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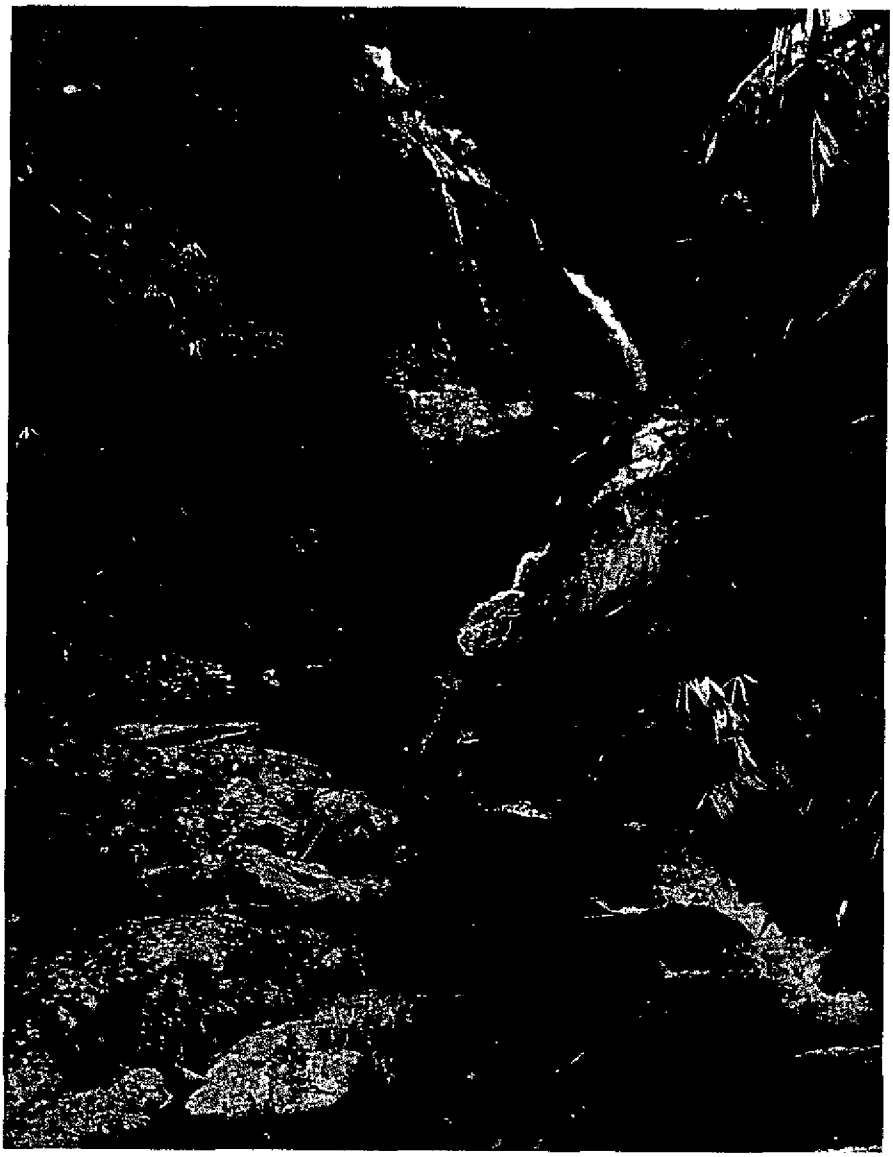
KILIKKALTHODU
MINI HYDROELECTRIC PROJECT
2 x 100 kW



DETAILED PROJECT REPORT

For

UNIDO Regional Centre for Small Hydropower

November 2005

PREFACE

UNIDO (*United Nations Industrial* Development Organisation), through its project No.US/IND/03/002 has established a Regional Centre for Small Hydro Power at the Energy Management Centre, Department of Power, Government of Kerala since April 2003. 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 three years of the initial duration of the project.

The United Nations Industrial Development Organization (UNIDO) opened its first Regional Centre for Small Hydro Power in Thiruvananthapuram, Kerala, India, on 4 April 2003. 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.

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 (Report Completed)
2. Kilikkalthodu	-	Mankulam Grama Panchayath
3. Rasathikuthu	-	Mannamkandam Panchayath (Adimaly Block)
4. Padivathil	-	Naranammozhi Panchayath (Ranni Block) Report Completed
5. Panamkudantha	-	Naranammozhi Panchayath (Ranni Block) Report Completed

The Kilikkalthodu Mini Hydro Electric Project is in Kilikkalthodu stream in Pooyamkutty basin and is located in Devikolam Block. The capacity of the scheme is 200 KW with an annual energy generation of 0.716 Mu.

The KSEB grid is yet to reach the village and the only power grid available is the 11kV evacuation line to evacuate the energy from the recently commissioned Pampumkayam micro hydel project. 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.

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 Rs2.73/Unit. Therefore this project is deemed financially viable.

CONTENTS

KILIKKALTHODU MHP

PART – I
GENERAL REPORT

CHAPTER - I

SALIENT FEATURES

1. Location		
1.1	***State***	Kerala
1.2	***District***	Idukki
1.3	***Thaluk***	Devikolam
1.4	***Panchayath***	Mankulam
1.5	***Access***	
	a. Road	15 km from Kallar up to Mankulam, then 6km jeep road to PH site via Perumankuthu, near to 6th Mile Kudi. From there 400m by foot path to weir site
	b. Rail	Kochi
	c. Airport	Kochi
	d. Harbour	Kochi
1.6	***Geographical Co-ordinates***	
	Latitude	10°06'35" N
	Longitude	76°57'55" E
2. River		
2.1	*River*	Kilikkalthodu, a tributary of Nallathanni River
2.2	*Basin*	Pooyamkutty
3. Hydrology		
3.1	*Catchment Area*	2.278 sq. km.
3.2	*Mean annual rainfall*	4977 mm
3.3	*Nearest rain gauge station*	Mankulam (Maintained by Forest Dept)
3.4	*Nearest river gauging station*	Viripara (Maintained by KSEB)
4. Component Structures		
4.1	***Diversion Structure***	
	i. Type	Gravity Weir with un-gated overflow portion
	ii. Length of weir	21m
	(a) Overflow portion	12m
	(b) Non Overflow portion	6m length on Left side and 3m on right side of overflow portion
	iii. Deepest Bed Level	592.50
	iv. Excavated level	592.00
	v. Top width of non -overflow	

	portion	1.00 m
	vi. Shape of the overflow portion	Ogee (Parabolic with vertical u/s face)
	vii. FSL	+595.00
	viii. Energy Dissipaters	Type II Stilling basin (IS)
	ix. Height of Weir at deepest bed level at overflow portion	3.00 m
	x. Top level of Non-overflow portion	+596.00
	xi. Size of river sluices and gate	0.5m dia, on left 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	+594.50
	iv. Size of Intake gate	1.0 x 1.0 m
	v. Control of gate	Manually operated vertical lift gates.
	vi. Floor level of Intake	+592.50
4.3	***Power channel***	
	i. Shape and width	Rectangular, 0.50m wide
	ii. Size	*190 m (Length) x 0.8 m (Height)*
	iii. Bed slope	1 in 500
	iv. Design discharge	0.382 m^3/sec
	v. Inlet bed level	+594.50
	vi. Outlet bed level	594.12
	vii. Velocity	1m/s
	viii. FSL	595.00
4.4	***Forebay***	
	i. Type	R.C.C rectangular tank with compartments
	ii. Size	8 x 6 x 4.00 (L x B x D)
	iii. Wall Thickness	50 cm
	iv. F. S. L	+595.00
	vi. M. D. D. L.	+593.50
	vii. Top of Tank	+595.75
	viii. Bottom level of tank	+591.75
	ix. Control gate	Electrically operated vertical lift gate (1.2x1m)
	x. C/L of penstock intake	592.57

4.5	***Penstock Pipe-(Steel Pipe)***	
	i. Number	1 No.
	ii. Diameter & Length	0.50m dia & 193 m long
	iii. Thickness of pipe	8 mm uniform
	iv. Design discharge	0.382 m^3/s
	v. No of feeder lines	Main penstock line bifurcating at PH end to feed 2 turbines (2 Nos. 0.40m dia)
	vi. Max. velocity	1.95m/sec
4.6	***Power House***	
	i. Type	Over Ground
	ii. Head (Net Head)	72.00m
	iii. Elevation of C/L of turbine	+520.00
	iv. Floor level of M/C hall	+337.00
	v. Tail water level (normal)	+519.00
	vi. Size	
	i. Length	7.0 m
	ii. Width	6.0 m
	iii. *Height*	8.0 m
	iv. Installed Capacity	200 kW
	v. Turbine type	Horizontal Francis turbine
	vi. No. of units & capacity	2 x 100kW
4.7	***Tail Race Channel***	
	i. Shape	Rectangular with rubble masonry sidewalls
	ii. Length	15 m
	iii. Size	1.0m x 1.0m
	iv. Sill level of channel at exit	+517.00
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***	0.716 Mu
6. Financial		
6.1	Total Cost of project	Rs. 107.90 Lakhs (incl. of transmission cost)
6.2	Cost per kW installed	Rs. 53950 /-
6.3	Cost of generation/ unit	Rs. 2.73 (incl. of transmission)

CHAPTER - II

INTRODUCTION

Kilikkalthodu waterfall is located in the Kilikkalthodu stream originating at an altitude of 1500m at Kanakkattumala. The stream drains into Nallathanni a second order stream to Karinthiri River. Project site is located in the remote side of Mankulam Panchayath near to 6th mile kudi very near to the forest regions. The site is characterised with its high head and reasonably good summer discharge of approximately 0.07m^3/s. The gross head of this site is estimated to be about 75m. The design head after deducting the losses comes to 72m

The Panchayath is very much un-electrified leaving apart a few beneficiaries from the recently commissioned Pampumkayam 100kW Micro hydel project and some community based micro hydro initiatives by the local people covering around 300 electric connections. In addition there are a number of Pico hydro equipments by individuals run on motorbike dynamos with batteries. The total population of the Panchayath is around 15,000 out of which 25% 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 500m away from 6th mile kudi a tribal settlement in Mankulam. The project will not cause any forest submergence with the proposed weir having a height of about 4 m. Regarding the water conductor system, the rectangular power channel (0.50m x 0.80m) is passing through the cultivated private lands. This project envisages 11kV power evacuation line of around 2 km to distribution locations.

The capacity of the scheme is 2 x100kW. The capacity is selected after detailed study of the availability of water in the stream by correlating the rain fall readings obtained from the Forest rain-gauge station, Mankulam.

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 just downstream of the forest boundary, so that the disturbance of the forest is minimum. On detailed study it is seen that the major fall available above the present weir location cannot be utilized due to the special nature of terrain in the locality, access and disturbance of forest.

A simple intake with vertical lift gate is proposed on the left bank of the river through the non overflow portion of the weir. A channel having a length of 190m is fixed 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 75m. The hydrology of the

scheme is worked out based on the rainfall records obtained from Kerala Forest Dept. The total catchment area of the stream is 2.278 km^2 and average annual rainfall is 4977mm. Though a weir gauge (Viripara diversion) station owned by KSEB is available the reading cannot be compared with the rainfall in the area. For computing the summer discharge attempt has been made to correlate the measured lean period discharge at Kozhiyilakuthu.

From the forebay a penstock having a length of about 193m, 50cm dia have to be installed for the generation of power. The turbine selected is Hori: Francis turbine to suit the available head and discharge. The machines selected are with denomination of 2 x 100kW, 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 1.079 Crores and cost per kWh is Rs. 2.73 with a pay back period of 11 years. This is economically viable and better to implement at the earliest. There is no eviction and 0.25 Ha of private land is involved in the channel route. There is Katcha approach road up to the powerhouse site and about 400m away from the weir site.

The main components of the structures of the project are

1. Concrete overflow weir of length 21m with Non-overflow portion of 6m on left bank and 3m on right bank.
2. A gated intake having an opening of 1.0x1.0m 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 the a rectangular channel having a 0.5m x 0.8 m section
5. A forebay with 3 min storage having a size of 8 x 6 x 4 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 rejection near the forebay.
7. A penstock having a dia of 50cm and thickness 8mm is to be provided and bifurcated near to the powerhouse.
8. A powerhouse having a size of 7 x 6x 8 m is to be provided
9. A tailrace channel of length 15m have to be cut and lined for the safe flow of water back to the river without being affected by the high flood conditions. The rectangular tailrace channel will have a width of 1m and depth of 1m.

CHAPTER - III
SURVEY AND INVESTIGATION

Reconnaissance survey was first conducted along the course of Kilikkalthodu stream from its confluence point with Nallathanni stream to upstream side. This survey revealed that the stream upstream of confluence point is passing through moderate slope to steep slope terrain. The contribution of the high head potential due to these waterfalls 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 in and the head potential to the optimum extent possible, after taking into consideration of all factors affecting the project, such as engineering, environmental, social and economical, so that there is an integrated approach.

A detailed investigation was carried out independently for this project. After conducting field investigation and environmental studies, taking into account of possible impact on the forest, it was decided to carry out construction activities limiting least disturbances to forest.

A large portion of land lying on the left bank of stream is private land owned by people in and around Mankulam. This land is being used for cultivating pepper, rubber, cashew areca nut and other cash crops and other agricultural produces by farmers. Data collected through reconnaissance study, reveals that the water conductor system, and power house etc can be located on the left bank of the stream, without having much impact on the forest, the tribal people and settlement system.

Since no level benchmark is established at this site, an arbitrary benchmark value of +600.00 is assigned at the top of the waterfalls. This value also confers with the spot level value shown in the survey of India topo sheets as well as the digital altimeter reading taken at the weir site. A preliminary topography survey is carried out covering 30 m on the either banks of the stream, along its course. The level difference of the ground at the top of the waterfall and the powerhouse site comes to 111 meters, i.e., (631.00 – 520.00). The upper waterfalls cannot be considered because of the typical topographic terrain and the thick forest area. Alternate proposals with weir site and P.H site at various levels were studied and for optimum utilisation of

the head potential and water availability, the present proposal with a weir below the first water fall at +592.50 and P.H. at+520.00 is selected.

Topography survey covering the whole project area was completed. A copy of the survey drawing is enclosed. Both the banks of the stream were surveyed with greater emphasis on the left bank of the stream. Alternate routes for the water conductor system were studied and a combination of open channel 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 kacha road. The site for power channel, 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. Majority of the area are in private land except the weir site, wherein there is revenue land (River bed).

CHAPTER – IV
HYDROLOGY

Kilikkalthodu Mini Hydro electric Scheme envisages the utilisation of water from Kilikkalthodu stream, the primary tributary of Nallathanni stream originating at an altitude of 1500m at Kanakkattumala. The Kilikkalthodu stream flows in the north-west direction before joining to the Nallathanni stream, which ultimately joins Karinthiri River. There is no river gauging in the stream. The rain gauge readings obtained from the rain gauge station maintained by Kerala Forest Department at Mankulam has been considered for working out the water availability. The rainfall readings of KSEB rain gauge station at Mankulam was checked and found that the readings are inconsistent. Therefore the rainfall readings of the Forest rain gauging station has been analysed and the runoff has been calculated based on that using Inglis formula for ghats region, R= (0.85P-300)A. The catchment area is computed from the topo sheets and it comes to 2.278km^2. The monthly rainfall readings from 1987-88 to 1997-98 were collected and attached in Table-1.

The discharge in the stream has been computed based on the rainfall readings as explained above in proportion to the rain fall and tabulated in Table-2. An attempt was made to assess the lean period discharge from the river. For this, the gauge reading obtained from Kozhiyilakuthu stream has been utilised. The readings taken and the discharge calculated proportional to the catchment area. The average lean period discharge obtained is 0.07m^3/s.

On computation from the monthly discharge it can be seen that

The average discharge of six months (monsoon period) is

1. For 11 years (1987-88 to 1997-98) = 0.502 m^3/s
2. 50% dependable year = 0.507 m^3/s
3. 75% dependable year = 0.461m^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 75% dependable year and the installed capacity is fixed as 200kW. Considering 10% overloading of turbine & generator the required discharge will be 0.382m^3/s.

The daily discharge so computed for the years 1987-88 to 1997-98 has been tabulated and the working table prepared.

Maximum flood estimation

Flood estimation is done using Ryve's formula, $Q_{max} = C(A)^{2/3}$.

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 $Q_{max} = 8.45 \times (2.278)^{2/3} = 14.629\ m^3/s$. 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 0.07 m^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 4977.50 mm. Rainfall is available from June to November. This scheme is a run of the river scheme and power generation is intended during monsoon season only.

Table – 1. Monthly Rainfall readings in mm from 1987-88 to 1997-98 of Forest Rain Gauge station at Mankulam

	June	July	August	September	October	November	December	January	February	March	April	May	Yearly Total
1987-88	362.50	464.70	986.00	332.50	342.20	195.00	146.80	0.00	0.00	0.00	326.20	51.20	**3207.10**
1988-89	583.50	1154.70	832.50	866.00	180.00	86.20	60.00	0.00	0.00	30.50	94.70	0.00	**3888.10**
1989-90	1057.50	2029.00	516.20	498.20	426.00	0.00	0.00	0.00	0.00	38.70	0.00	546.20	**5111.80**
1990-91	1016.10	1184.40	1325.20	121.10	326.20	139.90	0.00	0.00	100.00	90.00	118.70	45.00	**4466.60**
1991-92	1659.00	1410.00	837.50	43.50	294.20	124.60	0.00	0.00	3.70	0.00	184.30	346.65	**4903.45**
1992-93	1189.40	1672.50	977.80	569.10	376.90	371.40	4.00	0.00	96.50	63.50	161.30	292.20	**5774.60**
1993-94	990.20	1490.00	1100.20	371.80	692.50	230.20	58.50	27.20	49.50	0.00	302.20	216.20	**5528.50**
1994-95	1459.80	1642.20	971.00	446.00	693.50	300.80	0.00	54.50	17.00	44.80	229.80	523.00	**6382.40**
1995-96	888.00	1433.70	1194.90	753.20	340.50	204.20	0.00	34.30	28.50	42.50	409.70	109.80	**5439.30**
1996-97	958.30	1375.50	852.20	690.20	476.50	116.50	19.60	2.00	1.50	88.50	220.00	256.30	**5057.10**
1997-98	506.00	1823.25	991.00	490.00	399.50	328.00	153.20	2.00	1.20	73.50	94.00	132.00	**4993.65**
Average	**970.0**	**1425.5**	**962.2**	**471.1**	**413.5**	**190.6**	**40.2**	**10.9**	**27.1**	**42.9**	**194.6**	**229.0**	***4977.50***

Table – 2. Monthly inflow of Kilikkalthodu Catchment in m^3/sec

Year	June	July	August	September	October	November	December	January	February	March	April	May
1987-88	0.241	0.299	0.634	0.221	0.220	0.130	0.094	0.000	0.000	0.000	0.217	0.033
1988-89	0.396	0.759	0.547	0.588	0.118	0.059	0.039	0.000	0.000	0.020	0.064	0.000
1989-90	0.735	1.366	0.347	0.346	0.287	0.000	0.000	0.000	0.000	0.026	0.000	0.368
1990-91	0.699	0.789	0.882	0.083	0.217	0.096	0.000	0.000	0.074	0.060	0.082	0.030
1991-92	1.150	0.946	0.562	0.030	0.197	0.086	0.000	0.000	0.003	0.000	0.128	0.233
1992-93	0.834	1.135	0.664	0.399	0.256	0.260	0.003	0.000	0.073	0.043	0.113	0.198
1993-94	0.692	1.003	0.745	0.260	0.469	0.161	0.040	0.018	0.037	0.000	0.211	0.146
1994-95	1.030	1.122	0.663	0.315	0.474	0.212	0.000	0.037	0.013	0.031	0.162	0.357
1995-96	0.620	0.969	0.808	0.526	0.230	0.143	0.000	0.023	0.021	0.029	0.286	0.074
1996-97	0.666	0.925	0.573	0.480	0.320	0.081	0.013	0.001	0.001	0.060	0.153	0.172
1997-98	0.351	1.225	0.666	0.340	0.268	0.228	0.103	0.001	0.001	0.049	0.065	0.089
Total	**7.416**	**10.542**	**7.091**	**3.589**	**3.057**	**1.456**	**0.292**	**0.082**	**0.222**	**0.317**	**1.482**	**1.700**
Average	***0.674***	***0.958***	***0.645***	***0.326***	***0.278***	***0.132***	***0.027***	***0.007***	***0.020***	***0.029***	***0.135***	***0.155***

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 for 30m through the length of the power channel portion. 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 left 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 available at reasonable depth. It is revealed from the trial pit that the rock is available at a depth of about 3m below riverbed.

General geology is suitable for weir site powerhouse site and water conductor system. Regarding Forebay site rock is not available. Therefore forebay tank has to be designed for permeable foundation soil.

CHAPTER – VI

NEED & NECESSITY OF THE PROJECT

Mankulam Panchayath, an agricultural resource rich village in the Idukki district of Kerala State, devoid of communication facilities, is very much un-electrified leaving apart a few beneficiaries from the recently commissioned Pampumkayam 100kW Micro hydel project and some community based micro hydro initiatives by the local people covering around 100 electric connections from three schemes of capacities in the range of 5-15 kW. In addition there are a number of Pico hydro equipments by individuals run on motorbike dynamos with batteries. The total population of the Panchayath is around 15,000 out of which 25% of the population belongs to scheduled tribe category.

More than 6 waterfalls are available in this Panchayath, all of them having power generation potential. 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, which was commissioned in October 2004, with the financial and technical help from UNIDO Regional Centre for Small Hydropower Development (UNIDO-RC), functioning in Energy Management Centre, Kerala (EMC), an autonomous institution under Dept of Power, Govt. of Kerala.

The newly commissioned Pampumkayam micro hydel project could cater only a mere 5% of the population in the Mankulam Panchayath. The local bodies were still searching for an option to supply power to a great majority of the population, which is spread over the Panchayath. They looked up to the UNIDO-RC/EMC to give them more technical & financial help in developing another source of power, which can cater to the whole electricity needs of the Panchayath. Accordingly, EMC has made reconnaissance site visits to various potential mini hydropower project sites within the Mankulam Grama Panchayath area during February 2005 along with the representatives of the Panchayath.

After pondering through the various alternatives the engineers of UNIDO-RC/EMC has come up with the best possible option for hydropower generation in the Panchayath at Kilikkalthodu scheme which is situated at about 5km away from Mankulam in the tributary called Nallathanni stream of Karinthiri river. The scheme has a potential for 200kW power generation. This project can cater to the immediate power needs of the Panchayath to a great extend.

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

Kilikkalthodu 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 Power Channel.
11. Excavation of Fore Bay and surplus channel
12. Excavation of Penstock and anchor block.
13. Excavation of Power House, Tail Race and Switch Yard etc.
14. Concreting of weir
15. 1st Stage Concreting and roofing of Power House
16. Concreting of Anchor block and Erection of Penstock
17. Lining of Channel and other protective and drainage works
18. Concreting of Fore-Bay and surplus Channel
19. Concreting of Tail Race & Switch yard
20. Supply and erection of T & G equipments, substation equipments etc
21. Erection of Machinery 1st stage
22. PH second stage concreting
23. Supply and erection of Gates and valves.
24. Fabrication and erection of Penstock
25. Final Erection of Machines
26. Construction of 11 KV transmission line.
27. 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

Kilikkalthodu 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.

Only 0.4 Ha of private land is required for this project. The construction of the project will be in such a way, that the disturbance of forest due to this project is minimum. 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.)	3.30
	B. Works – Diversion structures, Water conductor System, Forebay, Powerhouse and Tail Race etc.	44.60
II	Electrical Works	
	i. Power plant equipments, accessories switchyard equipment	45.00
	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.	2.00
IV	Contingencies, consultancy, quality control, etc.	8.00
	Total	**107.90**

9.2 Year wise planning

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

Expenditure for 1st year	Rs. 58.00lakhs
Expenditure for 2nd year	Rs. 49.90 lakhs
Total	**Rs. 107.90 lakhs**

CHAPTER - X

BENEFITS AND FINANCIAL ASPECTS

Kozhiyilakuthu Micro 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 Mankulam area.

Direct benefit of this project is the availability of 0.7 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 30:70

The cost of Generation of energy is found to be Rs 2.73/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: - Kilikkalthodu MHP
INSTALLED CAPACITY - 0.2 MW
Total Cost of project = Rs. 107.9 Lakhs
Period of implementation of project: 2 years
Source of financing of project: 30% Equity, 70% loan
Equity = 32.37 say, Rs. 32.5 Lakhs Loan = 75.53 say, Rs. 75.4 Lakhs

Phasing of expenditure	30% Equity	70% loan	Total
1st Year	Rs. 32.5 Lakhs	Rs. 25.5 Lakhs	Rs. 58 Lakhs
2nd Year	Rs. 0 Lakhs	Rs. 49.9 Lakhs	Rs. 49.9 Lakhs

Interest on loan = 10%
Interest During Construction
1st Year = 25.5x(10%)/2 = 1.28 Lakhs
2nd Year = 49.9x(10%)/2+25.5x10% = 5.05 Lakhs
Total = 6.32 say, Rs. 6.32 Lakhs
Interest during construction is capitalized. Hence total loan = Rs.81.72 Lakhs
Total cost of project on completion will be 32.5 + 81.72 = Rs. 114.22 Lakhs

Annual recurring expenses
(a) Interest on loan @ 10% p.a = Rs. 8.18 Lakhs
(b) Operation and maintenance expenses @ 1% of Project cost = Rs. 1.079 Lakhs
(c) Depreciation @ 2.3% of project cost = Rs. 2.49 Lakhs
(d) Dividend on Equity at 10% = Rs. 3.25 Lakhs
(e) Total expenses = Rs. 15 Lakhs
Total power generated from the project = 0.716 Mu
Deducting
i. Power for auxiliary use @ 1% of generation = 0.00716 , provide 0.016 Mu
ii. Transmission and wheeling
Net power available = 0.70 Mu
Cost of generation of power per unit = 15/[0.70x10] = Rs. 2.15
If the loan amount is to be repaid in 11 years time, 5% of the loan amount is to be paid back every year; therefore repayment amount = Rs. 4.09 Lakhs
The total recurring cost per year will be = [15+4.09] = Rs. 19.08 Lakhs
Hence unit rate of power generation per unit =19.08/[0.70x10] = Rs. 2.73
The repayment and interest are to be made at a flat rate of [8.18 + 4.09] = Rs. 12.27 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.

Kilikkalthodu MHP 2 x 100kW

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} in Rs. Crores	O/M cost +depreciated expenses in Rs. Crores	Net Power Available for the company in Mu	Gross revenue @ in Rs Crores	Return on Equity @10% in Rs Crores	Net revenue col{8} - col{6}- col{9} in Rs Crores	Annual surplus +ve or -ve (col.{10}- col.{5}) in Rs Crores	Sum of expenditure (Loan) at the end of year col.{2} + col.{4} -col.{11} in Rs Crores
{1}	{2}	{3}	{4}	{5}	{6}	{7}	{8}	{9}	{10}	{11}	{12}
I	0.00	0.33	0.26	0.01						-0.01	0.27
II	0.27	0.00	0.50	0.05						-0.05	0.82
1	0.82	0.00	0.00	0.08	0.04	0.70	0.19	0.03	0.12	0.04	0.78
2	0.78	0.00	0.00	0.08	0.04	0.70	0.19	0.03	0.12	0.05	0.73
3	0.73	0.00	0.00	0.07	0.04	0.70	0.19	0.03	0.12	0.05	0.68
4	0.68	0.00	0.00	0.07	0.04	0.70	0.19	0.03	0.12	0.05	0.63
5	0.63	0.00	0.00	0.06	0.04	0.70	0.19	0.03	0.12	0.06	0.57
6	0.57	0.00	0.00	0.06	0.04	0.70	0.19	0.03	0.12	0.07	0.50
7	0.50	0.00	0.00	0.05	0.04	0.70	0.19	0.03	0.12	0.07	0.43
8	0.43	0.00	0.00	0.04	0.04	0.70	0.19	0.03	0.12	0.08	0.35
9	0.35	0.00	0.00	0.03	0.04	0.70	0.19	0.03	0.12	0.09	0.26
10	0.26	0.00	0.00	0.03	0.04	0.70	0.19	0.03	0.12	0.10	0.16
11	0.16	0.00	0.00	0.02	0.04	0.70	0.19	0.03	0.12	0.11	0.06
12	0.06	0.00	0.00	0.01	0.04	0.70	0.19	0.03	0.12	0.12	-0.06
13	-0.06	0.00	0.00	-0.01	0.04	0.70	0.19	0.03	0.12	0.13	-0.19
14	-0.19	0.00	0.00	-0.02	0.05	0.70	0.08	0.03	0.00	0.02	-0.21
15	-0.21	0.00	0.00	-0.02	0.05	0.70	0.08	0.03	0.00	0.02	-0.23
16	-0.23	0.00	0.00	-0.02	0.05	0.70	0.08	0.03	0.00	0.02	-0.25
17	-0.25	0.00	0.00	-0.03	0.05	0.70	0.08	0.03	0.00	0.03	-0.28
18	-0.28	0.00	0.00	-0.03	0.05	0.70	0.08	0.03	0.00	0.03	-0.30
19	-0.30	0.00	0.00	-0.03	0.05	0.70	0.08	0.03	0.00	0.03	-0.33
20	-0.33	0.00	0.00	-0.03	0.05	0.70	0.08	0.03	0.00	0.03	-0.37
21	-0.37	0.00	0.00	-0.04	0.05	0.70	0.08	0.03	0.00	0.04	-0.40
22	-0.40	0.00	0.00	-0.04	0.05	0.70	0.08	0.03	0.00	0.04	-0.44
23	-0.44	0.00	0.00	-0.04	0.05	0.70	0.08	0.03	0.00	0.04	-0.49
24	-0.49	0.00	0.00	-0.05	0.05	0.70	0.08	0.03	0.00	0.05	-0.54
25	-0.54	0.00	0.00	-0.05	0.05	0.70	0.08	0.03	0.00	0.05	-0.59

KILIKKALTHODU MHP

PART – II
DESIGN REPORT

CHAPTER - XI

WATER AVAILABILITY & POWER POTENTIAL STUDIES

Kilikkalthodu MHP scheme envisages utilisation of water in the Nallathanni stream a tributary of Karinthiri river in Pooyamkutty basin for power generation of 200 kW. The scheme is designed as a run of the river scheme with no storage provisions.

Average rainfall

Monthly rainfall data for 11 years from 1987-88 to 1997-98 of Mankulam rain gauge station maintained by Kerala Forest Department has been adopted for the hydrological studies. The average annual rainfall in the rain gauge station is 4977.50 mm.

The catchment area of the stream at the weir location is about 2.278km^2.

Rainfall Details in mm at Mankulam Forest Rain Gauge station 1987-88 to 1997-98

Year	Annual Rainfall
1987-88	3207.10
1988-89	3888.10
1989-90	5111.80
1990-91	4466.60
1991-92	4903.45
1992-93	5774.60
1993-94	5528.50
1994-95	6382.40
1995-96	5439.30
1996-97	5057.10
1997-98	4993.65
Average	***4977.50***

Average runoff can be calculated using Inglis formula for ghat region is R = 0.85P-300

i.e. R = 0.85 x 4977.5 -300 = 3920.45

The total rainfall occurs mainly on the monsoon seasons, which accounts for about 6 months. Therefore average discharge on a day will be

$= (3920.45 \times 2.278 \times 1000 \times 1000)/(1000 \times 180 \times 24 \times 60 \times 60) = 0.574\ m^3/s.$

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

1.	Full reservoir level	-	+595.00
2.	Sill level of intake	-	+594.50
3.	Bed level of power channel at inlet	-	+594.50

4.	Bed slope of channel	-	1:500
5.	Bed level of channel at fore bay end	-	+594.00
6.	F.S.L at Forebay	-	+595.00
7.	M.D.D.L at Forebay	-	+593.50
8.	Level of c/l of runner	-	+520.00
9.	Max Head available	-	75.00 m
10.	Net design head allowing a head loss of 3m	-	72.00 m

For a Power requirement of 1 kW

Power, P = 8.Q.H

$1000 = 8 \times Q \times H$

$H = 72$ m

Then power draft, $Q = \frac{1000}{8 \times 72} = 1.736$ m^3/s

Power draft for various capacities of turbines from 10kW to 220 kW are as follows

10 kW	= 0.017 m^3/s	= 1500 m^3/day
25 kW	= 0.043 m^3/s	= 3750 m^3/day
40 kW	= 0.069 m^3/s	= 6000 m^3/day
100 kW	= 0.174 m^3/s	=15000m^3/day
200 kW	= 0.347 m^3/s	=30000 m^3/day
220 kW	= 0.382 m^3/s	=33000 m^3/day

The power generation possible with turbines of capacity from 10 kW to 220 kW (10% overload of 200 kW) are worked out as attached. For optimum power utility, it is proposed to have two generators of 100 kW each. The power potential study has been conducted and attached. The Annual energy generation will be 0.716 Mu.

Power potential calculation for Kilikkalthodu MHP project for 75% dependable year – 1990-91

Date	Computed Discharge at Kilikkalthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x100	Mu/day
1-Jun-96	0.70	402.67	220.00	0.01
2-Jun-96	0.70	402.67	220.00	0.01
3-Jun-96	0.70	402.67	220.00	0.01
4-Jun-96	0.70	402.67	220.00	0.01
5-Jun-96	0.70	402.67	220.00	0.01
6-Jun-96	0.70	402.67	220.00	0.01
7-Jun-96	0.70	402.67	220.00	0.01
8-Jun-96	0.70	402.67	220.00	0.01
9-Jun-96	0.70	402.67	220.00	0.01
10-Jun-96	0.70	402.67	220.00	0.01
11-Jun-96	0.70	402.67	220.00	0.01
12-Jun-96	0.70	402.67	220.00	0.01
13-Jun-96	0.70	402.67	220.00	0.01
14-Jun-96	0.70	402.67	220.00	0.01
15-Jun-96	0.70	402.67	220.00	0.01
16-Jun-96	0.70	402.67	220.00	0.01
17-Jun-96	0.70	402.67	220.00	0.01
18-Jun-96	0.70	402.67	220.00	0.01
19-Jun-96	0.70	402.67	220.00	0.01
20-Jun-96	0.70	402.67	220.00	0.01
21-Jun-96	0.70	402.67	220.00	0.01
22-Jun-96	0.70	402.67	220.00	0.01
23-Jun-96	0.70	402.67	220.00	0.01
24-Jun-96	0.70	402.67	220.00	0.01
25-Jun-96	0.70	402.67	220.00	0.01
26-Jun-96	0.70	402.67	220.00	0.01
27-Jun-96	0.70	402.67	220.00	0.01
28-Jun-96	0.70	402.67	220.00	0.01
29-Jun-96	0.70	402.67	220.00	0.01
30-Jun-96	0.70	402.67	220.00	0.01
1-Jul-96	0.79	454.22	220.00	0.01
2-Jul-96	0.79	454.22	220.00	0.01
3-Jul-96	0.79	454.22	220.00	0.01
4-Jul-96	0.79	454.22	220.00	0.01
5-Jul-96	0.79	454.22	220.00	0.01
6-Jul-96	0.79	454.22	220.00	0.01
7-Jul-96	0.79	454.22	220.00	0.01
8-Jul-96	0.79	454.22	220.00	0.01
9-Jul-96	0.79	454.22	220.00	0.01
10-Jul-96	0.79	454.22	220.00	0.01
11-Jul-96	0.79	454.22	220.00	0.01
12-Jul-96	0.79	454.22	220.00	0.01
13-Jul-96	0.79	454.22	220.00	0.01
14-Jul-96	0.79	454.22	220.00	0.01
15-Jul-96	0.79	454.22	220.00	0.01
16-Jul-96	0.79	454.22	220.00	0.01

Catchment Area = 2.278km^2
Head = 72 m

Date	Computed Discharge at Kilikkalthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x100	Mu/day
17-Jul-96	0.79	454.22	220.00	0.01
18-Jul-96	0.79	454.22	220.00	0.01
19-Jul-96	0.79	454.22	220.00	0.01
20-Jul-96	0.79	454.22	220.00	0.01
21-Jul-96	0.79	454.22	220.00	0.01
22-Jul-96	0.79	454.22	220.00	0.01
23-Jul-96	0.79	454.22	220.00	0.01
24-Jul-96	0.79	454.22	220.00	0.01
25-Jul-96	0.79	454.22	220.00	0.01
26-Jul-96	0.79	454.22	220.00	0.01
27-Jul-96	0.79	454.22	220.00	0.01
28-Jul-96	0.79	454.22	220.00	0.01
29-Jul-96	0.79	454.22	220.00	0.01
30-Jul-96	0.88	508.22	220.00	0.01
31-Jul-96	0.88	508.22	220.00	0.01
1-Aug-96	0.88	508.22	220.00	0.01
2-Aug-96	0.88	508.22	220.00	0.01
3-Aug-96	0.88	508.22	220.00	0.01
4-Aug-96	0.88	508.22	220.00	0.01
5-Aug-96	0.88	508.22	220.00	0.01
6-Aug-96	0.88	508.22	220.00	0.01
7-Aug-96	0.88	508.22	220.00	0.01
8-Aug-96	0.88	508.22	220.00	0.01
9-Aug-96	0.88	508.22	220.00	0.01
10-Aug-96	0.88	508.22	220.00	0.01
11-Aug-96	0.88	508.22	220.00	0.01
12-Aug-96	0.88	508.22	220.00	0.01
13-Aug-96	0.88	508.22	220.00	0.01
14-Aug-96	0.88	508.22	220.00	0.01
15-Aug-96	0.88	508.22	220.00	0.01
16-Aug-96	0.88	508.22	220.00	0.01
17-Aug-96	0.88	508.22	220.00	0.01
18-Aug-96	0.88	508.22	220.00	0.01
19-Aug-96	0.88	508.22	220.00	0.01
20-Aug-96	0.88	508.22	220.00	0.01
21-Aug-96	0.88	508.22	220.00	0.01
22-Aug-96	0.88	508.22	220.00	0.01
23-Aug-96	0.88	508.22	220.00	0.01
24-Aug-96	0.88	508.22	220.00	0.01
25-Aug-96	0.88	508.22	220.00	0.01
26-Aug-96	0.88	508.22	220.00	0.01
27-Aug-96	0.88	508.22	220.00	0.01
28-Aug-96	0.88	508.22	220.00	0.01
29-Aug-96	0.88	508.22	220.00	0.01
30-Aug-96	0.88	508.22	220.00	0.01
31-Aug-96	0.88	508.22	220.00	0.01
1-Sep-96	0.08	47.99	47.99	0.00
2-Sep-96	0.08	47.99	47.99	0.00
3-Sep-96	0.08	47.99	47.99	0.00

Catchment Area = 2.278km^2
Head = 72 m

Date	Computed Discharge at Kilikkalthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x100	Mu/day
4-Sep-96	0.08	47.99	47.99	0.00
5-Sep-96	0.08	47.99	47.99	0.00
6-Sep-96	0.08	47.99	47.99	0.00
7-Sep-96	0.08	47.99	47.99	0.00
8-Sep-96	0.08	47.99	47.99	0.00
9-Sep-96	0.08	47.99	47.99	0.00
10-Sep-96	0.08	47.99	47.99	0.00
11-Sep-96	0.08	47.99	47.99	0.00
12-Sep-96	0.08	47.99	47.99	0.00
13-Sep-96	0.08	47.99	47.99	0.00
14-Sep-96	0.08	47.99	47.99	0.00
15-Sep-96	0.08	47.99	47.99	0.00
16-Sep-96	0.08	47.99	47.99	0.00
17-Sep-96	0.08	47.99	47.99	0.00
18-Sep-96	0.08	47.99	47.99	0.00
19-Sep-96	0.08	47.99	47.99	0.00
20-Sep-96	0.08	47.99	47.99	0.00
21-Sep-96	0.08	47.99	47.99	0.00
22-Sep-96	0.08	47.99	47.99	0.00
23-Sep-96	0.08	47.99	47.99	0.00
24-Sep-96	0.08	47.99	47.99	0.00
25-Sep-96	0.08	47.99	47.99	0.00
26-Sep-96	0.08	47.99	47.99	0.00
27-Sep-96	0.08	47.99	47.99	0.00
28-Sep-96	0.08	47.99	47.99	0.00
29-Sep-96	0.08	47.99	47.99	0.00
30-Sep-96	0.08	47.99	47.99	0.00
1-Oct-96	0.22	125.10	125.10	0.00
2-Oct-96	0.22	125.10	125.10	0.00
3-Oct-96	0.22	125.10	125.10	0.00
4-Oct-96	0.22	125.10	125.10	0.00
5-Oct-96	0.22	125.10	125.10	0.00
6-Oct-96	0.22	125.10	125.10	0.00
7-Oct-96	0.22	125.10	125.10	0.00
8-Oct-96	0.22	125.10	125.10	0.00
9-Oct-96	0.22	125.10	125.10	0.00
10-Oct-96	0.22	125.10	125.10	0.00
11-Oct-96	0.22	125.10	125.10	0.00
12-Oct-96	0.22	125.10	125.10	0.00
13-Oct-96	0.22	125.10	125.10	0.00
14-Oct-96	0.22	125.10	125.10	0.00
15-Oct-96	0.22	125.10	125.10	0.00
16-Oct-96	0.22	125.10	125.10	0.00
17-Oct-96	0.22	125.10	125.10	0.00
18-Oct-96	0.22	125.10	125.10	0.00
19-Oct-96	0.22	125.10	125.10	0.00
20-Oct-96	0.22	125.10	125.10	0.00
21-Oct-96	0.22	125.10	125.10	0.00
22-Oct-96	0.22	125.10	125.10	0.00

Catchment Area = 2.278km^2
Head = 72 m

Date	Computed Discharge at Kilikkalthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x100	Mu/day
23-Oct-96	0.22	125.10	125.10	0.00
24-Oct-96	0.22	125.10	125.10	0.00
25-Oct-96	0.22	125.10	125.10	0.00
26-Oct-96	0.22	125.10	125.10	0.00
27-Oct-96	0.22	125.10	125.10	0.00
28-Oct-96	0.22	125.10	125.10	0.00
29-Oct-96	0.22	125.10	125.10	0.00
30-Oct-96	0.22	125.10	125.10	0.00
31-Oct-96	0.22	125.10	125.10	0.00
1-Nov-96	0.10	55.44	55.44	0.00
2-Nov-96	0.10	55.44	55.44	0.00
3-Nov-96	0.10	55.44	55.44	0.00
4-Nov-96	0.10	55.44	55.44	0.00
5-Nov-96	0.10	55.44	55.44	0.00
6-Nov-96	0.10	55.44	55.44	0.00
7-Nov-96	0.10	55.44	55.44	0.00
8-Nov-96	0.10	55.44	55.44	0.00
9-Nov-96	0.10	55.44	55.44	0.00
10-Nov-96	0.10	55.44	55.44	0.00
11-Nov-96	0.10	55.44	55.44	0.00
12-Nov-96	0.10	55.44	55.44	0.00
13-Nov-96	0.10	55.44	55.44	0.00
14-Nov-96	0.10	55.44	55.44	0.00
15-Nov-96	0.10	55.44	55.44	0.00
16-Nov-96	0.10	55.44	55.44	0.00
17-Nov-96	0.10	55.44	55.44	0.00
18-Nov-96	0.10	55.44	55.44	0.00
19-Nov-96	0.10	55.44	55.44	0.00
20-Nov-96	0.10	55.44	55.44	0.00
21-Nov-96	0.10	55.44	55.44	0.00
22-Nov-96	0.10	55.44	55.44	0.00
23-Nov-96	0.10	55.44	55.44	0.00
24-Nov-96	0.10	55.44	55.44	0.00
25-Nov-96	0.10	55.44	55.44	0.00
26-Nov-96	0.10	55.44	55.44	0.00
27-Nov-96	0.10	55.44	55.44	0.00
28-Nov-96	0.10	55.44	55.44	0.00
29-Nov-96	0.10	55.44	55.44	0.00
30-Nov-96	0.10	55.44	55.44	0.00
1-Dec-96	0.00	0.00	0.00	0.00
2-Dec-96	0.00	0.00	0.00	0.00
3-Dec-96	0.00	0.00	0.00	0.00
4-Dec-96	0.00	0.00	0.00	0.00
5-Dec-96	0.00	0.00	0.00	0.00
6-Dec-96	0.00	0.00	0.00	0.00
7-Dec-96	0.00	0.00	0.00	0.00
8-Dec-96	0.00	0.00	0.00	0.00
9-Dec-96	0.00	0.00	0.00	0.00
10-Dec-96	0.00	0.00	0.00	0.00

Catchment Area = 2.278km^2
Head = 72 m

Date	Computed Discharge at Kilikkalthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x100	Mu/day
11-Dec-96	0.00	0.00	0.00	0.00
12-Dec-96	0.00	0.00	0.00	0.00
13-Dec-96	0.00	0.00	0.00	0.00
14-Dec-96	0.00	0.00	0.00	0.00
15-Dec-96	0.00	0.00	0.00	0.00
16-Dec-96	0.00	0.00	0.00	0.00
17-Dec-96	0.00	0.00	0.00	0.00
18-Dec-96	0.00	0.00	0.00	0.00
19-Dec-96	0.00	0.00	0.00	0.00
20-Dec-96	0.00	0.00	0.00	0.00
21-Dec-96	0.00	0.00	0.00	0.00
22-Dec-96	0.00	0.00	0.00	0.00
23-Dec-96	0.00	0.00	0.00	0.00
24-Dec-96	0.00	0.00	0.00	0.00
25-Dec-96	0.00	0.00	0.00	0.00
26-Dec-96	0.00	0.00	0.00	0.00
27-Dec-96	0.00	0.00	0.00	0.00
28-Dec-96	0.00	0.00	0.00	0.00
29-Dec-96	0.00	0.00	0.00	0.00
30-Dec-96	0.00	0.00	0.00	0.00
31-Dec-96	0.00	0.00	0.00	0.00
1-Jan-97	0.00	0.00	0.00	0.00
2-Jan-97	0.00	0.00	0.00	0.00
3-Jan-97	0.00	0.00	0.00	0.00
4-Jan-97	0.00	0.00	0.00	0.00
5-Jan-97	0.00	0.00	0.00	0.00
6-Jan-97	0.00	0.00	0.00	0.00
7-Jan-97	0.00	0.00	0.00	0.00
8-Jan-97	0.00	0.00	0.00	0.00
9-Jan-97	0.00	0.00	0.00	0.00
10-Jan-97	0.00	0.00	0.00	0.00
11-Jan-97	0.00	0.00	0.00	0.00
12-Jan-97	0.00	0.00	0.00	0.00
13-Jan-97	0.00	0.00	0.00	0.00
14-Jan-97	0.00	0.00	0.00	0.00
15-Jan-97	0.00	0.00	0.00	0.00
16-Jan-97	0.00	0.00	0.00	0.00
17-Jan-97	0.00	0.00	0.00	0.00
18-Jan-97	0.00	0.00	0.00	0.00
19-Jan-97	0.00	0.00	0.00	0.00
20-Jan-97	0.00	0.00	0.00	0.00
21-Jan-97	0.00	0.00	0.00	0.00
22-Jan-97	0.00	0.00	0.00	0.00
23-Jan-97	0.00	0.00	0.00	0.00
24-Jan-97	0.00	0.00	0.00	0.00
25-Jan-97	0.00	0.00	0.00	0.00
26-Jan-97	0.00	0.00	0.00	0.00
27-Jan-97	0.00	0.00	0.00	0.00
28-Jan-97	0.00	0.00	0.00	0.00

Catchment Area = 2.278km^2
Head = 72 m

Date	Computed Discharge at Kilikkalthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x100	Mu/day
29-Jan-97	0.00	0.00	0.00	0.00
30-Jan-97	0.00	0.00	0.00	0.00
31-Jan-97	0.00	0.00	0.00	0.00
1-Feb-97	0.07	42.46	42.46	0.00
2-Feb-97	0.07	42.46	42.46	0.00
3-Feb-97	0.07	42.46	42.46	0.00
4-Feb-97	0.07	42.46	42.46	0.00
5-Feb-97	0.07	42.46	42.46	0.00
6-Feb-97	0.07	42.46	42.46	0.00
7-Feb-97	0.07	42.46	42.46	0.00
8-Feb-97	0.07	42.46	42.46	0.00
9-Feb-97	0.07	42.46	42.46	0.00
10-Feb-97	0.07	42.46	42.46	0.00
11-Feb-97	0.07	42.46	42.46	0.00
12-Feb-97	0.07	42.46	42.46	0.00
13-Feb-97	0.07	42.46	42.46	0.00
14-Feb-97	0.07	42.46	42.46	0.00
15-Feb-97	0.07	42.46	42.46	0.00
16-Feb-97	0.07	42.46	42.46	0.00
17-Feb-97	0.07	42.46	42.46	0.00
18-Feb-97	0.07	42.46	42.46	0.00
19-Feb-97	0.07	42.46	42.46	0.00
20-Feb-97	0.07	42.46	42.46	0.00
21-Feb-97	0.07	42.46	42.46	0.00
22-Feb-97	0.07	42.46	42.46	0.00
23-Feb-97	0.07	42.46	42.46	0.00
24-Feb-97	0.07	42.46	42.46	0.00
25-Feb-97	0.07	42.46	42.46	0.00
26-Feb-97	0.07	42.46	42.46	0.00
27-Feb-97	0.07	42.46	42.46	0.00
28-Feb-97	0.07	42.46	42.46	0.00
1-Mar-97	0.06	34.52	0.00	0.00
2-Mar-97	0.06	34.52	0.00	0.00
3-Mar-97	0.06	34.52	0.00	0.00
4-Mar-97	0.06	34.52	0.00	0.00
5-Mar-97	0.06	34.52	0.00	0.00
6-Mar-97	0.06	34.52	0.00	0.00
7-Mar-97	0.06	34.52	0.00	0.00
8-Mar-97	0.06	34.52	0.00	0.00
9-Mar-97	0.06	34.52	0.00	0.00
10-Mar-97	0.06	34.52	0.00	0.00
11-Mar-97	0.06	34.52	0.00	0.00
12-Mar-97	0.06	34.52	0.00	0.00
13-Mar-97	0.06	34.52	0.00	0.00
14-Mar-97	0.06	34.52	0.00	0.00
15-Mar-97	0.06	34.52	0.00	0.00
16-Mar-97	0.06	34.52	0.00	0.00
17-Mar-97	0.06	34.52	0.00	0.00
18-Mar-97	0.06	34.52	0.00	0.00

Catchment Area = 2.278km^2
Head = 72 m

Date	Computed Discharge at Kilikkalthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x100	Mu/day
19-Mar-97	0.06	34.52	0.00	0.00
20-Mar-97	0.06	34.52	0.00	0.00
21-Mar-97	0.06	34.52	0.00	0.00
22-Mar-97	0.06	34.52	0.00	0.00
23-Mar-97	0.06	34.52	0.00	0.00
24-Mar-97	0.06	34.52	0.00	0.00
25-Mar-97	0.06	34.52	0.00	0.00
26-Mar-97	0.06	34.52	0.00	0.00
27-Mar-97	0.06	34.52	0.00	0.00
28-Mar-97	0.06	34.52	0.00	0.00
29-Mar-97	0.06	34.52	0.00	0.00
30-Mar-97	0.06	34.52	0.00	0.00
31-Mar-97	0.06	34.52	0.00	0.00
1-Apr-97	0.08	47.04	47.04	0.00
2-Apr-97	0.08	47.04	47.04	0.00
3-Apr-97	0.08	47.04	47.04	0.00
4-Apr-97	0.08	47.04	47.04	0.00
5-Apr-97	0.08	47.04	47.04	0.00
6-Apr-97	0.08	47.04	47.04	0.00
7-Apr-97	0.08	47.04	47.04	0.00
8-Apr-97	0.08	47.04	47.04	0.00
9-Apr-97	0.08	47.04	47.04	0.00
10-Apr-97	0.08	47.04	47.04	0.00
11-Apr-97	0.08	47.04	47.04	0.00
12-Apr-97	0.08	47.04	47.04	0.00
13-Apr-97	0.08	47.04	47.04	0.00
14-Apr-97	0.08	47.04	47.04	0.00
15-Apr-97	0.08	47.04	47.04	0.00
16-Apr-97	0.08	47.04	47.04	0.00
17-Apr-97	0.08	47.04	47.04	0.00
18-Apr-97	0.08	47.04	47.04	0.00
19-Apr-97	0.08	47.04	47.04	0.00
20-Apr-97	0.08	47.04	47.04	0.00
21-Apr-97	0.08	47.04	47.04	0.00
22-Apr-97	0.08	47.04	47.04	0.00
23-Apr-97	0.08	47.04	47.04	0.00
24-Apr-97	0.08	47.04	47.04	0.00
25-Apr-97	0.08	47.04	47.04	0.00
26-Apr-97	0.08	47.04	47.04	0.00
27-Apr-97	0.08	47.04	47.04	0.00
28-Apr-97	0.08	47.04	47.04	0.00
29-Apr-97	0.08	47.04	47.04	0.00
30-Apr-97	0.08	47.04	47.04	0.00
1-May-97	0.03	17.26	0.00	0.00
2-May-97	0.03	17.26	0.00	0.00
3-May-97	0.03	17.26	0.00	0.00
4-May-97	0.03	17.26	0.00	0.00
5-May-97	0.03	17.26	0.00	0.00
6-May-97	0.03	17.26	0.00	0.00

Catchment Area = 2.278km^2
Head = 72 m

Date	Computed Discharge at Kilikkalthodu (m^3/s)	Maximum Generatable Power (kW)	Power (kW) with 2x100	Mu/day
7-May-97	0.03	17.26	0.00	0.00
8-May-97	0.03	17.26	0.00	0.00
9-May-97	0.03	17.26	0.00	0.00
10-May-97	0.03	17.26	0.00	0.00
11-May-97	0.03	17.26	0.00	0.00
12-May-97	0.03	17.26	0.00	0.00
13-May-97	0.03	17.26	0.00	0.00
14-May-97	0.03	17.26	0.00	0.00
15-May-97	0.03	17.26	0.00	0.00
16-May-97	0.03	17.26	0.00	0.00
17-May-97	0.03	17.26	0.00	0.00
18-May-97	0.03	17.26	0.00	0.00
19-May-97	0.03	17.26	0.00	0.00
20-May-97	0.03	17.26	0.00	0.00
21-May-97	0.03	17.26	0.00	0.00
22-May-97	0.03	17.26	0.00	0.00
23-May-97	0.03	17.26	0.00	0.00
24-May-97	0.03	17.26	0.00	0.00
25-May-97	0.03	17.26	0.00	0.00
26-May-97	0.03	17.26	0.00	0.00
27-May-97	0.03	17.26	0.00	0.00
28-May-97	0.03	17.26	0.00	0.00
29-May-97	0.03	17.26	0.00	0.00
30-May-97	0.03	17.26	0.00	0.00
31-May-97	0.03	17.26	0.00	0.00
Yearly energy generation =				**0.716 Mu**

Catchment Area = 2.278km^2
Head = 72 m

CHAPTER – XII

DESIGN CRITERIA OF MAJOR COMPONENTS OF SCHEME

General

The river-bed is at secondary 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 divert the water under these heavy flow conditions having high velocities an overflow type diversion weir is adopted. The height of the weir is minimised in order to avoid any forest submergence due to the construction of the weir 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 kept as 3,0 m

The diversion weir of Ogee type is proposed with overflow portion having a length of 12m. The maximum flood discharge is 14.629 m^3/s. The lowest bed level of the stream at weir site is 592.50.

The Kilikkalthodu 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 Kilikkalthodu Stream, at about 6km from Mankulam. Total length of the concrete weir is 21m 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 12m and non-overflow sections of length 6m on left bank and 3m on right bank. Flood discharge capacity of the spillway is 26.136m^3/s. The scheme is designed as a run of the river scheme.

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 +594.50 m in the left bank non overflow portion of the weir.
c) A rectangular Power Channel of 190 m length and 0.50 m x 0.80 m section
d) A Forebay tank of 8 m × 6 m ×4 m
e) 1 No. Penstock pipes of diameter 0.50 m and length 193 m.

3. Power House

A surface powerhouse of size 7 m x 6 m to house two units of generating equipment of 100 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 2.5 m.

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

Catchment Area, A = 2.278 sq.km.

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

$Q_{max} = 8.45 \times (2.278)^{2/3} = 14.629 m^3/s$, is adopted as the design flood discharge, Q.

Length of waterway, $L = 4.83 (Q)^{0.5} = 4.83(14.629)^{0.5} = 18.474m$.

Provide a of overflow section 12m length.

Taking C_d as 2.2, k_a=0.1, L=12 m and

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

$H_d = 0.673$ m.

A design head of 0.6 m is adopted with level of non-overflow portion 1m above the overflow portion with free board of 0.4m.

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

$L_c = 11.88$m, with H_d= 0.6 m

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

Therefore $H_d = 0.679 < 1$ m, height provided for the non-overflow portion. Hence okay

$Q = 2 \times 11.88 \times (1)^{3/2} = 26.14 m^3/sec > 14.629 m^3/sec.$

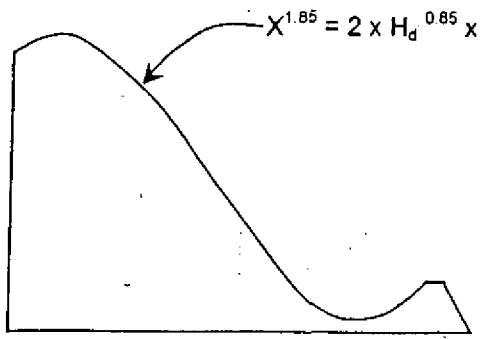
Hence a spillway length of 12 m and height of non-overflow portion above spillway crest of 1m is adopted. The excavated bed level is taken as +592.00

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 $\rightarrow X^{1.85} = 2 \times H_d^{0.85} \times Y$

$\frac{H_e}{H_d}$ 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 = 0.923 and Y = 0.665

Co-ordinates of Ogee Profile:

X	0.250	0.500	0.750	0.923
Y	0.059	0.214	0.453	0.665

Upstream Profile

Equation for upstream profile

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

$X_{max} = -0.27\,H_d = -0.162$ and corresponding $Y_{max} = 0.076$

River Sluice

A 0.50 m dia river sluice is provided at the left 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 +594.50, which opens into the power channel. The intake weir 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.

Power channel

The power channel is rectangular in section with a size of with bottom width 0.5m

Power channel design

Discharge, Q = 0.382 m^3/s

Assumed Velocity of Flow =1m/s

Q = A x V

Wetted Area = 0.382 m^2

Bottom Width, B = 0.5m

Depth of Flow, y = 0.5m

Wetted Perimeter, P = 1.5m

Assume, n = 0.014

R = A/P =0.255

Channel Slope, S =1 in 500 = 0.002

Using Manning's Equation,

The maximum achievable velocity, $V = {}^{1}/_{n}\, R^{2/3}\, S^{1/2}$ = 0.998m/s < 1m/s. Hence okay.

Depth of Channel with free board = 0.8 m

Hydraulic Depth D = a/(b+2yz) = 0.764

For Critical Flow, $V_{cr} = (g \times D)^{0.5}$ =2.738 > 0.998, hence safe against bed scour.

The channel will have a total depth of 0.80 m including a free board of 0.3m. The channel will have bed level at entrance as +594.50. The bed level of the 190 m long channel at the exit into the forebay will have a bed level of +594.12 and full supply level of 595.00.

Forebay and Penstock Bell mouth.

An RCC rectangular forebay tank 8m x 6m x 4m is proposed at exit of the power channel. The forebay will function as a balancing reservoir and will avoid air entry into the penstock.

Discharge required for an installed capacity of 200 kW with 10 % overload = 0.382m^3/s

A minimum of three minutes storage, i.e., 3 x 60 x 0.382 = 68.76 m^3 is to be provided in the forebay tank. Depth of live storage is fixed as 1.5m, so as to have a total storage of 72m^3.

The full supply level of the forebay will be kept as +595.00 with MDDL as +593.50 and a free board of 0.75m is to be provided.

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 0.6m 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 = 0.504 say 0.51m

Therefore top level of the penstock bell mouth will be = 595 – (1.5+0.51) = + 592.99

Level of centerline of bell mouth = +592.57

PENSTOCK PIPES

From the forebay the water is conveyed through penstock to the turbines. The length of penstock is 193m. It will be bifurcated near the Powerhouse to supply for two turbines of 100kW capacity each.

The penstock diameter from the forebay to the bifurcation points for feeder pipes is 0.50 m with a velocity of 1.95 m/s for the 110% load at the rated design head of 72m for a maximum output of 220 kW.

The length of the penstock line is 193 m for a maximum drop of 72 m from the centerline of the intake bell mouth at the forebay to the machine centerline. The penstock wall thickness arrived is 8mm after allowing for corrosion and handling allowances. There will be a minimum of five 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 100kW 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 72 m, for obtaining a generator terminal output of 100kW, that is for a turbine output of 105 kW = 0.174 m^3/s. The maximum discharge for each turbine for obtaining 10% over load is 0.191 m^3/s.

Diameter of penstock:

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

Length of the penstock = 193 m

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

Where, Q = design draft of the penstock = 0.382 m^3/s.

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

The corresponding flow velocity is 1.95 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 100 kW turbines will have a power draft of $0.191m^3/s$. The diameter of the two feeder pipes supplying to the 100kW machines is fixed as 0.40m to with velocity of flow as 1.385 m/s.

Head loss in penstock

Dia of the penstock = 0.5 m, Length of the penstock = 193 m

Velocity of flow through the penstock, v = 1.95 m/s

Velocity head = $\frac{v^2}{2g} = 0.193$

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

$k_e = 0.16$

$\therefore h_e = 0.16 \times 0.193 = 0.03$ 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)

$h_f = \frac{0.0125 \times 193 \times 1.95^2}{2 \times 9.81 \times 0.5} = 0.93$ m

(c) Loss of head due to bends (3 nos, 39.13°,19.8°,16.1°each)

Head loss due to, bends $h_b = \frac{v^2}{2g} \sum k_b = 0.06m$

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

$h_{gc} = 0.18 \frac{v^2}{2g} = 0.18 \times 0.193 = 0.03$ m

(e) Loss of head due to butterfly valve.

$h_{gc} = 0.2 \frac{v^2}{2g} = 0.2 \times 0.193 = 0.04$ m

Total head loss in penstock = 0.03+0.93+0.06+0.03+0.04 = 1.09m

Adding bifurcation losses and other losses in bifurcated pipe and valves, the total head loss is taken as 3 m for design purpose.

Full supply level of forebay tank = +595.00

Centre line level of turbine = +520.00

Normal tail water level = 519.00

Gross Head= 595-520.00 = 75

Net Head = 75-3 = 72m. A design head of 72 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 = 75.00

Conduit head loss at rated flow, meters = 3.00

Rated net head in meters = 72.00

Rated flow in cubic meters per second 0.382

Total power plant capacity (Including 10% overload) = 220 kW

Plant capacity factor = 0.41

Calculated runner throat diameter, (d) meters. = 0.160

Specified runner cavitation coefficient "k"= 0.08

Calculated specific speed. = 51.4rpm

No of runner blades = 13

Calculated synchronous speed range, rpm. = 3000.0

Generator power factor = 0.90

System frequency, Hz. = 50

Calculated peak efficiency. (%) = 91.0

Normal tail water elevation in meters= 519.00

Calculated horizontal shaft centerline elevation, m. 520.00

Powerhouse dimensions

Turbine throat diameter, m. = 0.160

Total length of powerhouse, excluding offices, m. 7.00

Powerhouse width=6.00 m

Ht. difference from Shaft centerline to upstream crane rail, =6.00 m

Turbine floor level, and draft tube gate sill level = +519.37

Lowest concrete level at turbine inlet = +518.59

Elevation of centerline of inlet pipe = +519.80

Powerhouse roof level = +527.00

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 width of 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 rise so far that it interferes with the runner or the flooding of the powerhouse.

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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 proposed 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	1200 m^2	170/100m^2	0.020
1.2	Temporary diversion arrangements	LS		0.100
1.3	Common excavation for foundation of weir, Energy dissipating arrangements etc.	35 m^3	210/m^3	0.0735
1.4	Rock excavation for foundation of weir, Energy dissipating arrangements etc.	40m^3	380/m^3	0.152
1.5	Foundation preparation	45 m^2	1180/10m^2	0.053
1.6	Providing anchor bars including drilling holes with jack hammer and grouting.	52kg	62/kg	0.0322
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	1.417
1.8	Cement concrete C_{20}-M_{200} for overflow, intake energy dissipating arrangements and training walls including piers & beams of intake	25 m^3	3250/m^3	0.813
1.9	Providing contraction joints with copper sealing strips	14 m	1350/m.	0.189
1.10	Providing reinforcement rods for the foundation of weir, spill way training walls, ogee portion, etc.	1.30 tons	40000/T	0.520
1.11	Fabricating and installing intake gates, and river sluices etc including erection.	2 Nos	LS	3.00
1.12	Contingencies			0.1303
	Sub Total			**6.500**

2	**Power Channel**			
2.1	Clearing the site	400 m^2	170/100m^2	0.007
2.2	Common excavation	80 m^3	210/m^3	0.168
2.3	Rock excavation	15 m^3	380/m^3	0.057
2.4	Cement concrete lining with concrete C_{20}-M_{200} for the bottom and sides of open channel	40 m^3	3250/m^3	1.300
2.5	Providing reinforcement for the concrete work	1 Tons	40000/T	0.400
2.6	Cross drainage works at places where the channel crosses the valley portion (Providing RCC pipe culvert)	LS		1.000
2.7	Constructing foot bridge over the channel for the use of local people staying on the sides of channel -- No. of out bridges	1 Nos	20000/E	0.200
2.8	Providing expansion joint @ 50 m intervals lengthwise with G I sheet sealing strip and bitumen flushing	3 joints	1000/E	0.030
2.9	Contingencies			0.038
	Sub Total			**3.200**
3	**Forebay & Surplus Channel**			
3.1	Common excavation	140 m^3	210/m^3	0.294
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	70 m^3	3300/m^3	2.310
3.4	Providing vertical lift gates including lifting arrangements (Power operated)	LS		1.000
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 power channel exit	0.5T	60000/T	0.300
3.7	Providing reinforcements for the concrete	5 Tones	40000/T	2.000
3.8	Contingencies			0.106
	Sub Total			**6.500**

4	**Penstock**			
4.1	Common excavation for track cutting, saddle supports, anchor blocks etc	45 m^3	210/m^3	0.095
4.2	Rock excavation	15 m^3	380/m^3	0.057
4.3	Cement concrete C_{40}-M_{200} for saddle supports and anchor blocks	8m^3	3300 / m^3	0.264
4.4	Providing reinforcements for the concrete works	2T	40000/T	0.800
4.5	Fabrication and transportation of Penstock pipes : Straight pipes Expansion joint pipes Bend pipe	 17.6t 1.3 t 1.6 t	 70000/T 80000/T 80000/T	 12.320 1.008 1.280
4.6	Erection of Penstock pipes including x-ray testing etc	20.5 Ton	6000 /T	1.230
4.7	*Painting the pipes*		L.S	0.300
4.8	Contingencies			0.146
	Sub Total			**17.500**
5.	**Power House**			
5.1	Clearing of site & Site levelling	190 m^2	170/100m^2	0.003
5.2	Common excavation for P.H Building and machine foundation	80 m^3	210/m^3	0.168
5.3	Rock excavation for P.H. Building and machine foundation	40m^3	380/m^3	0.152
5.4	Cement concrete M_{200} C_{40} for the foundation of column	8 m^3	3300/ m^3	0.264
5.5	Cement concrete M_{200} C_{20} for columns gantry beam, slabs etc in Power House building	18m^3	3300/ m^3	0.612
5.5	Cement concrete M_{200} C_{40} for machine foundation	10 m^3	3300/m^3	0.330
5.6	R. R masonry in CM 1:5 for the foundation and basement of Power House building	35 m^3	1750/m^3	0.613
5.7	Brick masonry walls in CM 1:5 for the Power House building walls	25 m^3	2730/ m^3	0.683

5.8	Supplying and fixing steel doors, windows and ventilation with glazed shutters and other fittings		Ls	0.500
5.9	Flooring with cement concrete M_{15} C_{40} for 15 cm thick including plastering with cement mortar two coats	40 m^2	3900/10 m^2	0.156
5.10	Steel structural for gantry girder, roof beam, etc. including fabrication, conveyance and erection	3.5 T	65000/T	2.275
5.11	Providing reinforcements to concrete bend tied and placed in position.	2.8	40000/T	1.120
5.12	Roofing the power house building with GI sheets over steel trusses	95 m^2	433/m^2	0.411
5.13	Finishing works like Plastering, Painting, etc including rolling shutters and doors		Ls	2.50
5.14	Providing water supply and sanitary facility in PH building		Ls	0.25
5.15	Providing Electrification inside, the power house and switch yard		Ls	0.25
5.16	Contingencies		Ls	0.113
	Sub Total			**10.400**
6.	**Tailrace Channel**			
6.1	Clearing site		Ls	0.01
6.2	Earthwork excavation in ordinary soil, mixed with boulders	30 m^3	210/m^3	0.063
6.3	Rock excavation	5 m^3	380/m^3	0.019
6.4	Concreting the bottom and sides of tail race channel	12 m^3	3300/m^3	0.396
6.5	Contingencies			0.012
	Sub Total			**0.500**
Grand Total (Civil Works)				**44.600**

CHAPTER - XV

COST ESTIMATE – ELECTRICAL WORKS

Turbine	Horizontal Francis
Number of units and rating	2 Nos. 100kW
Continuous overload capacity	10 %
Rated output	105 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	**45.00**

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 1 km @ Rs 2.5 Lakhs/km	2.50
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.	2.00
iv.	Contingencies, consultancy, quality control, etc.	8.00
	Total	**12.50**

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 – 0.25 Ha	0.80
	Total	**0.80**

CHAPTER - XVII

ABSTRACT OF ESTIMATE

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

i.	Weir	→	Rs. 6,50000
ii.	Power Channel		Rs. 3,20000
iii.	Fore-Bay		Rs. 6,50000
iv.	Penstock pipe	→	Rs. 17,50000
v.	Powerhouse civil works	→	Rs. 10,40000
vi.	Tailrace channel	→	Rs. 50000
Total			**Rs. 44,60,000**

Total **Rs. 44.60 Lakhs**

II Powerhouse T&G Equipments, Switchyard

i. Electromechanical Equipments = Rs. 45,00,000

Rs. 45.00 Lakhs

III Transmission of power

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

IV Developmental Works

i. Preliminary expenses, cost of land & buildings = **Rs. 13.30 Lakhs**

GRAND TOTAL **Rs. 107.90 Lakhs**

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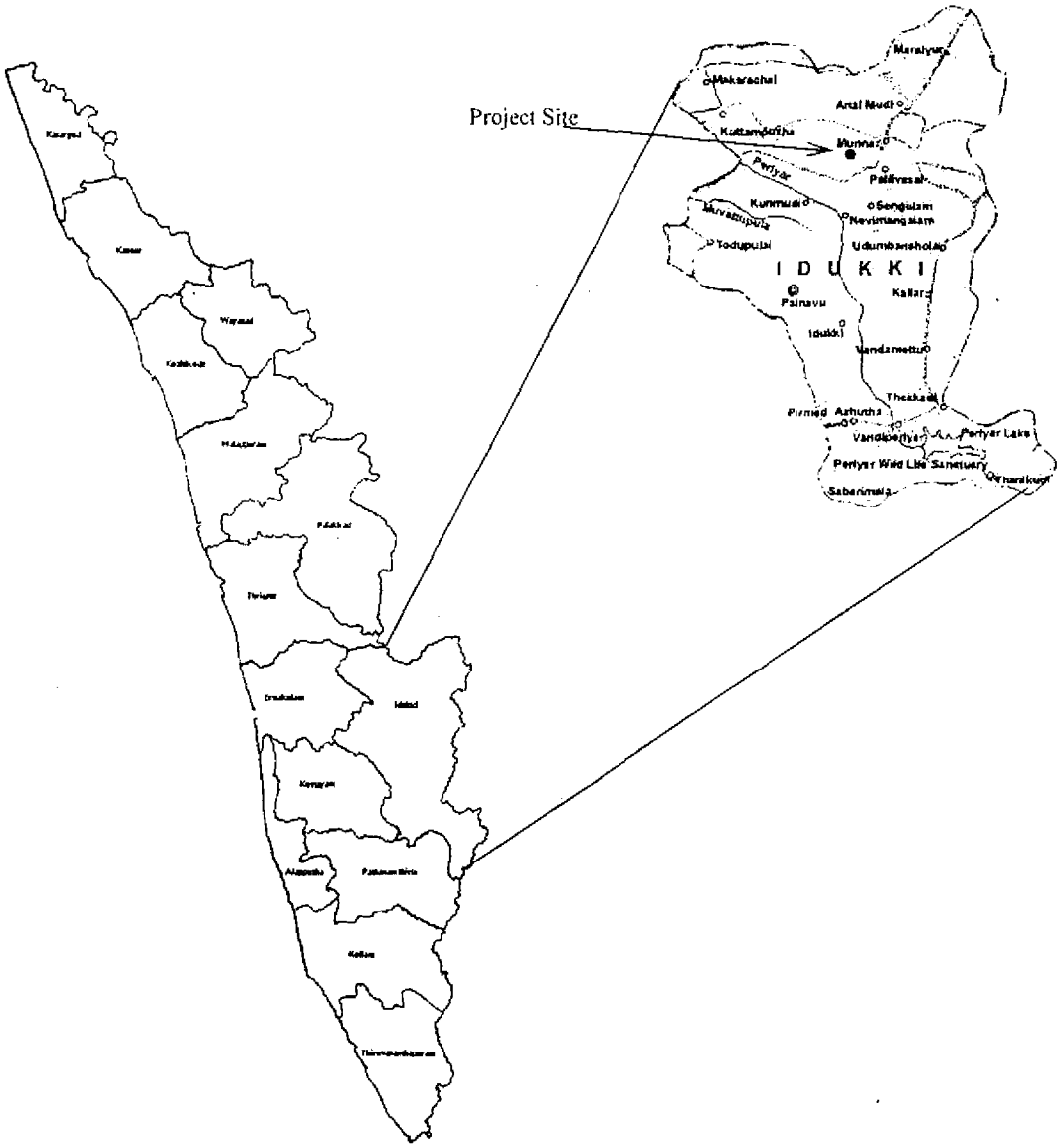
PART – IV
DRAWINGS



Project Report Drawing

UNIDO-RC FOR SHP DEVELOPMENT

KILIKKALTHODU SMALL HYDEL PROJECT

Title : INDEX MAP

Consultants: **ENERGY MANAGEMENT CENTRE – KERALA**
THYCAUD, THIRUVANANTHAPURAM - 695 014

Reference: URC/SHP/KLK/DPR/01	Sheet No.	Revision:	Scale: NS

Prepared:		Approved	