g}$ = 0.2 x 0.118 = 0.02 m

Total head loss in penstock = 0.02+1.77+0.09+0.02+0.02 = 1.92m

Adding bifurcation losses and other losses in bifurcated pipe and valves, the total head loss is taken as 8 m for design purpose.

Full supply level of forebay tank = +195.00

Centre line level of turbine = +78.00

Normal tail water level = +78.84

Gross Head= 195- 80.00 = 115.00

Net Head = 115-8 = 107.00 A design head of 96 m is adopted.

POWERHOUSE

For making the final design of Powerhouse, details from the manufacturer / supplier is necessary. In the absence of foundation details etc., a tentative design is made which will be modified on getting details from the supplier. Powerhouse will be located on the Left bank of the river.

Gross head in meters = 115.00

Conduit head loss at rated flow meters = 8.00

Rated net head in meters = 107.00

Rated discharge = 0.299 m^3/s

Total power plant capacity (Including 10% overload) = 275 kW

Plant capacity factor = 0.547

Total Generator unit output = 250 kW

Required turbine out put = 263 kW

Number of turbines = 2

Design Discharge, Q per turbine, with 10% overload capacity = 0.15 m^3/s

Sizing of Generator

No of poles provided = 4 poles or, 2 pairs of poles

Frequency = 50 Hz

Generator speed = 1500 rpm

Sizing & Design of Turbine

A Pelton turbine arrangement is selected for the project. At 1500 rpm the rotational speed of generator the specific speed of turbine will be close to 60 rpm, for single jet Pelton, which is too higher than the allowable 26 rpm (max).

Hence, No of jet proposed =2

Assumed Sp. Speed = 20.00, so as to get a rotational speed of approximately 1000 rpm with two jets

Adopt rotational speed of turbine as 1000 rpm for synchronized operation with generator. Then Gear ratio of speed increaser = 1.50

Actual specific speed/ jet =19.38, > 12 & < 26 hence okay

As per IS for selection of turbine and dimensioning of Power house

Dia of circumference tangent ,PCD

Assume, d/D ratio = 0.0555

q_3 =0.995

As per IS, Pitch Circle Dia, PCD = 0.58m

Distance between C/L of Penstock and C/L of Turbine = 2D = 1.16 m

Distance between. C/L of Turbine & top of servomotor = 3.7D = 2.15 m

Width of Turbine Chamber = 2.5D= 1.45 m

Distance between C/L of M/c to TWL = 2D = 1.16 m

Tail water pool Depth = 2D = 1.16 m

Jet Dimensions

Velocity of Jet at nozzle, v_{ch}= 44.44 m/s

Diameter of each jet = *0.048* m

Nozzle Diameter = 0.053 m

Bucket size in radial direction = 0.168 m

Therefore, runner inner circle Dia, D = 0.41

No of buckets = 19

Relevant elevations

C/L of Runner = +80.00

Tail water Level = +78.84

Tail water pool floor level = +77.68

Powerhouse dimensions

Total length of powerhouse, excluding offices = 7.00 m.

Powerhouse width=6.00 m

The powerhouse building proper will be having a size of 7m x 6m x 8 m. The roof proposed is with aluminium or G.I. sheets supported on steel trusses. The size and spacing of the R C columns and machine foundation blocks of the powerhouse will be finalized based on turbine manufacturer's drawings.

The 440 kV generation is stepped up at the switchyard to 11kV and will be taken to the distribution centres at a distance of about 2 km from the powerhouse.

Drains will be provided inside the powerhouse and connected to tailrace channel. Dewatering pumps are provided for draining water from the tailrace channel for repairs after closing draft tube gates.

TAILRACE CHANNEL

The water coming out from the turbine after power generation will be let back in to the river through the tailrace. The channel will be with length of about 15 m with a size of 1m x 1m. Protection with rock riprap is provided between the powerhouse and the stream. The design takes care of the high flows during flood season so that it does not cause erosion downstream of the tail race portion.

BALANTHODU MHP

PART – III
COST ESTIMATE

CHAPTER - XIII

COST ESTIMATE CRITERIA

The estimate cost of this project is prepared following the guide lines for the preparations of project estimates for hydro electric project" issued by the Central Electricity Authority. All the estimates under the detailed head "Civil works" are based on quantities worked out from detailed survey and preliminary design of component structure of the project. The project is to be executed either on "turnkey execution basis" or separate contract arrangements. As such the rates are worked out as detailed below

1. **Labour rates:** The current labour rates followed in the department is "Schedule of rates 2004.

2. **Rates for materials:** As stated in Chapter VI construction materials, such as rubble, coarse and fine aggregates are produced locally. Since sand mining in rivers is prohibited, crushed sand is proposed for the work and is being produced in the crushing plant. Non-levy cement only will be available for this work. Cost of cement at railhead at Kochi is taken and the cost at site is arrived by road transportation. Similarly, the tor steel structural steel, steel for Penstock pipes are to be procured from steel yard at Kochi and transported to site by rail and road.

3. **Rate for conveyance:** For manual head load conveyance the rates are taken from the present Schedule of rates. For lorry transport, the usual rate prevailing in this area is considered Special transportation charges are worked out and provided in the estimate for conveyance of Penstock pipes, trash-rack structures, vertical lift gates, hoists etc, as these items are very heavy and require extra care for transportation.

4. **Use rate for construction equipments:** Mechanised work is proposed for earthwork excavation, rock blasting, concreting etc. The use rate for various construction equipments are worked based on the present day value of machines and the output (capacity) of equipments as given by the manufactures of equipments.

5. **Electro-Mechanical part:** The estimate for electro-mechanical item, is worked out based on the budgetary offer received from reputed firms, manufacturing these item. For the transportation the rates are worked out separately taking into account the difficulty of the job.

6. **Estimate for transmission lines:** The estimate for the transmission lines is worked out based on the standard rate collected from the Chief Engineer, Transmission. K S E Board.

For all civil works the contractor's profit @ 10% and overhead charges @ 10 % are provided. Amenities to labour @ 30% is provided for labour part of the item, as stipulated in the guidelines.

CHAPTER - XIV

COST ESTIMATE – CIVIL WORKS

1	**Weir & Intake**			
1.1	Clearing the site	1800 m^2	170/100m^2	0.031
1.2	Temporary diversion arrangements	LS		0.100
1.3	Common excavation for foundation of weir, Energy dissipating arrangements etc.	45 m^3	210/m^3	0.0945
1.4	Rock excavation for foundation of weir, Energy dissipating arrangements etc.	50m^3	380/m^3	0.190
1.5	Foundation preparation	95 m^2	1180/10m^2	0.112
1.6	Providing anchor bars including drilling holes with jack hammer and grouting.	65kg	62/kg	0.0403
1.7	Cement concrete C_{40}-M_{150} for the foundation of overflow, non overflow, intake, body of overflow portion etc.	45 m^3	3150/m^3	1.418
1.8	Cement concrete C_{20}-M_{200} for overflow, intake energy dissipating arrangements and training walls including piers & beams of intake	28 m^3	3250/m^3	0.910
1.9	Providing contraction joints with copper sealing strips	21 m	1350/m	0.284
1.10	Providing reinforcement rods for the foundation of weir, spill way training walls, ogee portion, etc.	1.80 tons	40000/T	0.720
1.11	Fabricating and installing intake gates, and river sluices etc including erection.	2 Nos	LS	3.50
1.12	Contingencies			0.050
	Sub Total			**7.450**

2	**Low Pressure pipe (HDP Pipe)**			
2.1	Clearing the site	290 m^2	170/100m^2	0.005
2.2	Common excavation	150 m^3	210/m^3	0.315
2.3	Rock excavation	15 m^3	380/m^3	0.057
2.4	Providing reinforcement for concrete work	1.6 Tons	40000/T	0.640
2.5	Cross drainage works at places where the channel crosses the valley portion (Providing RCC pipe culvert)	LS		1.000
2.6	Supplying and erecting HDPE Pipe, to lines and levels	150m	2500/m	3.75
2.7	Contingencies			0.023
	Sub Total			**5.790**
3	**Forebay & Surplus Channel**			
3.1	Common excavation	150 m^3	210/m^3	0.315
3.2	Rock excavation	50 m^3	380/m^3	0.190
3.3	Cement concrete for walls, floor, foundation & counter fort with C_{20}-M_{200} concrete	80 m^3	3300/m^3	2.640
3.4	Providing vertical lift gates including lifting arrangements (Power operated)	LS		1.300
3.5	Providing a scour sluice to flush out the silt deposited in the tank	1 No	-	0.300
3.6	Providing a trash rack gate at LPP exit	0.5T	60000/T	0.300
3.7	Providing reinforcements for the concrete	7 Tones	40000/T	2.800
3.8	Contingencies			0.015
	Sub Total			**7.660**
4	**Penstock**			
4.1	Common excavation for track cutting, saddle supports, anchor blocks etc	80 m^3	210/m^3	0.168
4.2	Rock excavation	30 m^3	380/m^3	0.114
4.3	Cement concrete C_{40}-M_{200} for saddle supports and anchor blocks	15m^3	3300 / m^3	0.495
4.4	Providing reinforcements for concrete works	7T	40000/T	2.800

4.5	Fabrication and transportation of Penstock pipes : Straight pipes Expansion joint pipes Bend pipe	 63.00 T 2.60 T 3.20 T	 70000/T 80000/T 80000/T	 44.100 2.080 2.560
4.6	Erection of Penstock pipes including x-ray testing etc	68.8 Ton	6000 /T	4.128
4.7	Painting the pipes		L.S	0.800
4.8	Contingencies			0.055
	Sub Total			**57.300**
5.	**Power House**			
5.1	Clearing of site & Site levelling	200 m^2	170/100m^2	0.003
5.2	Common excavation for P.H Building and machine foundation	95 m^3	210/m^3	0.200
5.3	Rock excavation for P.H. Building and machine foundation	30m^3	380/m^3	0.114
5.4	Cement concrete M_{200} C_{40} for the foundation of column	8.5 m^3	3300/m^3	0.281
5.5	Cement concrete M_{200} C_{20} for columns gantry beam, slabs etc in Power House building	22m^3	3300/m^3	0.726
5.5	Cement concrete M_{200} C_{40} for machine foundation	12 m^3	3300/m^3	0.396
5.6	R. R masonry in CM 1:5 for the foundation and basement of Power House building	38 m^3	1750/m^3	0.665
5.7	Brick masonry walls in CM 1:5 for the Power House building walls	26 m^3	2730/ m^3	0.709
5.8	Supplying and fixing steel doors, windows and ventilation with glazed shutters and other fittings		Ls	0.600
5.9	Flooring with cement concrete M_{15} C_{40} for 15 cm thick including plastering with cement mortar two coats	45 m^2	3900/10m^2	0.175
5.10	Steel structural for gantry girder, roof beam, etc. with fabrication, conveyance & erection	4.5 T	65000/T	2.925

5.11	Providing reinforcements to concrete bend tied and placed in position.	3.7	40000/T	1.480
5.12	Roofing the power house building with GI sheets over steel trusses	108 m^2	433/m^2	0.468
5.13	Finishing works like Plastering, Painting, etc including rolling shutters and doors		Ls	2.60
5.14	Providing water supply and sanitary facility in PH building		Ls	0.35
5.15	Providing Electrification inside, the power house and switch yard		Ls	0.35
5.16	Contingencies		Ls	0.158
	Sub Total			12.200
6.	**Tailrace Channel**			
6.1	Clearing site		Ls	0.01
6.2	Earthwork excavation in ordinary soil, mixed with boulders	50 m^3	210/m^3	0.105
6.3	Rock excavation	5 m^3	380/m^3	0.019
6.4	R.R Masonry in cement mortar	15m3	1750	0.263
6.5	Concreting the bottom and sides of tail race channel	15 m^3	3300/m^3	0.495
6.5	Contingencies			0.028
	Sub Total			**0.920**
Grand Total (Civil Works)				91.520

CHAPTER - XV

COST ESTIMATE – ELECTRICAL WORKS

Turbine	Horizontal Pelton
Number of units and rating	2 Nos.125kW
Continuous overload capacity	10 %
Rated output	263 kW
Rated voltage	440 V
Governor	Electronic
Valve	Butterfly valve

	Item	Amount (Rs Lakhs)
1.	**E & M Equipments and auxiliaries**	
1.	Cost of Design, manufacture, tests at manufacturers works, supply, delivery at site, erection and commissioning of hydro turbine generating sets and auxiliaries as per the above requirements and as per standard specification, including Civil and structural works of switchyard including Earthment, lighting arrester. Switchyard accessories, connection hardware, communication and fire fighting equipments. Emergency lighting, ventilation and air-conditioning of control room, cable ducts, power cable Termination kits and all other accessories as per specification etc. complete including taxes, duties, insurance and provision of escalation etc.	
	Sub Total	75.00

2	Transmission works	
2.1	Constructing 11 kV line from the switchyard of power house to distribution locations = 2 km @ Rs. 2.5 lakhs/km	5.00
	Sub Total	**5.00**

CHAPTER – XVI

COST ESTIMATE –DEVELOPMENTAL WORKS

a . Preliminary

	Item	Amount (Rs Lakhs)
i	Construction of approach roads 0.45 km @ Rs 2.5 Lakhs/km	1.13
iii.	Establishment charges including Project Management, Audit and Accounts, Running cost of vehicles, Welfare to workers, Inspection of UNIDO and other Experts and Officials, Maintenance of roads during the construction period, Camp equipments, forest and other clearances etc.	7.00
iv.	Contingencies, consultancy, quality control, etc.	12.00
	Total	20.13

b. Cost of land

The forest land required for the project may be taken on long-term lease from Forest.

	Item	Amount (Rs Lakhs)
1	Private land required – 0.50 Ha	2.750
	Total	**2.750**

CHAPTER - XVII

ABSTRACT OF ESTIMATE

i. *Civil Works – water diversion works, water conductor system, Power House and tailrace channel*

i.	Weir	⇒	Rs. 7,45000
ii.	Low pressure pipe		Rs. 5,79000
iii.	Fore-Bay		Rs. 7,86000
iv.	Penstock pipe	⇒	Rs. 57,30000
v.	*Powerhouse civil works*	⇒	*Rs. 12,20000*
vi.	Tailrace channel	⇒	Rs. 92000
Total			Rs. 91,52,000

Total — Rs.91.52 Lakhs

II. **Powerhouse T&G Equipments, Switchyard**

i. Electromechanical Equipments = Rs. 75,00,000

Rs. 75.00 Lakhs

III Transmission of power

i. Transmission line works and LT distribution = **Rs. 5.00 Lakhs**

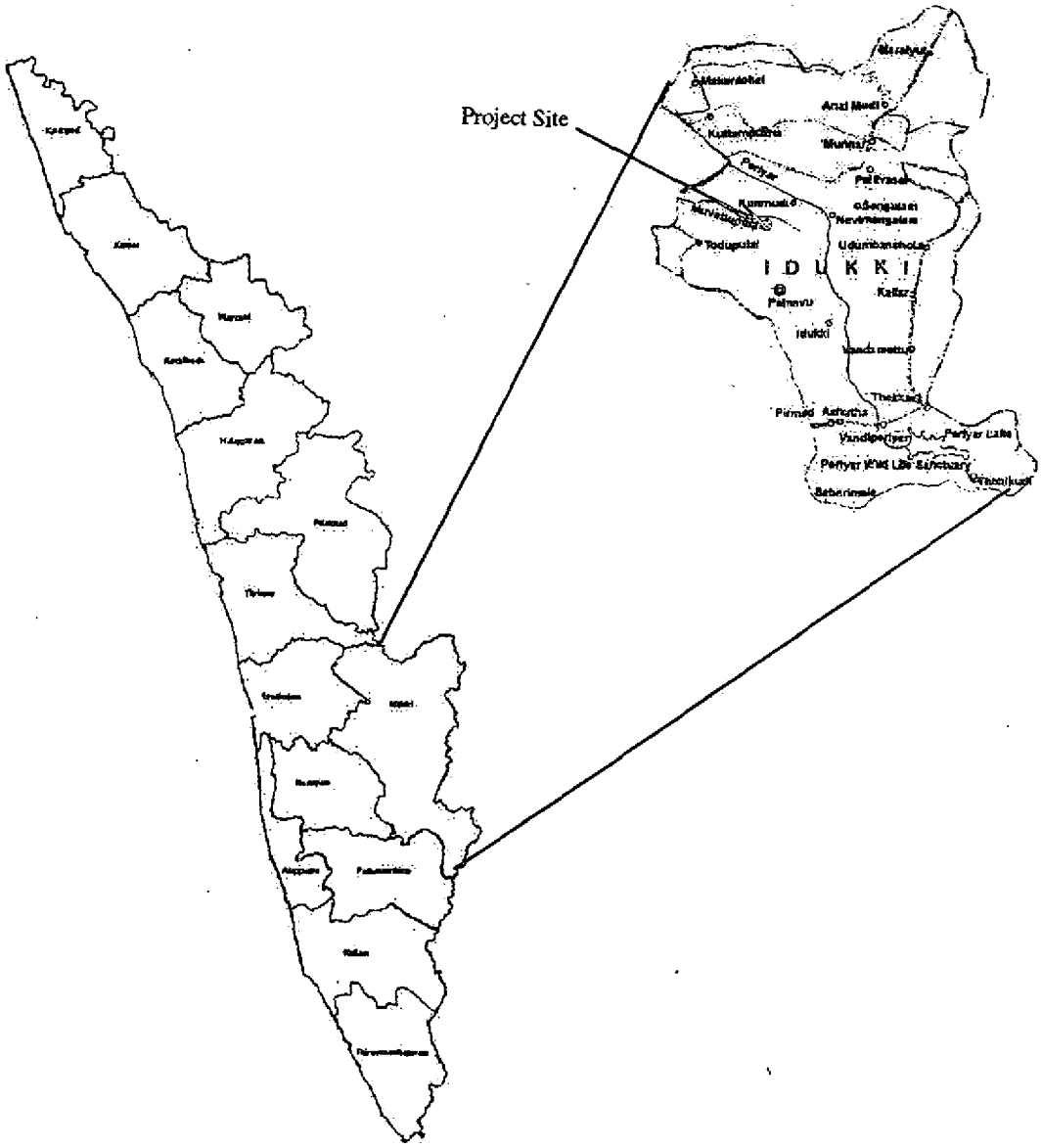
IV Developmental Works

i. Prelim: expenses, cost of land, approach roads & buildings = **Rs. 22.88 Lakhs**

GRAND TOTAL — **Rs. 194.40 Lakhs**

BALANTHODU MHP

PART – IV
DRAWINGS

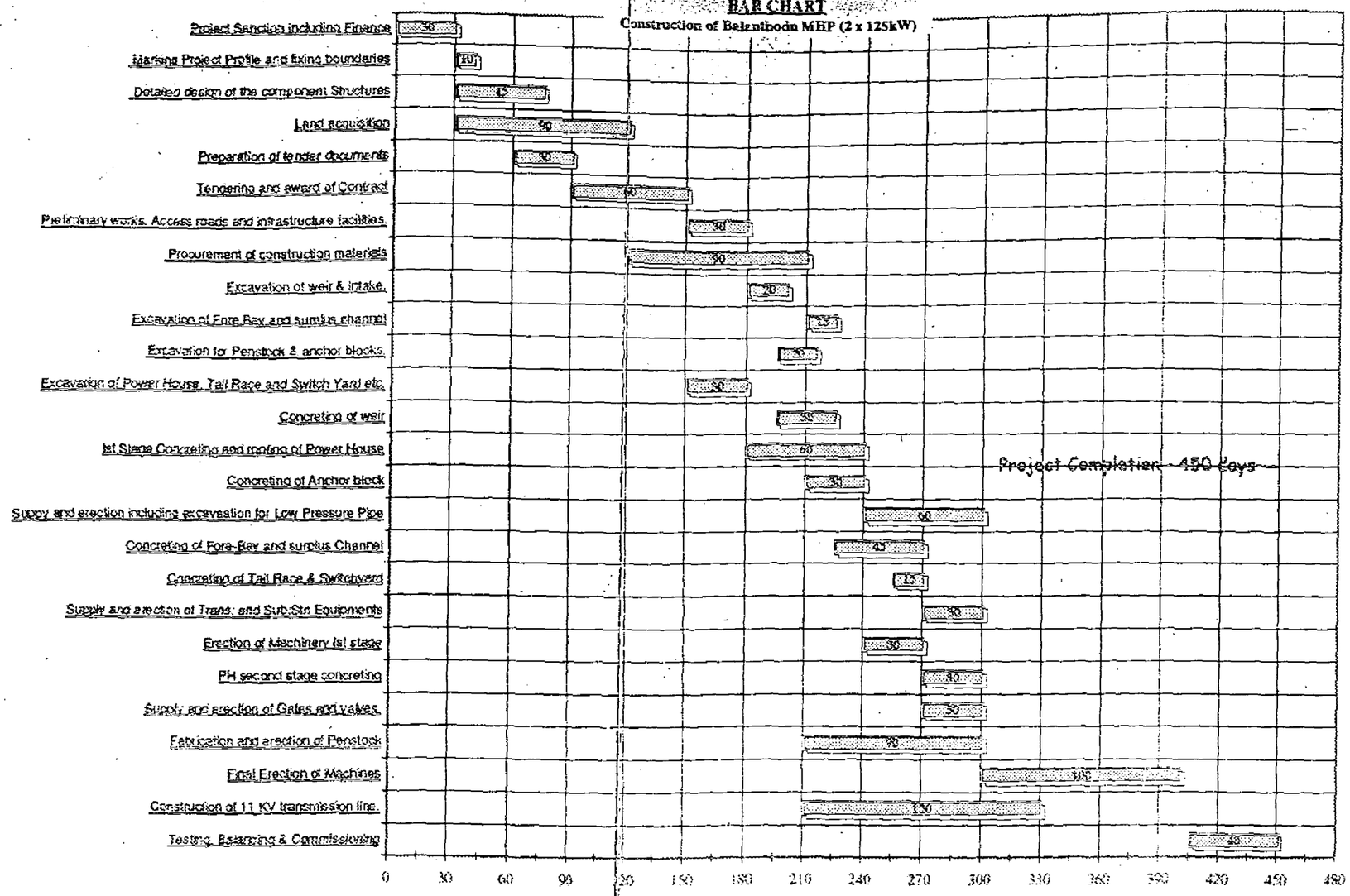


Project Report Drawing

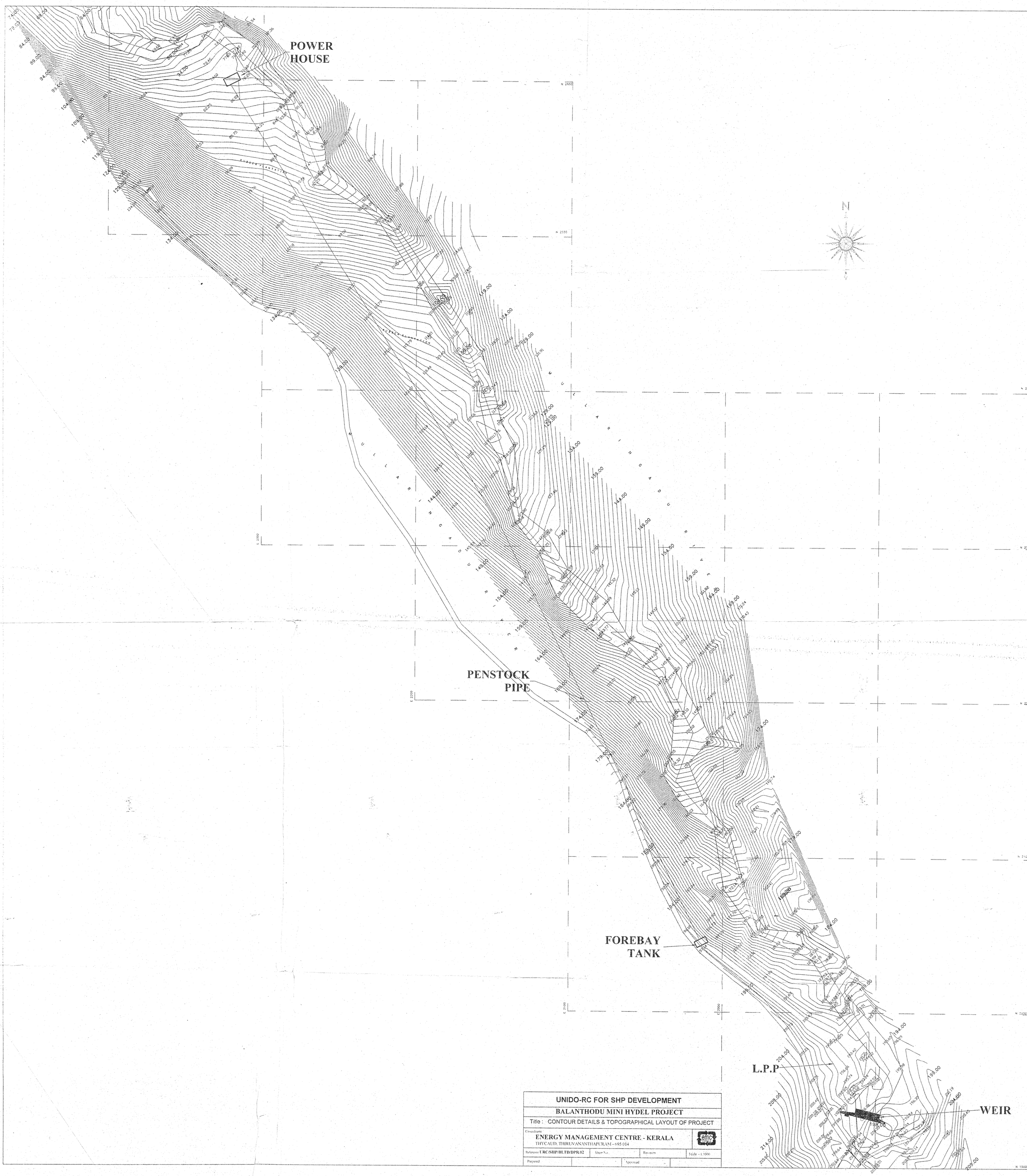
UNIDO-RC FOR SHP DEVELOPMENT			
BALANTHODU SMALL HYDEL PROJECT			
Title : INDEX MAP			
Consultants: ENERGY MANAGEMENT CENTRE – KERALA THYCAUD, THIRUVANANTHAPURAM - 695 014			
Reference: URC/SHP/BLTD/DPR/01	Sheet No.	Revision:	Scale: NS
Prepared:		Approved	

BAR CHART

Construction of Balanthodu MHP (2 x 125kW)



UNDP-GEF FOR SHP DEVELOPMENT			
BALANTHODU SMALL HYDEL PROJECT			
Title : PROJECT SCHEDULE			
Consultants: ENERGY MANAGEMENT CENTRE – KERALA THYCAUD, THIRUVANANTHAPURAM - 695 014			
Reference: URC/SHP/BLTD/DPR/03	Sheet No.	Revision:	Scale: NS
Prepared:	Approved		



UNIDO-RC FOR SHP DEVELOPMENT			
BALANTHODU MINI HYDEL PROJECT			
Title : CONTOUR DETAILS & TOPOGRAPHICAL LAYOUT OF PROJECT			
Consultants: ENERGY MANAGEMENT CENTRE - KERALA, THYCAUD, THIRUVANANTHAPURAM - 695 014			emc
Reference URC/SHP/BLTD/DPR/02	Sheet No.	Revision	Scale - 1:1000
Prepared		Approved	