KSEB
KERALA STATE ELECTRICITY BOARD Ltd.
(Incorporated under the Indian Companies Act, 1956)
Office of the Project Manager,
Chembukadavu III and Maripuzha SHEPs,
Engapuzha, P.O. Puduppadi, Kozhikode-673586,
Phone: 0495 2985600, CUG-9446008429
Email: pmchembukadavu@gmail.com

150 YEARS OF CELEBRATING THE MAHATMA

No: PM/CH III & MRPZA/DB-23/2017-18/07 Dated: 17-04-2023.

From

The Project Manager

To

The Divisional Forest Officer,
Kozhikode.

Sir,

Sub: Maripuzha SHEP (2x3 MW) – Diversion of 1.9801 Ha of Forest Land – Information / clarification - reg.

Ref : 1. Online proposal No. FP/KL/HYD/37412/2018

2. Letter No. 4-KLB1440/2023-BAN/74 dated 24-03-2023 of Asstt. Inspector General of Forest, Ministry of Environment, Forest & Climate Change, Bangalore to the Additional Chief Secretary, Government of Kerala, Forests & Wildlife (C) Department, Thiruvananthapuram.

Kind references to the above. The information / clarification requested as per letter vide reference (2) above for the proposal referred (1) above is submitted as follows.

1. Justification of locating the project in forest area:

The proposal is for diversion of 1.9801 Ha of forest land in Kozhikode Division for the implementation of Maripuzha SHEP under Edathara Section of Thamarassery Range across Iruvanjipuzha stream. The requirement of forest land is for the construction of trench weir and intake structures (1.6163 Ha), Surplus Escape (0.0483 Ha) and Power house and allied structures (0.3154 Ha). The requirement of forest land is along the sides of the river course. Other components of the Scheme involve construction of power channel, forebay, penstock, etc located in private land owned by the User Agency.

KSEBL had ascertained the legal status of land required for the implementation of the project from the Divisional Forest Officer, Kozhikode. It was ascertained categorically through site inspection and verification of records that the legal status of the land covered as river bed and streams are "Forest Land". Accordingly, the

proposal of KSEBL was formulated such that the requirement of forest land is limited within the river course by proposing a trench type weir so as to avoid any impoundment of forest land/creation of a water body or obstruction of natural flow. In short the proposal was finalized limiting the requirement of forest land to the bare minimum. On either side of the river course is revenue land under private cultivation. The total extent of forest land required is 1.9801 Ha and private land is 6.4903 Ha. The proposed area does not form a part of National park, Wild Life Sanctuary and any heritage site.

2. The details of alternatives examined and reason for their rejection:

The proposal of KSEBL was formulated such that the requirement of forest land is limited within the river course by proposing a trench type weir so as to avoid any impoundment of forest land/creation of a water body or obstruction of natural flow. In short the proposal was finalized limiting the requirement of forest land to the bare minimum. On either side of the river course is revenue land under private cultivation. The total extent of forest land required is 1.9801 Ha and private land is 6.4903 Ha. The proposed area does not form a part of National park, Wild Life Sanctuary and any heritage site.

Small Hydro Electric Project are site specific and utilize the head of water stream between the power house and weir. The area is a steep slope ad the difference in height as per detailed survey and investigation by the competent officials of the utility has reported as most suitable for a power project.

3. Detailed Project Report of the Project:

Copy appended

4. Whether the proposal involves transmission line component for evacuation of power from the proposed Hydal project:

The proposal involves power evacuation component for evacuation of power from the proposed Maripuzha SHEP by construction of 33 Kv single circuit feeder from the proposed power house of the project to Thambalamanna Substation. It is emphatically submitted that the proposed drawing of evacuation line does not require any diversion of forest land.

The information/clarification regarding CA land proposed by the Forest department as mentioned as Serial No. 5 of the letter vide reference (2) above may kindly be forwarded from that office. It is requested to take kind necessary action to submit the details as instructed vide reference (2) above at the earliest in the Parivesh Portal.

Yours faithfully,

Project Manager.

Acc: Copy of DPR through e-mail

Copy submitted to: The Chief Engineer, Civil-Construction (North), Kozhikode.

Copy to: The Assistant Executive Engineer, Maripuzha SHEP.

FC.✓

DETAILED PROJECT REPORT

OF

MARIPUZHA SMALL H.E SCHEME

(2 X 3 MW – 14.84 Mu)

Volume – I

DECEMBER 2014	CHIEF ENGINEER (C), INVESTIGATION & PLANNING VYDYUTHI BHAVANAM, PATTOM, THIRUVANANTHAPURAM – 4.

KERALA STATE ELECTRICITY BOARD LTD.

(Incorporated under the Indian Companies Act,1956)
Registered office: Vydyuthi Bhavanam,Pattom,Thiruvananthapuram-04

Abstract

Maripuzha Small Hydro Electric Project (2 x 3 MW) – Administrative Sanction accorded - Orders issued.

Corporate Office (SBU-G/C)

BO(DB)No.3373/2014 (DGC/AEE-1/MARIPUZHA/2014) Dated, TVPM, 23.12.2014

Read:
1) Minutes of the DPR approval committee meeting held on 18.06.2013.
2) Note No. CE(C-I&P)/SHDPR/MARP/2006-07 dated 30.11.2013 of the Chief Engineer (Civil – I&P).
3) Note No. CE(C-I&P)/SHDPR/MARP/2006-07 dated 22.09.2014 & 27.09.2014 of the Chief Engineer (Civil – I&P)
4) Note No DGC/AEE-1/MARIPUZHA/2014 dated 20.10.2014 of CMD, KSEB LTD
5) Proceedings of the Board of Directors meeting held on 24.11.2014 Agenda item No.5-11/2014)

ORDER

The Chief Engineer (Civil-I&P) as per note read as 2nd paper above has submitted a proposal for the implementation of Maripuzha Small Hydro Electric Project (2 x 3 MW), in Chaliyar basin. The proposed project is located in Nellipoyil village of Kodenchery Panchayath in Kozhikode (Dist). The project is planned as a run -of - the river scheme and envisages development of power by using the inflow of Iruyanjipuzha of Chaliyar basin. The river flow is proposed to be intercepted by a trench type weir and diverted to a fore bay tank through power channel. A surface pen stock carries the power draft to two Horizontal type Francis Turbines to generate 6MW of Electricity. The average energy per annum expected is 15.31Mu under a net head of 118m and the annual generation for 90% dependable year comes to 14.84 Mu.

The DPR of the scheme was approved by the DPR approval committee. Later on, Board decided to implement this scheme by adopting cost effective methods of construction. Accordingly the Chief Engineer (Civil-I&P) as per note read as 3rd paper above has submitted a modified proposal for the implementation of this scheme incorporating certain cost effective designs such as colgrout masonry concrete weir, trapezoidal power channel, spirally welded steel pipes for penstock etc. The scheme is eligible for financial assistance from MNRE for setting up Small Hydro Electric Projects and the expected MNRE grant for this scheme is ₹ 20 Crore. The financial analysis has been done by considering financial support from MNRE.

The estimated cost of the project is ₹ 54.08 Crore based on PWD SOR-2012. Out of

CONTENTS

LIST OF TABLES

LIST OF GRAPHS

PREFACE

Kerala is having a vast potential of hydro power still lying untapped. Hydro power, especially from small hydro power projects is recognized as a renewable source of energy, which is economic, non – polluting, environmentally benign and need a relatively short time for implementation and not generally affected by the constraints associated with large hydro electric projects. Also such hydro power projects that are developed and operated in an economically viable, environmentally sound and socially responsible manner represent sustainable development at its best; that is to say "Development that meets the needs of the people today without compromising the ability of future generations to meet their own needs".

Realizing these facts the State Government / K.S.E.Board have embarked on an ambitious programme for harnessing the known and yet to be known small hydro power resources of the state. The contribution of Small Hydro Power (or shall we say States Hidden Potential), have become more significant as SHPs require minimum submergence, rehabilitation and minimal impact to environment.

Despite a high initial cost and the work involved in steering the small hydro project to fruition, once installed the hydro electric turbines offer the promise of clean green energy, almost for free.

Chaliyar basin is a mine of cascading small H.E scheme in Kerala. The Malabar migration during 70's created enough access to various tributaries of Chaliyar river of western ghat at various elevations. The forest involvement of different schemes identified in this basin is very minimal or practically nil. Preservation of forest and avoiding environmental impact is getting prime importance in the gestation of every project.

Maripuzha Small H.E scheme is such an environmental friendly project in Chaliyar basin, which requires no forest land. The scheme utilizes the inflow of Iruvanjipuzha. The river flow is intercepted by a trench type weir and diverted to a Forebay tank through power channel and a surface penstock carries the power draft to two Horizontal Francis turbines and generates 6MW for an annual power generation of 14.84 Mu at 90% dependability under a net head of 118m and generate 15.31Mu of average energy per annum.

In the construction industry, new technologies developed and new inventions and methodology have been introduced in materials, construction equipments etc.. The small hydel projects can be made more economical and attractive by applying new inventions/methodology.

Here, efforts have been made to implement the cost effective methods of construction in the proposal of Maripuzha Small Hydro Electric Project, as suggested/recommended by the expert committee. Possibility of colgrout masonry for apron both upstream and down stream faces of trench weir, spirally welded steel pipes for penstock in place of conventionally used steel pipes, trapezoidal section for power channel instead of rectangular section where the terrain suits etc. are explored. An amount of Rs. 171.62 Lakhs can be saved by adopting these cost effective techniques.

The overall cost of the project is estimated as 54.08crores (2012 SOR for Civil items). With a view to improve the financial viability of the scheme it is proposed to avail subsidy for small hydro projects provided by MNRE, Government of India.

The financial analysis is worked out as per SERC guide lines. The cost including IDC is Rs 54.41 crores after availing MNRE grant. The payback of the project will be 11 years with a debt equity ratio of 70:30. The levelised tariff (at discounting rate of 12%) is Rs 4.92/unit. The net present value is Rs 1.29 crores and Internal Rate of Return is 12.21%.

The construction of the project is to be commenced during 2014-15 and completed in a period of 2 $^{1}/_{2}$ years. This detailed project report is prepared based on the detailed Investigation and survey works conducted for the scheme by the Investigation Division, Kozhikode under Investigation Circle, Thrissur.

Trivandrum
December 2014

Chief Engineer (C- I & P)

Chapter - 1
INTRODUCTION

1.1 Scheme

Maripuzha small H.E scheme envisages power development by using the inflow of Iruvanjipuzha of Chaliyar basin. The total catchment area of the scheme is 15.92km^2. The diversion structure consists of a trench weir of 18m width in Iruvanjipuzha. The intercepting stream in the right bank of Iruvanjipuzha is proposed to divert suitably by providing a small diversion weir across the stream and an open channel adjacent to intake chamber and water is diverted to forebay through a power duct of 80m and a head race channel of 1104.6m. A 319.02 m long penstock feeds the turbines. The scheme is planned as a run off the river scheme with a net head of 118m. The installed capacity of the scheme is 6MW (2 x 3 MW Horizontal Francis turbines) and the expected average annual generation is 15.31Mu. The annual generation for 90% dependable year comes to 14.84 Mu.

1.2 Location of project

The scheme is located in Iruvanjipuzha river of Chaliyar basin. The exact location of the scheme area is locally known as Kundanthodu and lies in Nellipoil Village of Kozhikode Taluk in Kozhikode District of Kerala state. The Power House of scheme is located at 11° 26' 45" N latitude and 76° 05' 25.50" E longitude. The only access to the site is from Thiruvambadi Village along left bank. This is an isolated bit of private land having Iruvanjipuzha in south side and forest in all other side. The Scheme is 49 km away from Kozhikode City. The access to the site from Kozhikode is Via. Thiruvambadi-Anakkampoyil-Muthappanpuzha. One ghat road is available through forest and the access is limited from January to May. Only four wheel drive vehicles can ply this ghat road and this road cannot be used for construction purposes.

1.3 Access

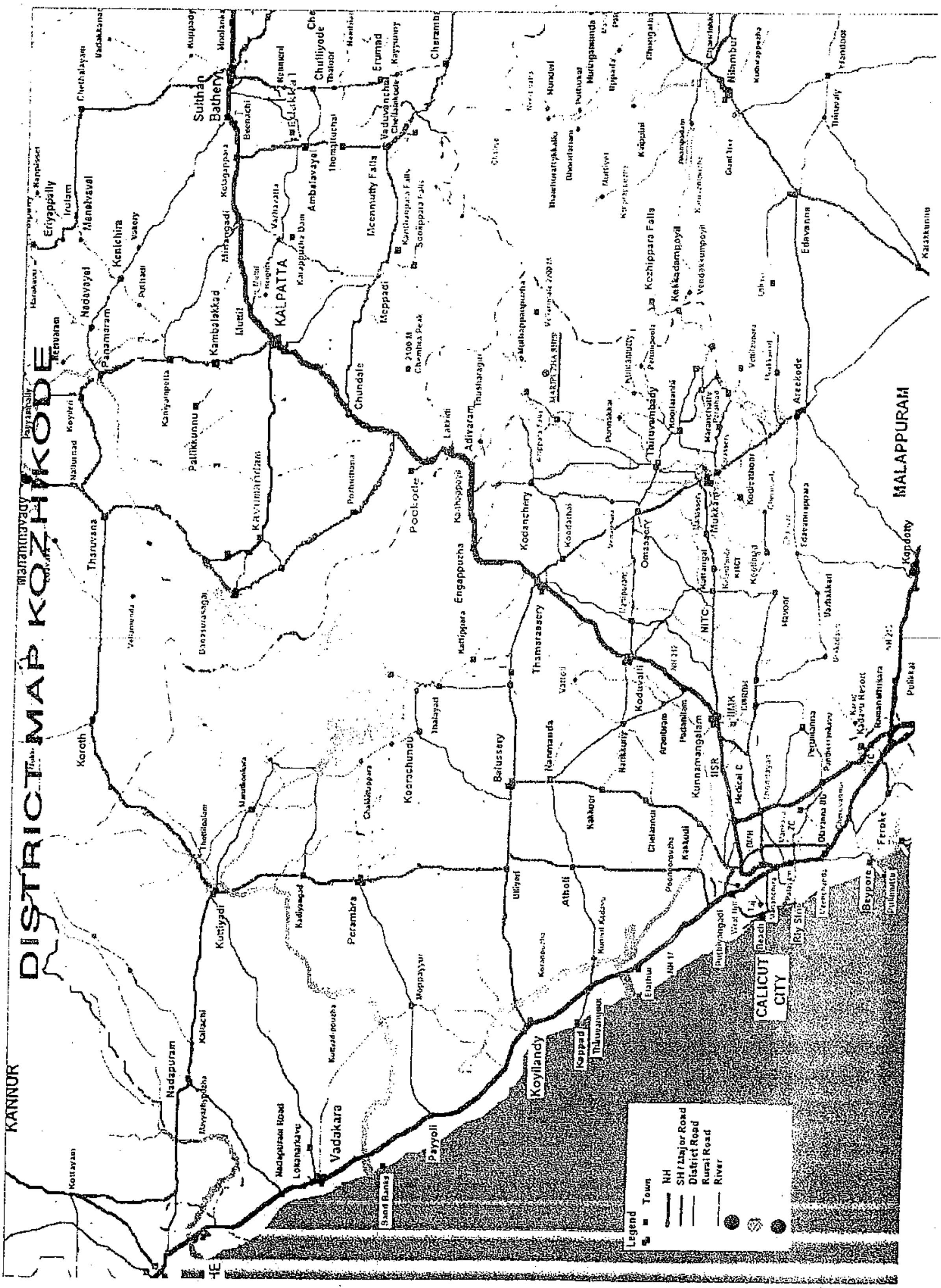
The Scheme is 49 km away from Kozhikode City. The access to the site from Kozhikode is Via. Thiruvambadi-Anakkampoyil-Muthappanpuzha. The nearest township is Anakkampoyil. One ghat road is available through forest and the access is limited from January to May. Only four wheel drive vehicles can ply this ghat road and this road cannot be used for construction purposes.

One permanent concrete bridge is required to access the power house. A 10m span steel bridge and two culverts of 5m and 4m span respectively are also required at weir site for construction purpose. One permanent concrete bridge is required to access the power house. A 10m span steel bridge is also required at weir site for construction purpose

1.4 General Climatic Conditions

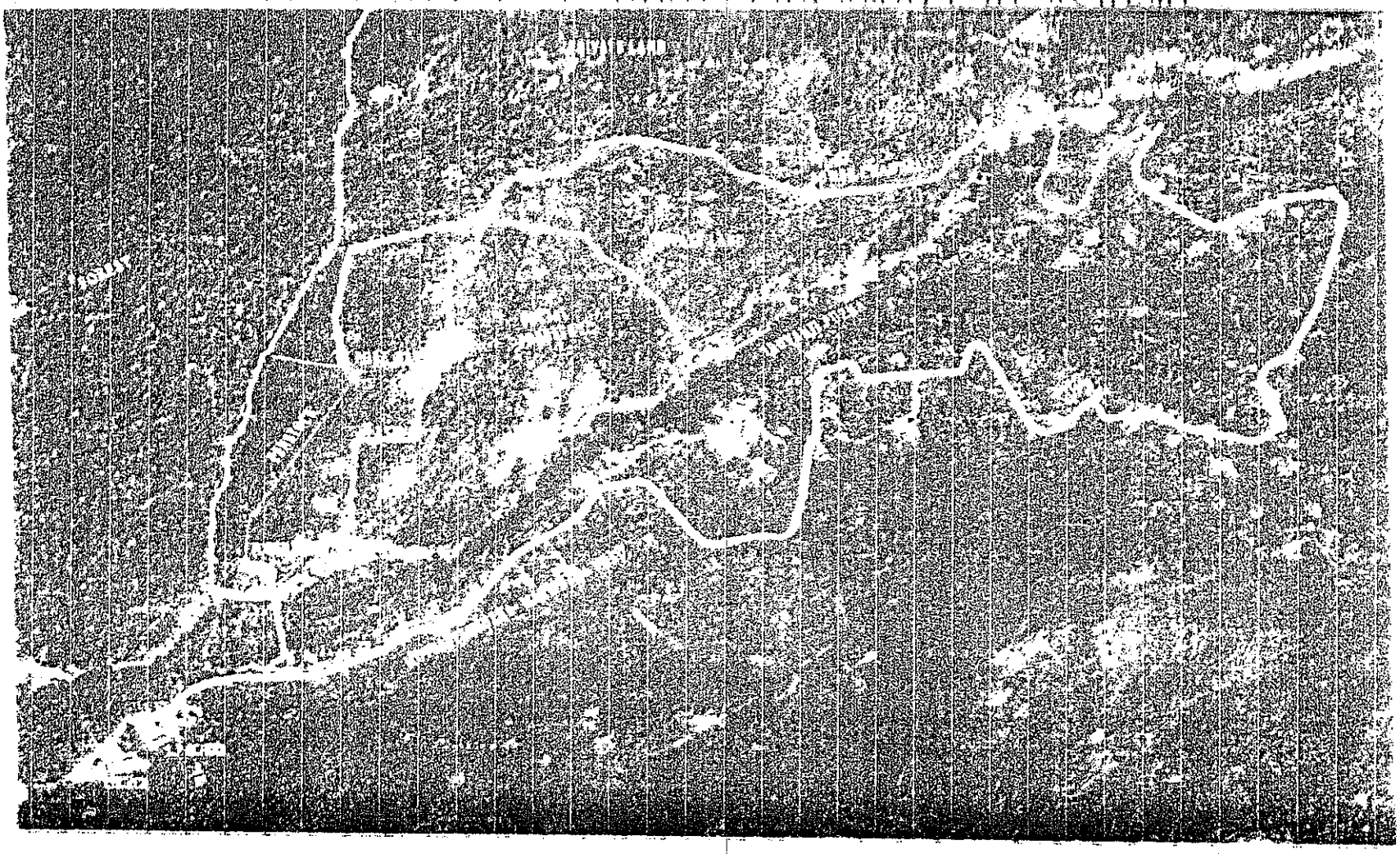
The area experiences heavy south-west monsoon. Relative humidity is so high and is nearly 90-95% during rainy season. Thunder storms are common. Lightening arresters are required at Power house, switch yard. The river is ill famous for flash floods and death tolls. Average annual rainfall is 6006 mm. The highest rainfall occurred is 9261.60mm during 97-98. Due to heavy rainfall experience in July, the construction activities are rather difficult.

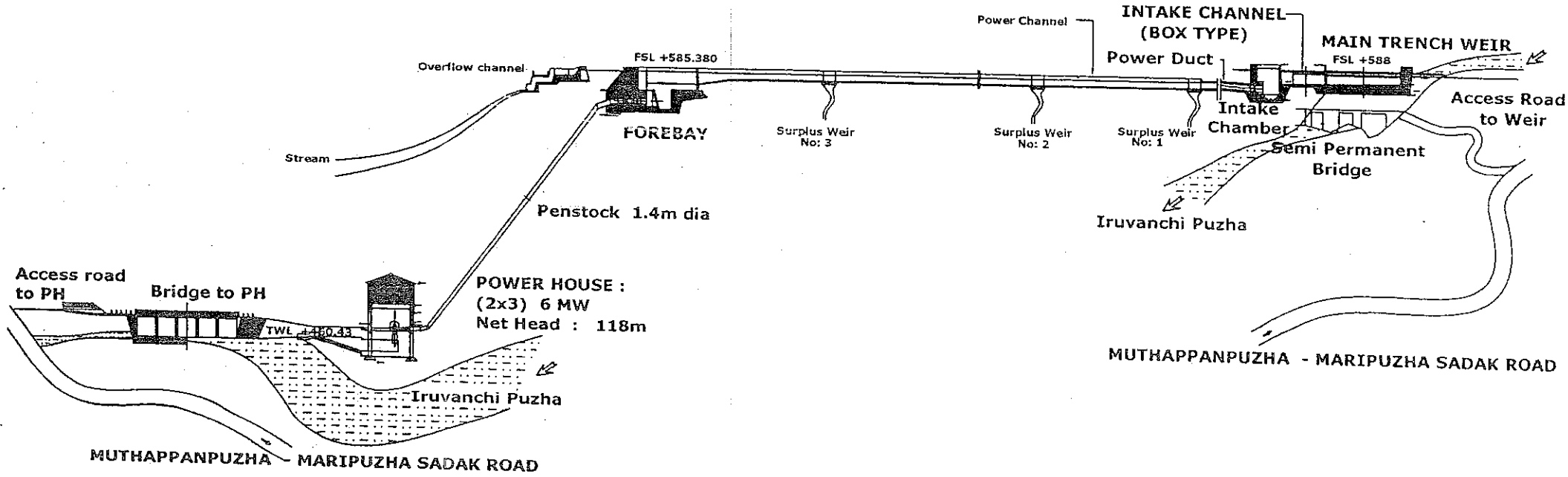
1.5 District Map -Kozhikode



1.6 Satellite image of Brisbane area

SATELLITE IMAGE OF MARIPEZHA SMALL HYDEL SCHEME





DATE:		KERALA STATE ELECTRICITY BOARD
		MARIPUZHA SMALL H.E. SCHEME (6MW)
ASSISTANT ENGINEER		SCHEMATIC DIAGRAM
ASST: EXE: ENGINEER	SCALE AS SHOWN	DRG.NO: MARP/1/R1
EXECUTIVE ENGINEER	APPROVED	CHIEF ENGINEER (C-I&P)

CHAPTER - 2

NEED OF THE PROJECT

Energy crisis in Kerala is a major issue as the supply of energy is not in pace with the day to day increase in demand of energy. The main sources of energy are thermal, nuclear and hydro electric power. The development of nuclear and thermal projects have the least scope in Kerala's power scenario. The main affordable source of energy is hydro power. But due to some impediments such as environmental and socio-economic factors, many of major hydro electric projects were dropped or postponed. The development of major hydro schemes with large submergence of land could not be taken up due to issues relating to forest and environmental clearance. Thus the development of small HE Schemes becomes significant now a days.

The scope of Small HE Schemes are limited and its contribution to the system will be quite small as compared to the demand, but implementation of series of such schemes would have a noticeable effect in the power generation sector. Small hydro electric schemes would provide an opportunity for the development of rural area. The advantage of this type of scheme is that it can be completed within a shorter period. Compared to other sources of energy, quick benefits are derived with out much ecological disturbance.

It is an accepted fact that Kerala has so far explored only about 1/3rd of the already identified hydropower potential. Though much effort has been spared to conceive Hydro Electric Projects, many have been entangled in Environment and Forest related issues. Tapping the hydropower with least disturbance to the surroundings became the core issue while planning a hydro electric project.

The peak demand and energy requirement as per the 17th power survey of Central Electricity Authority, Ministry of Power, Government of India are given in Table - 2 (1). Accordingly the demand of power by 2014-2015 will be 4,168 MW / 23,484 Mu. Considering 20% outage of machines,

the installed capacity required to meet the above demand shall be 5,001.6 MW. The state is going to witness a giant leap in developmental activities with many prestigious projects on the anvil viz. Vallarpadam Container Terminal, Smart City at Kochi, Techno City at Thiruvananthapuram, Vizhinjam port etc. This demand cannot be met from the power projects already available in the state. Hence to meet the demand, new power projects have to be taken up.

The details of commissioned generating stations are given in Table – 2 (2). From this, it can be seen that 2787.38 MW equivalent to 12,481.35 Mu is presently available. The projects under construction [details are given in Table - 2 (3)] will immediately add another 211.10 MW and 653.12 Mu. The lists of the schemes to be taken up in the near future are given in Table – 2 (4). This will add another 312.70 MW and 623.70 Mu to the power grid. The availability from the existing schemes, schemes under construction and which are proposed to be implemented will be 3,311.18 MW / 13,758.17Mu. The short fall of Installed Capacity is to be compensated to meet the projected demands. Hence new schemes have to be investigated and implemented. Priority is being given for hydro stations wherein the environmental and resettlement impacts are minimum and which could be executed in minimum time with the most sophisticated machinery. Hydel schemes have certain specific advantages such as cheap and simple in maintenance, no escalation in cost of production, long service etc. when compared to thermal, nuclear, diesel power plants etc.

Exploitation of all possible hydel sources including the proposed scheme is the need of the hour. The proposed "Maripuzha Small HE Scheme" is located in Kundanthodu and lies in Nellipoil Village of kozhikode Taluk in kozhikode District. The scheme contemplates the power development by utilising the water of Iruvanjipuzha river of Chaliyar basin. The diversion trench weir site is located in the upstream of "Pottankayam" a tributary stream confluence of Iruvanjipuzha with a maximum utilisable discharge of 7.175 m^3/sec and a net head of 118m. This scheme will lead to the socio-economic development of the locality. No forest land is required for the scheme. The Maripuzha Small HE Scheme with 6 MW installed capacity when completed will add 14.84 Mu to the grid annually.

TABLE – 2 (1)

ENERGY AND PEAK LOAD

AS PER 17th ANNUAL POWER SURVEY

Years	Energy requirement (Mu)	Peak load Demand (MW)
2007-2008	15,217	2,856
2008-2009	16,096	3,004
2009-2010	17,025	3,159
2010-2011	18,077	3,335
2011-2012	19,230	3,528
2012-2013	20,631	3,743
2013-2014	22,053	3,957
2014-2015	23,484	4,168
2015-2016	24,914	4,374

TABLE – 2 (2)

SCHEMES COMMISSIONED

Sl. No	Station	Installed Capacity (MW)	Annual Energy (Mu)
(A)	HYDRO		
1	PALLIVASAL	37.50	284
2	SENGULAM	50.8	182
3	PORINGALKUTHU LEFT BANK	32	170
4	NERIAMANGALAM	52.50	237
5	PANNIAR	30	158
6	SHOLAYAR	54	233
7	SABARIGIRI	300	1338
8	KUTTIYADI	75	268
9	IDUKKI	780	2398
10	IDAMALAYAR	75	380
11	KALLADA	15	65
12	PEPPARA	3	11.5
13	MADUPATTY	2	6.4
14	LOWER PERIYAR	180	493
15	KAKKAD	50	262
16	PORINGAL KUTHU L/B EXT.	16	75
17	KUTTIYADI EXTENSION	50	75
18	MALAMPUZHA	2.50	5.6
19	CHEMBUKKADAVU –I	2.70	6.24
20	CHEMBUKKADAVU –II	3.75	9.65
21	URUMI – I	3.75	9.53
22	URUMI – II	2.40	6.09
23	MALANKARA	10.50	65.00
24	LOWER MEENMUTTY	3.50	10.14
25	NERIAMANGALAM EXT.	25	58.76
26	KUTTIYADI TAIL RACE	3.75	17.10
27	KUTTIYADI ADDT.EXTENSION	100	240.50
28	POOZHITHODU	4.8	10.97

29	RANNI PERINADU	4	16
30	PEECHI	1.25	3.52
31	Vilangadu	7.5	23.63
32	AUGMENTATION SCHEMES		
	a] Narakakkanam Diversion to Idukki		7
	b] Sabarigiri Augmentation		125
	c] Panniar Augmentation		10
	d] Poringal – Idamalayar diversion		60
	e] Azhutha Diversion to Idukki		57
	f] Vazhikkadavu Diversion		24
	g] Vadakkepuzha Diversion		12
	h] Kuttiyar Diversion		37
	TOTAL	**1,978.20**	**7450.43**

Sl. No.	Station	Installed Capacity (MW)	Annual Energy (Mu)
(B)	**DIESEL / THERMAL**		
1	BRAHMAPURAM	106.6	606
2	KOZHIKODE	128	896
(C)	**INDEPENDENT POWER PRODUCERS**		
1	MANIYAR (HYDRO)	12	36
2	KUTHUNKAL (HYDRO)	21	79
3	KAYAMKULAM (THERMAL)	359.58	2158
4	BSES COCHIN (THERMAL)	157	1099
5	KASARAGOD	20	140
6	IRUTTUKANAM SMALL HEP	3	11.92
(D)	**WIND**		
1	KANJIKODE	2	5
	TOTAL	**809.18**	**5030.92**
	GRAND TOTAL	**2,787.38**	**12,481.35**

TABLE – 2 (3)

SCHEMES UNDER EXECUTION

Sl. No	Name of Project	Installed Capacity (MW)	Annual Energy (Mu)
A	Hydro		
1	Pallivasal Extension	60	153.90
2	Adiyanpara	3.5	7.31
3	Thottiyar	40.00	99
4	Chathankottunada – II	6	14.76
5	Sengulam Augmentation		84
6	Barapole	15	36
7	Kakkayam	3	10.39
8	Mankulam	40	82.08
9	Anakkayam	7.5	27.09
10	Perumthenaruvi	6	25.77
11	Chimoni	2.5	6.03
12	Vellathooval HEP	3.6	12.17
13	Bhoothathankettu HEP	24	94.62
TOTAL		**211.10**	**653.12**

TABLE – 2 (4)

SCHEMES TO BE TAKEN UP IMMEDIATELY

Sl.No	Name of Project	Installed Capacity (MW)	Annual Energy (Mu)
A	**Hydro (Major)**		
1	Athirappilly	163	233
2	Achencoil	30	75.81
3	Poringalkuthu HEP	24	45.02
B	**Hydro (Small)**		
1	Peechadu	3	7.7
2	Chinnar	24	76.45
3	Upper Kallar	2	5.14
4	Chembukkadavu III	6	14.92
5	Poovaramthodu	2.7	5.88
6	Olikkal	4.50	5.88
7	Ladrum	3.5	12.13
8	Pazhassi Sagar	15	42.14
9	Peruvannamoozhy	6	24.70
10	Western Kallar	5	17.41
11	Upper Sengulam	24	53.22
	GRAND TOTAL	**312.70**	**623.7**

CHAPTER - 3

SUMMARY OF THE PROJECT

3.1 Introduction

The Maripuzha Small H E scheme is located in Iruvanjipuzha of Chaliyar basin. The scheme envisages power development by using the inflow of Iruvanjipuzha. The total catchment area of the scheme is 15.92km^2. The river flow is intercepted by a trench type weir and diverted to a Forebay tank through power channel and a surface penstock carries the power draft to two Horizontal Francis turbines and generates 6MW for an annual power generation of 14.84 Mu at 90% dependability under a net head of 118m and generate 15.31Mu of average energy per annum

The main components of the scheme are

- A diversion trench weir 18m long and 2.00m wide.
- A small diversion weir across the stream and an open channel of length approximately 50m adjacent to intake chamber.
- A closed type free flow intake channel (Box type) of length 9m and 2.00m wide.
- An intake chamber of size 4m x 4m x 9.00 m
- Intake gate of size1.70m x 1.70m.
- Power duct of size 1.70m x 1.70m and length 80m
- Three nos surplus weirs at chainage :37, 370 & 1020.
- 355m long R.C rectangular power channel and 240 m of cut & cover channel of size 2.90m x 1.50m with 0.75m free board and 1 in 750 bed slope & 510m length of Trapezoidal open channel, base width of 1.4m, depth of flow 1.50m & side slope of channel 1in1&6 nos of transition length 30m
- A rectangular RC Forebay tank having a live storage of 920m^3 .
- Three slot vertical trash rack with 1:4 slope for easy raking.
- 1.02m x 1.40m penstock gate, bell mouth entry, transition
- 1.40m dia single surface penstock of spirally welded steel pipe 319.02m long bifurcates in to two feeder pipes of 1.1m dia and 14m long.

- A Surface Power house of size 29.50 x 10m for housing 2 Horizontal Francis Turbines each of 3000kw.
- A rectangular tail race chamber of 15.00m x 12.50m and a tailrace channel of 3.7m wide and 1.00m water deep + 0.75 m free board to lead the water let into the same river after power generation.

The installed capacity is estimated as 6MW and expected average energy is 15.31Mu. The annual generation for 90% dependable year comes to 14.84 Mu. The generated power is transmitted to 33 kV Substation at Thambalamanna near Thiruvambady.

3.2 Historical background of the project

A previous instance of Detailed Investigation was carried out for this scheme in November 2008 along the left bank of Iruvanjipuzha. The weir site was located at the confluence of Maripuzha stream and Iruvanjipuzha. Some land sliding was later reported at this weir site and a new Sadak Road under the scheme PMRY was built between Muthappanpuzha and Maripuzha. This road interferes with the project components at several locations. The power house and switch yard location in this proposal was located in a tribal colony and grave yard. The power house site was also located very near to Muthappanpuzha LP School. The land value also increased considerably due to better accessibility. The land acquisition and construction activities, such as blasting etc. are rather difficult due to the proximity of school and tribal colony.

The right bank of Iruvanjipuzha adjacent to Maripuzha is Kundanthodu desam having scanty population. This location lies in Kodenchery Panchayat even though there is no access from Kodenchery Panchayat. The only motorable access to Kundanthodu is a coup road passing through forest which starts from Muthappanpuzha bazaar near Kilikallu. A ford is available from January to March to cross Iruvanjipuzha at Kilikallu.

Since the implementation of left bank scheme is found difficult due to recent infrastructural changes in the locality, a revised detailed investigation is carried out along right bank to explore the possibility of fitting a scheme in the available private land amidst of forest and river.

3.3 Geographical disposition

The weir site is situated at 11^0 27' 02" North Latitude and 76^0 05' 57.50" East Longitude. The intercepting stream in the right bank of Iruvanjipuzha is proposed to divert suitably by providing a small diversion weir across the stream and an open channel adjacent to intake chamber.

3.4 Survey and Investigation

3.4.1 Field Reconnaissance

The field survey works were initiated based on GTS study (GTS No. 58A/3) and satellite imagery obtained from Google earth. Since the canal is passing through a narrow strip of private land in between the area ear marked for social forestry and forest land, there is no alternative to change the alignment of power channel.

Various locations were considered for weir site.

First location selected was about 50m d/s of Pottankayam where rock out crop can be seen at right flank. The FSL level at this location will be about +578.000m but the area ear marked for social forestry interfere the power channel route.

The second location was near a ford in Iruvanjipuzha at an elevation of about +615.000m. The approach to this location from left bank is easy but the channel alignment at this elevation is lengthy and difficult. The width of river is also more. The convenient canal FSL is +598.000m, but the river at this location is flowing into two branches and the banks are so steep and high, so that diversion weir and allied structures cannot be accommodated.

The selected location is a narrow neck of about 20m wide at an elevation of +588.000m. The location is situated in the upstream of Pottankayam.

The power house location as well as penstock route has been aligned through an available strip of private land. Alternate location / route is not possible.

A road from power house to forebay is not feasible due to lack of private land. One permanent bridge is required at power house site and another one is required at weir site. Penstock tracks are necessary for erection as well as maintenance of penstock.

3.4.2 Traverse survey

A closed traverse survey has been conducted to establish traverse stations at important project component locations. The northing and easting of beginning station is assumed and the elevation is transferred from that established at Anakkampoyil weir site.

3.4.3 Topographical survey

Topographical survey with total station has been carried out to prepare the contour map and profile of water conductor system and river etc.

3.5 Topography and physiography of the basin

The tributaries of Iruvanjipuzha originate from the various peaks of Western Ghats Kuratimala at El. +2339 and Vellarimala at El. +2240 and flows downwards in south-western direction. It reaches the plains and then takes a meandering course and joins the main Chaliyar river, a little up stream of Mavoor. These rivers are known for their frequent flash floods and are mainly comprised of huge boulders along the river course. The steep falling course of the river is not suitable for developing major storage schemes but the topography is suitable for developing run-of-river type schemes for generating power as Mini/Small Schemes.

3.6 Geology

The left bank of the weir site is a vertical cliff comprised of large boulders and soil. Right bank is also a steep slope and huge boulders to the size of 5 to 8m can be seen along this bank. The diversion weir is located in a tributary stream which joins Iruvanjipuzha about 50m d/s of weir site.

Exploratory drillings were done at weir site, forebay site, penstock route, power house site and bridge site. Weir site and bridge site showed over burden soil with mixed boulders through out the drilling depth. Sound rock is available at reasonable depth at forebay, penstock and power house. Core logging is completed .

Considering the absence of rock strata in weir site, trench weir is recommended as diversion structure. The initial reach of water conductor system (about 170m from intake chamber) is passing through an area, where ground settling is observed due to soil piping.

Ch. 170 to Ch. 545 in channel route, the ground slope is mild and stable. From Ch. 545 to Ch. 570, the ground slope is observed as sliding prone.

Forebay and penstock alignment is through stable slopes. Rock stratum is available at the base slab level of forebay tank. Anchor blocks can be founded on rock strata at shallow depths.

The rock out crop at power house site is at elevation +455.000m.

One tributary stream is flowing along the west side of the power house.

3.7 Hydrology

The major share of rainfall in Maripuzha catchment depends on South West Monsoon. The high peaks such as Kuratimala and Vellarimala in the North East side of the basin intercept heavy rainfall during monsoon. The catchment area is thick tropical forest having thick bottom cover. The slopes are very steep. Flash flood is very common. Non monsoon discharge is meager.

3.7.1 Weir Gauge and Discharge data

There is no gauging station available in this catchment. There was a weir gauge station in Chakkipara near the weir site of Chembukadavu Stage-I Small H.E Scheme which is an adjacent catchment of this river and lies in the same basin. It was about 6 km North West of proposed weir site. The daily discharge reading of this station from 01.06.89 to 31.05.2000 is available.

3.7.2 High Flood Level

Long term flood level study in Iruvanjipuzha is not available. Flood level measurement at Power house site was conducted for the monsoon season of 2011. The high flood level is based on this set of readings and from local enquiry.

3.8 Location of the project area

The exact location of the scheme area is locally known as Kundanthodu and lies in Nellipoil Village of Kozhikode Taluk in Kozhikode District. The only access to the site is from Thiruvambadi Village along left bank. This is an isolated bit of private land having Iruvanjipuzha in south side and forest in all other side. The Scheme is 49 km away from Kozhikode City. The access to the site from Kozhikode is Via. Thiruvambadi-Anakkampoyil-Muthappanpuzha. One ghat road

is available through forest and the access is limited from January to May. Only four wheel drive vehicles can ply this ghat road and this road cannot be used for construction purposes.

3.9 Population and socio-economic aspects

The Scheme area lies completely in private land and possessed by about 12 people. Due to heavy loss in agriculture and want of better communication and transport facilities, the inhabitants of this area is migrating to the left bank of Iruvanjipuzha. The population is very scanty. There is a tribal colony and a primary school in the opposite bank near power house and is sufficiently away from the construction activities. The approach road to power house is passing through the vacant spaces of colony so as to avoid hindrance to their normal life. Only two houses are coming directly in the acquisition land. They can be suitably relocated to the adjacent land. Unskilled labour force is available in plenty. The scheme implementation will definitely improve the overall socio-economic growth of the region.

3.10 Necessity - Needs and Opportunities for development

To meet the ever-increasing demand of energy, major hydro projects, thermal or nuclear power plants are to be set up. But due to the impediments involved in environmental and socio-economic factors, many of such major or medium type schemes, especially hydel schemes had to be dropped or set aside. In this context, the relevance of small/mini hydel schemes gain importance. Even though the full requirements of the state at any stage cannot be met by the installation of small hydel schemes, they have got their own inherent advantages such as short gestation period, cheap and simple maintenance, no escalation in cost of operation, since there is no fuel cost involved, long service, quick benefits, low investment and no adverse impact on ecology and environment.

A number of other schemes which are in the implementation stages are located in the nearby area such as Anakkamploylil S.H.E 12MW, Narangathodu 9MW, Arippara S.H.E 2.70MW, Muthappanpuzha S.H.E 6MW.

3.11 Land Requirement

Sl. No	Structure	Area (m^2)	Unit	Value (Lakh/Ha)	Amount (Lakhs)
	Govt. Land				
1	**River**				
	i) at weir site	5170	m^2		
	ii) at PH site	4806	m^2		
	iii) stream at diversion weir site	124	m^2		
2	Road near ch: 787	350	m^2		
	Side of dumping yard-3	400	m^2		
	Total Area of Govt. Land	10850	m^2		
	Say	**1.10**	**Ha**	1.00	1.10
	Private Land				
3	**Diversion Weir**				
	i) Right bank upto intake chamber	1718	m^2		
	ii) Left bank	2040	m^2		
4	**Power channel route**				
	i)Area between intake chamber	6486	m^2		
	ii) Power channel	18562	m^2		
	iii) near ch 332	77	m^2		
	iv) near ch 665`	160	m^2		
	v) near 737	264	m^2		
	vi)Strip of land up to forest boundary@ch 975 to ch1075m as dumping yard -1	1650	m^2		
	vii)Strip of land upto forest boundary@ch 1075 to Forebay, adjacent to overflow channel as dumping yard -2	3156	m^2		
	viii) near ch 1138	340	m^2		
5	**Forebay**	2380	m^2		
6	**Overflow channel**	780	m^2		
7	**Penstock**	9725	m^2		
8	**Power house and Switch yard**	6285	m^2		
9	**Access road**	9385	m^2		
	i) to PH site	965	m^2		
	ii) to weir site	7325	m^2		
10	**Dumping yard-3 at power channel route**	3600	m^2		
	Total Area of Private Land	**74898**	**m^2**		
	Say	**7.50**	**Ha**	23.50	176.25
	Total cost of Land (in Lakhs)				**177.35**

Note:- No forest land required for this project

3.12 Construction materials

Cement and steel required for the scheme is proposed to be supplied by the contractor. The cement and reinforcement steel can be procured in bulk from Thiruvambadi (15km). Other materials such as rubble, broken stone etc. are available at reasonable distance from the site.

3.13 Accommodation

For accommodation of the staff and workers during the period of construction, temporary buildings such as dormitory is proposed.

3.14 Direct benefits

The installed capacity of the scheme is 6.00 MW and the average annual energy is 15.31 Mu and annual generation for 90% dependable year comes to 14.84 Mu. At present the people in the proposed scheme area is experiencing acute power shortage for meeting their requirements. Hence implementation of this scheme will be a great relief to the local people and also alleviate power shortage in nearby areas to some extent and will help in the overall development of the area.

3.15 Communication facilities

Power House road and bridge

The length of power house road is 165m and the formation width is 5.50m. This road crosses Iruvanjipuzha between Ch. 101 and Ch. 126. A 25m long bridge is required to cross the river. Bore hole No. 2 was drilled up to a depth of 23.95m and shows no rock deposits. A multiple box type bridge with a bottom raft and cut off wall is provided. Initial 100m length of road is passing through tribal colony in a convenient location so as to avoid any interference to inhabitants.

Weir site road and bridge

The length of weir site road is 334m and consists of one steel bridge of span 10m and two culverts of span 5m and 4m respectively. The steel bridge is proposed to abut on two large boulders situated in the upstream side of Pottankayam. The stability of structure on these boulders shall be ascertained before construction.

1 in 10 gradient is adopted for the road. The maximum excavation depth for this road is 16m. Gabion retaining walls are provided to retain the soil. The excavation activities shall be arranged during non monsoon period to minimize the saturated soil pressure. The stability analysis of this excavation slopes shall be determined. An alternate location for access road to weir site is available near the suspension bridge site at Mainavalavu. But the length of bridge and road will be more and this alignment will be costlier than the above.

3.16 Power Evacuation

Power evacuation for the subject scheme consists of the following

- Construction of 33 KV Single circuit feeder from Maripuzha SHEP to location CKT-47 through Narangathodu and Anakkampoyil for a length of 8.8 Km.
- Construction of 33 KV Double Circuit Feeder from Thambalamanna substation to Location CKT- 47 along existing 33 KV Chembukadavu line route with 110 KV DC line parameters using existing RoW (Right of way) for a length of 7 Km.
- Dismantling of 7 Km Single Circuit line using a pole with maximum span of 55 Mtrs (Chembukadavu – Thambalamanna line).
- Construction of 33 KV feeder bay in 110 KV parameter at 33 KV substation Thambalamanna.

CHAPTER - 4

SALIENT FEATURES

4.1 Location

State	:	Kerala
District	:	Kozhikode
Taluk	:	Kozhikode
Village	:	Nellipoyil
Panchayath	:	Kodenchery
Access		
Road	:	49 Kms from Kozhikode (Via) Thiruvambady – Anakkampoyil – Muthappanpuzha.
Rail	:	Nearest Railway station, Kozhikode
Air port	:	Nearest airport Karippoor, Kozhikode
Sea port	:	Kochi

4.2 Geographical dispositions

Weir

Latitude	:	11° 27' 02" N
Longitude	:	76° 05' 57.50" E

PH

Latitude	:	11° 26' 45" N
Longitude	:	76° 05' 25.50" E
GTS NO	:	58 A/3

4.3 River basin

River basin	:	Chaliyar
River	:	Iruvanjipuzha

4.4 Hydrology

Catchment area	:	15.92 sq.km
Average monsoon discharge:		70.71 Mm^3
Average Annual Rain fall	:	6006 mm

4.5 Head

Gross head	:	123.250 m
Net head	:	118 m

4.6 Component structures

a) Weir (Ch -76to - 58)

Type	:	Trench weir
F.S.L	:	+ 588.000m
H.F.L	:	+ 589.500m (after construction)
Lowest bed level	:	+ 587.020m
Length of weir	:	18.00m
Width	:	2.00 m
Depth	:	1.50 to 2.22 m below FSL
Bed slope	:	1 : 25
Free board	:	0.25 (Average)

b) Free flow intake duct (Box type) (Ch -58to - 49)

Type	:	RCC Box shaped channel
Location	:	Trench weir to intake chamber
Length from trench weir to intake chamber	:	9 m
Width	:	2 m
Depth	:	2.72 to 3.08 m below FSL
Free board	:	0.50 m

c) Intake Chamber (Ch -49to - 43)

Intake Chamber	:	4m x 4m x 9.00m top open
Service gate	:	1.7m x 1.7m
Flushing pipe	:	600mm dia, 100m long
F.S.L	:	+587.640m
Centre line of distributory	:	+583.97m

d)Power Duct (Ch -43to 37)

Size	:	1.7m x 1.7 m
Type	:	Concrete box shaped
Longitudinal slope	:	1 in 400

Length	:	80 m

e) Surplus weir No.1 (Ch 37to 43.4)

Depth	:	3.00 (average)
Surplus weir length	:	6.4m (2m Transition)
Surplus channel width	:	2.50m
Depth	:	1.10m + 0.85m free board

f) Power Channel (Ch 43.4 to 1148)

i. Rectangular Open Channel (Ch 43 to 300 , Ch 1050 to 1148)

Size	:	2.9 x 1.50 + (0.75 free board)
Type	:	Rectangular R.C Channel
Longitudinal slope	:	1 in 750
Length of rectangular open channel	:	355 m

ii. Trapezoidal Open Channel (Ch 300 to 540 , Ch 630 to 840 , Ch 990 to 1050)

Size	:	1.4 x 1.50 + (0.75 free board)
Side slope	:	1 in 1
Type	:	Trapezoidal Open Channel
Length of Trapezoidal open channel	:	510 m

iii. Cut & cover portion (Ch 540 to 630 , Ch 840 to 990)

Length of cut & cover portion	:	240 m

iv. Surplus weir No.2 & 3 (Ch 370 to 380 , Ch 1020 to 1030)

g) Fore bay tank

Type	:	Rectangular Reinforced concrete
Size	:	28m x 13m x 2.9 to 11.50
Live storage	:	$920m^3$
M.W.L	:	+586.000m
F.S.L	:	+585.38m
M.D.D.L	:	+582.38m
Top level	:	+586.500m
Bottom level	:	+575.00 m
Lowest bed level	:	+576.576m
Trash rack	:	2.0x1.46, 3 panels in each slot
No. of slots	:	3
Slope	:	1H : 4V

Raking	:	Manual

h) Penstock (0 to 291)(Spirally Welded Steel Pipe)

Number of Penstock pipes	:	1 No
Length of penstock	:	319.02m
Chainage	:	0 to 291
Diameter of penstock	:	1.40 m
Design discharge	:	7.175 m^3/s
Design velocity	:	4.66 m/s
Thickness of steel plate	:	8 mm
Number of feeder pipes	:	2 Nos
Diameter of feeder pipes	:	1.10m
Total Length of feeder pipes	:	14.00 x 2 Nos

i) Power House

Type	:	Over ground
Overall dimension	:	29.50 m x 10 m
Installed capacity	:	2 Nos 3000 KW
Type of Turbine	:	Horizontal Francis Turbine
Normal tail water level	:	+461.000m
Minimum tail water level	:	+460.090m
Machine floor level	:	+457.67m
Service bay level	:	+464.50m
Yard level	:	+464.50m
Bottom level of crane	:	+469.50 m
Top of PH	:	+473.50 m
Control room	:	8.24 x 5 m
Switch gear room	:	6.45 x 5 m

j) Tail race pool & Channel

Tail race pool	:	15.00 x 12.50 x 6.90m
Length of tail race channel	:	30m
Channel size	:	3.7m x 1m water depth+0.75 m free board
Lined channel	:	6.05 m
Unlined Channel	:	23.95 m

4.7 Access Roads

Access road to weir site	:	334 m
Access road to Forebay	:	By 3.60 m wide service road & length 1111m
Access road to power house	:	165 m

4.8 Land Requirements

Forest Land	:	Nil
Government Land	:	1.1 Ha (1.00 River + 0.10 Tribal)
Private Land	:	7.50 Ha
Total Requirements	:	8.60 Ha

4.9 Power Evacuation

Power evacuation for the subject scheme consists of the following

- Construction of 33 KV Single circuit feeder from Maripuzha SHEP to location CKT-47 through Narangathodu and Anakkampoyil for a length of 8.8 Km.
- Construction of 33 KV Double Circuit Feeder from Thambalamanna substation to Location CKT- 47 along existing 33 KV Chembukadavu line route with 110 KV DC line parameters using existing RoW (Right of Way) for a length of 7 Km.
- Dismantling of 7 Km Single Circuit line using a pole with maximum span of 55 Mtrs (Chembukadavu – Thambalamanna line).
- Construction of 33 KV feeder bay in 110 KV parameter at 33 KV substation Thambalamanna.

4.10 Generation & cost

Average Annual Generation	:	15.31 Mu.
90% Dependable year	:	14.84 Mu
Total cost of project	:	Rs 54.08 Cr
Total cost of project including IDC	:	Rs 54.41 Cr
Cost per MW of installation	:	Rs 9.01 Cr
Levellised Tariff	:	Rs 4.92 /Unit
Internal Rate of Return	:	12.21%
Pay back period	:	11 years
Net present value	:	Rs 1.29 Cr
Period of completion	:	2 ½ years

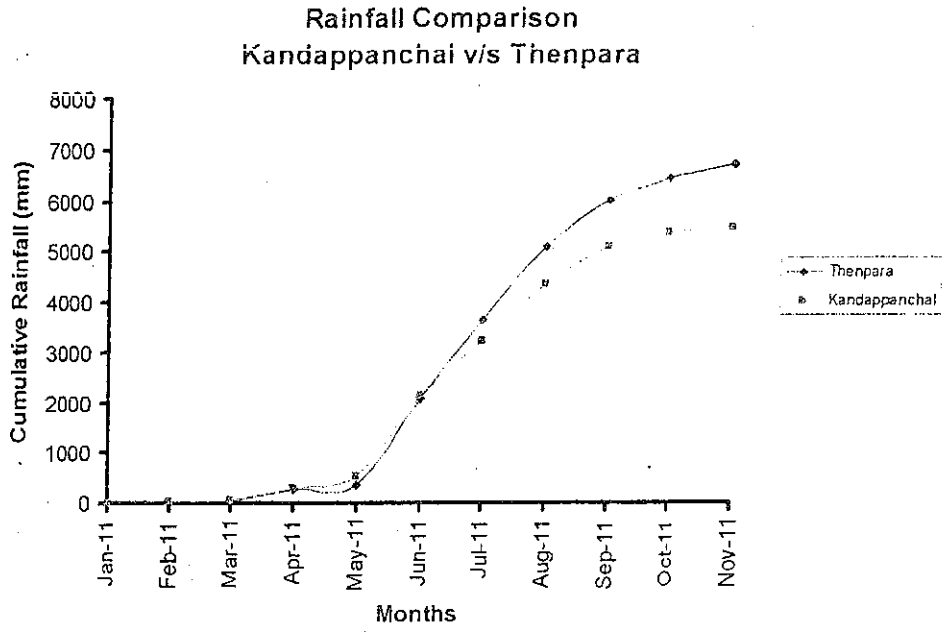
CHAPTER - 5

HYDRO METEOROLOGICAL STUDIES

5.1 Hydrology

The project site is located in the upper reaches of Iruvanjipuzha in Chaliyar basin. The catchment area is more or less steep terrain. Flash floods are common. The weir gauge data from 01.06.89 to 31.05.2000 is available at Chakkippara gauging weir in the adjacent catchment of the same basin. Vattachira raingauge station lies in the Chakkippara weir gauge catchment.

K.S.E Board is maintaining a rain gauge station at Kandappanchal at an elevation +260 near the proposed power house of Anakkampoyil S.H.E Scheme. This raingauge station falls outside the catchment (about 4km downstream of weir site). The catchment area of Maripuzha scheme lies between elevations +588 and +2339 and hence K.S.E Board established another rain gauge at Thenpara at an elevation +700, which is very close to forest area from May 2011 onwards. The monthly rain fall readings at Thenpara is about 21% more than that of Kandappanchal.



The rainfall readings of Thenpara and Kandappanchal for the period of Jan-2011 to November-2011 are given below.

Month	Thenpara	Kandappanchal
Jan-11	7.50	10.00
Feb-11	31.00	31.20
Mar-11	24.80	23.60
Apr-11	189.00	236.40
May-11	112.10	228.00
Jun-11	1700.30	1613.60
Jul-11	1580.60	1083.80
Aug-11	1455.80	1136.80
Sep-11	902.00	742.80
Oct-11	440.00	254.40
Nov-11	258.70	167.2
Total	6701.80	5527.80
% increase	21%	

Table 1 Monthly Rainfall Data – Thenpara & Kandappanchal

Eventhough there is a percentage increase in the rainfall of Thenpara compared to that of Kandappanchal ,for additional safety, the rainfall of Kandappanchal is considered for obtaining run off of Maripuzha . Yearly abstract of rainfall in Kandappanchal is shown below.

YEARLY RAINFALL OF KANDAPPANCHAL

year	Rainfall in mm
1997-98	9261.6
1998-99	6920.8
1999-00	5308
2000-01	5165.6
2001-02	5628.2
2002-03	4816.6
2003-04	4171.2
2004-05	5565.8
2005-06	8295
2006-07	5778.2
2007-08	7458.8
2008-09	4891.8
2009-10	5426.8
2010-11	5395.2

AVERAGE 6006 mm

Average annual rainfall is 6006 mm. The highest rainfall occurred is 9261.60mm during 97-98.

5.1.1 Rainfall runoff Model

The linear correlation generally used is based on comparing the monthly runoff and monthly rainfall. A linear correlation does not give fair values when extending to daily discharge data. It shows abrupt declination in discharge when there is no rain in a single day during heavy monsoon. The effect of past rain in runoff will not reflect in linear correlation. Hence Multivariate linear regression method as prescribed in the CBIP Manual page 36 is used for regression analysis.

The daily discharge data and daily rainfall of Chalipuzha (tributary of Iruvanjipuzha) is available from 01-04-1995 to 31-05-2000. The correlation equation is prepared by taking rainfall of present day and previous two days with the runoff depth obtained from Chakkippara gauging weir. Excel function LINEST is used for calculating the regression values. The regression coefficients

of above period were worked out and the set contains regression coefficient near unity (better regression) is selected. When the additive constant α becomes –ve, the set contains next higher regression coefficient has been selected.

Month	1995	1996	1997	1998	1999
May	-	0.6768	0.2019	0.2883	0.4419
June	0.5183	0.6407	0.7923	0.6870	0.7163
July	0.3041	0.8346	0.3962	0.4279	0.8265
Aug	0.0725	0.0206	0.6382	0.2158	0.7335
Sep	-	0.0455	0.1783	0.4637	0.1261
Oct	-	0.5207	0.0174	0.6018	0.0267
Nov	0.1119	0.9349	0.2092	0.4321	0.0433

Regression Coefficients

The regression values obtained are given below.

Month	β1	β2	β3	α
May	0.1019	-0.0333	0.0525	0.22
June	0.6707	0.0216	0.0231	8.88
July	0.3209	0.3270	0.2811	2.54
August	0.8941	0.0634	0.2243	8.15
September	0.1326	0.0922	0.2989	8.47
October	0.5904	0.0871	0.1970	10.50
November	0.0803	0.2597	-0.0059	2.32

Rainfall / Runoff Regression Values

Multi Variate regression for different months are shown in **table V-1**

Let R be the runoff depth, P_0, P_{-1}, P_{-2} be the rainfall of today, yesterday and day before yesterday of the scheme catchment.

Runoff, R = $\beta_1 \times P_0 + \beta_2 \times P_1 + \beta_3 \times P_2 + \alpha$

Inflow at weir site in Mm^3 = R /1000 x Catchment Area (km^2)

This equation has been used for determining the proportional discharge in scheme catchment with the rainfall details from Kandappanchal rainguage.

Discharge calculation for Maripuzha is shown in **table V-2.** Yearly abstract of inflow in Maripuzha is shown in **table V - 3.**

TABLE V-1

MUTI VARIATE LINEAR REGRESSION FOR DIFFERENT MONTHS

Multivariate Linear Regression of May

Weir guage station	Chakkipara	Rain guage station	Vattachira
Dependent variable	Runoff	Independent variable 2	Rainfall of -1st day
Independent variable 1	Rainfall of that day	Independent variable 3	Rainfall of -2nd day

Date	Chakkipara Discharge Mm^3	Runoff depth (Y)	Rainfall D-0 (X0)	Rainfall D-1 (X1)	Rainfall D-2 (X2)
29/04/96	0.0203	0.99	0.00		
30/04/96	0.0315	1.54	0.00		
01/05/96	0.0231	1.13	13.00	0.00	0.00
02/05/96	0.0128	0.62	0.00	13.00	0.00
03/05/96	0.0149	0.73	7.20	0.00	13.00
04/05/96	0.0118	0.58	0.00	7.20	0.00
05/05/96	0.0095	0.46	0.00	0.00	7.20
06/05/96	0.0060	0.29	0.00	0.00	0.00
07/05/96	0.0044	0.21	0.00	0.00	0.00
08/05/96	0.0037	0.18	0.00	0.00	0.00
09/05/96	0.0042	0.20	0.00	0.00	0.00
10/05/96	0.0042	0.20	0.00	0.00	0.00
11/05/96	0.0042	0.20	0.00	0.00	0.00
12/05/96	0.0042	0.20	0.00	0.00	0.00
13/05/96	0.0042	0.20	0.00	0.00	0.00
14/05/96	0.0041	0.20	0.00	0.00	0.00
15/05/96	0.0037	0.18	0.00	0.00	0.00
16/05/96	0.0034	0.17	0.00	0.00	0.00
17/05/96	0.0032	0.16	0.00	0.00	0.00
18/05/96	0.0032	0.16	0.00	0.00	0.00
19/05/96	0.0032	0.16	0.00	0.00	0.00
20/05/96	0.0032	0.16	0.00	0.00	0.00
21/05/96	0.0032	0.16	3.00	0.00	0.00
22/05/96	0.0032	0.16	3.20	3.00	0.00
23/05/96	0.0059	0.29	0.00	3.20	3.00
24/05/96	0.0076	0.37	15.00	0.00	3.20
25/05/96	0.0048	0.23	5.20	15.00	0.00
26/05/96	0.0038	0.19	0.00	5.20	15.00
27/05/96	0.0542	2.64	5.40	0.00	5.20
28/05/96	0.0348	1.70	13.20	5.40	0.00
29/05/96	0.1492	7.28	44.20	13.20	5.40
30/05/96	0.0583	2.84	51.40	44.20	13.20
31/05/96	0.0306	1.49	0.00	51.40	44.20
Regression factors		**0.0525**	**-0.0333**	**0.1019**	**0.22**
		β3	β2	β1	α

Multivariate Linear Regression of June

Weir guage station	Chakkipara	Rain guage station	Vattachira
Dependent variable	Runoff	Independent variable 2	Rainfall of -1st day
Independent variable 1	Rainfall of that day	Independent variable 3	Rainfall of -2nd day

Date	Discharge Mm^3	Runoff depth (Y)	Rainfall D-0 (X0)	Rainfall D-1 (X1)	Rainfall D-2 (X2)
30/05/99	0.6702	32.69	11.00		
31/05/99	0.4084	19.92	31.30		
01/06/99	0.2961	14.44	0.00	31.30	11.00
02/06/99	0.2722	13.28	5.00	0.00	31.30
03/06/99	0.2351	11.47	0.00	5.00	0.00
04/06/99	0.2478	12.09	11.00	0.00	5.00
05/06/99	0.2211	10.79	29.00	11.00	0.00
06/06/99	0.1801	8.79	14.20	29.00	11.00
07/06/99	0.3531	17.22	0.00	14.20	29.00
08/06/99	0.1681	8.20	46.20	0.00	14.20
09/06/99	0.2121	10.35	0.00	46.20	0.00
10/06/99	0.2794	13.63	49.00	0.00	46.20
11/06/99	0.7551	36.83	21.30	49.00	0.00
12/06/99	1.2206	59.54	80.00	21.30	49.00
13/06/99	1.4477	70.62	94.00	80.00	21.30
14/06/99	1.1785	57.49	110.00	94.00	80.00
15/06/99	0.7107	34.67	55.30	110.00	94.00
16/06/99	0.7070	34.49	15.00	55.30	110.00
17/06/99	1.9648	95.84	57.00	15.00	55.30
18/06/99	2.9017	141.55	106.30	57.00	15.00
19/06/99	2.2346	109.00	153.00	106.30	57.00
20/06/99	1.5235	74.32	94.00	153.00	106.30
21/06/99	1.0463	51.04	53.00	94.00	153.00
22/06/99	0.6311	30.79	9.00	53.00	94.00
23/06/99	0.3914	19.09	3.00	9.00	53.00
24/06/99	0.3024	14.75	11.00	3.00	9.00
25/06/99	0.2592	12.64	0.00	11.00	3.00
26/06/99	0.2091	10.20	1.00	0.00	11.00
27/06/99	0.1554	7.58	0.00	1.00	0.00
28/06/99	0.1309	6.39	4.00	0.00	1.00
29/06/99	0.1265	6.17	0.00	4.00	0.00
30/06/99	0.1111	5.42	0.00	0.00	4.00
Regression factors		**0.0231**	**0.0216**	**0.6707**	**8.88**
		$\beta 3$	$\beta 2$	$\beta 1$	α

Multivariate Linear Regression of July

Weir guage station	Chakkipara	Rain guage station	Vattachira
Dependent variable	Runoff	Independent variable 2	Rainfall of -1st day
Independent variable 1	Rainfall of that day	Independent variable 3	Rainfall of -2nd day

Date	Discharge Mm^3	Runoff depth (Y)	Rainfall D-0 (X0)	Rainfall D-1 (X1)	Rainfall D-2 (X2)
29/06/96	0.1203	5.87	0.00		
30/06/96	0.1024	5.00	0.00		
01/07/96	0.0867	4.23	0.00	0.00	0.00
02/07/96	0.0723	3.53	0.00	0.00	0.00
03/07/96	0.0708	3.45	0.00	0.00	0.00
04/07/96	0.0708	3.45	0.00	0.00	0.00
05/07/96	0.0708	3.45	0.00	0.00	0.00
06/07/96	0.0777	3.79	0.00	0.00	0.00
07/07/96	0.0901	4.40	9.20	0.00	0.00
08/07/96	0.3548	17.31	8.30	9.20	0.00
09/07/96	0.1111	5.42	40.80	8.30	9.20
10/07/96	0.2020	9.85	5.20	40.80	8.30
11/07/96	0.3874	18.90	28.00	5.20	40.80
12/07/96	0.2870	14.00	14.00	28.00	5.20
13/07/96	0.4078	19.89	71.00	14.00	28.00
14/07/96	0.2735	13.34	10.00	71.00	14.00
15/07/96	0.8051	39.27	12.30	10.00	71.00
16/07/96	0.5532	26.99	70.30	12.30	10.00
17/07/96	1.0256	50.03	15.40	70.30	12.30
18/07/96	1.5182	74.06	97.30	15.40	70.30
19/07/96	1.6970	82.78	87.30	97.30	15.40
20/07/96	1.6868	82.28	98.00	87.30	97.30
21/07/96	1.7327	84.52	104.00	98.00	87.30
22/07/96	1.8425	89.88	78.30	104.00	98.00
23/07/96	1.3540	66.05	86.00	78.30	104.00
24/07/96	1.2130	59.17	49.20	86.00	78.30
25/07/96	1.5624	76.21	58.30	49.20	86.00
26/07/96	2.0169	98.39	63.00	58.30	49.20
27/07/96	1.3008	63.45	63.10	63.00	58.30
28/07/96	1.0045	49.00	47.20	63.10	63.00
29/07/96	1.1317	55.20	26.20	47.20	63.10
30/07/96	0.6696	32.66	62.10	26.20	47.20
31/07/96	0.5722	27.91	8.20	62.10	26.20
Regression factors		**0.2811**	**0.3270**	**0.3209**	**2.54**
		β3	β2	β1	α

Multivariate Linear Regression of August

Weir guage station	Chakkipara	Rain guage station	Vattachira
Dependent variable	Runoff	Independent variable 2	Rainfall of -1st day
Independent variable 1	Rainfall of that day	Independent variable 3	Rainfall of -2nd day

Date	Discharge Mm^3	Runoff depth (Y)	Rainfall D-0 (X0)	Rainfall D-1 (X1)	Rainfall D-2 (X2)
30/07/99	0.8524	41.58	26.00		
31/07/99	0.8833	43.09	48.00		
01/08/99	1.4252	69.52	33.00	48.00	26.00
02/08/99	1.3614	66.41	76.00	33.00	48.00
03/08/99	0.7986	38.96	15.30	76.00	33.00
04/08/99	0.6110	29.80	25.00	15.30	76.00
05/08/99	1.0360	50.54	8.30	25.00	15.30
06/08/99	2.2555	110.02	60.00	8.30	25.00
07/08/99	1.8669	91.07	113.00	60.00	8.30
08/08/99	2.5899	126.34	72.00	113.00	60.00
09/08/99	4.1520	202.54	121.00	72.00	113.00
10/08/99	1.1577	56.47	93.60	121.00	72.00
11/08/99	0.7049	34.39	2.00	93.60	121.00
12/08/99	0.5285	25.78	18.00	2.00	93.60
13/08/99	0.3271	15.96	0.00	18.00	2.00
14/08/99	0.2211	10.79	0.00	0.00	18.00
15/08/99	0.2051	10.00	0.00	0.00	0.00
16/08/99	0.2051	10.00	3.40	0.00	0.00
17/08/99	0.2392	11.67	0.00	3.40	0.00
18/08/99	0.5975	29.15	43.00	0.00	3.40
19/08/99	0.4683	22.84	7.20	43.00	0.00
20/08/99	0.3860	18.83	28.00	7.20	43.00
21/08/99	0.2162	10.55	2.00	28.00	7.20
22/08/99	0.7443	36.31	0.00	2.00	28.00
23/08/99	0.3949	19.26	5.00	0.00	2.00
24/08/99	0.2105	10.27	0.00	5.00	0.00
25/08/99	0.2366	11.54	2.00	0.00	5.00
26/08/99	0.3461	16.88	15.30	2.00	0.00
27/08/99	0.2706	13.20	4.00	15.30	2.00
28/08/99	0.2459	12.00	8.00	4.00	15.30
29/08/99	0.1941	9.47	7.00	8.00	4.00
30/08/99	0.2826	13.79	0.00	7.00	8.00
31/08/99	0.1557	7.60	21.00	0.00	7.00
Regression factors		0.2243	0.0634	0.8941	8.15
		β3	β2	β1	α

Multivariate Linear Regression of September

Weir guage station	Chakkipara	Rain guage station	Vattachira
Dependent variable	Runoff	Independent variable 2	Rainfall of -1st day
Independent variable 1	Rainfall of that day	Independent variable 3	Rainfall of -2nd day

Date	Discharge Mm^3	Runoff depth (Y)	Rainfall D-0 (X0)	Rainfall D-1 (X1)	Rainfall D-2 (X2)
30/08/98	0.2845	13.88	0.00		
31/08/98	0.2417	11.79	0.00		
01/09/98	0.2115	10.32	3.00	0.00	0.00
02/09/98	0.1612	7.86	10.30	3.00	0.00
03/09/98	0.1476	7.20	0.00	10.30	3.00
04/09/98	0.2642	12.89	5.00	0.00	10.30
05/09/98	0.2813	13.72	24.20	5.00	0.00
06/09/98	0.1084	5.29	67.00	24.20	5.00
07/09/98	0.3209	15.65	42.00	67.00	24.20
08/09/98	0.2635	12.85	5.20	42.00	67.00
09/09/98	1.3977	68.18	23.00	5.20	42.00
10/09/98	0.4711	22.98	134.30	23.00	5.20
11/09/98	0.6959	33.95	3.40	134.30	23.00
12/09/98	1.4353	70.01	103.00	3.40	134.30
13/09/98	0.8633	42.11	57.20	103.00	3.40
14/09/98	1.0041	48.98	27.00	57.20	103.00
15/09/98	0.8411	41.03	59.50	27.00	57.20
16/09/98	0.4648	22.67	44.20	59.50	27.00
17/09/98	0.2995	14.61	12.50	44.20	59.50
18/09/98	0.2392	11.67	1.20	12.50	44.20
19/09/98	0.2064	10.07	0.00	1.20	12.50
20/09/98	0.3497	17.06	0.00	0.00	1.20
21/09/98	0.1788	8.72	32.00	0.00	0.00
22/09/98	0.1896	9.25	2.20	32.00	0.00
23/09/98	0.3063	14.94	26.50	2.20	32.00
24/09/98	0.2254	11.00	24.20	26.50	2.20
25/09/98	0.2461	12.00	0.00	24.20	26.50
26/09/98	0.9056	44.18	27.00	0.00	24.20
27/09/98	0.2845	13.88	57.50	27.00	0.00
28/09/98	0.8555	41.73	2.00	57.50	27.00
29/09/98	0.2925	14.27	1.20	2.00	57.50
30/09/98	0.2446	11.93	7.30	1.20	2.00
Regression factors		**0.2989**	**0.0922**	**0.1326**	**8.47**
		β3	β2	β1	α

Multivariate Linear Regression of October

Weir guage station	Chakkipara	Rain guage station	Vattachira
Dependent variable	Runoff	Independent variable 2	Rainfall of -1st day
Independent variable 1	Rainfall of that day	Independent variable 3	Rainfall of -2nd day

Date	Discharge Mm^3	Runoff depth (Y)	Rainfall D-0 (X0)	Rainfall D-1 (X1)	Rainfall D-2 (X2)
29/09/98	0.2925	14.27	1.20		
30/09/98	0.2446	11.93	7.30		
01/10/98	0.5696	27.79	12.00	7.30	1.20
02/10/98	0.4471	21.81	27.00	12.00	7.30
03/10/98	0.3640	17.76	11.00	27.00	12.00
04/10/98	0.2999	14.63	2.00	11.00	27.00
05/10/98	0.3797	18.52	12.30	2.00	11.00
06/10/98	0.6419	31.31	14.00	12.30	2.00
07/10/98	0.3228	15.75	21.00	14.00	12.30
08/10/98	0.3530	17.22	0.00	21.00	14.00
09/10/98	1.3700	66.83	14.30	0.00	21.00
10/10/98	1.5308	74.67	55.00	14.30	0.00
11/10/98	1.9256	93.93	70.50	55.00	14.30
12/10/98	1.4548	70.97	124.00	70.50	55.00
13/10/98	0.9317	45.45	20.00	124.00	70.50
14/10/98	1.4437	70.42	33.30	20.00	124.00
15/10/98	1.4891	72.64	57.20	33.30	20.00
16/10/98	0.8019	39.12	39.20	57.20	33.30
17/10/98	0.7512	36.64	12.20	39.20	57.20
18/10/98	0.4939	24.09	34.30	12.20	39.20
19/10/98	0.3951	19.27	6.30	34.30	12.20
20/10/98	0.2972	14.50	0.00	6.30	34.30
21/10/98	0.2351	11.47	0.00	0.00	6.30
22/10/98	0.2051	10.00	0.00	0.00	0.00
23/10/98	0.1442	7.03	0.00	0.00	0.00
24/10/98	0.1183	5.77	0.00	0.00	0.00
25/10/98	0.1311	6.40	0.00	0.00	0.00
26/10/98	0.1330	6.49	50.20	0.00	0.00
27/10/98	0.1103	5.38	0.00	50.20	0.00
28/10/98	0.1015	4.95	3.00	0.00	50.20
29/10/98	0.0977	4.77	0.00	3.00	0.00
30/10/98	0.0938	4.58	0.00	0.00	3.00
31/10/98	0.3031	14.79	10.20	0.00	0.00
Regression factors		**0.1970**	**0.0871**	**0.5904**	**10.50**
		β3	β2	β1	α

Multivariate Linear Regression of November

Weir guage station	Chakkipara	Rain guage station	Vattachira
Dependent variable	Runoff	Independent variable 2	Rainfall of -1st day
Independent variable 1	Rainfall of that day	Independent variable 3	Rainfall of -2nd day

Date	Discharge Mm^3	Runoff depth (Y)	Rainfall D-0 (X0)	Rainfall D-1 (X1)	Rainfall D-2 (X2)
30/10/96	0.0977	4.77	0.00		
31/10/96	0.1261	6.15	0.00		
01/11/96	0.1343	6.55	53.30	0.00	0.00
02/11/96	0.3611	17.61	10.00	53.30	0.00
03/11/96	0.0977	4.77	4.00	10.00	53.30
04/11/96	0.0821	4.00	8.00	4.00	10.00
05/11/96	0.0733	3.58	0.00	8.00	4.00
06/11/96	0.0694	3.39	0.00	0.00	8.00
07/11/96	0.0664	3.24	0.00	0.00	0.00
08/11/96	0.0664	3.24	0.00	0.00	0.00
09/11/96	0.0664	3.24	0.00	0.00	0.00
10/11/96	0.0656	3.20	0.00	0.00	0.00
11/11/96	0.0629	3.07	1.20	0.00	0.00
12/11/96	0.0620	3.02	10.20	1.20	0.00
13/11/96	0.0592	2.89	0.00	10.20	1.20
14/11/96	0.0584	2.85	0.00	0.00	10.20
15/11/96	0.0560	2.73	0.00	0.00	0.00
16/11/96	0.0539	2.63	0.00	0.00	0.00
17/11/96	0.0515	2.51	0.00	0.00	0.00
18/11/96	0.0494	2.41	0.00	0.00	0.00
19/11/96	0.0487	2.38	0.00	0.00	0.00
20/11/96	0.0690	3.37	2.00	0.00	0.00
21/11/96	0.0457	2.23	0.00	2.00	0.00
22/11/96	0.0442	2.16	0.00	0.00	2.00
23/11/96	0.0470	2.29	0.00	0.00	0.00
24/11/96	0.0421	2.05	0.00	0.00	0.00
25/11/96	0.0404	1.97	3.00	0.00	0.00
26/11/96	0.0381	1.86	0.00	3.00	0.00
27/11/96	0.0380	1.85	0.00	0.00	3.00
28/11/96	0.0364	1.78	0.00	0.00	0.00
29/11/96	0.0355	1.73	0.00	0.00	0.00
30/11/96	0.0336	1.64	0.00	0.00	0.00
Regression factors		**-0.0059**	**0.2597**	**0.0803**	**2.32**
		β3	β2	β1	α

TABLE V -2

DISCHARGE CALCULATION OF MARIPUZHA FOR 90% DEPENDABLE YEAR

Month	β1	β2	β3	α
May	0.1019	-0.0333	0.0525	0.22
June	0.6707	0.0216	0.0231	8.88
July	0.3209	0.3270	0.2811	2.54
August	0.8941	0.0634	0.2243	8.15
September	0.1326	0.0922	0.2989	8.47
October	0.5904	0.0871	0.1970	10.50
November	0.0803	0.2597	-0.0059	2.32

Discharge = $\alpha + \beta_1 \times X_1 + \beta_2 \times X_2 + \beta_3 \times X_3$

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall			Maripuzha run off	maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)		
30/12/00	0.00	0.00	0.00	0.00		
31/12/00	18.80	18.80	0.00	0.00		
01/01/01	0.00	0.00	18.80	0.00		
02/01/01	0.00	0.00	0.00	18.80		
03/01/01	0.00	0.00	0.00	0.00		
04/01/01	0.00	0.00	0.00	0.00		
05/01/01	0.00	0.00	0.00	0.00		
06/01/01	0.00	0.00	0.00	0.00		
07/01/01	0.00	0.00	0.00	0.00		
08/01/01	0.00	0.00	0.00	0.00		
09/01/01	0.00	0.00	0.00	0.00		
10/01/01	0.00	0.00	0.00	0.00		
11/01/01	0.00	0.00	0.00	0.00		
12/01/01	6.80	6.80	0.00	0.00		
13/01/01	0.00	0.00	6.80	0.00		
14/01/01	0.00	0.00	0.00	6.80		
15/01/01	0.00	0.00	0.00	0.00		
16/01/01	0.00	0.00	0.00	0.00		
17/01/01	0.00	0.00	0.00	0.00		
18/01/01	0.00	0.00	0.00	0.00		
19/01/01	0.00	0.00	0.00	0.00		
20/01/01	0.00	0.00	0.00	0.00		
21/01/01	0.00	0.00	0.00	0.00		
22/01/01	0.00	0.00	0.00	0.00		
23/01/01	0.00	0.00	0.00	0.00		
24/01/01	0.00	0.00	0.00	0.00		
25/01/01	0.00	0.00	0.00	0.00		
26/01/01	0.00	0.00	0.00	0.00		
27/01/01	0.00	0.00	0.00	0.00		
28/01/01	0.00	0.00	0.00	0.00		
29/01/01	0.00	0.00	0.00	0.00		
30/01/01	0.00	0.00	0.00	0.00		
31/01/01	0.00	0.00	0.00	0.00		

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall			Maripuzha run off	maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)		
01/02/01	0.00	0.00	0.00	0.00		
02/02/01	5.20	5.20	0.00	0.00		
03/02/01	4.80	4.80	5.20	0.00		
04/02/01	0.00	0.00	4.80	5.20		
05/02/01	0.00	0.00	0.00	4.80		
06/02/01	16.80	16.80	0.00	0.00		
07/02/01	0.00	0.00	16.80	0.00		
08/02/01	0.00	0.00	0.00	16.80		
09/02/01	0.00	0.00	0.00	0.00		
10/02/01	0.00	0.00	0.00	0.00		
11/02/01	0.00	0.00	0.00	0.00		
12/02/01	0.00	0.00	0.00	0.00		
13/02/01	0.00	0.00	0.00	0.00		
14/02/01	0.00	0.00	0.00	0.00		
15/02/01	0.00	0.00	0.00	0.00		
16/02/01	0.00	0.00	0.00	0.00		
17/02/01	0.00	0.00	0.00	0.00		
18/02/01	0.00	0.00	0.00	0.00		
19/02/01	0.00	0.00	0.00	0.00		
20/02/01	0.00	0.00	0.00	0.00		
21/02/01	0.00	0.00	0.00	0.00		
22/02/01	0.00	0.00	0.00	0.00		
23/02/01	0.00	0.00	0.00	0.00		
24/02/01	0.00	0.00	0.00	0.00		
25/02/01	0.00	0.00	0.00	0.00		
26/02/01	0.00	0.00	0.00	0.00		
27/02/01	0.00	0.00	0.00	0.00		
28/02/01	0.00	0.00	0.00	0.00		

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall			Maripuzha run off	maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)		
01/03/01	0.00	0.00	0.00	0.00		
02/03/01	0.00	0.00	0.00	0.00		
03/03/01	0.00	0.00	0.00	0.00		
04/03/01	0.00	0.00	0.00	0.00		
05/03/01	0.00	0.00	0.00	0.00		
06/03/01	0.00	0.00	0.00	0.00		
07/03/01	0.00	0.00	0.00	0.00		
08/03/01	0.00	0.00	0.00	0.00		
09/03/01	0.00	0.00	0.00	0.00		
10/03/01	0.00	0.00	0.00	0.00		
11/03/01	0.00	0.00	0.00	0.00		
12/03/01	0.00	0.00	0.00	0.00		
13/03/01	0.00	0.00	0.00	0.00		
14/03/01	0.00	0.00	0.00	0.00		
15/03/01	0.00	0.00	0.00	0.00		
16/03/01	14.40	14.40	0.00	0.00		
17/03/01	0.00	0.00	14.40	0.00		
18/03/01	0.00	0.00	0.00	14.40		
19/03/01	0.00	0.00	0.00	0.00		
20/03/01	0.00	0.00	0.00	0.00		
21/03/01	0.00	0.00	0.00	0.00		
22/03/01	0.00	0.00	0.00	0.00		
23/03/01	0.00	0.00	0.00	0.00		
24/03/01	0.00	0.00	0.00	0.00		
25/03/01	0.00	0.00	0.00	0.00		
26/03/01	0.00	0.00	0.00	0.00		
27/03/01	0.00	0.00	0.00	0.00		
28/03/01	0.00	0.00	0.00	0.00		
29/03/01	0.00	0.00	0.00	0.00		
30/03/01	0.00	0.00	0.00	0.00		
31/03/01	8.80	8.80	0.00	0.00		

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall			Maripuzha run off	maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)		
01/04/01	0.00	0.00	8.80	0.00		
02/04/01	0.00	0.00	0.00	8.80		
03/04/01	0.00	0.00	0.00	0.00		
04/04/01	0.00	0.00	0.00	0.00		
05/04/01	0.00	0.00	0.00	0.00		
06/04/01	0.00	0.00	0.00	0.00		
07/04/01	0.00	0.00	0.00	0.00		
08/04/01	0.00	0.00	0.00	0.00		
09/04/01	0.00	0.00	0.00	0.00		
10/04/01	0.00	0.00	0.00	0.00		
11/04/01	37.60	37.60	0.00	0.00		
12/04/01	27.20	27.20	37.60	0.00		
13/04/01	76.40	76.40	27.20	37.60		
14/04/01	14.00	14.00	76.40	27.20		
15/04/01	14.80	14.80	14.00	76.40		
16/04/01	0.00	0.00	14.80	14.00		
17/04/01	26.00	26.00	0.00	14.80		
18/04/01	14.80	14.80	26.00	0.00		
19/04/01	39.60	39.60	14.80	26.00		
20/04/01	4.80	4.80	39.60	14.80		
21/04/01	25.60	25.60	4.80	39.60		
22/04/01	0.00	0.00	25.60	4.80		
23/04/01	15.20	15.20	0.00	25.60		
24/04/01	9.20	9.20	15.20	0.00		
25/04/01	0.00	0.00	9.20	15.20		
26/04/01	0.00	0.00	0.00	9.20		
27/04/01	0.00	0.00	0.00	0.00		
28/04/01	0.00	0.00	0.00	0.00		
29/04/01	2.40	2.40	0.00	0.00		
30/04/01	0.00	0.00	2.40	0.00		

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall			Maripuzha run off	maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)		
01/05/01	8.80	8.80	0.00	2.40	1.24	0.0197
02/05/01	0.00	0.00	8.80	0.00	0.00	0.0000
03/05/01	0.00	0.00	0.00	8.80	0.68	0.0108
04/05/01	0.00	0.00	0.00	0.00	0.22	0.0035
05/05/01	0.00	0.00	0.00	0.00	0.22	0.0035
06/05/01	12.40	12.40	0.00	0.00	1.48	0.0236
07/05/01	15.60	15.60	12.40	0.00	1.40	0.0223
08/05/01	24.80	24.80	15.60	12.40	2.88	0.0458
09/05/01	0.00	0.00	24.80	15.60	0.21	0.0033
10/05/01	0.00	0.00	0.00	24.80	1.52	0.0242
11/05/01	0.00	0.00	0.00	0.00	0.22	0.0035
12/05/01	2.80	2.80	0.00	0.00	0.51	0.0081
13/05/01	0.00	0.00	2.80	0.00	0.13	0.0021
14/05/01	0.00	0.00	0.00	2.80	0.37	0.0059
15/05/01	0.00	0.00	0.00	0.00	0.22	0.0035
16/05/01	0.00	0.00	0.00	0.00	0.22	0.0035
17/05/01	0.00	0.00	0.00	0.00	0.22	0.0035
18/05/01	0.00	0.00	0.00	0.00	0.22	0.0035
19/05/01	0.00	0.00	0.00	0.00	0.22	0.0035
20/05/01	0.00	0.00	0.00	0.00	0.22	0.0035
21/05/01	0.00	0.00	0.00	0.00	0.22	0.0035
22/05/01	23.20	23.20	0.00	0.00	2.58	0.0411
23/05/01	4.00	4.00	23.20	0.00	0.00	0.0000
24/05/01	31.60	31.60	4.00	23.20	4.52	0.0720
25/05/01	4.00	4.00	31.60	4.00	0.00	0.0000
26/05/01	52.40	52.40	4.00	31.60	7.09	0.1129
27/05/01	44.00	44.00	52.40	4.00	3.17	0.0505
28/05/01	25.20	25.20	44.00	52.40	4.07	0.0648
29/05/01	42.80	42.80	25.20	44.00	6.05	0.0963
30/05/01	6.40	6.40	42.80	25.20	0.77	0.0123
31/05/01	33.20	33.20	6.40	42.80	5.64	0.0898

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall				maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)	Maripuzha run off	
01/06/01	0.00	0.00	33.20	6.40	9.74	0.1551
02/06/01	0.00	0.00	0.00	33.20	9.65	0.1536
03/06/01	48.80	48.80	0.00	0.00	41.61	0.6624
04/06/01	2.80	2.80	48.80	0.00	11.81	0.1880
05/06/01	0.00	0.00	2.80	48.80	10.07	0.1603
06/06/01	53.20	53.20	0.00	2.80	44.63	0.7105
07/06/01	50.00	50.00	53.20	0.00	43.56	0.6935
08/06/01	44.80	44.80	50.00	53.20	41.24	0.6565
09/06/01	20.00	20.00	44.80	50.00	24.42	0.3888
10/06/01	27.20	27.20	20.00	44.80	28.59	0.4552
11/06/01	65.60	65.60	27.20	20.00	53.93	0.8586
12/06/01	46.80	46.80	65.60	27.20	42.31	0.6736
13/06/01	72.00	72.00	46.80	65.60	59.70	0.9504
14/06/01	89.20	89.20	72.00	46.80	71.34	1.1357
15/06/01	93.60	93.60	89.20	72.00	75.25	1.1980
16/06/01	17.20	17.20	93.60	89.20	24.50	0.3900
17/06/01	28.80	28.80	17.20	93.60	30.73	0.4892
18/06/01	37.60	37.60	28.80	17.20	35.12	0.5591
19/06/01	46.40	46.40	37.60	28.80	41.48	0.6604
20/06/01	29.60	29.60	46.40	37.60	30.60	0.4872
21/06/01	15.20	15.20	29.60	46.40	20.79	0.3310
22/06/01	33.60	33.60	15.20	29.60	32.43	0.5163
23/06/01	136.40	136.40	33.60	15.20	101.44	1.6149
24/06/01	82.40	82.40	136.40	33.60	67.87	1.0805
25/06/01	15.60	15.60	82.40	136.40	24.27	0.3864
26/06/01	23.60	23.60	15.60	82.40	26.95	0.4290
27/06/01	10.40	10.40	23.60	15.60	16.73	0.2663
28/06/01	30.80	30.80	10.40	23.60	30.31	0.4825
29/06/01	14.00	14.00	30.80	10.40	19.18	0.3053
30/06/01	24.80	24.80	14.00	30.80	26.53	0.4224

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall			Maripuzha run off	maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)		
01/07/01	6.80	6.80	24.80	14.00	16.77	0.2670
02/07/01	16.00	16.00	6.80	24.80	16.87	0.2686
03/07/01	80.00	80.00	16.00	6.80	35.36	0.5629
04/07/01	42.40	42.40	80.00	16.00	46.80	0.7451
05/07/01	32.00	32.00	42.40	80.00	49.16	0.7826
06/07/01	79.20	79.20	32.00	42.40	50.34	0.8014
07/07/01	118.80	118.80	79.20	32.00	75.56	1.2029
08/07/01	129.60	129.60	118.80	79.20	105.24	1.6754
09/07/01	54.80	54.80	129.60	118.80	95.90	1.5267
10/07/01	88.00	88.00	54.80	129.60	85.13	1.3553
11/07/01	80.80	80.80	88.00	54.80	72.65	1.1566
12/07/01	44.80	44.80	80.80	88.00	68.07	1.0837
13/07/01	0.00	0.00	44.80	80.80	39.90	0.6352
14/07/01	23.60	23.60	0.00	44.80	22.71	0.3615
15/07/01	0.00	0.00	23.60	0.00	10.26	0.1633
16/07/01	4.80	4.80	0.00	23.60	10.71	0.1705
17/07/01	4.00	4.00	4.80	0.00	5.39	0.0858
18/07/01	4.00	4.00	4.00	4.80	6.48	0.1032
19/07/01	6.00	6.00	4.00	4.00	6.90	0.1098
20/07/01	11.60	11.60	6.00	4.00	9.35	0.1489
21/07/01	10.40	10.40	11.60	6.00	11.36	0.1809
22/07/01	2.40	2.40	10.40	11.60	9.97	0.1587
23/07/01	0.00	0.00	2.40	10.40	6.25	0.0995
24/07/01	15.60	15.60	0.00	2.40	8.22	0.1309
25/07/01	4.40	4.40	15.60	0.00	9.05	0.1441
26/07/01	31.60	31.60	4.40	15.60	18.50	0.2945
27/07/01	10.20	10.20	31.60	4.40	17.38	0.2767
28/07/01	32.80	32.80	10.20	31.60	25.28	0.4025
29/07/01	81.20	81.20	32.80	10.20	42.19	0.6717
30/07/01	6.40	6.40	81.20	32.80	40.37	0.6427
31/07/01	40.00	40.00	6.40	81.20	40.29	0.6414

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall			Maripuzha run off	maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)		
01/08/01	0.00	0.00	40.00	6.40	12.12	0.1930
02/08/01	81.60	81.60	0.00	40.00	90.08	1.4341
03/08/01	71.20	71.20	81.60	0.00	76.98	1.2255
04/08/01	16.80	16.80	71.20	81.60	45.99	0.7322
05/08/01	58.40	58.40	16.80	71.20	77.40	1.2322
06/08/01	10.40	10.40	58.40	16.80	24.92	0.3967
07/08/01	13.20	13.20	10.40	58.40	33.71	0.5367
08/08/01	9.20	9.20	13.20	10.40	19.55	0.3112
09/08/01	16.00	16.00	9.20	13.20	26.00	0.4139
10/08/01	0.00	0.00	16.00	9.20	11.23	0.1788
11/08/01	10.00	10.00	0.00	16.00	20.68	0.3292
12/08/01	22.80	22.80	10.00	0.00	29.17	0.4644
13/08/01	14.00	14.00	22.80	10.00	24.36	0.3878
14/08/01	38.00	38.00	14.00	22.80	48.13	0.7662
15/08/01	14.40	14.40	38.00	14.00	26.57	0.4230
16/08/01	28.80	28.80	14.40	38.00	43.34	0.6900
17/08/01	71.20	71.20	28.80	14.40	76.87	1.2238
18/08/01	35.20	35.20	71.20	28.80	50.60	0.8056
19/08/01	40.40	40.40	35.20	71.20	62.47	0.9945
20/08/01	32.80	32.80	40.40	35.20	47.93	0.7630
21/08/01	15.60	15.60	32.80	40.40	33.24	0.5292
22/08/01	22.40	22.40	15.60	32.80	36.52	0.5814
23/08/01	44.00	44.00	22.40	15.60	52.41	0.8344
24/08/01	24.00	24.00	44.00	22.40	37.42	0.5957
25/08/01	41.60	41.60	24.00	44.00	56.74	0.9033
26/08/01	9.60	9.60	41.60	24.00	24.75	0.3940
27/08/01	16.80	16.80	9.60	41.60	33.11	0.5271
28/08/01	3.60	3.60	16.80	9.60	14.59	0.2323
29/08/01	4.00	4.00	3.60	16.80	15.72	0.2503
30/08/01	7.60	7.60	4.00	3.60	16.01	0.2549
31/08/01	4.80	4.80	7.60	4.00	13.82	0.2200

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall				maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)	Maripuzha run off	
01/09/01	0.00	0.00	4.80	7.60	11.18	0.1780
02/09/01	4.00	4.00	0.00	4.80	10.44	0.1662
03/09/01	0.00	0.00	4.00	0.00	8.84	0.1407
04/09/01	0.00	0.00	0.00	4.00	9.67	0.1539
05/09/01	0.00	0.00	0.00	0.00	8.47	0.1348
06/09/01	0.00	0.00	0.00	0.00	8.47	0.1348
07/09/01	0.00	0.00	0.00	0.00	8.47	0.1348
08/09/01	0.00	0.00	0.00	0.00	8.47	0.1348
09/09/01	25.60	25.60	0.00	0.00	11.86	0.1888
10/09/01	0.00	0.00	25.60	0.00	10.83	0.1724
11/09/01	7.20	7.20	0.00	25.60	17.08	0.2719
12/09/01	4.00	4.00	7.20	0.00	9.66	0.1538
13/09/01	0.00	0.00	4.00	7.20	10.99	0.1750
14/09/01	0.00	0.00	0.00	4.00	9.67	0.1539
15/09/01	40.00	40.00	0.00	0.00	13.77	0.2192
16/09/01	76.80	76.80	40.00	0.00	22.34	0.3557
17/09/01	108.00	108.00	76.80	40.00	41.83	0.6659
18/09/01	79.20	79.20	108.00	76.80	51.89	0.8261
19/09/01	4.00	4.00	79.20	108.00	48.58	0.7734
20/09/01	48.00	48.00	4.00	79.20	38.88	0.6190
21/09/01	168.80	168.80	48.00	4.00	36.47	0.5806
22/09/01	59.20	59.20	168.80	48.00	46.23	0.7360
23/09/01	38.40	38.40	59.20	168.80	69.47	1.1060
24/09/01	12.00	12.00	38.40	59.20	31.30	0.4983
25/09/01	0.00	0.00	12.00	38.40	21.05	0.3351
26/09/01	60.80	60.80	0.00	12.00	20.12	0.3203
27/09/01	0.00	0.00	60.80	0.00	14.08	0.2242
28/09/01	19.20	19.20	0.00	60.80	29.19	0.4647
29/09/01	0.00	0.00	19.20	0.00	10.24	0.1630
30/09/01	49.60	49.60	0.00	19.20	20.79	0.3310

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall			Maripuzha run off	maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)		
01/10/01	59.20	59.20	49.60	0.00	49.77	0.7923
02/10/01	17.20	17.20	59.20	49.60	35.58	0.5664
03/10/01	0.00	0.00	17.20	59.20	23.66	0.3767
04/10/01	0.00	0.00	0.00	17.20	13.89	0.2211
05/10/01	0.00	0.00	0.00	0.00	10.50	0.1672
06/10/01	21.60	21.60	0.00	0.00	23.25	0.3701
07/10/01	4.00	4.00	21.60	0.00	14.74	0.2347
08/10/01	12.40	12.40	4.00	21.60	22.42	0.3569
09/10/01	14.80	14.80	12.40	4.00	21.11	0.3361
10/10/01	0.00	0.00	14.80	12.40	14.23	0.2265
11/10/01	16.80	16.80	0.00	14.80	23.33	0.3714
12/10/01	2.00	2.00	16.80	0.00	13.14	0.2092
13/10/01	2.00	2.00	2.00	16.80	15.16	0.2413
14/10/01	7.20	7.20	2.00	2.00	15.32	0.2439
15/10/01	38.00	38.00	7.20	2.00	33.96	0.5406
16/10/01	21.20	21.20	38.00	7.20	27.74	0.4416
17/10/01	0.00	0.00	21.20	38.00	19.83	0.3157
18/10/01	5.20	5.20	0.00	21.20	17.75	0.2826
19/10/01	0.00	0.00	5.20	0.00	10.95	0.1743
20/10/01	35.60	35.60	0.00	5.20	32.54	0.5180
21/10/01	3.60	3.60	35.60	0.00	15.73	0.2504
22/10/01	12.00	12.00	3.60	35.60	24.91	0.3966
23/10/01	0.00	0.00	12.00	3.60	12.25	0.1950
24/10/01	0.00	0.00	0.00	12.00	12.86	0.2047
25/10/01	2.00	2.00	0.00	0.00	11.68	0.1859
26/10/01	16.00	16.00	2.00	0.00	20.12	0.3203
27/10/01	13.20	13.20	16.00	2.00	20.08	0.3197
28/10/01	3.60	3.60	13.20	16.00	16.93	0.2695
29/10/01	0.00	0.00	3.60	13.20	13.41	0.2135
30/10/01	0.00	0.00	0.00	3.60	11.21	0.1785
31/10/01	5.80	5.80	0.00	0.00	13.92	0.2216

Date	Kandappachal Rainfall (mm)	Maripuzha Rainfall			Maripuzha run off	maripuzha Discharge in Mm^3
		Rainfall X_1 (mm)	Rainfall X_2 (mm)	Rainfall X_3 (mm)		
01/11/01	52.80	52.80	5.80	0.00	8.07	0.1285
02/11/01	0.00	0.00	52.80	5.80	16.00	0.2547
03/11/01	12.80	12.80	0.00	52.80	3.04	0.0484
04/11/01	0.00	0.00	12.80	0.00	5.64	0.0898
05/11/01	0.00	0.00	0.00	12.80	2.24	0.0357
06/11/01	0.00	0.00	0.00	0.00	2.32	0.0369
07/11/01	113.40	113.40	0.00	0.00	11.43	0.1820
08/11/01	90.00	90.00	113.40	0.00	39.00	0.6209
09/11/01	8.00	8.00	90.00	113.40	25.67	0.4087
10/11/01	0.00	0.00	8.00	90.00	3.87	0.0616
11/11/01	17.40	17.40	0.00	8.00	3.67	0.0584
12/11/01	0.00	0.00	17.40	0.00	6.84	0.1089
13/11/01	0.00	0.00	0.00	17.40	2.22	0.0353
14/11/01	44.20	44.20	0.00	0.00	5.87	0.0935
15/11/01	8.40	8.40	44.20	0.00	14.47	0.2304
16/11/01	71.60	71.60	8.40	44.20	9.99	0.1590
17/11/01	26.00	26.00	71.60	8.40	22.95	0.3654
18/11/01	0.00	0.00	26.00	71.60	8.65	0.1377
19/11/01	2.40	2.40	0.00	26.00	2.36	0.0376
20/11/01	0.00	0.00	2.40	0.00	2.94	0.0468
21/11/01	0.00	0.00	0.00	2.40	2.31	0.0368
22/11/01	0.00	0.00	0.00	0.00	2.32	0.0369
23/11/01	36.80	36.80	0.00	0.00	5.28	0.0841
24/11/01	15.80	15.80	36.80	0.00	13.15	0.2093
25/11/01	0.00	0.00	15.80	36.80	6.21	0.0989
26/11/01	0.00	0.00	0.00	15.80	2.23	0.0355
27/11/01	0.00	0.00	0.00	0.00	2.32	0.0369
28/11/01	10.20	10.20	0.00	0.00	3.14	0.0500
29/11/01	7.00	7.00	10.20	0.00	5.53	0.0880
30/11/01	0.00	0.00	7.00	10.20	4.08	0.0650

YEARLY ABSTRACT- INFLOW OF MARIPUZHA

YEAR	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	TOTAL FOR YEAR
1997	0.32	14.47	47.90	36.98	15.34	14.42	5.19	134.62
1998	1.05	19.72	28.83	23.09	10.61	14.13	2.29	99.71
1999	1.81	16.56	23.14	22.59	5.87	21.03	1.55	92.55
2000	0.38	15.77	14.43	27.57	7.87	13.65	1.59	81.26
2001	0.74	17.46	16.85	18.82	10.51	9.74	3.88	78.01
2002	1.48	15.98	17.40	20.94	5.92	14.99	2.06	78.52
2003	0.52	16.58	11.84	15.87	5.57	11.14	1.38	62.90
2004	1.78	21.05	16.02	22.27	9.29	11.01	3.18	84.59
2005	0.68	17.55	41.81	24.66	12.98	13.35	2.51	113.52
2006	2.06	20.26	23.56	18.97	11.77	11.28	2.73	90.63
2007	0.59	20.02	38.47	30.32	12.98	10.15	1.41	113.91
2008	0.78	18.89	16.63	19.84	8.68	12.79	1.53	79.30
2009	0.53	11.73	31.93	13.24	11.14	12.52	2.51	83.03
2010	0.93	18.11	18.80	17.54	10.07	12.36	4.20	82.00
2011	0.54	22.70	17.32	25.01	10.94	8.66	2.34	87.13
TOTAL FOR MONTH	14.18	266.85	364.91	337.71	149.54	191.22	38.33	1361.68
MONTHLY AVERAGE	0.945	17.790	24.327	22.514	9.969	12.748	2.555	90.78

5.2 Catchment area

The total catchment area of the scheme at the weir site is 15.92 sq . km

5.3 Climate

The area experiences heavy south-west monsoon. Relative humidity is so high and is nearly 90-95% during rainy season. Thunder storms are common. Lightening arresters are required at Power house, and switch yard. The river is ill famous for flash floods and death tolls. Average annual rainfall is 6696.65mm. The highest rainfall occurred is 9261.60mm during 97-98. Due to heavy rainfall experience in July, the construction activities are rather difficult.

5.4 Design flood

There is no reliable meteorological record or any historical flood marks in the area. Therefore flood estimation has been done by the Ryve's formula and is estimated as 221.45 m^3/s in trench weir site .

6. POWER POTENTIAL STUDIES

6.1 General

Maripuzha small H.E scheme envisages power development by using the inflow of Iruvanjipuzha in Chaliyar basin. The total catchment area of the scheme is 15.92 km^2. The scheme is planned as a run - of- the river scheme with a net head of 118m. The installed capacity of the scheme is 6 MW (2 x 3 MW horizontal Francis turbines) and the expected average annual generation is 15.31 Mu and the annual generation for 90% dependable year comes to 14.84 Mu.

6.2 Hydrological studies

The project site is located in the upper reaches of Iruvanjipuzha in Chaliyar basin. The catchment area is more or less steep terrain. Flash floods are common.

K.S.E Board is maintaining a rain gauge station at Kandappanchal at an elevation +260 near the proposed power house of Anakkampoyil S.H.E Scheme. This rainguage station falls outside the catchment (about 4km downstream of weir site). The catchment area of Maripuzha scheme lies between elevations +588 and +2339 and hence K.S.E Board established another rain guage at Thenpara in May 2011 at an elevation +700, which is very close to forest area.. The monthly rain fall readings at Thenpara is about 21% more than that of Kandappanchal. For power potential studies, rainfall of Kandappanchal is considered for arriving discharge of Maripuzha..

6.2.1 Water supply & Irrigation demand

At present, there is no irrigation or water supply intakes located within the scheme area of the river course. One local water supply intake is located about 250m u/s of weir site and the discharge diameter of this pipe is only 50mm. Since

the discharge is quite negligible hence it is not considered in the power potential analysis.

6.3 Design Head

6.3.1 Gross Head

Maximum head = F.S.L – T.W.L(60%)

= 585.384 – 460.09

= 125.29 m

Minimum head = M.D.D.L – T.W.L (max)

= 582.384 – 461.12

= 121.26m

Average gross head = 123.275 m

6.3.2 Net Head

Net head = Average Gross head – Losses

= 123.275 – 5.48

= 117.79 m

say 118 m

6.3.3 Check for head variation

Head variation permissible = 125% to 65%

125% = 147.50 m

65% = 76.70 m

All working heads lies between the permissible head variation. Hence design head of 118m is safe.

6.4 Working Table

The lowest efficiency of Francis turbine corresponding to minimum load

60% load = 86.20%

From efficiency size step up curve, the step up value corresponding to 0.65m runner diameter is 1.60%

Corrected efficiency η_t = 86.20 + 1.60 = 87.80%

Efficiency of Generator η_g = 95%

Power output P = 9.8 Q H η_t η_g

= 9.80 x 0.878 x 0.95 Q H

= 8.174 Q H

Say take P = 8.15 Q . H for power potential study

And P = 8 .15 Q H for component sizing

Where

P = power

Q = discharge

H = net head = 118m

As per Table-1 of IS 12800-Part 3, the permitted load variation of horizontal Francis turbine is 60% to 115%. Even though the hydraulic design of component structures are designed to cater the demand of 10% overloading, the energy available through overloading is not considered in the power potential calculation.

The power potential study of the scheme is done based on the daily discharge data obtained from the rainfall – runoff model generated for Maripuzha. Load variation is limited between 60% and 100%. The daily working table for a period of 1997 to 2011 is worked out based on the utilization of water for various installed capacities. Monthly abstract and yearly abstract of the daily working table is shown in table 6-1. Daily working table for 90% dependable year for 6MW installed capacity is shown in Table 6- 2 .Average Annual Energy for a period of 1997 to 2011 comes to 15.31 MU. Optimization chart for various

installed capacities ranging from 2 MW to 14 MW is done and is shown in table 6-3 .and annual energy generation for 90% dependable year 2001 comes to14.84 MU.

TABLE 6-1

MONTHLY ABSTRACT 1997

Month	inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-97	0.316	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.000	0.000	0.000	0.000	0.000	0.000
Jun-97	14.471	5.122	6.026	6.837	7.523	8.170	8.726	9.179	8.893	8.841	9.414	9.579	9.723	10.442
Jul-97	47.903	5.570	6.963	8.355	9.748	11.140	12.533	13.925	15.318	16.710	19.495	20.888	22.281	25.027
Aug-97	36.976	5.470	6.708	7.898	9.040	10.161	11.239	12.052	13.064	13.972	15.498	16.110	16.919	18.409
Sep-97	15.343	5.228	6.324	7.313	8.130	8.893	9.657	10.421	10.780	11.344	12.510	12.617	12.803	13.208
Oct-97	14.416	5.545	6.766	7.832	8.759	9.535	10.232	10.870	11.340	11.735	12.030	12.143	11.758	11.920
Nov-97	5.195	3.895	4.144	4.215	4.155	4.245	4.108	4.074	3.716	3.446	3.176	2.797	2.586	1.908
Total	**134.619**	**30.974**	**37.075**	**42.594**	**47.498**	**52.288**	**56.639**	**60.665**	**63.112**	**66.049**	**72.123**	**74.133**	**76.068**	**80.913**

MONTHLY ABSTRACT 1998

Month	inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-98	1.048	0.724	0.732	0.662	0.489	0.489	0.489	0.362	0.362	0.362	0.000	0.000	0.000	0.000
Jun-98	19.715	5.266	6.321	7.245	8.142	8.972	9.776	10.505	10.941	11.511	12.183	12.672	12.701	13.014
Jul-98	28.828	5.570	6.963	8.355	9.703	10.955	12.168	13.337	14.412	15.420	17.356	18.254	19.152	20.846
Aug-98	23.094	5.570	6.926	8.202	9.422	10.634	11.811	12.951	14.001	14.920	16.075	16.693	17.219	17.741
Sep-98	10.609	5.301	6.275	7.187	7.959	8.639	9.104	9.508	9.672	9.700	8.896	8.785	8.830	8.682
Oct-98	14.134	5.508	6.611	7.656	8.623	9.475	10.221	10.883	11.429	11.844	11.539	11.646	11.901	12.149
Nov-99	2.287	1.594	1.477	1.295	1.211	1.211	0.874	0.752	0.608	0.459	0.459	0.263	0.263	0.263
Total	**99.714**	**29.533**	**35.305**	**40.601**	**45.549**	**50.376**	**54.442**	**58.298**	**61.425**	**64.216**	**66.508**	**68.312**	**70.067**	**72.694**

MONTHLY ABSTRACT 1999

Month	inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-99	1.806	1.579	1.416	1.195	1.019	0.916	0.684	0.684	0.684	0.379	0.192	0.000	0.000	0.000
Jun-99	16.557	6.734	7.438	8.070	8.671	9.277	9.644	10.161	10.082	9.802	10.085	10.194	10.688	11.377
Jul-99	23.145	5.090	6.289	7.526	8.739	9.901	10.937	11.916	12.860	13.720	15.199	15.873	16.502	17.679
Aug-99	22.586	5.515	6.741	7.816	8.745	9.599	10.435	11.157	11.707	12.368	13.297	13.381	13.582	13.919
Sep-99	5.871	4.789	5.122	5.352	5.517	5.600	5.645	5.690	4.215	3.641	2.695	2.501	2.097	1.866
Oct-99	21.032	5.569	6.916	8.219	9.487	10.745	11.841	12.796	13.660	14.474	15.826	16.507	17.096	17.773
Nov-99	1.552	0.668	0.568	0.489	0.405	0.310	0.191	0.191	0.191	0.191	0.191	0.000	0.000	0.000
Total	**92.550**	**29.944**	**34.489**	**38.668**	**42.584**	**46.346**	**49.377**	**52.595**	**53.397**	**54.575**	**57.485**	**58.456**	**59.965**	**62.614**

MONTHLY ABSTRACT 2000

Month	inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-00	0.383	0.059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jun-00	15.768	5.306	6.459	7.527	8.502	9.264	9.911	10.478	10.707	11.201	11.892	11.853	12.167	12.540
Jul-00	14.427	4.565	5.492	6.492	7.480	8.391	9.225	9.917	10.347	10.830	11.507	11.835	12.073	12.218
Aug-00	27.571	5.547	6.894	8.159	9.324	10.406	11.482	12.473	13.406	14.051	15.488	16.187	16.849	17.561
Sep-00	7.869	5.174	6.137	6.808	7.246	7.618	7.790	7.838	7.329	7.174	6.828	6.628	6.205	5.092
Oct-00	13.651	5.526	6.664	7.593	8.419	9.170	9.769	10.265	10.759	11.219	11.133	11.435	11.455	11.037
Nov-00	1.588	0.531	0.517	0.487	0.487	0.487	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270
Total	**81.257**	**26.707**	**32.163**	**37.065**	**41.459**	**45.335**	**48.446**	**51.241**	**52.819**	**54.745**	**57.118**	**58.209**	**59.019**	**58.718**

MONTHLY ABSTRACT 2001

Month	inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-01	0.740	0.436	0.371	0.299	0.209	0.113	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.219
Jun-01	17.460	5.320	6.497	7.661	8.775	9.825	10.810	11.662	12.408	12.545	13.455	13.952	14.278	14.817
Jul-01	16.850	5.088	5.988	6.882	7.548	8.064	8.628	9.126	9.611	9.932	10.609	11.089	11.493	12.205
Aug-01	18.824	5.569	6.881	8.067	9.187	10.235	11.234	12.071	12.850	13.589	14.587	14.934	15.444	15.812
Sep-01	10.512	5.051	5.773	6.402	6.988	7.477	7.881	8.285	7.980	7.837	7.553	7.581	7.761	7.569
Oct-01	9.743	5.551	6.688	7.481	8.123	8.603	8.905	9.123	9.302	9.461	8.874	8.724	8.141	7.069
Nov-01	3.881	2.431	2.502	2.673	2.452	2.488	2.475	2.396	2.303	2.189	2.089	2.089	1.880	1.650
Total	**78.011**	**29.446**	**34.699**	**39.465**	**43.282**	**46.805**	**49.934**	**52.663**	**54.454**	**55.553**	**57.168**	**58.368**	**58.996**	**59.341**

MONTHLY ABSTRACT 2002

Month	inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-02	1.476	1.058	1.033	0.955	0.873	0.777	0.668	0.668	0.522	0.216	0.216	0.216	0.000	0.000
Jun-02	15.976	5.274	6.389	7.392	8.261	9.070	9.845	10.563	11.121	11.265	12.174	12.709	13.132	13.237
Jul-02	17.400	5.302	6.485	7.524	8.438	9.139	9.948	10.715	11.411	12.084	13.071	13.128	13.368	13.597
Aug-02	20.940	5.486	6.650	7.699	8.688	9.635	10.533	11.432	12.171	12.873	14.025	14.767	15.428	15.780
Sep-02	5.922	4.902	5.359	5.676	5.832	5.918	5.922	5.922	4.696	4.385	3.165	2.565	2.360	2.132
Oct-02	14.994	5.517	6.653	7.552	8.302	9.020	9.739	10.453	11.082	11.649	11.722	12.072	11.962	11.526
Nov-02	1.807	0.930	0.744	0.671	0.588	0.588	0.469	0.469	0.469	0.000	0.000	0.000	0.000	0.000
Total	**78.515**	**28.468**	**33.314**	**37.471**	**40.982**	**44.148**	**47.125**	**50.223**	**51.472**	**52.472**	**54.372**	**55.457**	**56.250**	**56.272**

MONTHLY ABSTRACT 2003

Month	inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-03	0.522	0.150	0.150	0.082	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jun-03	16.581	5.043	5.887	6.644	7.301	7.930	8.543	9.127	8.427	9.011	9.758	10.256	10.534	11.038
Jul-03	11.837	5.215	6.251	7.172	7.896	8.547	9.159	9.685	9.969	10.016	10.524	10.281	10.184	9.892
Aug-03	15.871	5.433	6.616	7.682	8.622	9.367	9.996	10.579	10.653	10.905	11.676	11.796	12.110	12.237
Sep-03	5.573	4.705	5.041	5.261	5.390	5.480	5.530	5.573	3.777	3.005	2.665	2.085	1.880	1.643
Oct-03	11.136	5.533	6.648	7.577	8.272	8.853	9.314	9.764	10.187	10.506	10.116	9.832	9.876	9.178
Nov-03	1.381	0.402	0.345	0.197	0.108	0.108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	**62.902**	**26.480**	**30.939**	**34.615**	**37.588**	**40.285**	**42.544**	**44.728**	**43.013**	**43.442**	**44.739**	**44.250**	**44.584**	**43.988**

MONTHLY ABSTRACT 2004

Month	Inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-04	1.778	1.396	1.257	1.042	1.042	0.734	0.516	0.389	0.389	0.389	0.389	0.000	0.000	0.000
Jun-04	21.049	5.099	6.201	7.200	8.183	9.030	9.805	10.569	11.184	11.465	12.787	13.416	13.835	14.561
Jul-04	16.019	5.524	6.872	8.160	9.328	10.386	11.310	11.933	12.592	13.181	14.020	14.413	14.704	14.903
Aug-04	22.271	5.340	6.328	7.317	8.223	8.942	9.651	9.891	10.309	10.803	10.879	11.292	11.696	12.505
Sep-04	9.293	5.308	6.546	7.563	8.299	8.837	9.034	9.127	8.940	9.006	9.016	9.016	8.811	7.884
Oct-04	11.006	5.457	6.355	7.155	7.828	8.320	8.724	9.091	9.329	9.533	8.361	8.110	7.823	8.041
Nov-04	3.175	1.458	1.578	1.597	1.508	1.561	1.273	1.318	1.363	1.251	1.162	1.207	1.042	1.131
Total	**84.591**	**29.583**	**35.138**	**40.033**	**44.412**	**47.810**	**50.313**	**52.318**	**54.107**	**55.629**	**56.614**	**57.454**	**57.910**	**59.025**

MONTHLY ABSTRACT 2005

Month	Inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-05	0.683	0.438	0.441	0.360	0.277	0.182	0.182	0.182	0.182	0.182	0.000	0.000	0.000	0.000
Jun-05	17.550	5.195	6.194	7.107	7.971	8.780	9.533	10.252	10.511	10.724	11.734	12.242	12.247	12.817
Jul-05	41.806	5.570	6.963	8.355	9.748	11.140	12.533	13.925	15.318	16.710	19.495	20.882	22.229	24.824
Aug-05	24.659	5.399	6.574	7.742	8.869	9.896	10.872	11.405	12.303	12.928	14.070	14.611	15.133	16.033
Sep-05	12.975	5.083	6.073	7.036	7.938	8.795	9.591	10.302	9.959	10.517	11.139	11.339	11.429	11.608
Oct-05	13.346	5.532	6.700	7.837	8.768	9.392	9.931	10.449	10.898	11.303	11.208	11.513	11.782	12.031
Nov-05	2.505	1.638	1.583	1.628	1.673	1.705	1.251	1.120	1.120	0.964	0.964	0.568	0.568	0.346
Total	**113.525**	**28.855**	**34.527**	**40.065**	**45.244**	**49.890**	**53.892**	**57.634**	**60.291**	**63.328**	**68.611**	**71.154**	**73.388**	**77.659**

MONTHLY ABSTRACT 2006

Month	Inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-06	2.059	1.085	1.205	1.313	1.376	1.466	1.511	1.530	1.382	1.382	1.382	1.382	1.382	1.382
Jun-06	20.263	5.176	6.210	7.185	8.057	8.911	9.719	10.473	10.579	10.938	11.870	12.408	12.902	13.473
Jul-06	23.556	5.507	6.836	8.060	9.273	10.473	11.428	12.420	13.312	14.166	15.829	16.543	17.006	17.897
Aug-06	18.970	5.299	6.315	7.218	8.062	8.794	9.468	9.618	10.073	10.497	11.353	11.421	11.855	12.160
Sep-06	11.774	5.254	6.294	7.198	8.013	8.710	9.204	9.651	9.770	9.857	10.094	10.129	10.294	9.874
Oct-06	11.285	5.555	6.728	7.803	8.655	9.282	9.766	10.119	10.369	10.548	10.214	9.714	9.803	9.766
Nov-06	2.726	2.079	1.972	1.808	1.489	1.392	1.392	1.392	1.245	1.096	0.758	0.758	0.758	0.296
Total	**90.634**	**29.956**	**35.559**	**40.584**	**44.925**	**49.028**	**52.488**	**55.203**	**56.731**	**58.484**	**61.500**	**62.355**	**64.001**	**64.847**

MONTHLY ABSTRACT 2007

Month	Inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-07	0.587	0.269	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.000	0.000	0.000	0.000	0.000
Jun-07	20.024	5.316	6.471	7.533	8.477	9.378	10.201	10.998	11.565	12.083	13.018	13.602	13.932	14.516
Jul-07	38.465	5.570	6.963	8.355	9.709	10.947	12.097	13.220	14.343	15.466	17.578	18.566	19.554	21.499
Aug-07	30.317	5.497	6.769	8.006	9.154	10.252	11.296	12.183	13.171	13.945	15.647	16.261	17.070	18.573
Sep-07	12.977	5.386	6.663	7.855	8.990	10.019	10.753	11.266	11.583	11.829	12.102	12.099	12.234	11.965
Oct-07	10.148	5.527	6.528	7.365	8.086	8.686	9.109	9.350	9.575	9.729	8.724	8.219	8.287	7.883
Nov-07	1.389	0.425	0.308	0.308	0.220	0.117	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	**113.907**	**27.991**	**33.857**	**39.578**	**44.791**	**49.555**	**53.611**	**57.173**	**60.392**	**63.052**	**67.070**	**68.747**	**71.077**	**74.436**

MONTHLY ABSTRACT 2008

Month	Inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-08	0.785	0.358	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.000	0.000	0.000	0.000
Jun-08	18.894	5.388	6.584	7.692	8.695	9.569	10.422	11.276	12.064	12.721	13.564	13.757	14.341	15.224
Jul-08	16.628	5.028	6.106	7.179	8.160	8.950	9.714	10.473	10.684	11.286	12.005	12.297	12.521	12.970
Aug-08	19.841	5.495	6.722	7.782	8.735	9.633	10.486	11.206	11.711	12.190	13.191	13.537	13.997	13.840
Sep-08	8.678	5.040	5.969	6.724	7.320	7.816	8.189	8.378	7.592	7.366	7.411	7.411	7.411	6.503
Oct-08	12.953	5.470	6.409	7.237	8.013	8.642	9.208	9.688	10.037	10.311	9.250	9.283	9.281	9.406
Nov-08	1.527	0.518	0.499	0.499	0.499	0.404	0.404	0.404	0.404	0.404	0.225	0.225	0.225	0.000
Total	**79.305**	**27.297**	**32.476**	**37.300**	**41.609**	**45.202**	**48.611**	**51.612**	**52.679**	**54.465**	**55.646**	**56.510**	**57.777**	**57.944**

MONTHLY ABSTRACT 2009

Month	Inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-09	0.527	0.160	0.160	0.085	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jun-09	11.727	5.197	6.066	6.758	7.239	7.643	8.048	8.392	8.276	8.253	7.939	7.531	7.711	7.584
Jul-09	31.925	5.334	6.636	7.895	9.153	10.411	11.631	12.676	13.830	14.953	17.192	18.233	19.266	21.107
Aug-09	13.240	5.546	6.853	7.973	8.958	9.774	10.415	10.916	11.321	11.512	12.063	12.288	12.100	11.752
Sep-09	10.824	5.288	6.325	7.280	8.165	8.898	9.453	9.842	10.201	9.923	9.346	9.391	9.436	9.295
Oct-09	12.521	5.438	6.258	6.829	7.282	7.653	7.954	8.223	8.493	8.762	7.201	7.180	7.145	6.510
Nov-09	2.263	1.348	1.147	1.211	1.255	1.255	1.255	1.001	0.719	0.558	0.558	0.558	0.558	0.558
Total	**83.028**	**28.312**	**33.445**	**38.031**	**42.052**	**45.634**	**48.756**	**51.051**	**52.840**	**53.963**	**54.299**	**55.181**	**56.216**	**56.806**

MONTHLY ABSTRACT 2010

Month	Inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-10	0.928	0.776	0.691	0.622	0.622	0.516	0.516	0.389	0.389	0.389	0.389	0.000	0.000	0.000
Jun-10	18.115	5.308	6.417	7.480	8.459	9.312	10.089	10.810	11.382	11.787	12.657	13.147	13.347	14.084
Jul-10	18.797	5.570	6.963	8.280	9.538	10.780	11.923	12.875	13.757	14.484	15.562	15.894	16.208	16.372
Aug-10	17.539	5.404	6.514	7.532	8.457	9.290	10.099	10.730	11.157	11.498	12.468	13.000	13.279	13.875
Sep-10	10.066	5.369	6.592	7.654	8.357	8.832	9.160	9.456	9.646	9.619	9.611	9.466	9.511	9.069
Oct-10	12.358	5.545	6.592	7.459	8.270	8.973	9.528	10.017	10.432	10.823	10.455	10.578	9.935	9.836
Nov-10	4.197	2.799	3.059	2.964	3.144	3.323	3.447	3.069	2.922	2.457	2.457	2.263	2.052	1.824
Total	**82.000**	**30.770**	**36.827**	**41.992**	**46.848**	**51.026**	**54.762**	**57.346**	**59.686**	**61.056**	**63.599**	**64.349**	**64.331**	**65.059**

MONTHLY ABSTRACT 2011

Month	Inflow at Maripuzha	Utilisation of water for various capacities of machines											
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
May-11	0.540	0.267	0.269	0.269	0.182	0.182	0.182	0.182	0.182	0.182	0.000	0.000	0.000	0.000
Jun-11	22.611	5.390	6.737	7.967	9.087	10.165	11.243	12.275	13.153	13.975	15.402	15.986	16.570	16.972
Jul-11	17.322	5.514	6.715	7.778	8.772	9.698	10.596	11.262	11.972	12.606	13.618	13.535	13.872	13.828
Aug-11	25.012	5.570	6.946	8.294	9.641	10.942	12.063	13.085	14.018	14.862	16.409	17.082	17.548	18.868
Sep-11	10.940	5.041	5.832	6.449	6.960	7.448	7.872	8.247	7.631	7.796	7.818	7.892	7.748	7.698
Oct-11	8.663	5.435	6.334	7.151	7.774	8.170	8.383	8.521	8.611	8.663	6.821	6.821	6.821	6.583
Nov-11	2.039	1.177	1.134	1.031	0.937	0.937	0.937	0.000	0.811	0.660	0.478	0.478	0.269	0.269
Total	**87.127**	**28.394**	**33.967**	**38.939**	**43.353**	**47.542**	**51.275**	**53.572**	**56.378**	**58.745**	**60.545**	**61.795**	**62.828**	**64.217**

TABLE 6-2
YEARLY ABSTRACT

Year	Inflow at Maripuzha	Utilisation of water for various capacities of machines												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
		2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
1997	134.62	30.97	37.07	42.59	47.50	52.29	56.64	60.67	63.11	66.05	72.12	74.13	76.07	80.91
1998	99.71	29.53	35.30	40.60	45.55	50.38	54.44	58.30	61.43	64.22	66.51	68.31	70.07	72.69
1999	92.55	29.94	34.49	38.67	42.58	46.35	49.38	52.60	53.40	54.58	57.49	58.46	59.97	62.61
2000	81.26	26.71	32.16	37.07	41.46	45.33	48.45	51.24	52.82	54.74	57.12	58.21	59.02	58.72
2001	**78.01**	**29.45**	**34.70**	**39.47**	**43.28**	**46.80**	**49.93**	**52.66**	**54.45**	**55.55**	**57.17**	**58.37**	**59.00**	**59.34**
2002	78.52	28.47	33.31	37.47	40.98	44.15	47.12	50.22	51.47	52.47	54.37	55.46	56.25	56.27
2003	62.90	26.48	30.94	34.62	37.59	40.28	42.54	44.73	43.01	43.44	44.74	44.25	44.58	43.99
2004	84.59	29.58	35.14	40.03	44.41	47.81	50.31	52.32	54.11	55.63	56.61	57.45	57.91	59.03
2005	113.52	28.85	34.53	40.06	45.24	49.89	53.89	57.63	60.29	63.33	68.61	71.15	73.39	77.66
2006	90.63	29.96	35.56	40.58	44.93	49.03	52.49	55.20	56.73	58.48	61.50	62.35	64.00	64.85
2007	113.91	27.99	33.86	39.58	44.79	49.56	53.61	57.17	60.39	63.05	67.07	68.75	71.08	74.44
2008	79.30	27.30	32.48	37.30	41.61	45.20	48.61	51.61	52.68	54.47	55.65	56.51	57.78	57.94
2009	83.03	28.31	33.44	38.03	42.05	45.63	48.76	51.05	52.84	53.96	54.30	55.18	56.22	56.81
2010	82.00	30.77	36.83	41.99	46.85	51.03	54.76	57.35	59.69	61.06	63.60	64.35	64.33	65.06
2011	87.13	28.39	33.97	38.94	43.35	47.54	51.27	53.57	56.38	58.74	60.55	61.79	62.83	64.22
Total	**1361.68**	**432.71**	**513.78**	**587.00**	**652.18**	**711.27**	**762.21**	**806.32**	**832.79**	**859.77**	**897.40**	**914.73**	**932.48**	**954.53**
Average water utilised		**28.85**	**34.25**	**39.13**	**43.48**	**47.42**	**50.81**	**53.75**	**55.52**	**57.32**	**59.83**	**60.98**	**62.17**	**63.64**
Energy Mu		**7.71**	**9.15**	**10.45**	**11.61**	**12.67**	**13.57**	**14.36**	**14.83**	**15.31**	**15.98**	**16.29**	**16.61**	**17.00**
% of utilisation		**31.78**	**37.73**	**43.11**	**47.89**	**52.23**	**55.98**	**59.22**	**61.16**	**63.14**	**65.90**	**67.18**	**68.48**	**70.10**
PLF		**43.99**	**41.78**	**39.78**	**37.88**	**36.15**	**34.44**	**32.79**	**30.78**	**29.13**	**24.97**	**24.33**	**23.25**	**21.56**

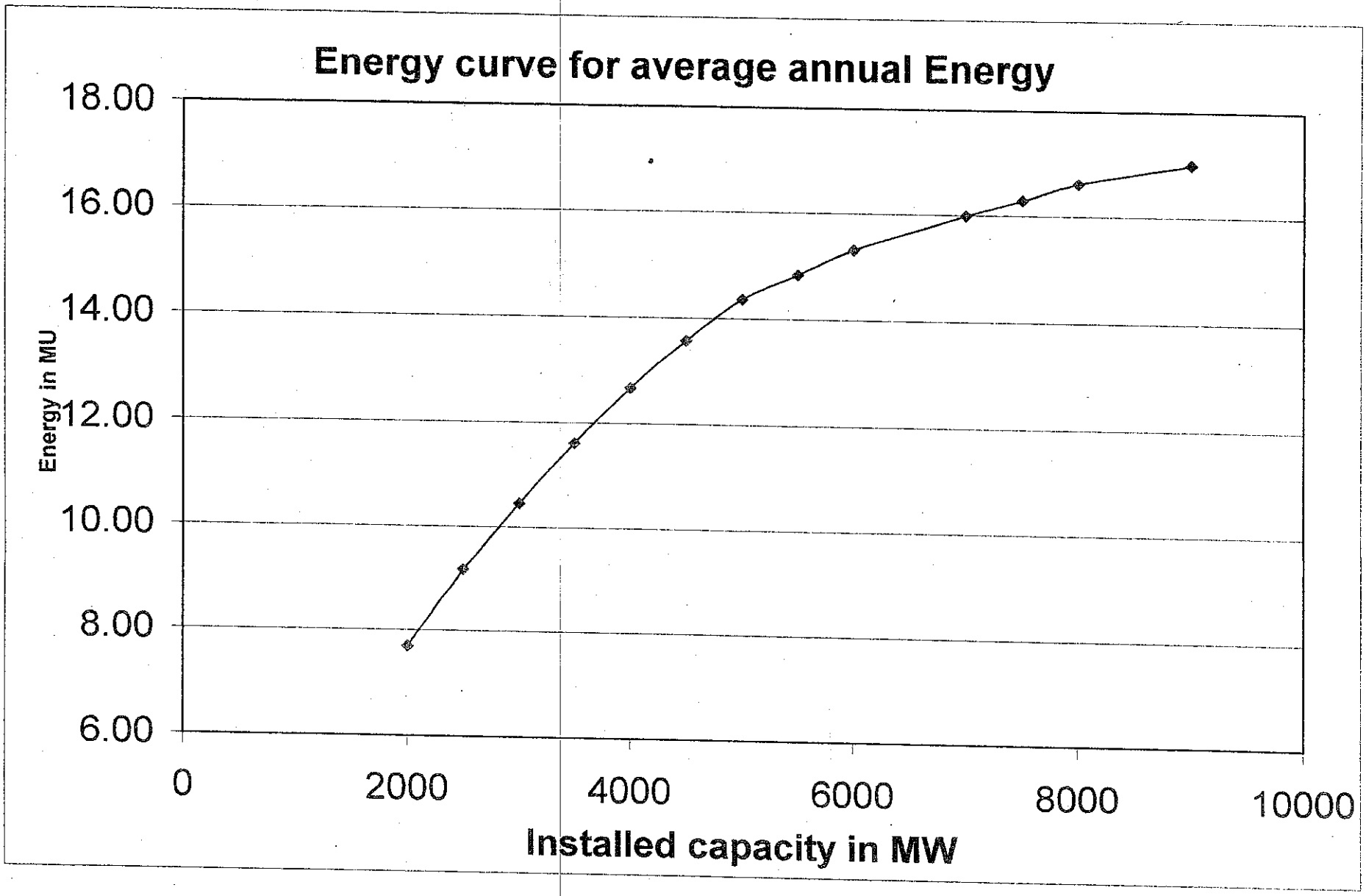

Energy curve for average annual Energy
18.00
16.00
14.00
12.00
10.00
8.00
6.00
Energy in MU
0
2000
4000
6000
8000
10000
Installed capacity in MW

TABLE 6-3

DAILY WORKING TABLE FOR 90 % DEPENDABLE YEAR (2001)

CATCHMENT AREA	15.92 sq.km					HEAD in m	118							
	Qmax	0.1797	0.225	0.270	0.314	0.359	0.404	0.449	0.494	0.539	0.629	0.674	0.719	0.809
	Qmin	0.054	0.067	0.081	0.094	0.108	0.121	0.135	0.148	0.162	0.189	0.202	0.216	0.243
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
DATE	DAILY INFLOW at maripuzha	Utilisation of water for various capacities of machines (Mm^3)												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
	Mm^3	2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
1-May-01	0.0198	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
2-May-01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
3-May-01	0.0109	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
4-May-01	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5-May-01	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
6-May-01	0.0236	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
7-May-01	0.0222	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
8-May-01	0.0458	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9-May-01	0.0034	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
10-May-01	0.0242	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
11-May-01	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
12-May-01	0.0080	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
13-May-01	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
14-May-01	0.0058	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
15-May-01	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
16-May-01	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
17-May-01	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
18-May-01	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19-May-01	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
20-May-01	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
21-May-01	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
22-May-01	0.0411	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
23-May-01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
24-May-01	0.0720	0.0720	0.0720	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
25-May-01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
26-May-01	0.1128	0.1128	0.1128	0.1128	0.1128	0.1128	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
27-May-01	0.0504	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
28-May-01	0.0649	0.0649	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
29-May-01	0.0964	0.0964	0.0964	0.0964	0.0964	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
30-May-01	0.0123	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
31-May-01	0.0897	0.0897	0.0897	0.0897	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000

DATE	DAILY INFLOW at maripuzha	Utilisation of water for various capacities of machines (Mm^3)												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
	Mm^3	2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
1-Jun-01	0.1551	0.1551	0.1551	0.1551	0.1551	0.1551	0.1551	0.1551	0.16	0.0000	0.0000	0.0000	0.0000	0.0000
2-Jun-01	0.1536	0.1536	0.1536	0.1536	0.1536	0.1536	0.1536	0.1536	0.15	0.0000	0.0000	0.0000	0.0000	0.0000
3-Jun-01	0.6624	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6624	0.6624	0.6624
4-Jun-01	0.1880	0.1797	0.1880	0.1880	0.1880	0.1880	0.1880	0.1880	0.19	0.1880	0.0000	0.0000	0.0000	0.0000
5-Jun-01	0.1603	0.1603	0.1603	0.1603	0.1603	0.1603	0.1603	0.1603	0.16	0.0000	0.0000	0.0000	0.0000	0.0000
6-Jun-01	0.7104	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7104	0.7104
7-Jun-01	0.6935	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.6935	0.6935
8-Jun-01	0.6565	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6565	0.6565	0.6565
9-Jun-01	0.3887	0.1797	0.2246	0.2695	0.3144	0.3594	0.3887	0.3887	0.39	0.3887	0.3887	0.3887	0.3887	0.3887
10-Jun-01	0.4552	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.46	0.4552	0.4552	0.4552	0.4552	0.4552
11-Jun-01	0.8585	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
12-Jun-01	0.6736	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6736	0.6736	0.6736
13-Jun-01	0.9504	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
14-Jun-01	1.1358	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
15-Jun-01	1.1979	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
16-Jun-01	0.3900	0.1797	0.2246	0.2695	0.3144	0.3594	0.3900	0.3900	0.39	0.3900	0.3900	0.3900	0.3900	0.3900
17-Jun-01	0.4892	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.4892	0.4892	0.4892	0.4892	0.4892
18-Jun-01	0.5591	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.5591	0.5591	0.5591	0.5591
19-Jun-01	0.6603	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6603	0.6603	0.6603
20-Jun-01	0.4872	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.4872	0.4872	0.4872	0.4872	0.4872
21-Jun-01	0.3309	0.1797	0.2246	0.2695	0.3144	0.3309	0.3309	0.3309	0.33	0.3309	0.3309	0.3309	0.3309	0.3309
22-Jun-01	0.5162	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5162	0.5162	0.5162	0.5162	0.5162
23-Jun-01	1.6149	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
24-Jun-01	1.0805	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
25-Jun-01	0.3864	0.1797	0.2246	0.2695	0.3144	0.3594	0.3864	0.3864	0.39	0.3864	0.3864	0.3864	0.3864	0.3864
26-Jun-01	0.4290	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4290	0.43	0.4290	0.4290	0.4290	0.4290	0.4290
27-Jun-01	0.2663	0.1797	0.2246	0.2663	0.2663	0.2663	0.2663	0.2663	0.27	0.2663	0.2663	0.2663	0.2663	0.2663
28-Jun-01	0.4825	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.48	0.4825	0.4825	0.4825	0.4825	0.4825
29-Jun-01	0.3053	0.1797	0.2246	0.2695	0.3053	0.3053	0.3053	0.3053	0.31	0.3053	0.3053	0.3053	0.3053	0.3053
30-Jun-01	0.4223	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4223	0.42	0.4223	0.4223	0.4223	0.4223	0.4223

DATE	DAILY INFLOW at maripuzha	Utilisation of water for various capacities of machines (Mm^3)												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
	Mm^3	2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
1-Jul-01	0.2669	0.1797	0.2246	0.2669	0.2669	0.2669	0.2669	0.2669	0.27	0.2669	0.2669	0.2669	0.2669	0.2669
2-Jul-01	0.2686	0.1797	0.2246	0.2686	0.2686	0.2686	0.2686	0.2686	0.27	0.2686	0.2686	0.2686	0.2686	0.2686
3-Jul-01	0.5629	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.5629	0.5629	0.5629	0.5629
4-Jul-01	0.7451	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.7451
5-Jul-01	0.7827	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.7827
6-Jul-01	0.8014	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8014
7-Jul-01	1.2029	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
8-Jul-01	1.6754	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
9-Jul-01	1.5267	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
10-Jul-01	1.3553	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
11-Jul-01	1.1566	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
12-Jul-01	1.0837	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
13-Jul-01	0.6352	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6352	0.6352	0.6352
14-Jul-01	0.3615	0.1797	0.2246	0.2695	0.3144	0.3594	0.3615	0.3615	0.36	0.3615	0.3615	0.3615	0.3615	0.3615
15-Jul-01	0.1633	0.1633	0.1633	0.1633	0.1633	0.1633	0.1633	0.1633	0.16	0.1633	0.0000	0.0000	0.0000	0.0000
16-Jul-01	0.1706	0.1706	0.1706	0.1706	0.1706	0.1706	0.1706	0.1706	0.17	0.1706	0.0000	0.0000	0.0000	0.0000
17-Jul-01	0.0859	0.0859	0.0859	0.0859	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
18-Jul-01	0.1032	0.1032	0.1032	0.1032	0.1032	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19-Jul-01	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
20-Jul-01	0.1488	0.1488	0.1488	0.1488	0.1488	0.1488	0.1488	0.1488	0.15	0.0000	0.0000	0.0000	0.0000	0.0000
21-Jul-01	0.1808	0.1797	0.1808	0.1808	0.1808	0.1808	0.1808	0.1808	0.18	0.1808	0.0000	0.0000	0.0000	0.0000
22-Jul-01	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.16	0.0000	0.0000	0.0000	0.0000	0.0000
23-Jul-01	0.0995	0.0995	0.0995	0.0995	0.0995	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
24-Jul-01	0.1309	0.1309	0.1309	0.1309	0.1309	0.1309	0.1309	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
25-Jul-01	0.1441	0.1441	0.1441	0.1441	0.1441	0.1441	0.1441	0.1441	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
26-Jul-01	0.2946	0.1797	0.2246	0.2695	0.2946	0.2946	0.2946	0.2946	0.29	0.2946	0.2946	0.2946	0.2946	0.2946
27-Jul-01	0.2767	0.1797	0.2246	0.2695	0.2767	0.2767	0.2767	0.2767	0.28	0.2767	0.2767	0.2767	0.2767	0.2767
28-Jul-01	0.4025	0.1797	0.2246	0.2695	0.3144	0.3594	0.4025	0.4025	0.40	0.4025	0.4025	0.4025	0.4025	0.4025
29-Jul-01	0.6717	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6717	0.6717	0.6717
30-Jul-01	0.6426	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6426	0.6426	0.6426
31-Jul-01	0.6415	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6415	0.6415	0.6415

DATE	DAILY INFLOW at maripuzha	Utilisation of water for various capacities of machines (Mm^3)												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
	Mm^3	2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
1-Aug-01	0.1930	0.1797	0.1930	0.1930	0.1930	0.1930	0.1930	0.1930	0.19	0.1930	0.1930	0.0000	0.0000	0.0000
2-Aug-01	1.4341	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
3-Aug-01	1.2256	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
4-Aug-01	0.7321	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.7321
5-Aug-01	1.2322	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
6-Aug-01	0.3967	0.1797	0.2246	0.2695	0.3144	0.3594	0.3967	0.3967	0.40	0.3967	0.3967	0.3967	0.3967	0.3967
7-Aug-01	0.5367	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5367	0.5367	0.5367	0.5367	0.5367
8-Aug-01	0.3112	0.1797	0.2246	0.2695	0.3112	0.3112	0.3112	0.3112	0.31	0.3112	0.3112	0.3112	0.3112	0.3112
9-Aug-01	0.4139	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4139	0.41	0.4139	0.4139	0.4139	0.4139	0.4139
10-Aug-01	0.1787	0.1787	0.1787	0.1787	0.1787	0.1787	0.1787	0.1787	0.18	0.1787	0.0000	0.0000	0.0000	0.0000
11-Aug-01	0.3292	0.1797	0.2246	0.2695	0.3144	0.3292	0.3292	0.3292	0.33	0.3292	0.3292	0.3292	0.3292	0.3292
12-Aug-01	0.4644	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.46	0.4644	0.4644	0.4644	0.4644	0.4644
13-Aug-01	0.3877	0.1797	0.2246	0.2695	0.3144	0.3594	0.3877	0.3877	0.39	0.3877	0.3877	0.3877	0.3877	0.3877
14-Aug-01	0.7662	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.7662
15-Aug-01	0.4231	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4231	0.42	0.4231	0.4231	0.4231	0.4231	0.4231
16-Aug-01	0.6899	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.6899	0.6899
17-Aug-01	1.2237	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
18-Aug-01	0.8055	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8055
19-Aug-01	0.9946	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
20-Aug-01	0.7631	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.7631
21-Aug-01	0.5292	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5292	0.5292	0.5292	0.5292	0.5292
22-Aug-01	0.5815	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.5815	0.5815	0.5815	0.5815
23-Aug-01	0.8344	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
24-Aug-01	0.5958	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.5958	0.5958	0.5958	0.5958
25-Aug-01	0.9032	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
26-Aug-01	0.3941	0.1797	0.2246	0.2695	0.3144	0.3594	0.3941	0.3941	0.39	0.3941	0.3941	0.3941	0.3941	0.3941
27-Aug-01	0.5271	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5271	0.5271	0.5271	0.5271	0.5271
28-Aug-01	**0.2322**	0.1797	0.2246	0.2322	0.2322	0.2322	0.2322	0.2322	0.23	0.2322	0.2322	0.2322	0.2322	0.0000
29-Aug-01	0.2503	0.1797	0.2246	0.2503	0.2503	0.2503	0.2503	0.2503	0.25	0.2503	0.2503	0.2503	0.2503	0.2503
30-Aug-01	0.2548	0.1797	0.2246	0.2548	0.2548	0.2548	0.2548	0.2548	0.25	0.2548	0.2548	0.2548	0.2548	0.2548
31-Aug-01	0.2200	0.1797	0.2200	0.2200	0.2200	0.2200	0.2200	0.2200	0.22	0.2200	0.2200	0.2200	0.2200	0.0000

DATE	DAILY INFLOW at maripuzha	Utilisation of water for various capacities of machines (Mm^3)												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
	Mm^3	2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
1-Sep-01	0.1781	0.1781	0.1781	0.1781	0.1781	0.1781	0.1781	0.1781	0.18	0.1781	0.0000	0.0000	0.0000	0.0000
2-Sep-01	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.17	0.1661	0.0000	0.0000	0.0000	0.0000
3-Sep-01	0.1407	0.1407	0.1407	0.1407	0.1407	0.1407	0.1407	0.1407	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
4-Sep-01	0.1539	0.1539	0.1539	0.1539	0.1539	0.1539	0.1539	0.1539	0.15	0.0000	0.0000	0.0000	0.0000	0.0000
5-Sep-01	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
6-Sep-01	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
7-Sep-01	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
8-Sep-01	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.1348	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9-Sep-01	0.1889	0.1797	0.1889	0.1889	0.1889	0.1889	0.1889	0.1889	0.19	0.1889	0.1889	0.0000	0.0000	0.0000
10-Sep-01	0.1724	0.1724	0.1724	0.1724	0.1724	0.1724	0.1724	0.1724	0.17	0.1724	0.0000	0.0000	0.0000	0.0000
11-Sep-01	0.2719	0.1797	0.2246	0.2695	0.2719	0.2719	0.2719	0.2719	0.27	0.2719	0.2719	0.2719	0.2719	0.2719
12-Sep-01	0.1539	0.1539	0.1539	0.1539	0.1539	0.1539	0.1539	0.1539	0.15	0.0000	0.0000	0.0000	0.0000	0.0000
13-Sep-01	0.1750	0.1750	0.1750	0.1750	0.1750	0.1750	0.1750	0.1750	0.17	0.1750	0.0000	0.0000	0.0000	0.0000
14-Sep-01	0.1539	0.1539	0.1539	0.1539	0.1539	0.1539	0.1539	0.1539	0.15	0.0000	0.0000	0.0000	0.0000	0.0000
15-Sep-01	0.2193	0.1797	0.2193	0.2193	0.2193	0.2193	0.2193	0.2193	0.22	0.2193	0.2193	0.2193	0.2193	0.0000
16-Sep-01	0.3557	0.1797	0.2246	0.2695	0.3144	0.3557	0.3557	0.3557	0.36	0.3557	0.3557	0.3557	0.3557	0.3557
17-Sep-01	0.6659	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6659	0.6659	0.6659
18-Sep-01	0.8260	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
19-Sep-01	0.7735	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.7735
20-Sep-01	0.6189	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6189	0.6189	0.6189	0.6189
21-Sep-01	0.5807	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.5807	0.5807	0.5807	0.5807
22-Sep-01	0.7360	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.7360
23-Sep-01	1.1060	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.8086
24-Sep-01	0.4982	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.4982	0.4982	0.4982	0.4982	0.4982
25-Sep-01	0.3352	0.1797	0.2246	0.2695	0.3144	0.3352	0.3352	0.3352	0.34	0.3352	0.3352	0.3352	0.3352	0.3352
26-Sep-01	0.3203	0.1797	0.2246	0.2695	0.3144	0.3203	0.3203	0.3203	0.32	0.3203	0.3203	0.3203	0.3203	0.3203
27-Sep-01	0.2241	0.1797	0.2241	0.2241	0.2241	0.2241	0.2241	0.2241	0.22	0.2241	0,2241	0.2241	0.2241	0.0000
28-Sep-01	0.4647	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.46	0.4647	0.4647	0.4647	0.4647	0.4647
29-Sep-01	0.1630	0.1630	0.1630	0.1630	0.1630	0.1630	0.1630	0.1630	0.16	0.1630	0.0000	0.0000	0.0000	0.0000
30-Sep-01	0.3309	0.1797	0.2246	0.2695	0.3144	0.3309	0.3309	0.3309	0.33	0.3309	0.3309	0.3309	0.3309	0.3309

DATE	DAILY INFLOW at maripuzha	Utilisation of water for various capacities of machines (Mm^3)												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
	Mm^3	2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
1-Oct-01	0.7924	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6289	0.6738	0.7187	0.7924
2-Oct-01	0.5665	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.5665	0.5665	0.5665	0.5665
3-Oct-01	0.3767	0.1797	0.2246	0.2695	0.3144	0.3594	0.3767	0.3767	0.38	0.3767	0.3767	0.3767	0.3767	0.3767
4-Oct-01	0.2211	0.1797	0.2211	0.2211	0.2211	0.2211	0.2211	0.2211	0.22	0.2211	0.2211	0.2211	0.2211	0.0000
5-Oct-01	0.1672	0.1672	0.1672	0.1672	0.1672	0.1672	0.1672	0.1672	0.17	0.1672	0.0000	0.0000	0.0000	0.0000
6-Oct-01	0.3702	0.1797	0.2246	0.2695	0.3144	0.3594	0.3702	0.3702	0.37	0.3702	0.3702	0.3702	0.3702	0.3702
7-Oct-01	0.2347	0.1797	0.2246	0.2347	0.2347	0.2347	0.2347	0.2347	0.23	0.2347	0.2347	0.2347	0.2347	0.0000
8-Oct-01	0.3570	0.1797	0.2246	0.2695	0.3144	0.3570	0.3570	0.3570	0.36	0.3570	0.3570	0.3570	0.3570	0.3570
9-Oct-01	0.3360	0.1797	0.2246	0.2695	0.3144	0.3360	0.3360	0.3360	0.34	0.3360	0.3360	0.3360	0.3360	0.3360
10-Oct-01	0.2266	0.1797	0.2246	0.2266	0.2266	0.2266	0.2266	0.2266	0.23	0.2266	0.2266	0.2266	0.2266	0.0000
11-Oct-01	0.3715	0.1797	0.2246	0.2695	0.3144	0.3594	0.3715	0.3715	0.37	0.3715	0.3715	0.3715	0.3715	0.3715
12-Oct-01	0.2093	0.1797	0.2093	0.2093	0.2093	0.2093	0.2093	0.2093	0.21	0.2093	0.2093	0.2093	0.0000	0.0000
13-Oct-01	0.2414	0.1797	0.2246	0.2414	0.2414	0.2414	0.2414	0.2414	0.24	0.2414	0.2414	0.2414	0.2414	0.0000
14-Oct-01	0.2439	0.1797	0.2246	0.2439	0.2439	0.2439	0.2439	0.2439	0.24	0.2439	0.2439	0.2439	0.2439	0.2439
15-Oct-01	0.5406	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.5406	0.5406	0.5406	0.5406
16-Oct-01	0.4417	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4417	0.44	0.4417	0.4417	0.4417	0.4417	0.4417
17-Oct-01	0.3157	0.1797	0.2246	0.2695	0.3144	0.3157	0.3157	0.3157	0.32	0.3157	0.3157	0.3157	0.3157	0.3157
18-Oct-01	0.2825	0.1797	0.2246	0.2695	0.2825	0.2825	0.2825	0.2825	0.28	0.2825	0.2825	0.2825	0.2825	0.2825
19-Oct-01	0.1744	0.1744	0.1744	0.1744	0.1744	0.1744	0.1744	0.1744	0.17	0.1744	0.0000	0.0000	0.0000	0.0000
20-Oct-01	0.5181	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5181	0.5181	0.5181	0.5181	0.5181
21-Oct-01	0.2504	0.1797	0.2246	0.2504	0.2504	0.2504	0.2504	0.2504	0.25	0.2504	0.2504	0.2504	0.2504	0.2504
22-Oct-01	0.3966	0.1797	0.2246	0.2695	0.3144	0.3594	0.3966	0.3966	0.40	0.3966	0.3966	0.3966	0.3966	0.3966
23-Oct-01	0.1951	0.1797	0.1951	0.1951	0.1951	0.1951	0.1951	0.1951	0.20	0.1951	0.1951	0.0000	0.0000	0.0000
24-Oct-01	0.2048	0.1797	0.2048	0.2048	0.2048	0.2048	0.2048	0.2048	0.20	0.2048	0.2048	0.2048	0.0000	0.0000
25-Oct-01	0.1860	0.1797	0.1860	0.1860	0.1860	0.1860	0.1860	0.1860	0.19	0.1860	0.0000	0.0000	0.0000	0.0000
26-Oct-01	0.3203	0.1797	0.2246	0.2695	0.3144	0.3203	0.3203	0.3203	0.32	0.3203	0.3203	0.3203	0.3203	0.3203
27-Oct-01	0.3197	0.1797	0.2246	0.2695	0.3144	0.3197	0.3197	0.3197	0.32	0.3197	0.3197	0.3197	0.3197	0.3197
28-Oct-01	0.2695	0.1797	0.2246	0.2695	0.2695	0.2695	0.2695	0.2695	0.27	0.2695	0.2695	0.2695	0.2695	0.2695
29-Oct-01	0.2136	0.1797	0.2136	0.2136	0.2136	0.2136	0.2136	0.2136	0.21	0.2136	0.2136	0.2136	0.0000	0.0000
30-Oct-01	0.1785	0.1785	0.1785	0.1785	0.1785	0.1785	0.1785	0.1785	0.18	0.1785	0.0000	0.0000	0.0000	0.0000
31-Oct-01	0.2217	0.1797	0.2217	0.2217	0.2217	0.2217	0.2217	0.2217	0.22	0.2217	0.2217	0.2217	0.2217	0.0000

DATE	DAILY INFLOW at maripuzha	Utilisation of water for various capacities of machines (Mm^3)												
		2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	7500	8000	9000
	Mm^3	2x1000	2x1250	2x1500	2x1750	2x2000	2x2250	2x2500	2x2750	2x3000	2x3500	2x3750	2x4000	2x4500
1-Nov-01	0.1284	0.1284	0.1284	0.1284	0.1284	0.1284	0.1284	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
2-Nov-01	0.2547	0.1797	0.2246	0.2547	0.2547	0.2547	0.2547	0.2547	0.25	0.2547	0.2547	0.2547	0.2547	0.2547
3-Nov-01	0.0483	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
4-Nov-01	0.0899	0.0899	0.0899	0.0899	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5-Nov-01	0.0357	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
6-Nov-01	0.0369	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
7-Nov-01	0.1819	0.1797	0.1819	0.1819	0.1819	0.1819	0.1819	0.1819	0.18	0.1819	0.0000	0.0000	0.0000	0.0000
8-Nov-01	0.6208	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4492	0.49	0.5390	0.6208	0.6208	0.6208	0.6208
9-Nov-01	0.4086	0.1797	0.2246	0.2695	0.3144	0.3594	0.4043	0.4086	0.41	0.4086	0.4086	0.4086	0.4086	0.4086
10-Nov-01	0.0616	0.0616	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
11-Nov-01	0.0584	0.0584	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
12-Nov-01	0.1089	0.1089	0.1089	0.1089	0.1089	0.1089	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
13-Nov-01	0.0353	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
14-Nov-01	0.0934	0.0934	0.0934	0.0934	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
15-Nov-01	0.2304	0.1797	0.2246	0.2304	0.2304	0.2304	0.2304	0.2304	0.23	0.2304	0.2304	0.2304	0.2304	0.0000
16-Nov-01	0.1590	0.1590	0.1590	0.1590	0.1590	0.1590	0.1590	0.1590	0.16	0.0000	0.0000	0.0000	0.0000	0.0000
17-Nov-01	0.3654	0.1797	0.2246	0.2695	0.3144	0.3594	0.3654	0.3654	0.37	0.3654	0.3654	0.3654	0.3654	0.3654
18-Nov-01	0.1377	0.1377	0.1377	0.1377	0.1377	0.1377	0.1377	0.1377	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19-Nov-01	0.0376	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
20-Nov-01	0.0469	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
21-Nov-01	0.0367	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
22-Nov-01	0.0369	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
23-Nov-01	0.0840	0.0840	0.0840	0.0840	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
24-Nov-01	0.2093	0.1797	0.2093	0.2093	0.2093	0.2093	0.2093	0.2093	0.21	0.2093	0.2093	0.2093	0.0000	0.0000
25-Nov-01	0.0988	0.0988	0.0988	0.0988	0.0988	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
26-Nov-01	0.0355	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
27-Nov-01	0.0369	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
28-Nov-01	0.0500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
29-Nov-01	0.0881	0.0881	0.0881	0.0881	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
30-Nov-01	0.0649	0.0649	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL	**78.011**	**29.446**	**34.699**	**39.465**	**43.282**	**46.805**	**49.934**	**52.663**	**54.454**	**55.553**	**57.168**	**58.368**	**58.996**	**59.122**
Energy Mu		**7.87**	**9.27**	**10.54**	**11.56**	**12.50**	**13.34**	**14.07**	**14.55**	**14.84**	**15.27**	**15.59**	**15.76**	**15.79**
% of utilisation		**37.75**	**44.48**	**50.59**	**55.48**	**60.00**	**64.01**	**67.51**	**69.80**	**71.21**	**73.28**	**74.82**	**75.62**	**75.79**
PLF		**44.90**	**42.33**	**40.12**	**37.71**	**35.68**	**33.84**	**32.12**	**30.19**	**28.24**	**24.90**	**23.73**	**22.49**	**20.03**

Table 6-4

OPTIMISATION CHART for average energy (214 days)

MACHINE (KW)	No	INSTALLEDC APACITY (KW)	ENERGY (Mu)	INCREMEN TAL INCREASE	E/C	AVERAGE WATER UTILISED	% UTILISATI ON	PLF %
1000	2	2000	7.71		3.9	28.85	31.78%	43.99%
1500	2	3000	10.45	2.74	3.5	39.13	43.10%	39.76%
2000	2	4000	12.67	2.22	3.2	47.41	52.23%	36.16%
2500	2	5000	14.36	1.69	2.9	53.75	59.21%	32.79%
3000	**2**	**6000**	**15.31**	**0.95**	**2.6**	**57.32**	**63.14%**	**29.13%**
3500	2	7000	15.98	0.67	2.3	59.83	65.91%	26.06%
4000	2	8000	16.61	0.63	2.1	62.16	68.47%	23.70%
4500	2	9000	17.00	0.39	1.9	63.64	70.10%	21.56%
5000	2	10000	17.33	0.33	1.7	64.88	71.47%	19.78%
5500	2	11000	17.41	0.08	1.6	65.16	71.78%	18.07%

6.4.1 Determination of installed capacity & Computation of Dependable year as per CEA Guidelines

First step is to determine 90% dependable year

i) 10 daily hydrological inflow data in m^3/s for all the hydrological years is prepared The unrestricted energy generation in Mu is found out in Table 6(4).

ii) The unrestricted energy generation is arranged in descending order -Table 6(5).

iii) 0.9 $(n+1)^{th}$ year is the 90% dependable year where 'n' is the number of years for which the hydrological inflow data is available.

90% dependable year computed as above is 2001 by arranging the unrestricted energy generation from the inflow of Maripuzha .Power potential studies with various installed capacities ranging from 2000 KW to 9000 KW has been done.

The optimization table for 90% dependable year 2001 is shown in table 6(6). Following graphs are also drawn for 90% dependable year,

i) Flow Duration curve with % time and discharge (Graph No. 6.1)

ii) Flow Duration curve with no. of days and discharge (Graph No. 6.2)

iii) Energy Capacity curve (Graph No. 6.3)

iv) Incremental Energy curve (Graph No. 6.4)

v) Installed capacity Vs Cumulative Incremental Energy (Graph No. 6.5)

v) Monthly forecast of generation in 2001. (graph 6.6).

Table 6-5

10 DAILY ABSTRACT OF INFLOW (2001)

Year	Month	Period	Avg. 10 Daily discharge in m^3/s	Unrestricted Power in KW (P)=8.15*Q*H	Unrestricted Energy in MU for 10 daily discharge P*24*no. of days /10^6	Unrestricted Energy in MU yearly Abstract
	May	1 to 10	0.182	174.700	0.0419	
		11 to 20	0.047	44.993	0.0108	
		21 to 31	0.571	549.579	0.1451	
	June	1 to 10	4.889	4701.434	1.1283	
		11 to 20	8.567	8239.112	1.9774	
		21 to 30	6.753	6494.099	1.5586	
	July	1 to 10	10.634	10226.682	2.4544	
		11 to 20	4.651	4473.023	1.0735	
2001		21 to 31	3.834	3686.973	0.9734	
	August	1 to 10	7.702	7406.641	1.7776	
		11 to 20	7.925	7621.680	1.8292	
		21 to 31	5.600	5385.847	1.4219	
	September	1 to 10	1.782	1713.520	0.4112	
		11 to 20	4.877	4690.294	1.1257	
		21 to 30	5.508	5297.271	1.2713	
	October	1 to 10	4.223	4060.785	0.9746	
		11 to 20	3.865	3716.596	0.8920	
		21 to 31	2.900	2788.728	0.7362	
	November	1 to 10	2.161	2077.960	0.4987	
		11 to 20	1.473	1416.978	0.3401	
		21 to 30	0.858	824.828	0.1980	
						20.8399

TABLE 6-6

Dependable year

Year	Unrestricted Energy	Unrestricted Energy in descending order	Corresponding year	
1997	35.9620	35.9620	1997	
1998	26.8277	30.4352	2007	
1999	24.7236	30.3269	2005	
2000	21.7068	26.8277	1998	
2001	20.8399	24.7236	1999	
2002	20.9744	24.2119	2006	
2003	16.8035	23.2749	2011	
2004	22.5975	22.5975	**2004**	**50%** Dep. Year
2005	30.3269	22.0446	2009	
2006	24.2119	21.9053	2010	
2007	30.4352	21.7068	2000	
2008	21.1853	21.1853	**2008**	**75%** Dep. Year
2009	22.0446	20.9744	2002	
2010	21.9053	20.8399	**2001**	**90%** Dep. Year
2011	23.2749	16.8035	2003	

90% Dependable year = 0.9 (n+1) = 0.9 (15 +1) = 14^{th} = 2001

75% Dependable year = 0.75 (n+1) = 0.75 (15+ 1) = 12^{th} = 2008

50 % Dependable year = 0.5 (n+1) = 0.5 (15+1) = 8^{th} = 2004

TABLE 6-7

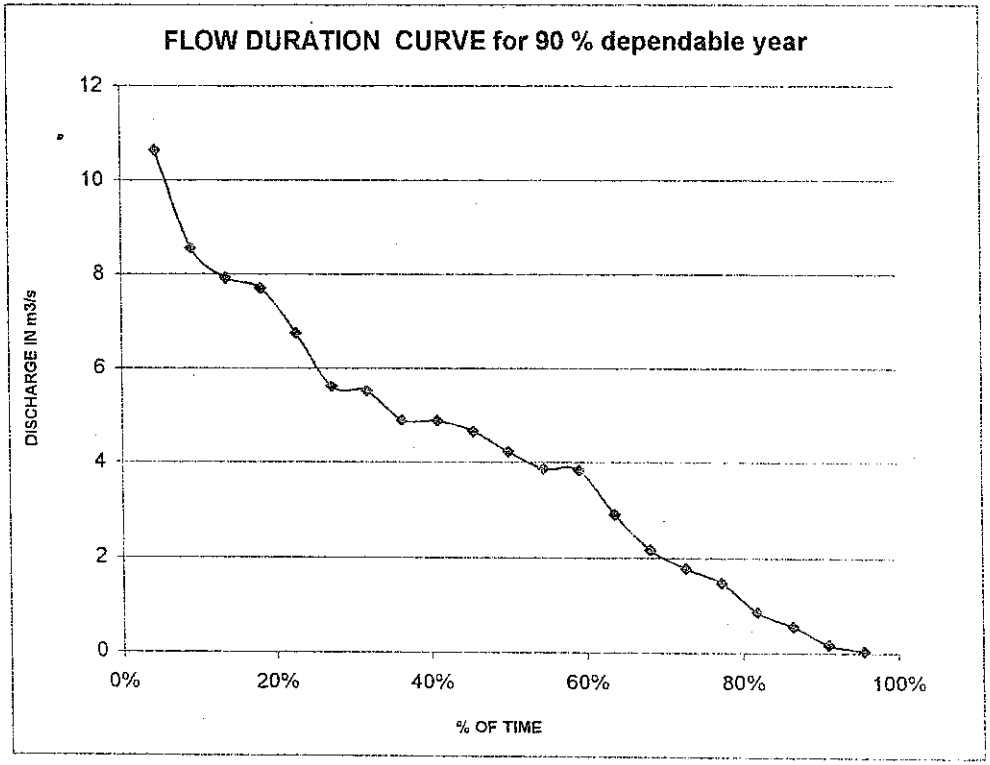
OPTIMIZATION TABLE FOR 90% DEPENDABLE YEAR 2001(214 days)

WATER UTILISED Mm^3	NO: OF UNITS	CAPACITY	TOTAL CAPACITY	POWER (KW)	Annual ENERGY (Mu)	E/C RATIO	% UTILIZATION	PLF
29.45	2	1000	2000	327760	7.866	3.93	37.75	44.90
34.70	2	1250	2500	386230	9.270	3.7	44.48	42.33
39.47	2	1500	3000	439282	10.543	3.5	50.59	40.12
43.28	2	1750	3500	481763	11.562	3.3	55.48	37.71
46.80	2	2000	4000	520974	12.503	3.1	60.00	35.68
49.93	2	2250	4500	555805	13.339	3.0	64.01	33.84
52.66	2	2500	5000	586176	14.068	2.8	67.51	32.12
54.45	2	2750	5500	606115	14.547	2.6	69.80	30.19
55.55	2	3000	6000	618352	14.840	2.5	71.21	28.24
57.17	2	3500	7000	636323	15.272	2.2	73.28	24.90
58.37	2	3750	7500	649682	15.592	2.1	74.82	23.73
59.00	2	4000	8000	656673	15.760	2.0	75.62	22.49
59.34	2	4500	9000	660510	15.852	1.8	76.07	20.11

TABLE 6-8

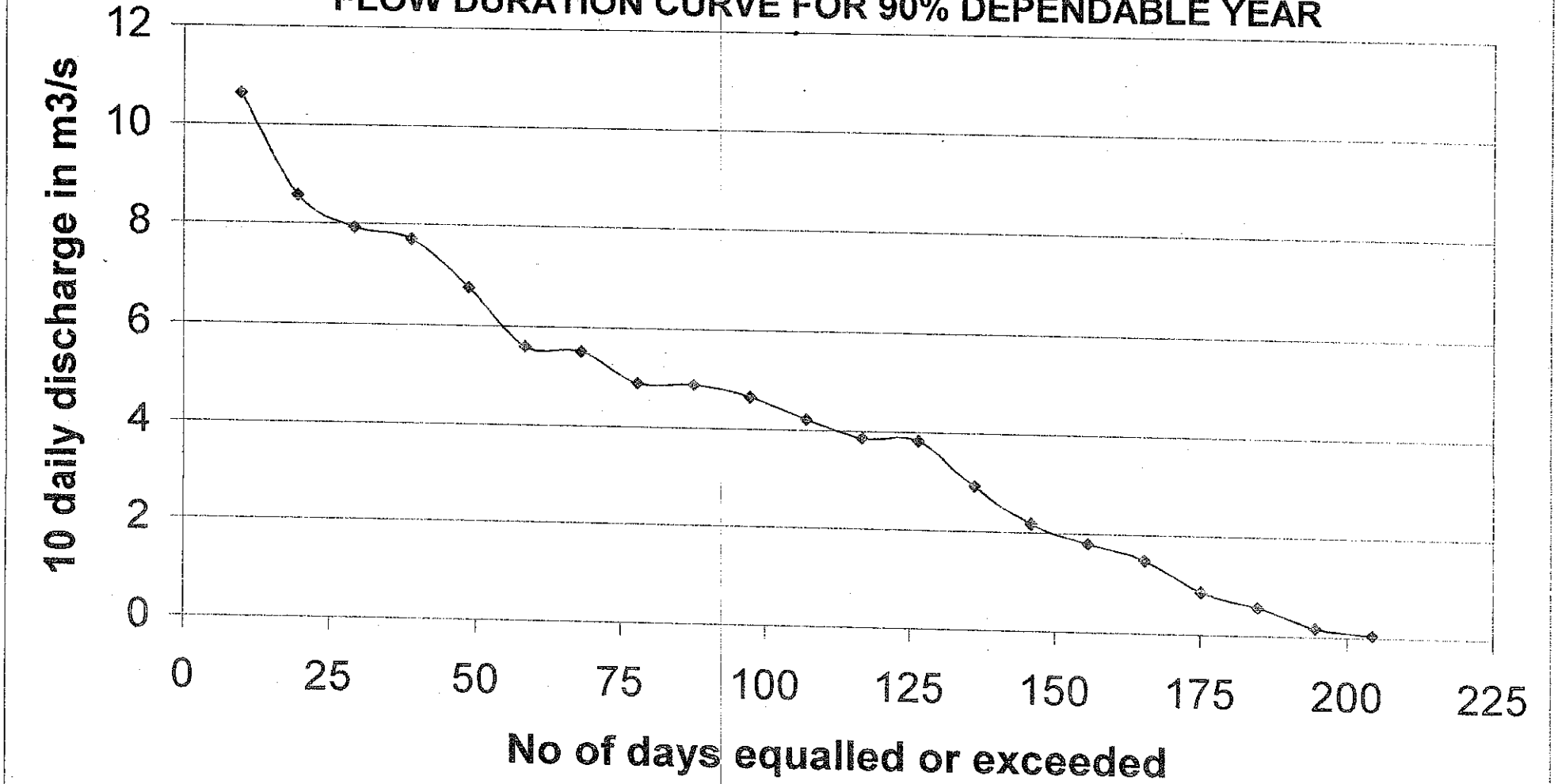
90% Dependable Year -2001 FDC of MARIPUIZHA(10DAILY)				
Sl no	Average of 10 daily in m3/sec	Average of 10 daily in descending order	% TIME equalled or exceeded	No of days equalled or exceeded
1	0.1817	10.6340	4.55%	9.73
2	0.0468	8.5672	9.09%	19.45
3	0.5715	7.9252	13.64%	29.18
4	4.8887	7.7016	18.18%	38.91
5	8.5672	6.7527	22.73%	48.64
6	6.7527	5.6003	27.27%	58.36
7	10.6340	5.5082	31.82%	68.09
8	4.6512	4.8887	36.36%	77.82
9	3.8338	4.8771	40.91%	87.55
10	7.7016	4.6512	45.45%	97.27
11	7.9252	4.2225	50.00%	107.00
12	5.6003	3.865	54.55%	116.73
13	1.7818	3.8338	59.09%	126.45
14	4.8771	2.900	63.64%	136.18
15	5.5082	2.161	68.18%	145.91
16	4.2225	1.7818	72.73%	155.64
17	3.865	1.473	77.27%	165.36
18	2.900	0.8577	81.82%	175.09
19	2.161	0.5715	86.36%	184.82
20	1.473	0.1817	90.91%	194.55
21	0.8577	0.0468	95.45%	204.27

Graph 6-1

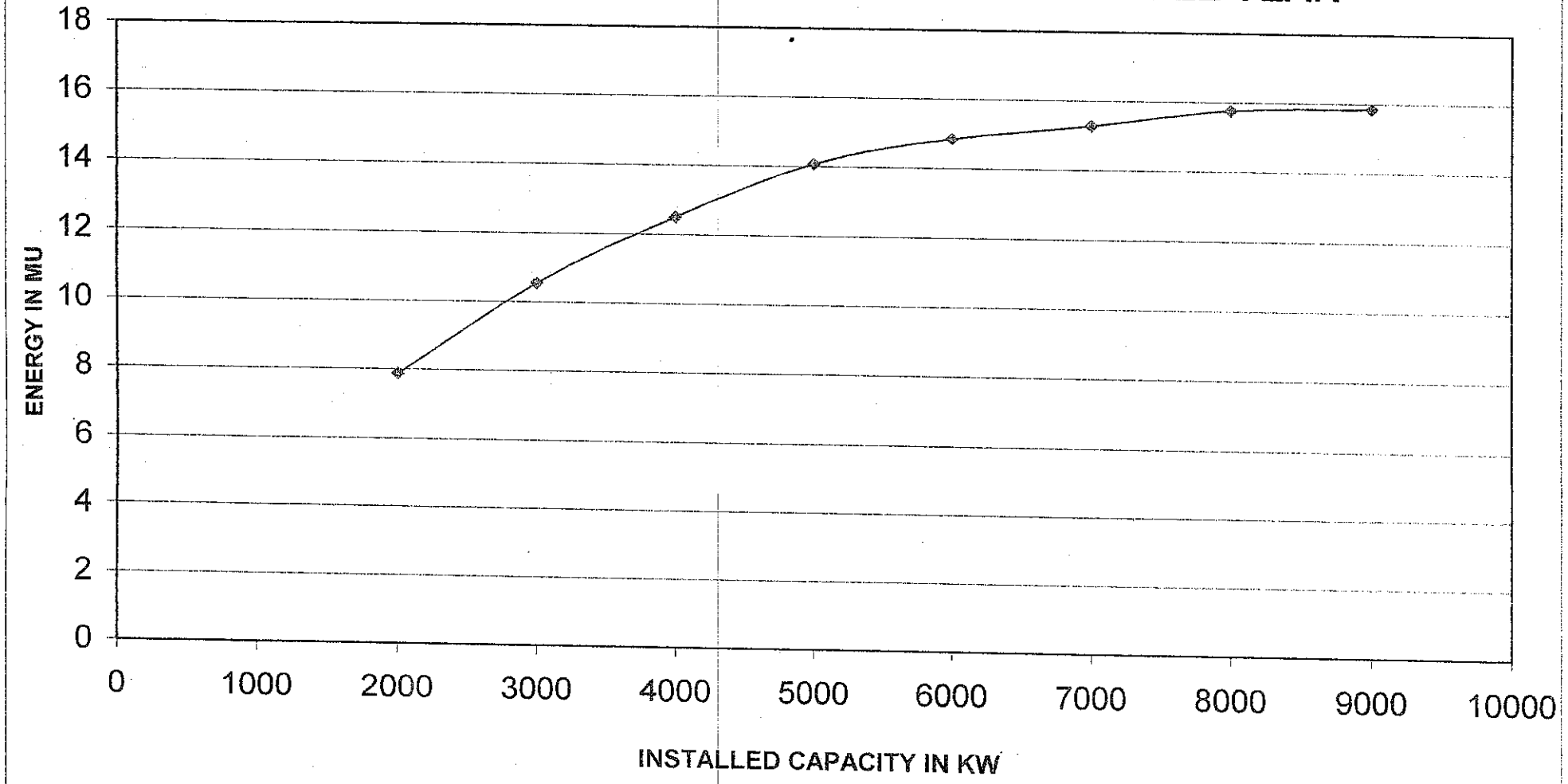


Graph 6-2

FLOW DURATION CURVE FOR 90% DEPENDABLE YEAR

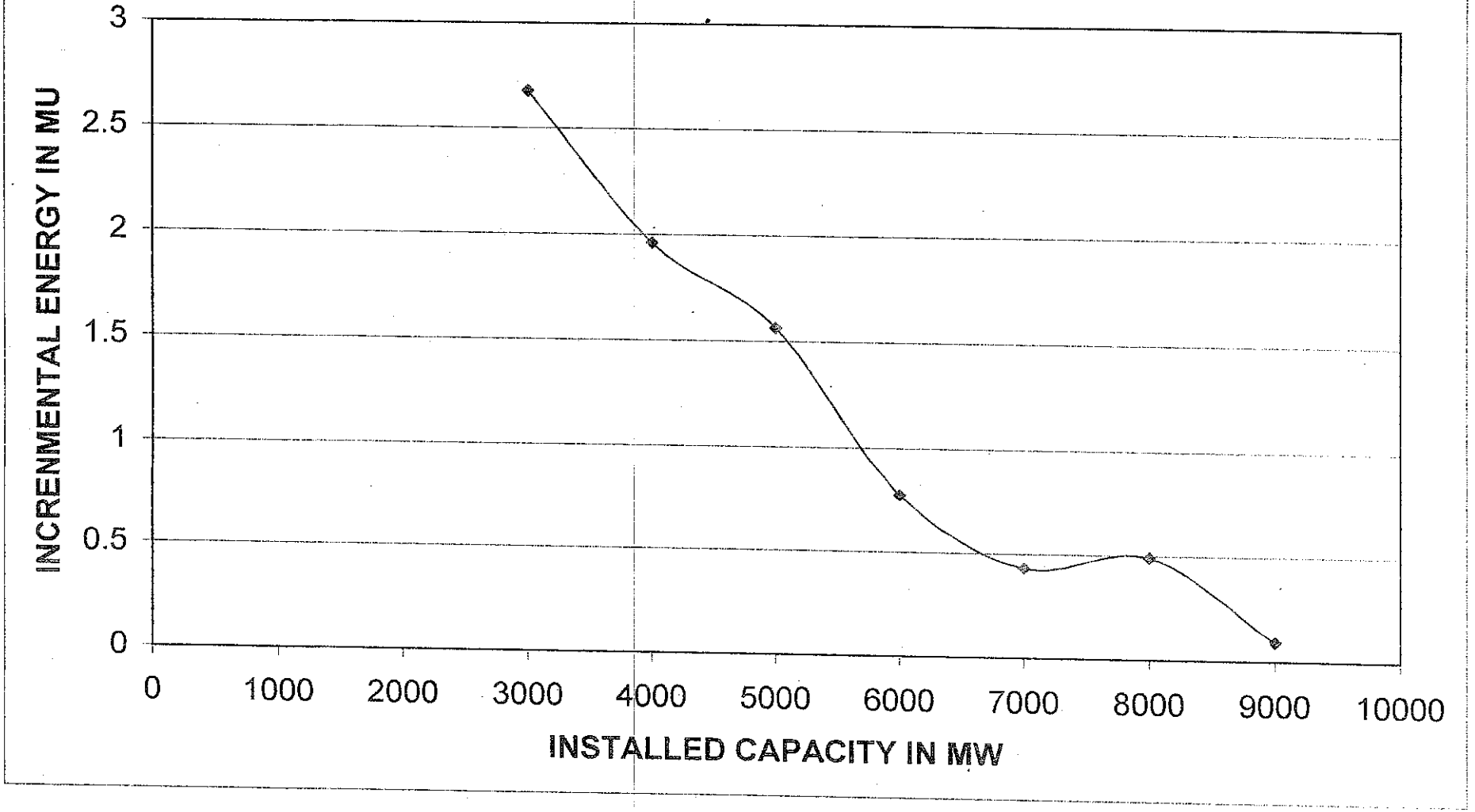


GRAPH 6-3
ENERGY GENERATION CHART IN 90% DEPENDABLE YEAR

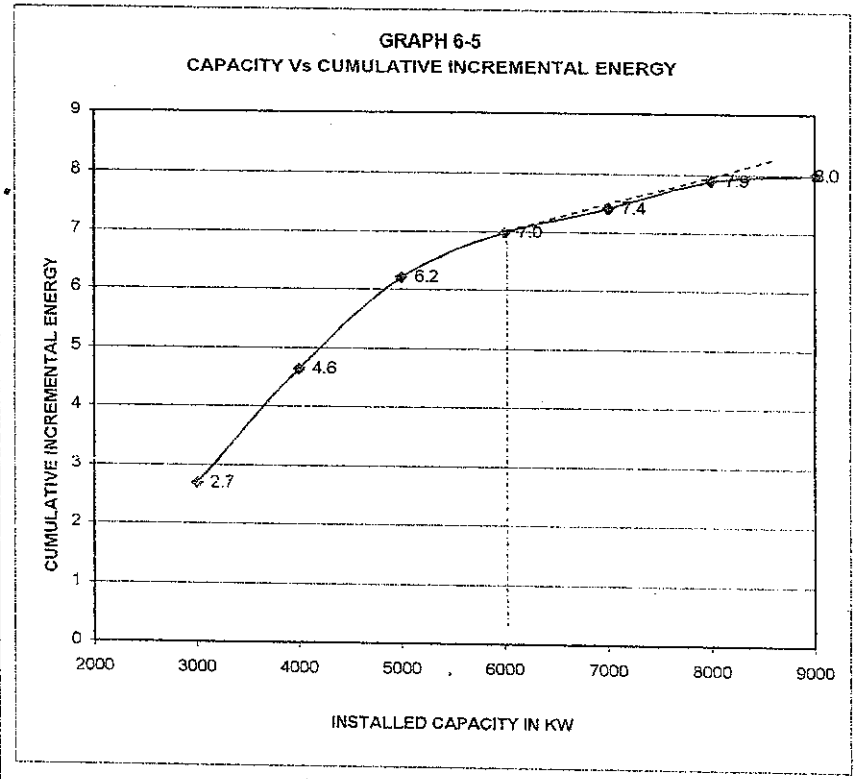


GRAPH 6-4

INCREMENTAL ENERGY CURVE FOR 90 % DEPENDABILE YEAR



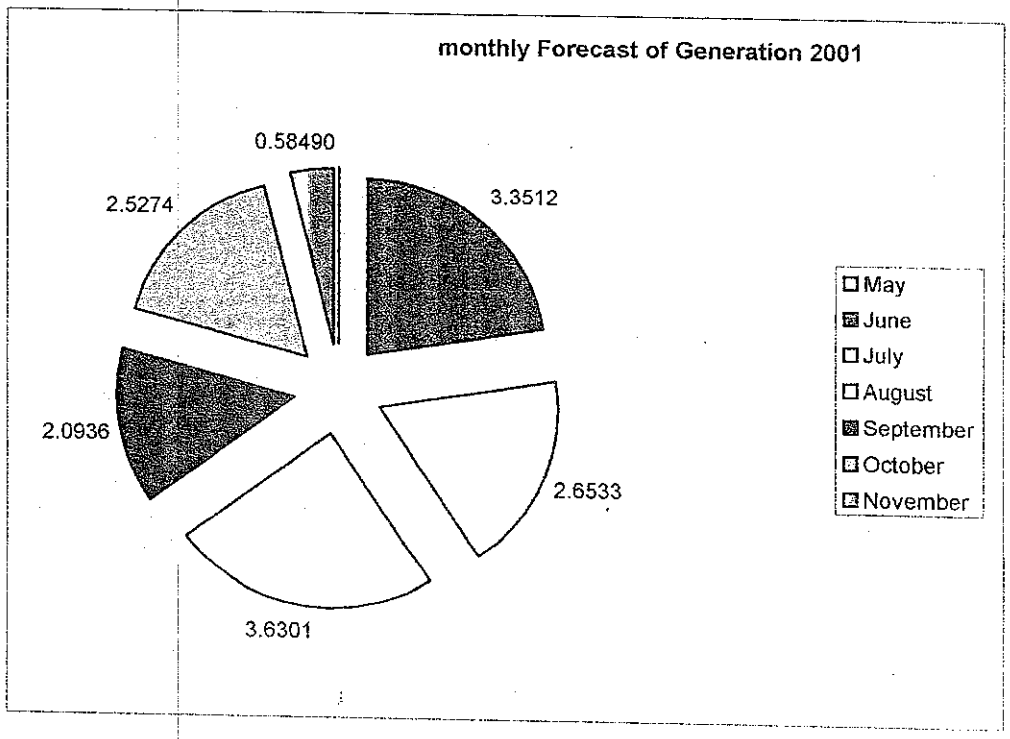
DATA FOR CAPACITY AND INCREMENTAL ENERGY GRAPH -90%dependable year (2001)				
WATER UTILISED Mm^3	INSTALLED CAPACITY IN KW	ENERGY IN Mu	INCREMENTAL ENERGY IN Mu	CUMULATIVE INCREMENT IN Mu
29.45	2000	7.866		
39.47	3000	10.543	2.677	2.677
46.805	4000	12.503	1.960	4.637
52.663	5000	14.068	1.565	6.202
55.553	6000	14.840	0.772	6.974
57.168	7000	15.270	0.430	7.404
58.996	8000	15.760	0.490	7.894
59.341	9000	15.852	0.092	7.986



GRAPH 6-6

Monthly Abstract of Energy Generation in 2001(90% Dependable Year)

Month	Water utilised in Mm^3	Energy in Mu
May	0.000	0
June	12.545	3.3512
July	9.932	2.6533
August	13.589	3.6301
Septembe	7.837	2.0936
October	9.461	2.5274
Novembe	2.189	0.5849
Total	55.553	14.840



Optimization table and the graphs are analyzed. In the Power vs Incremental Energy curve drawn for the 90% dependable year, for 6MW installed capacity "fall in the graph is sharp". The plant load factor for 6MW is 28.24. The energy generated per MW comes to be 2.5Mu with percentage water utilization 71.21. Hence an installed capacity of 6MW (2 x 3MW) with energy 14.84 Mu, in 90% dependable year is found suitable. Average Annual Energy from the working table for a period of 1997 to 2011 for 6 MW installed capacity comes to 15.31 Mu.

6.4.2 Design Energy Computation

The 10-daily unrestricted energy generation in 90% dependable year has been restricted to 95% of the installed capacity of the power house. The total of these 10-daily restricted energies for the year gives the annual design energy generation. Annual design energy generation for 6MW installed capacity is 18.0283 Mu. The details are shown in Table 6(9). Average annual energy generation during the period from 1997 – 2011 is 15.31Mu.

6.4.3 Flow Duration Curve

The flow duration curve for 90% dependable year 2001 is prepared for the months of May to November where daily discharge data is available. The shaded area is the possible energy generation. The upper limit of shaded area shows 100% load and the lower limit shows 60% load on machine.

Full load discharge Q = 6000/(8.15*118) = 6.24 m^3/s

Minimum load Q_{min} = 0.6*3000/8.15*118

= 1.87 m^3/s

From the FDC of 90 % dependable Year 2001, monsoon flows, the full load discharge corresponds to 27.10% of time. Flow Duration curve for 15 years data is prepared and is shown in graph 6-6

Full load generation = 27.10% of 214 days = 58 days

For 90% dependability year, full load operation will be possible for 58 days.

Table 6-9

Design Energy Computation

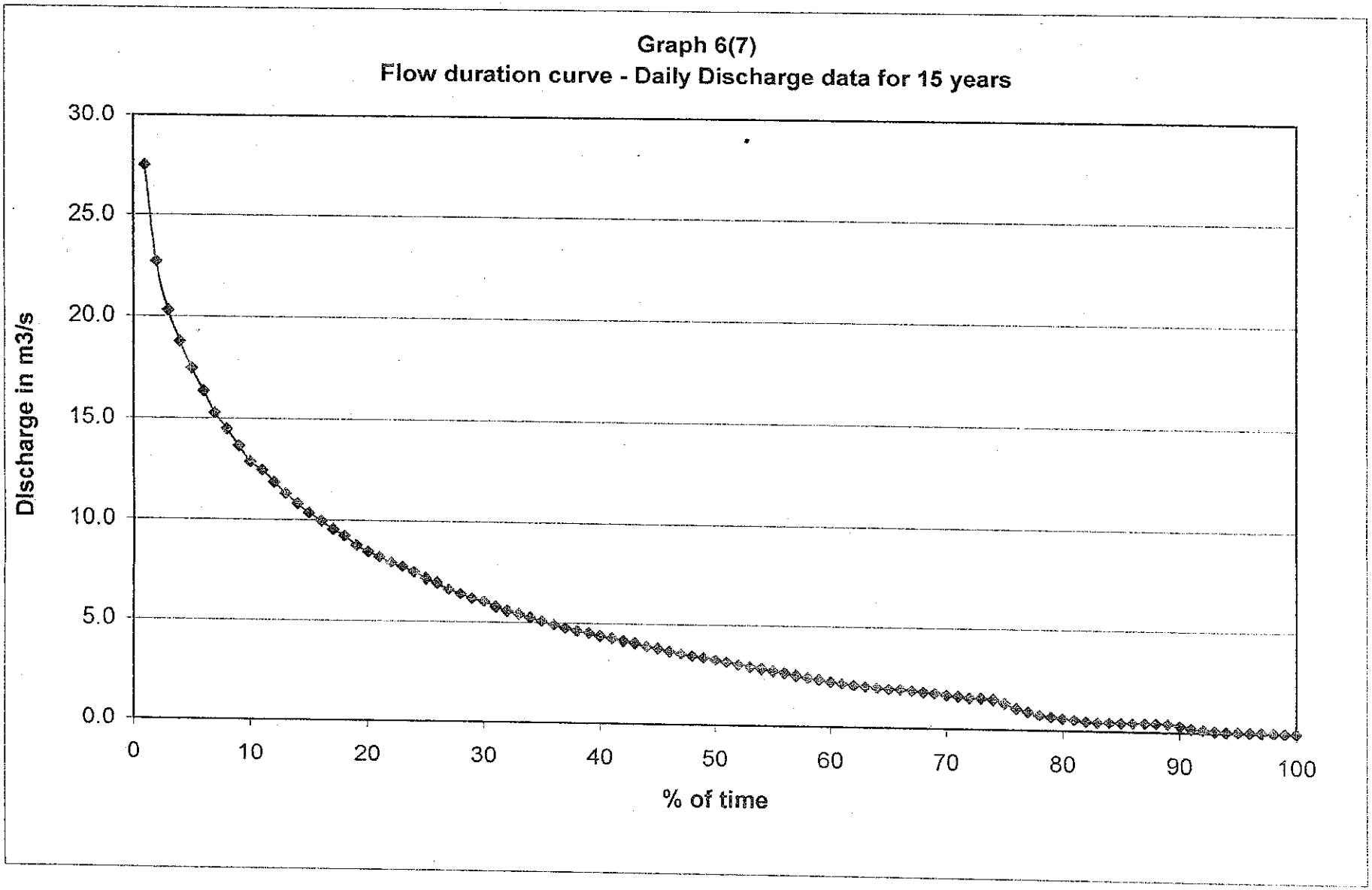
Year	Month	Avg. 10 Daily discharge in m^3/s	Unrestricted Power in KW (P)=8.15*Q*H	Unrestricted Energy in MU for 10 daily discharge P*24*no. of days /10^6	Energy restricted to 95 % Installed capacity
	May	0.182	174.700	0.0419	0.0419
		0.047	44.993	0.0108	0.0108
		0.571	549.579	0.1451	0.1451
	June	4.889	4701.434	1.1283	1.1283
		8.567	8239.112	1.9774	1.3680
		6.753	6494.099	1.5586	1.3680
	July	10.634	10226.682	2.4544	1.3680
		4.651	4473.023	1.0735	1.0735
2001		3.834	3686.973	0.9734	0.9734
	August	7.702	7406.641	1.7776	1.3680
		7.925	7621.680	1.8292	1.3680
		5.600	5385.847	1.4219	1.3680
	September	1.782	1713.520	0.4112	0.4112
		4.877	4690.294	1.1257	1.1257
		5.508	5297.271	1.2713	1.2713
	October	4.223	4060.785	0.9746	0.9746
		3.865	3716.596	0.8920	0.8920
		2.900	2788.728	0.7362	0.7362
	November	2.161	2077.960	0.4987	0.4987
		1.473	1416.978	0.3401	0.3401
		0.858	824.828	0.1980	0.1980
				20.8399	**18.0288**

TABLE 6- 10

DATA FOR FLOW DURATION CURVE FOR 15 YEARS (1997-2011)

%time	Sorted discharge in m3/s	cumulative discharge
1	27.52	27.52
2	22.69	50.22
3	20.30	70.51
4	18.77	89.28
5	17.44	106.72
6	16.34	123.06
7	15.27	138.33
8	14.47	152.80
9	13.64	166.44
10	12.86	179.29
11	12.47	191.76
12	11.84	203.60
13	11.30	214.91
14	10.80	225.71
15	10.35	236.05
16	9.96	246.01
17	9.56	255.58
18	9.23	264.81
19	8.77	273.58
20	8.45	282.03
21	8.20	290.23
22	7.90	298.13
23	7.68	305.81
24	7.40	313.21
25	7.11	320.33
26	6.90	327.23
27	6.60	333.83
28	6.38	340.20
29	6.15	346.35
30	5.98	352.34
31	5.73	358.07
32	5.55	363.62
33	5.42	369.04
34	5.25	374.29
35	5.07	379.36
36	4.90	384.26
37	4.75	389.01
38	4.61	393.62
39	4.50	398.11
40	4.37	402.49
41	4.26	406.75
42	4.15	410.90
43	4.05	414.95
44	3.90	418.85
45	3.81	422.66

46	3.68	426.34
47	3.56	429.89
48	3.45	433.34
49	3.37	436.71
50	3.26	439.97
51	3.15	443.12
52	3.03	446.15
53	2.92	449.07
54	2.85	451.93
55	2.75	454.68
56	2.66	457.34
57	2.54	459.88
58	2.45	462.33
59	2.36	464.70
60	2.27	466.97
61	2.19	469.16
62	2.12	471.28
63	2.05	473.33
64	1.99	475.32
65	1.94	477.25
66	1.94	479.19
67	1.89	481.07
68	1.81	482.89
69	1.75	484.64
70	1.67	486.31
71	1.64	487.95
72	1.56	489.51
73	1.56	491.07
74	1.50	492.57
75	1.32	493.89
76	1.09	494.98
77	0.92	495.90
78	0.77	496.67
79	0.68	497.35
80	0.61	497.96
81	0.56	498.52
82	0.48	499.00
83	0.43	499.43
84	0.43	499.86
85	0.43	500.28
86	0.43	500.71
87	0.43	501.14
88	0.43	501.56
89	0.41	501.98
90	0.32	502.30
91	0.21	502.51
92	0.15	502.65
93	0.09	502.74
94	0.04	502.78
95	0.04	502.82
96	0.04	502.86
97	0.04	502.90
98	0.02	502.92
99	0.00	502.92
100	0.00	502.92


Graph 6(7)
Flow duration curve - Daily Discharge data for 15 years
Discharge in m3/s
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
10
20
30
40
50
60
70
80
90
100
% of time

6.4.4 Monthly Generation Forecast of 90% Dependable Year

Monthly Generation Forecast of 2001 is shown in graph 6-6

6.4.4 Machine Selection

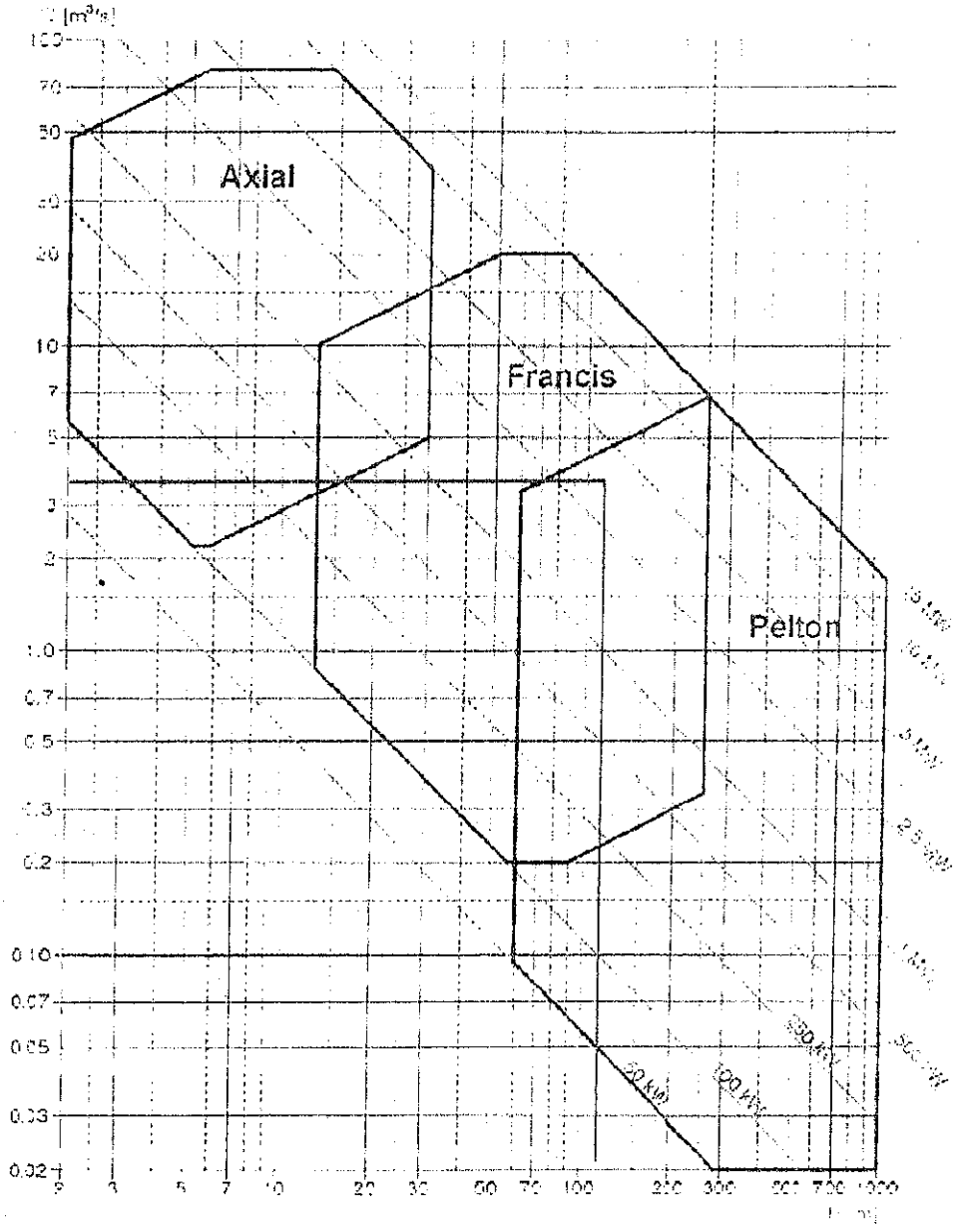


Figure 1 Turbine Selection Diagram

The installed capacity of Maripuzha Small H.E Scheme is 2 x 3000 KW

Net head = 118m

Discharge for single machine=3000/8.15*118 = 3.11 m^3/sec

Appropriate type of machine is selected from the manufacturer's selection chart.

For 3.11 cumecs discharge and 118m head, the machine falls in the transition region between Francis and Pelton. Two numbers Horizontal axis Francis turbine with a capacity of 3000 KW is selected.

CHAPTER - 7
GEOLOGICAL FEATURES

7.1 Geology

a) Regional Geology

The major rock types exposed in the area belong to the Wayanad Group (WG), Charnockite Group (CG) of Archaean age, Peninsular Gneissic Complex – II (PGC – II) of Archaean to Palaeo Proterozoic age and acid Intrusives of Neo-Proterozoic age and basic intrusives of Meso-Proterozoic age. Meta pyrixenite, meta gabbro, amphibolite, magnetite quartzite and garnet biotite gneiss are the principal restites belonging to the WG. The dominant rock type is charnockite, which occupies most of the area (Plate-2). It is flanked on either side by biotite hornblende gneiss of PGC-II. Pegmatite and quartz veins are the acid intrusives and metagabbro is the basic intrusives of Proterozoic age. Mesozoic dolerite and gabbro dykes are the youngest basic intrusives. Extensive lateritisation of migmatite is seen in the southeast.The mineral assemblage indicates granulite facies of metamorphism in charnockite and upper amphibolite to granulite facies in the Supracrustal rocks. Some of the grains of hornblende in the gneisses show relict cleavage of pyroxenes indicating retrograde metamorphism.

The foliation trend varies between NE – SW to NW – SE in most parts. In the northwest, central and eastern parts, the trend of foliation is N – S with steep dips on either side. E – W trend is also seen in some parts of north and south. Minor shears are noticed in charnockite and biotite gneiss.

Placer gold is widely reported from the riverbeds of Kanjirapuzha and Chaliyarpuzha. Gold is also reported in the laterite and quartz veins near Nilambur. Charnockite and biotite gneiss are extensively quarried for metal at various places in the Nilambur valley.

b) Geology of the site

At the proposed weir site, no sizeable exposures are observed on either side of the river due thick overburden, expect some patchy outcrops of Charnockite on

the river banks (Plate-2). However, accumulations of huge boulders were common all along the river, especially at the Trench Weir site. Since the site was not approachable during the site visit, the attitude of lithologies could not be taken. However, foliation at the project site is trending E-W with steep dip towards south, as measured on rough planes.

c) Seismotectonic Evaluation

In the Seismic Zoning Map of India, the project lies in Seismic Zone – III (Plate -3), which implies that occurrence of earthquakes up to a magnitude of 6 (Intensity – VII) cannot be ruled out. Seismotectonic map of India shows that, within 100 km radius from the project site, one major earthquake of magnitude 5 was recorded by IMD and USGS on 29.07.1972, near Coimbatore. The location is roughly 100 Km SE of the project site. There is no major event reported near the project site.

Three minor lineaments of underfined status are marked near the project site, trending in E – W to ENE – WSW direction. In general the project site exhibits low to moderate seismicity. In view of the above factors, it is opined that the project components may require suitable seismic resistant design to withstand earthquakes of moderate magnitude.

The report on preliminary stage Geotechnical Investigation of Maripuzha SHEP is enclosed as annexure.

CHAPTER - 8

ENVIRONMENT AND ECOLOGY

8.1 General

Maripuzha small hydro electric scheme is a run – off – river Hydro Electric Scheme. The Trench weir is free from submergence issue. Moreover the scheme does not involve the highly sensitive issues of displacement of people due to construction of the project. The infrastructure facilities for the scheme and its construction and maintenance staff will not cause any adverse effect on the environment. Slopes shall be stabilized with adequate slope stabilization measures thereby ensuring that there is no danger of any erosion, slips and rock movements etc.

8.2 Environment and Ecological aspects

Maripuzha small hydro electric scheme is a run – off – river Hydro Electric Scheme. The Maripuzha SHEP has been proposed to utilize the head of natural slope of river which exists within a reach of 1.00km. The catchment area of the Maripuzha SHEP is predominantly forest land. The proposed scheme will not have any adverse effect on the catchment area.

The excavation slopes are proposed to be protected by planting Vetiver plant. The vetiver is widely used for preventing soil erosion and slope stabilization. The roots of vetiver plants penetrates about 2.50 to 3m and its tensile strength is more or less equal to steel fibres.

10% of revenue earned by trading REC's are earmarked for the maintenance of Vetiver plants.

The area lies in seismic zone III and not susceptible to damages in the event of earthquake of high intensity. The project is very small with almost all the structures are not susceptible to large horizontal forces. Proper seismic coefficient shall be taken for design of various structures to prevent damages due to earthquake. Since there is no submergence of land, water logging is not at all anticipated. This project will not create any adverse effect on the environment, as no stagnation of water will occur.

8.3 Population and social – economic aspects

The scheme area lies completely in private land and possessed by about 12 people. The population is very scanty. The land requirement of scheme is 8.50 Hectare. Five dwellings will be interfered by the scheme and other three residences are located in the vicinity of construction activities. They can be suitably relocated in the near by lands available. Only two houses are coming directly in the acquisition land. All other land is private cultivated land. The scheme implementation will definitely improve the overall socio – economic growth of regions.

8.4 Effect of construction activities on ecology of the area

The site selection for the scheme has been done keeping in view of the ecological setting of the area. The predominant existing land use in the area is undulated cultivated land. There is no impounding reservoir and hence there is no danger of failure of weir. The slopes are adequately protected by gabion walls and vetiver grass planting. Soil erosion and excavation slope failures are thus eliminated.

The infrastructure facilities to be created for the construction staff (in the construction phase) and the maintenance staffs (in the operation phase) are also not likely to have any negative environmental impact. In view of the small scale of construction activities most of the labours will be drawn from the local areas and the construction facilities will be temporary in nature impacts resulting from the movement of transport vehicles etc will be limited to the project area and will not have any significant impact on environmental quality.

The scheme area lies adjacent to the forest land. A nallah separates the scheme area from forest land. Proper care shall be observed to prevent any damage to forest. The construction of access roads and bridges to power house and weir site may be completed before other construction activities so that the ghat road through the forest need not be utilized.

8.5 Aquatic wildlife or fish

In small hydropower schemes there is no significant changes in the velocity of water current and hence no change in the ambient condition for the aquatic life.

Bye pass conduit is provided in the trench weir to divert the water during low flow period and thus form a safe passage of aquatic life.

8.6 Miscellaneous

The scheme will not have any impact on public health scenario. As no wild life is to be found in the project area, the project will not affect the flora & fauna of the region. The construction labours and project staff will be educated in environmental matters and anti – poaching laws so that harmony between man and nature is not disturbed.

8.7 Estimation of Affected land and Project Affected Families

Ownership status land to be acquired for Maripuzha SHEP

Type of land	Area (Ha)
Private land	7.5 Ha

Details of Project Affected Families (PAF)

Details of land category	**Numbers of PAFs**
Only land	10
Only Homestead	Nil
Both land and Homestead	2

Source; Field studies

CHAPTER - 9

TECHNICAL FEATURES OF THE PROJECT

Detailed field investigations have been conducted in the scheme area. The observations and layout descriptions of the various component structures are as follows.

9.1 Layout of Components Structures

9.1.1 Diversion Structure (chainage : (- 76 to - 58)

The diversion structure consists of a trench weir of 18m width in Iruvanjipuzha. The intercepting stream in the right bank of Iruvanjipuzha is proposed to divert suitably by providing a small diversion weir across the stream and an open channel adjacent to intake chamber. The bore hole details at weir site shows no rock strata for a depth of 23.94m. The choice of gravity weir may not economical and thus a trench type weir is selected. The left bank of weir site is a vertical cliff of about 22m high consists of earth and large boulders. A 3m offset is provided for the excavation slope of trench weir to avoid interference with this cliff.

9.1.2 Intake Channel / Feeder Channel (Box type) (chainage : (- 58 to - 49)

A closed type free flow intake channel of width 2m and depth varying from 2.72 m to 3.08 m and slope of 1 in 25 leads water from trench weir to intake chamber.

9.1.3 Intake Chamber(chainage : (- 49 to - 43)

Intake chamber is located at 9m from the trench weir. Huge boulders are expected during excavation.

9.1.4 Power Duct (chainage : (- 43 to 37)

The intake conduit is passing through a rather difficult terrain. Hence a 80m long RCC duct is provided.

Ch. 10 to 37m

The ground slope of the initial reach of power duct is very steep. Dry rubble retaining walls are provided along river side to minimize the excavation quantity. R.C.C rectangular power duct of Type-A is provided.

9.1.5 Surplus weir No.1(chainage 37 to 43.4) (4.4m +2m)

A surplus weir No.1 is provided at the end of the power duct, The head of water over the crest level of surplus weir is limited to 500 mm. Transition 2m is provided.

9.1.6 Power Channel (chainage 43.4 m to 1148 m) (Including 6 nos of Transition)

Ch.43.4m to 176m (cut & cover)

Cut & cover Rectangular R.C Channel of Type – D is provided.

Ch. 176m to 287m

Rectangular R.C Channel of Type – B is provided. Canal is passing through level ground. Shifting the alignment towards downstream may cause unwanted increase in length of canal.

Ch. 287 to 291m

Canal is crossing the ghat road. Since the inhabitants are using this road for traffic, a box culvert is provided for a length of 4m. Box shaped R.C Channel of Type – C is provided.

Ch. 291 to 305m

Canal is crossing a minor ridge to minimize length. Double cutting sections are inevitable. Maximum excavation depth is 5.50m. Rectangular R.C Channel of Type – B is provided.

Ch. 305 to 370m

Canal is crossing a minor ridge to minimize length. Double cutting sections are inevitable. Maximum excavation depth is 5.50m. Trapezoidal Channel of Type – F is provided.

Ch. 370 to 380m (Surplus weir No.2)

Canal is crossing a local valley. Surplus weir No.2 of 10m width is provided with a crest level of 100mm above F.S.L. Cross drainage works may also be provided to bye pass the surface runoff. Rectangular R.C Channel of Type – E is provided. Service road level is lowered by 1m to form an Irish drain.

Ch. 380 to 545m

Canal is passing through a moderate slope. Cutting and filling are almost balanced. Trapezoidal Channel of Type – F is provided. Cross drainage work is required at Ch. 463.

Ch. 545 to 570m (cut & cover)

Canal is passing through a jungle where traces of land sliding are observed. The bearing capacity of soil is very poor. Box shaped R.C Channel of Type – C is provided to avoid the risk of sliding.

Ch. 570 to 635m

Canal is passing through an area comprised of large boulders and exposed rock. Excavation slope is taken as 1H:4V. Rectangular R.C Channel of Type – B is provided.

Ch. 635 to 835m

Canal is passing through moderately sloping terrain. Excavation slope is 1H:1V. 2m wide benching is provided when cutting depth exceeds 6m. Trapezoidal Channel of Type – F is provided. Cross drainage work is required at Ch. 762.

Ch. 835 to 972m (cut & cover)

Canal is passing below existing ghat road. Cut & cover Rectangular R.C Channel of Type – D is provided. Service road shifted to right side of alignment at Ch. 870. A rising gradient of 1 in 20 is provided for service road from Ch. 830 to Ch. 900 and a falling gradient of 1 in 20 is provided from Ch. 900 to 970. Since the canal is covered, there is no risk of falling of earth into canal and hence a cutting slope of 1H:2V is adopted. 2m wide benching is provided when cutting depth exceeds 6m.

Ch. 972 to 990

Canal is passing through moderately sloping terrain. Excavation slope is 1H:1V. Rectangular R.C Channel of Type – B is provided.

Ch. 990 to 1020

Trapezoidal Channel of Type – F is provided

Ch. 1020 to 1030 (Surplus weir No.3)

Surplus weir No.3 is provided to bye pass the canal to near by stream in case of emergency. Rectangular R.C Channel of Type – E is provided. Service road level is lowered by 1m to form an Irish drain.

Ch. 1030 to 1050

Trapezoidal Channel of Type – F is provided

Ch. 1050 to 1148

Canal is passing through steep terrain. Excavation slope of 1H:1V is provided. 2m wide benching is provided when cutting depth exceeds 6m. Rectangular R.C Channel of Type – B is provided. The downstream area up to stream can be utilized as dumping yard.

9.1.7 Forebay

A rectangular Forebay tank of >120 seconds live storage is provided to buffer the fluctuation in inflow and fluctuation due to load acceptance and rejection. The rock level as per bore hole No. 8 is +574.645m and bore hole No. 9 is +578.035m and is more or less matching the tank bottom level. The forebay tank can be suitably founded on hard rock. Rock excavation is also observed as minimum, but plenty of boulders are likely to intercept during excavation. A 10m wide Overflow weir is provided in the crest of forebay tank. A 95m overflow channel is required to divert the spilled water to natural stream. This natural stream is situated in forest boundary. Hence suitable energy dissipation arrangements shall be provided to avoid the erosion of banks.

9.1.8 Penstock (Spirally Welded Steel Pipe)

Single line surface penstock of diameter 1.40m is provided. Total length of penstock from Transition to bifurcation point is 326.64m. The single line penstock branches at a manifold to two separate feeder pipes of 1.10m dia to feed the two turbines. Since there is no road access to penstock route, penstock tracks of sufficient width shall be formed for erection and maintenance of penstock.

The excavation slope is adopted as 1H:1V. The penstock is supported on Ring girders and Rocker supports at an average horizontal interval of 10m. The rocker supports may be founded on rock or overburden soil suitably.

One penstock culvert is required at Ch. 248m for crossing a ghat road.

One compound bend (horizontal and vertical) is provided at Ch. 235m and vertical bends at Ch. 8m, Ch. 120m in main penstock and at Ch. 295.50m in feeder pipes. The anchor blocks at bend points may be founded on hard rock. The anticipated rock line based on bore hole details is shown in the drawing named Longitudinal Ground Profile of Penstock Route .

9.1.9 Power House

A surface power house of 29.50m x 10m is provided to house the 2 Horizontal Francis Turbines. The yard level of power house is kept at +464.50m. Erection bay level is fixed at +464.50m. Machine floor level is at +457.67m. There is a seasonal flowing nallah passing near the power house site. Proper protection works of nallah sides are necessary. Since the machine floor level is below the surrounding yard level and the ground water table is high, concrete walls with water tight construction is necessary up to the service bay level.

9.1.10 Tail race pool & Tail race channel

A Tail race pool of size 15x12.50m and a rectangular box shaped tail race channel of 3.7m wide and 1m deep is provided to discharge the water back in to the river. The length of box channel is 6.05m and the remaining 23.95m consists of bed preparation in river course.

9.1.11 Switch yard

A switch yard of size 20m x 20m is ear marked near Power house site. The switch yard can be accessed from the approach road to power house.

9.1.12 Access roads

Power House road and bridge

The length of power house road is 165m and the formation width is 5.50m. This road crosses Iruvanjipuzha between Ch. 101 and Ch. 126. A 25m long bridge is required to cross the river. Bore hole No. 2 was drilled up to a depth of 23.95m and shows no rock deposits. A multiple box type bridge with a bottom raft and cutoff wall is provided. Initial 100m length of road is passing through tribal colony in a convenient location so as to avoid any interference to inhabitants.

Weir site road and bridge

The length of weir site road is 334m and consists of one steel bridge of span 10m and two culverts of span 5m and 4m respectively. The steel bridge is proposed to abut on two large boulders situated in the upstream side of Pottankayam. The stability of structure on these boulders shall be ascertained before construction. 1 in 10 gradient is adopted for the road. The maximum excavation depth for this road is 16m. Gabion retaining walls are provided to retain the soil. The excavation activities shall be arranged during non monsoon period to minimize the saturated soil pressure. The stability analysis of this excavation slopes shall be determined. An alternate location for access road to weir site is available near the suspension bridge site at Mainavalavu. But the length of bridge and road will be more and this alignment will be costlier than the above.

9.1.13 Dumping yard

Around 32000 m^3 of surplus earth is estimated in the excavation of power channel. To avoid the delay of project due the conveyance of excavated earth and to save the cost of conveyance, a dumping yard of 100m x 20m is identified in the downstream of power channel between Ch. 450 and Ch. 550. The average filling height is 4m. Another location is identified between forebay and surplus weir no. 2

9.2. Design aspects

Design Discharge

The design discharge of various components of water conductor system are different.

9.2.1 Trench weir

The plant is designed to run with an overloading of 15%.

Installed capacity = 6MW with15% overloading

Design head(Net head) = 118m

Discharge of Turbine, Q_T = $\frac{6000 \times 1.15}{8.15 \times 118}$

(With 15% overloading)

= 7.175 m^3/sec

Ref: Guidelines for Hydraulic Design Of Small Hydro Plants/May 2011. (As per clause No:1.3.2).

Bed load flushing flow = $0.20 \times Q_T$

= 0.20×7.175

= 1.435 m^3/sec

Desilting flushing flow = $0.20 \times Q_T$

= 0.20×7.175

= 1.435 m^3/sec

Design discharge of trench weir = 7.175+1.435+1.435

= 10.045 m^3/sec

The trench weir is assumed to be designed for the full discharge

Design discharge of Trench weir = **10.045** m^3/sec

9.2.2 Power Duct

Design discharge of feeder conduit = 7.175+1.435

= **8.610** m^3/sec

9.2. 3 Power Channel

Design discharge of power channel Q_T = **7.175** m^3/sec

9.2. 4 Escape Weir

Design discharge of Escape weir = **8.610** m^3/sec

9.2. 5 Penstock

Design discharge of Penstock Q_T = **7.175** m^3/sec

9.2. 6 Tail Race Channel

Design discharge of Tail race Q_T = **7.175** m^3/sec

9.3 Diversion Structure

Due to lack of rock strata and the steepness of river course (5.6%), a trench type diversion structure is proposed. The inflow of Iruvanjipuzha (catchment area -14.855 sq.km) and an intercepting stream (catchment area -1.065 sq.km) in the right bank is proposed to utilize for this scheme. An 18m long trench weir and is proposed to tap the power draft. To utilize the inflow of intercepting stream a small diversion weir and an open channel is proposed.

9.3.1 Trench weir

Design reference: Section 1.3.3 of AHEC Guidelines For Hydraulic Design Of Small Hydro Plants/May 2011

The main trench weir is proposed in Iruvanjipuzha at a narrow section about 65m upstream of Pottankayam. The left bank of weir site is a vertical cliff of about 22m high consists of earth and large boulders. A 3m offset is provided for the excavation slope of trench weir to avoid interference with this cliff. The available width of river bed is 21m. Hence the length of trench weir is limited to 18m.

The plant is designed to run with an overloading of 15%

Installed capacity = 6 MW (15% overload)

Design Head (Net head) = 118 m

Design discharge Q_t (With 15% overload) = $\frac{1.15 \times 6000}{8.15 \times 118}$

= 7.175 m^3/sec

Design flows

The following design flows are considered

1. Bed load flushing flow (from collector box) = 0.2 Q_T
2. Desilting – flushing flow = 0.2 Q_T
3. Turbine flow = $\underline{1.0}$ Q_T

= $\underline{1.4}$ Q_T

Hence total design discharge of

Trench Weir = 1.4 x 7.175

= 10.045m^3/sec

Depth of flow = 0.12 m (assumed)

Approach velocity $= \frac{Q}{A} = \frac{Q}{BxD} = \frac{10.045}{18 \times 0.12}$

$= 4.65$ m/s

Energy head of approaching flow, H_0 $= \frac{V_a^2}{2g} = \frac{(4.65)^2}{2 \times 9.81} = 1.10$ m

Depth at upstream edge of rack, y_1 $= k \frac{2}{3} h_0$

Adjustment factor k is a function of rack slope from table 2.2 1/1,

Rack slope $=$ 1 in 10 $= \tan^{-1}(1/10) = 5.7106°$

For 4° = 0.961 and 6° = 0.944

Then, k for 5.7106° $= 0.946$

Depth at upstream edge of rack, y_1 $= 0.946 \times \frac{2}{3} \times 1.10 = 0.694$m

Sloped length across collector trench $= L = \frac{1.50q}{E_1 E_2 C.\cos\alpha^{3/2} \sqrt{2 g.y_1}}$

Where

q = unit flow entering intake

$= \frac{10.045}{18} = 0.558$ m^3/sec / m

E_1 = Blockage factor = 30%

E_2 = Effective screen area $= \frac{e}{m}$

e = clear distance between bars

say 25 mm

m = c/c distance between bars

= 25+10 = 35mm

Effective screen area, E_2 $= \frac{25}{35} = 0.714$

Contraction coefficient, C $= 0.65$

$$L = \frac{1.50q}{E_1 E_2 C.\cos\alpha^{3/2} \sqrt{2 g.y_1}}$$

$$= \frac{1.5 \times 0.558}{0.3 \times 0.714 \times 0.65 \times \cos 5.7106^{3/2} \sqrt{2 \times 9.81 \times 0.694}}$$

$= 1.67$ m

Width of Trench weir, B = LCos α = 1.67 x Cos 5.7106

= 1.66m

Say provide 2m wide and 18m long trench weir.

9.3.2 BED SLOPE

Clear gap between racker bars = 25 mm

Assume maximum particle size entering through rack is 25 mm

Scouring slope, $S_s = \frac{0.66\ d^{9/7}}{q_0^{6/7}}$

Flow per unit width at outlet, $q_o = \frac{10.045}{2} = 5.02\ m^3/sec / m$

Scouring slope, $S_s = \frac{0.66 \times 0.025^{9/7}}{5.02^{6/7}} = 1.447 \times 10^{-3}$

= 1 in 691

When single machine is running at 60% load, turbine efficiency will be 91.50%

Discharge will be $= \frac{3000 \times 0.6}{8.15 \times 118} = 1.872\ m^3/sec$

Flow per unit width at outlet, $q_o = \frac{1.872}{2} = 0.936\ m^3/sec / m$

Scouring slope, $S_s = \frac{0.66 \times 0.025^{9/7}}{0.936^{6/7}} = 6.10 \times 10^{-03}$

Minimum slope required = 1 in 163.93

Considering clogging in trench, provide a longitudinal bed slope of 1 in 25

9.3.3 Check for discharge capacity

L = 18 m

Q = 10.045 m^3/sec

top width, T = 2 m

Provide a depth of 1.50m at left bank and 2.22m at right bank with a bed slope of 1 in 25.

Average depth available $= \frac{1.5+2.22}{2} = 1.86$ m

Average area provided = 1.86 x 2 = 3.72 m^2

Wetted perimeter = 2 x 1.86 + 2 = 5.72 m

Hydraulic radius, R $= \frac{A}{P} = \frac{3.72}{5.72} = 0.65$

Bed slope s $= \frac{1}{25} = 0.04$

Using Manning's equation discharge Q $= \frac{1}{n} A.R^{2/3} S^{1/2}$

Manning's rugosity coefficient 'n' for trench is taken as 0.018.

$$Q = \frac{1}{0.018} \times 3.72 \times 0.65^{2/3} \times 0.04^{1/2}$$

$$= 31.015 \text{ m}^3/\text{sec}$$

9.3.4 Check for adequacy of capacity when 50% area clogged

Available depth		= 1.86 / 2	= 0.930 m
Area	A	= 2 x 0.930	= 1.86 m^2
Wetted perimeter,	P	= 2 x 0.930+ 2	= 3.86 m
Hydraulic radius,	R	= $\frac{1.86}{3.86}$	= 0.482

$$Q = \frac{1}{0.018} \times 1.86 \times (0.482)^{2/3} \times (0.04)^{1/2}$$

$$= 12.70 \text{ m}^3/\text{sec} > 10.045 \text{ m}^3/\text{sec}$$

.9.3.5 Bye Pass Conduit

A bye pass conduit of 600mm dia NP2 class concrete pipe is provided through the left bank abutment of main weir for bye passing the dry weather flow to facilitate the annual maintenance work in trench weir, intake channel, intake chamber etc. The flow through trench weir can be diverted by constructing a temporary bund. The mouth of the bye pass conduit is closed by a dummy cap during monsoon.

9.3.6 Design flood

weir site

The catchment area of weir site including catchment area of 1.065 Km^2 of intercepted stream is 15.92km^2. From local enquiry, the high flood level reached +591.000m.

By Ryve's formula, Q $= CA^{2/3}$

Considering the steepness of terrain and the chances of land sliding induced floods, a value 35 is taken for C.

Flood discharge at weir site $= 35 \times 15.92^{2/3}$

$= 221.45 \text{ m}^3/\text{s}.$

9.3.6.1 H.F.L of Trench Weir

The H.F.L of trench weir will be lowered after the construction of 18m long upstream and downstream aprons. There is no chance of heading up of water anywhere in the

river course. The rugosity coefficient is greatly reduced and hence the flow depth will be lowered.

Design flood of trench weir		= 221.45 m^3/s
Width of approach		= 18 m
Take rugosity coefficient,	n	= 0.020
Take a trial depth,	d	= 0.9 m
Cross sectional area	A	= 16.2 m^2
Wetted perimeter	P	= 19.8 m
Hydraulic radius,	R	= A / P = 16.2/ 19.8
		= 0.8181
Slope of upstream apron	S	= 1 / 10 = 0.100
By manning's equation	Q	= $\frac{A}{n} R^{2/3} S^{1/2}$
		= $\frac{16.2}{0.020} \times 0.8181^{2/3} \times 0.100^{1/2}$
		= 224.05 ≈ 221.45 m^3/s
Anticipated maximum depth of flow		= 0.870m
Upstream crest level of trench		= +588.485m
Modified H.F.L		= +588.485 + 0.9 = +589.355m
	Say	= +589.500m

9.3.7 Wing walls

Elevation of wing walls near trench = 589.500 + 1.50 = +591.000m

Elevation of wing walls at u/s end = +593.000m

Elevation of wing walls at d/s end = +588.000m

9.3.8 Aprons

Upstream and downstream aprons are provided to achieve a uniform flow across trench weir. The aprons will also help to avoid erosion of river bed. Since there is no flooding up of water in the upstream of trench weir, a minimum of 900mm thick Colgrout masonry concrete cast in site as core and a topping of M_{20} concrete of 20cm thickness is provided. 1500x1500x1000mm Gabion revetments are provided to make up any pools in river bed in the vicinity of upstream and downstream aprons.

9.3.9 Trash rack

The trash rack of the trench weir is kept at the same bed slope of upstream aprons.

Slope of trash rack	=	1 in 10
Clear gap of trash rack bars	=	25mm
Size of trash rack bars	=	100mm x 10mm

The 18m long trash rack is divided in to 12 panels of 1500mm long.

Panel end bars may be made out of 200mm x 16mm. 3 Nos 90x90x10 MS angles shall be provided between end bars for supporting the internal bars.

9.4 Intake Channel / Feeder Channel (Box type)(Ch: -58 to -49m)

The cross section and bed slope of trench is adopted for intake channel to avoid clogging. Intake channel will be functioning even if the channel is clogged 50% of its depth. Box channel is provided with a wall thickness of 350mm. 50mm thick abrasion resistant coat is provided on sides and bottom.

Inside width of intake channel	=	2000 mm
Free board	=	500 mm
Bed level at inlet	=	+585.780
Bed slope	=	1 in 25
Length of channel	=	9 m
Bed level of channel at intake chamber	=	+585.42m
Depth of Channel (incl. free board)	=	2720 ~ 3080 mm

Provide a vent pipe of 150mm dia GI pipe near trench weir.

9.5 Intake Chamber (Ch: -49 to -43m)

Design Reference: Section 1.3.5 of AHEC Guidelines For Hydraulic Design Of Small Hydro Plants /May 2011

The guide lines do not specify the capacity of intake chamber. A rectangular RC tank of 4m x 4m is provided. 1.50m deep conical bottom is provided to flush out the bed load coming from trench weir. Flushing pipe shall be designed for 5% design discharge of trench weir, velocity shall be taken as 4 -5 m/sec. Flushing of sediment is done in high flow condition in stream. The head available to flush the sediment shall be equal to difference in HFL in intake well and HFL in the stream at the fall of the pipe. A gate valve is provided to flush out the bed load. A valve chamber of 1200x1500 is provided.

To prevent vortices, length of intake well is kept 2-3 times width of trench/ intake channel. Sufficient space in provided for accumulation of sediment in intake well. Bed level of intake well is usually at least 0.5m – 1m lower than bed level of power duct. Water level in power duct is fixed 0.15m below water level in intake well to provide sufficient head for flow into duct. Intake chamber with gravel excluder were provided for a length of 100m and the same can be discharged to down stream along the power duct route. Reverse slope 1 in 1 is limited up to a length of 20m & bed slope of 1:400.

9.5.1 Intake Gate

Since the feeder conduit is box shaped, having a size of 1.7m x 1.7m, the gate section of same size is provided. Hence there is no need of complicated transitions.

Height of gate opening = 1700 mm

Width of opening = 1700 mm

9.5.2 Bell mouth entry

Ref: IS 9761: 1995

Elliptical Bell mouths are provided to minimize the entry loss and avoiding turbulence.

Top and Bottom profile semi major axis = 1.10 x 1700 = 1870 mm

Top and Bottom semi minor axis = 0.291 x 1700 = 494.7mm

Say = 495 mm

Side profile semi major axis = 0.55 x 1700 = 935 mm

Side profile semi minor axis = 0.2143 x 1500 = 321.5 mm

Say = 322 mm

Ref: (Permissible velocity page no.16)

Design discharge = 8.61 m^3/s

Area of gate = 1.7 x 1.7 = 2.89 m2

Velocity at gate = $\frac{8.61}{2.89}$ = 2.979 m/s

(AITEC guide lives in hydraulic design of small hydro plants, clause 1.4.2 page 15)

Submergence depth, S = $0.725\ V.D^{0.50}$

= $0.725 \times 3.0 \times 1.7^{0.50}$

Say S = 2.82 m

Length of channel = 9 m

Slope 1 in 25, hence loss = $\frac{9}{25}$ = 0.36m

Loss of head in intake channel = 0.36 m

F.S.L in Intake chamber = 588.000 – 0.36

= +587.64m

Required centre line of power duct = 587.64 – 1.70/2 – 2.82

= +583.97m

Say provide = +583.97m

9.5.3 Safety grill

Since the entry of water from river is through trash rack, no separate trash racks are provided in front of bell mouth entry to intake pipe. The top of intake chamber is open to atmosphere. The top level is kept above the maximum flood water level. The top of intake chamber is covered with M.S safety grill to prevent the accidental falling of any foreign matters in to the chamber. An Inspection chamber shall be provided at a suitable corner to access the intake chamber for maintenance. Cat ladder shall be provided by means of 16mm dia M.S rungs near the inspection chamber.

9.6 Power Duct (Chainage -43.00 m to 37.00 m)

Design discharge = 8.61 m^3/s

Take non settling velocity as 3 m/s.

Required area of box conduit = $\frac{8.61}{3}$ = 2.87 m^2

Required size = 1.7 m

Provide 1.7m x 1.7m RCC M25 grade box conduit with a 150mm chamfering at corners.

Actual area of cross section = 1.7 x 1.7– 4 x 0.50 x 0.15 x 0.15

= 2.845 m^2

Actual velocity = $\frac{8.61}{2.845}$ = 3.03 m/s > 3

Frictional loss = $\frac{flv^2}{2gD}$

Coefficient of friction, f = 0.012

D is taken as the diameter of an equivalent perimeter section

Perimeter of 1.70 x 1.70m box conduit = $6.8 - 4 \times 0.30 + 4 \times 0.15 / 0.707$

= 6.45

Hydraulic mean radius R = $\frac{A}{P} = \frac{2.845}{6.45} = 0.44$ m

Ref: IS:4880 (Part-III) Section 4.1.2

Equivalent diameter D = $4R = 4 \times 0.44 = 1.76$m

Frictional loss = $\frac{flv^2}{2gD}$

Friction coefficient, f = $\frac{K_s}{D}$

Assume surface characteristics are **rough** by continuous erosion of sharp materials in transit.

Take, K_s = 0.60 mm

Friction coefficient, f = $\frac{0.60}{1760} = 0.3409 \times 10^{-4}$

Frictional loss = $\frac{0.3409 \times 10^{-4} \times 80 \times 2.979^2}{1.76 \times 2 \times 9.81}$

= 0.000701m

Loss in bell mouth = $\frac{k v^2}{2g}$

Where k = 0.10, velocity at gate, v = 2.979 m/s

Loss in bell mouth = $\frac{0.10 \times 2.979^2}{2 \times 9.81}$

= 0.045m

Total loss = 0.000701 + 0.047

= 0.047701m

The difference between intake chamber F.S.L and Feeder Channel F.S.L must be greater than total loss in pipe.

F.S.L of intake chamber = +587.64m

F.S.L of Power channel = +586.920m

Difference in F.S.L = 587.64 – 586.920

= 0.72m > 0.047701

9.7 Surplus Weir No.1(Chainage;37m to 43.4m)

H.F.L in Intake chamber = +589.5000

Crest level of surplus weir = +586.920

Difference in head = 589.500 – 586.920 = 2.58 m

Ignoring other losses

Discharge through gate = $C_d \times b \times d \times \sqrt{2gH}$

Take C_d as 0.75 = $0.75 \times 1.50 \times 1.50 \times \sqrt{2} \times 9.81 \times 2.58$

= 12.01 m^3/s

Surplus discharge required = 12.01 – 8.61 = 3.3961 m^3/s

To minimize the entry of excess flow during high flood, the head of water over the crest level of surplus weir is limited to 500mm.

Ref: IS 6934: 1998

Approach flow depth P = 1.50 m

Design head H_d = 0.50 m

P/H_d = 3

From Fig. 3 of IS 6934, coefficient C = 0.74

Length of Ogee weir required = $\frac{Q}{2/3 \times C \times \sqrt{2g}\, H^{3/2}}$

= $\frac{3.4}{2/3 \times 0.74 \times \sqrt{2} \times 9.81 \times 0.50^{3/2}}$

= 4.4 m

Say provide = 4.4 m

Transition 2m is provided. = 4.4 +2

Length of Ogee weir required = 6.4 m

9.7.1 Ogee Profile of Surplus Weir

Approach flow depth P = 1.50 m

Head over crest, H_d = 0.50 m

Ratio, $\frac{P}{H_d} = \frac{1.50}{0.50} = 3.00$

From Fig. 2 of IS 6934,

$\frac{A_1}{H_d} = 0.280$, $\frac{B1}{H_d} = 0.164$, $K_2 = 2$

Upstream profile Semi Major Axis, A_1 = 0.28 x 0.50 = 0.140 m

Upstream profile Semi Minor Axis, B_1 = 0.164 x 0.50 = 0.082 m

Down stream profile $X_2^{1.85} = K_2 H_d^{0.85} Y_2$

Substituting different values for Y_2, we get corresponding X_2

Y_2	0.02	0.04	0.06	0.08	0.1	0.12	0.14	0.16	0.18	0.25	0.3	
X_2	0.128	0.186	0.231	0.270	0.305	0.336	0.365	0.393	0.419	0.500	0.552	
Y_2	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
X_2	0.687	0.727	0.766	0.803	0.838	0.872	0.905	0.938	0.969	0.999	1.029	1.058

Ogee profile co-ordinates of Surplus weir

9.7.2 Surplus Channel

Design discharge = 3.4 m^3/s

Assume width of channel B = 2.50 m

Depth of channel d = 1.10 m

Rugosity coefficient, n = 0.018

Area A = 2.75 m^2

Wetted Perimeter P = 5.62 m

Hydraulic radius, R = $\frac{A}{P}$

= 0.489

Slope of channel s = 1/400 = 0.0025

Discharge, Q = $1/0.018 \times 2.75 \times 0.489^{2/3} \times 0.0025^{0.50}$

= 4.74 m^3/s > 3.4 m^3/s

Provide 2.50 x 1.10 (water depth) + 0.85m free board for surplus channel.

9.8 Power Channel (Chainage: 43.4 to 1148)

RC Rectangular and Trapezoidal shaped Power channel leads the water from intake chamber to forebay. The maximum flow velocity in RCC lined channel is limited to 2 m/s.

9.8.1 Channel Section (Rectangular)

Design discharge Q = 7.175 m^3/s

Assume width of channel B = 2.9m

Trial Depth of channel d = 1.50 m

Provide 200mm haunch at bottom corner for structural safety.

Rugosity coefficient, n = 0.018

Area	A	=	2.9 x 1.50
		=	4.35 m^2
Wetted Perimeter	P	=	2.9+2x1.50
		=	5.9 m
Hydraulic radius,	R	=	A / P
		=	0.737
Slope of channel	s	=	1 / 750
Velocity as per Manning's equation, V		=	$\frac{1}{0.018} \times 0.737^{2/3} \times 1/750^{0.50}$
		=	1.654 m/s < 2.00 m/s
Discharge,	Q	=	1.655 x 4.35
		=	7.196 m^3/s > 7.175 m^3/s

Provide 2.90 x 1.50 (water depth) for power channel.

9.8.2 Channel Section (Trapezoidal)

Design discharge,	Q	=	7.175m^3/s
Assume base width of channel,b		=	1.40 m
Depth of channel (flow)	d	=	1.50 m
Side slope of channel,	i	=	1 in 1
Rugosity coefficient,	n	=	0.018
Area,	A	=	(b+ i x d) d
		=	(1.40 + 1x 1.50) x 1.50
		=	4.35 m^2
Wetted Perimeter,	P	=	(b + 2d) x $\sqrt{1+i}$
			= 1.40 + (2 x 1.50) x $\sqrt{1+1}$
		=	5.643 m
Hydraulic radius,	R	=	$\frac{A}{P} = \frac{4.35}{5.643}$ = 0.771
Slope of channel	s	=	1/750
Velocity as per Manning's equation, V		=	$\frac{1}{0.018} x 0.771^{2/3} x \frac{1}{750}^{0.50}$
		=	1.706 m/s
Discharge,	Q	=	4.35 x 1.706

= 7.421 m^3/s >7.175m^3/s

Top width of channel = (b + 2nd) = (1.40 + 2 x 1.50)

= 4.40m

9.8.3 Free board

Provide a minimum free board of 750mm.

(Refer, AHEC page 24 clause 2.1.3)

9.9 Surplus Weir No: 2 & 3

Location: @ Chainage – 370 to 380 , @ Chainage – 1020 to 1030

The Surplus weir permits a safe route to discharge water in case of accidental blockage in open channel and limits the breaching of canal bank to a minimum extent. The free board of canal is reduced to 100mm permitting overflowing through this section. The overflow section is constructed as a narrow crested weir and the downstream service road is lowered to form an Irish drain to permit a safe passage of spilling water.

9.9.1 Narrow Crested Weir

Design discharge Q = 8.61 m^3/s

Assume C_d = 0.623

Since the escape weir is placed parallel to the flow, the velocity approach may be neglected.

Assume length of emergency escape = 10 m

Head over the crest H = $\frac{\sqrt[2/3]{3\,Q}}{\sqrt{2}\,C_d\,b\,\sqrt{2\,g}}$

= $\frac{\sqrt[2/3]{3 \times 8.61}}{\sqrt{2} \times 0.623 \times 10 \times \sqrt{2 \times 9.81}}$

= 0.603m

Available depth = 0.75 – 0.10 = 0.650 > 0.603

9.9.2 Irish Drain

The service road is lowered by 0.50m to form an Irish drain for a width of 12.5m.

Side slope of Irish drain is taken as 1 in 10.

Design discharge Q = 8.61m^3/s

Bottom width = 12.5 m

Side slope		=	1 in 10
Bed slope across service road, s		=	1 in 100
Rugosity coefficient	n	=	0.020
Trial depth of flow	d	=	0.29 m
Top width		=	18.30 m
Area	A	=	4.466 m^2
Wetted perimeter	P	=	18.30 m
Hydraulic radius	R	=	0.244
Velocity by Manning's	V	=	$\frac{1}{0.020} \times 0.244^{2/3} \times 0.01^{1/2}$
		=	1.954 m/s
Actual Discharge		=	4.466 x 1.954 = 8.726> 8.61
Width of revetment for Irish drain		=	wetted perimeter + 1.00
		=	18.30 + 1.00 = 19.30 m
	Say	=	19.50 m

Provide 3.50 + 12.5 + 3.50 m wide revetment at a longitudinal bed slope of 1 in 100 and side slope of 1 in 10.

9.10 Forebay

The live storage volume of the forebay tank should be determined according to the response characteristics of the turbine governors. Normally, a volume of 2 minutes design discharge of turbine is provided. The live storage draw down of 1 to 2m

below the crest of escape weir is recommended. But the KSEB's practice is to design for a higher depth for minimizing the tank area. Live storage depth of 3m is taken for the hydraulic design of forebay tank. The crest level of escape weir is kept lowered than the full supply level of power canal exit to minimize the effect of back water curve in canal. This arrangement can minimize the undue increase in canal free board.

Design discharge	Q_P	=	7.175 m^3/s
Live storage required		=	2 x 60 x 7.175 = 861.00 m^3
F.S.L of Canal exit		=	+585.38
F.S.L of forebay		=	+585.38

Crest level of escape weir	=	+584.88
Height of automatic falling shutter	=	0.50 m
M.D.D.L of forebay	=	585.384 – 3.00 = +582.384
Live Capacity provided (Ref. Drawing)	=	[13 x 18 +1/2 (5.64 x 4.77)] x 3
		+[(2.8 + 13) x10/2] 2.25
	=	920 m^3 > 861

9.10.1 Intake Gate

Height of gate opening	=	dia of penstock = 1400 mm
Width of opening	=	1400 x 0.785 = 1099 mm
Say provide	=	1099 mm

9.10.2 Bell mouth entry

Ref: IS 9761: 1995

Elliptical Bell mouths are provided to minimize the entry loss and avoiding turbulence.

Top and Bottom profile semi major axis	=	1.10 x 1400 = 1540 mm
Top and Bottom semi minor axis	=	0.291 x 1400 = 407.4 mm
Side profile semi major axis	=	0.55 x 1099 = 604.45 mm
Side profile semi minor axis	=	0.2143 x 1099= 235.52 mm
Design discharge penstock	=	7.175 m^3/s
Area of gate	=	1.4 x 1.099 = 1.539 m^2
Velocity at gate	=	$\frac{7.175}{1.539}$ = 4.66 m/s

Submergence depth,	S	=	0.725 $V.D^{0.50}$
		=	0.725 x 4.66 x $1.40^{0.50}$
		=	3.997 m
Say	S	=	3.997 m
Required centre line of intake pipe		=	582.38 – 3.997 – 1.40/2
		=	+577.683m
Say provide		=	+577.683m
Sill level of Bell mouth		=	577.85– 1.40/2 – 0.407
		=	+576.576m

Considering silt storage if any, provide the bottom level of tank as +575.000m

Size of Fore bay tank = 28 x 13 x 2.5 to 11.5m

9.10.3 Trash Rack

The vertical trash rack in fore bay separates the floating debris and foreign materials entering to the open water conductor system during the course of travel. Trash racks are installed as panels for easy maintenance and installation. The flow velocity through trash rack bars are limited to 0.75 m/s for manual raking. The trash racks should be sloped at 14° to vertical (4V:1H) to facilitate manual raking.

Design discharge = 7.175 m^3/sec

Limiting velocity for manual racking = 0.75 m/sec

Consider 50% area is clogged

Area of trash rack required = $2 \times \frac{Q}{V_{limit}}$ = $2 \times \frac{7.175}{0.75}$

= 19.13 m^2

Provide 10mm thick MS flat at a clear gap of 50mm

Assume Ratio of Actual area to Net area=1.30

Slope of trash rack panels = 4V:1H

Provide 3 Nos Trash rack slots symmetrically arranged in the shape of a semi hexagon.

Clear width of trash rack slot = 1.9m

Slanting length of trash rack slot = 4.4 m

No. of panels per slot = 3 Nos

Total effective area of trash racks = $3x \frac{1.9 \times 4.4}{1.30}$

= 19.29 m^2 > 19.13 m^2

Overall size of panels = 2000 x 1460 (9 Nos)

9.10.4 Intake gates

A service gate of size 1.1m x 1.40m is provided to control the flow. The bell mouth curve ends at 1.54m from the inner face of forebay. The service gate shall be placed at 2.15m away from inner face.

9.10.5 Air Vent

Ref . AHEC – Guidelines for Hydraulic Design of small Hydro plants / Feb2008

$$Av = \frac{Q_T}{25}$$

$$= \frac{6.86}{25}$$

$$= 0.2744$$

Diameter required d = 0.594m

Say provide an air vent pipe of 600mm dia.

9.10.6 Escape Weir

Escape weir is provided on the rim of fore bay tank. Since the desilting tank is operated intermittently, the discharge allocated for silt flushing is also likely to enter in fore bay.

Ref: IS 6934: 1998

Design discharge Q = 8.61

Approach flow depth P = 2.35 m

Design head H_d = 0.50 m

P/H_d = 4.70

From Fig. 3 of IS 6934, coefficient C = 0.742

Length of Ogee weir required = $\frac{Q}{2/3 \times C \times \sqrt{2g}\, H^{3/2}}$

= $\frac{8.61}{2/3 \times 0.742 \times \sqrt{2} \times 9.81 \times 0.5^{3/2}}$

= 11.12 m

Say provide = 11 m

9.10.7 Ogee Profile of Escape Weir

From Fig. 2 of IS 6934,

$\frac{A_1}{H_d}$ = 0.280, $\frac{B_1}{H_d}$ = 0.614 , K_2 = 2

Upstream profile Semi Major Axis, A_1 = 0.280x 0.50 = 0.140m

Upstream profile Semi Minor Axis , B_1= 0.164x.50 = 0.082m

Down stream profile $x_2^{1.85}$ = $K_2 H_d 0.85 Y_2$

Substituting different values for Y_2 , we get corresponding X_2

Y_2	0.02	0.04	0.06	0.08	0.1	0.12	0.14	0.16	0.18	0.25	0.3	
X_2	0.128	0.186	0.231	0.270	0.305	0.336	0.365	0.393	0.419	0.500	0.552	
Y_2	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
X_2	0.687	0.727	0.766	0.803	0.838	0.872	0.905	0.938	0.969	0.999	1.029	1.058

Ogee profile co-ordinates of Escape weir

9.10.8 Escape Channel

Design discharge		=	8.61 m^3/s
Assume width of channel	B	=	4.00 m
Trial Depth of channel	d	=	1.180 m
Rugosity coefficient,	n	=	0.018
Area	A	=	4.72 m^2
Wetted Perimeter	P	=	6.36 m
Hydraulic radius,	R	=	$\frac{A}{P}$
		=	0.742
Slope of channel	s	=	$\frac{1}{450}$
		=	0.00222
Discharge,	Q	=	$\frac{1}{0.018} \times 4.2 \times 0.742^{2/3} \times 0.00222^{0.50}$
		=	10.12m^3/s > 8.61 m^3/s

Provide 3.00 x 1.18 (water depth) + 0.62m free board for escape channel.

Overall size of escape channel

Inside width	=	4.00 m
Height	=	1.80 m

9.11.Penstock (Spirally Welded Steel Pipe)

The total length of penstock from fore bay transition to the feeder pipe branching point near power house is 319.02m. IS 2002, Gr. II steel (Minimum tensile strength 410 MPa) is used for penstock shell. The penstock is designed as a surface penstock supported on rocker supports preferably at 10m interval. For SHP's the velocity in penstock is preferably less than 5m/s. Spirally welded Steel pipe confirming to IS – 3589-1981 is proposed to be used for penstock.

9.11.1 Hydraulic Design of Main Pipe

Design discharge	Q	=	7.175 m^3/s
Net head	H	=	118 m
	V	=	5 m/sec

$$A = \frac{Q}{V}$$

$$= \frac{7.175}{5}$$

$$= 1.435 \text{ m}^2$$

$$\frac{\pi \times d^2}{4} = 1.435$$

$$d = 1.35\text{m}$$

Provide 1.4 m diameter penstock.

Select 1.40m dia penstock.

Actual area $A = \frac{\pi \times 1.40^2}{4} = 1.539 \text{ m}^2$

Actual velocity	$= \frac{Q}{A} = \frac{7.175}{1.539} =$ **4.66** m/s

Minimum tensile strength of IS 2002, Gr.II = 410 N/mm^2 (IS – 3589-1981clause 6.1)

Ultimate strength = 530 N/mm^2

Yield strength = 265 N/mm^2

Tensile strength / 3 = 136.667 N/mm^2

50% of yield strength = 132.500 N/mm^2

Permissible strength = 132.500 N/mm^2

Minimum handling thickness $= \frac{D + 50}{400} = 4.55$ mm

Maximum thickness of pipe required,t = Pd/ 2 fs

Where, p = wh

W = Specific weight of water in kg/m^3

Fs = Allowable tensile stress

To accommodate surge effect due to sudden closure 25% allowance in head is taken for calculation.

h = (FSL at forebay – Lowest C/L of penstock at power house end) 1.25

= (585.5 – 466.527) 1.25

= 148.7

$t = \frac{1000 \times 148.7 \times 1.4}{2 \times 13250}$

= 7.85 mm

Provide 8 mm thickness.

9.11.2 Hydraulic Design of Feeder Pipe

The penstock bifurcates into two feeder pipes to feed the two machines. Let Q be the discharge in main pipe and Q_1 be the discharge in feeder pipe. D be the diameter of main pipe and D_1 be the diameter of feeder pipe.

The ratio between Q and Q_1 will be 2.

$$\frac{Q}{Q_1} = \frac{D^{2.50}}{D_1^{2.50}}$$

$$2 = \frac{1.4^{2.50}}{D_1^{2.50}}$$

$$D_1 = \left(\frac{1.4^{2.50}}{(2)}\right)^{2/5}$$

Diameter of feeder pipe = 1.06 m

Say provide 1.1m dia feeder pipe.

Actual area A = $\frac{\pi \times d2}{4} = \frac{\pi \times 1.1^2}{4} =$ 0.95 m^2

Actual velocity = $\frac{Q}{A} = \frac{7.175}{2 \times 0.95} =$ **3.78** m/s

9.11.3 Feeder pipes

Provide 8mm thick 1100mm ID feeder pipe with IS 2002, Gr. II. The feeder pipes are fully encased in concrete.

9.11.4 Y – Piece

The Y – Piece at bifurcation junction may be fabricated with 8mm IS 2002, Gr. II steel plates

9.12 Power House (Horizontal Francis Turbine)

9.12.1 Runner Diameter

Trial specific speed (based on economy criterion)

n_s varies between $\frac{1553}{\sqrt{Hr}}$ & $\frac{2334}{\sqrt{Hr}}$

Average net head / Design head with 2 machine combination working full gate = 120.38m

Corresponding rated discharge = 6.116 m^3/sec

(Hr) Rated head = 120.38

Rated out put of turbine = $\frac{3000}{0.95}$ = 3158 KW

Pr = $\frac{3158}{0.736}$

= 4291 MHP

Trial specific speed ns' = $\frac{1553}{\sqrt{120.38}}$ to $\frac{2334}{\sqrt{120.38}}$

= 141.54 to 212.73

Average ns' = $\frac{141.54 + 212.73}{2}$

= 177.13

Trial rotational speed n' = $\frac{ns\ (Hr)^{5/4}}{\sqrt{Pr}}$

= $\frac{177.13 \times (120.38)^{5/4}}{\sqrt{4291}}$

= 1078

For 3 pair poles , n = 60 x 50/3 = 1000 rpm

For 2 pair poles , n = 1500 rpm

Maximum gross head = FRL – TWL

= 585.38 – 460

= 125.38

Minimum gross head = MDDL - TWL

= 582.38 – 461.5

= 120.88

Variation of head = 125.38 – 120.88

= 4.5m

10 % of 120.38 = 12.38

4.5 < 12.38 , Hence select higher speed

Design rotational speed n = 1500 rpm

Design specific speed ns = $\frac{n\sqrt{Pr}}{}$

$$Hr^{5/4}$$

$$= \frac{1500 \times (4291)^{1/2}}{(120.88)^{5/4}}$$

$$= 245.15$$

Turbine setting , Hs = Hb – Hv - σHcr

At 20 degree Celsius Hb – Hv = 9.35

For one m/c working at over loading,Hcr = FRL – TWL (one machine over loading)

$$= 585.38 - 460.6298$$

$$= 124.75$$

$$\sigma = \frac{ns^{1.64}}{50327}$$

$$= \frac{245.15^{(1.64)}}{50327}$$

$$= 0.165$$

There fore , Hs = 9.35 – 0.165 x 124.75

$$= -11.23$$

Hence sitting is too low, choose next lower speed.

Design speed for revised rotational speed

$$ns = \frac{n\sqrt{Pr}}{Hr^{5/4}}$$

$$= \frac{1000 \times (4291)^{1/2}}{(120.88)^{5/4}}$$

$$= 163.43$$

$$\sigma = \frac{ns^{1.64}}{50327}$$

$$= \frac{163.43^{(1.64)}}{50327}$$

$$= 0.0847$$

There fore , Hs = 9.35 – 0.0847 x 124.75

$$= -1.129$$

Centre line of machine = 460.6298 – 1.129

		=	459.5
Rock level at PH site		=	455.6 m
Velocity ratio	θ_3	=	$0.0211 \times ns^{2/3}$
		=	$0.0211 \times 163.43^{2/3}$
		=	0.6286 ~0.63
Runner dia	D_3	=	$\frac{84.47\ \theta_3 \sqrt{H_r}}{n}$
		=	$\frac{84.47 \times 0.63 \times (120.88)^{0.5}}{1000}$
	D_3	=	0.59m
C/L of machine		=	459.5
C/L of distributor		=	459.5– 1.4 x 0.59
		=	458.67

As per IS 12800 (part 3) 1991

From fig. of Power House layout – Horizontal Francis turbine

Machine floor level	=	458.67 – 1
	=	457.67
Depth of draft tube	=	$4.5 \times D_3 + 1$
From C/L distributor	=	4.5 x 0.59 + 1
	=	2.75 + 1
	=	3.66
Bottom of draft tube chamber	=	458.67 – 3.66
	=	+ 455.01 m
Width of individual tail race	=	3.8 D
	=	3.8 x 0.59
	=	2.3 m
Length of draft tube chamber	=	5D
	=	2.95 m
Unit width (Unit spacing)	=	4D + 2.7
	=	4 x 0.59 + 2.7
	=	5.06
Say	=	5.1
Floor Level of Tail Race Pool	=	459.5– 3.66 – 2

= 453.84

9.12.2 POWER HOUSE BUILDING

Highest flood level at tail race exit = + 460.850 m

Yard level = +464.50m

Service bay level = +464.50m

Control room level = +468.50m

Switch gear room level = + 464.50m

Service bay width = 1.25 x unit width

Ls = 1.25 x 5.1

= 6.12 m ~ 6.2 m

INSIDE LENGTH OF POWER HOUSE

Inside length of power house at machine room level

= space of service bay + (turbine + shaft+ gear box + generator) 2+clearence

= 6.2+(2.3x0.59+2x0.59+3+2.8)2+2+3.04+1.4

= 29.50 m

Width of power house = (4D + 2.7)+ space to BFV + wall thickness

= 5.1 + 2.5 + 1

= 8.56 m

Considering the space for approach, stair case and operating space a total thick of 10m is provided at machine floor level.

The size of machine room will be = 29.50 x 10 m

Space for control room, battery room etc are provided in addition to the above considering the maximum size of parts to be erected and the clearance required the height crane bottom from service bay is taken 7 m ,(+471.500 m)

Height of power house above crane hook level = 3 m

Height of power house building from service bay = 8 m (+ 474.500 m)

9.13 Tail Race

9.13.1 Tail race pool

After power generation, the tail race channel leads the water back in to the river. A head regulating weir is provided at the outlet of tail race pool.

Provide length of tail race chamber = 15.00m

Provide a reverse bed slope of 1 in 3.50 up to the tailrace weir crest level.

Overall size of tail race pool = 15 m x 12.50m

9.13.2 Tail race weir

Discharge, Q = $\frac{6000}{8.15 \times 120.38}$

= 6.116 m^3/s

Discharge at machine full load = 6.116 m^3/s

Assume length of tail race weir crest = 3.5 m

Discharge, H = $\frac{(Q)^{2/3}}{(1.7 C_d L)}$

Head over crest, H = $\frac{[6.116]^{2/3}}{[1.7 \times 1 \times 3.5]}$

= 1.02m

Say = 1.000 m

Normal tail-water level = +461.000

Tail race crest level = 461.000 – 1.000 = +460.000

9.13.3 Minimum Tail water level

Discharge at no load condition = 0.156 m^3/s

Head over crest = $\frac{[0.156]^{2/3}}{[1.7 C_d L)}$

= $\frac{[0.156]^{2/3}}{[1.7 \times 1 \times 3.5]}$

= 0.088 m

Rounded to = 0.090 m

Minimum tail water level = 460.000 + 0.090 = +460.090m

9.13.4 Maximum tail water level

Maximum discharge when overloading = 1.15 x 6.116

= 7.033 m^3/s

Head over crest = $[7.033]^{2/3}$

$$= \frac{[1.7\ C_d\ L)}{[7.033]^{2/3}} \quad [1.7 \times 1 \times 3.5]$$

Rounded to = 1.12

Maximum tail water level = 460.000 + 1.12

= +461.12m

9.13.5 Tail race channel

A rectangular section of tail race channel is provided. An R.C.C box culvert of 5m wide is provided to cross the tail race channel.

Design discharge	Q	=	7.033 cumecs	
Assume width	b	=	3.7 m	
Trial depth	d	=	0.99 m	
Area	A	=	3.7 x 0.99	= $3.663m^2$
Wetted perimeter,	P	=	5.68	
Hydraulic mean depth,	R	=	0.64	
Rugosity coefficient n		=	0.018	
Slope of Channel	s	=	1 in 400	
Actual velocity,	V	=	$\frac{1}{0.018} \times 0.64^{2/3} \times \frac{1^{1/2}}{400}$	
		=	1.967 m/s < 2 m/s	

Permissible velocity in concrete channel is 2 m/s

Actual discharge, Q = A V = 3.663 x 1.967

= 7.21 Cumecs > 7.033

Hence provide a box section of 3.7 m wide, 1.00m water depth with a free board of 0.750m and longitudinal bed slope of 1 in 400 up to the boundary wall and open channel with aprons in the river bed.

9.13.6

HEAD LOSSES IN PENSTOCK

Different losses in penstock are calculated as follows.

Velocity in penstock	v	= 4.66	m/s

1 Frictional loss

Ref :IS 11625, section 4.4.1.2

Penstock Pipe

Total length of main pipe ,	L	= 307.18	m
Diameter of pipe ,	D	= 1.4	m
Manning's roughness coefficient,	n	= 0.012	m2
	A	$= \frac{\pi \times 1.4^2}{4}$	
		= 1.539	m^2
Hydraulic radius	R	= A/P	m^2
		$= \frac{1.539}{\pi \times 1.4}$	
		= 0.350	m
Slope of energy gradient ,	s	$= \left(\frac{(V \times n)^2}{(R^{2/3})}\right)$	
		$= \left(\frac{4.66 \times 0.012^{\ 2}}{0.350^{2/3}}\right)$	
		= 1.2677791E-02	
		= 0.0126777913	
Head loss	hfp	= Lx S	
		= 307.18 x0.0127	
		= **3.901 m**	

Feeder Pipe

Length of feeder pipe	L	= 14	
Velocity in feeder pipe	v	= 3.78	m/s
	A	$= \frac{\pi \times 1.1^2}{4}$	
		=	0.950 m^2

Hydraulic radius R

$= A/P$

$= \frac{0.95}{\pi \times 1.1}$

$= 0.275$ m

Slope of energy gradient S

$= \left(\frac{(V \times n)^2}{(R^{2/3})} \right)$

$= \left(\frac{3.78 \times 0.012^2}{0.275^{2/3}} \right)$

$= 1.1505421E-02$

$= 0.012$

Head loss Hfp

$= L \times S$

$= 14 \times 0.012$

$= \mathbf{0.168}$ m

2 Trash rack loss

By Kirschmer formula,Trash rack loss, Ht

$= \frac{Kt(t)^{1/3} \times (V0^2)\sin\Phi}{(b) \times (2g)}$

Coefficient forplane flat bars Kt

$= 2.40$

Clear gap between trash rack bars , b

$= 0.05$

Thickness of trash rack bars , t

$= 0.01$

Limiting velocity V0

$= 0.75$ m/s

Angle of trash rack from horizontal, Φ

$= 75^\circ 57' 50''$

Ht

$= \frac{2.4(0.010)^{1/3} \times (0.75^2) \sin 75^\circ 57' 50''}{(0.050) \times (2 \times 9.81)}$

$= \mathbf{0.0044}$ m

3 Entrance loss

Entrance loss , he

$= KeV^2/2g$

For bellmouth entry Ke

$= 0.10$

$= \frac{0.10 \times 4.66^2}{2 \times 9.81}$

$= \mathbf{0.111}$ m

4 Gate loss

Valve loss Hg = $KgV^2/2g$ m^2

Coefficient , Kg = 0.10

$$= \frac{0.10 \times 4.66^2}{2 \times 9.81}$$

= **0.111 m**

5 Bend loss

Bend - 1 (vertical)

u/s angle from horizontal , ά = 0.0

d/s angle from horizontal , β = 21° 26' 52"

Deflection angle , Δ = 21° 26' 52"

From fig 3 , Kb for Δ = 21° 26' 52" and r/D ratio 4 is = 0.04

Bend loss , Hb = $KbV^2/2g$

$$= \frac{0.04 \times 4.66^2}{2 \times 9.81}$$

= **0.04427**

Bend - 2 (vertical)

u/s angle from horizontal , ά = 21° 26' 52"

d/s angle from horizontal , β = 19° 37' 20"

Deflection angle , Δ = 1° 49' 32"

From fig 3 , Kb for Δ = 1° 49' 32" and r/D ratio 4 is = 0.004

Bend loss , Hb = $KbV^2/2g$

$$= \frac{0.04 \times 4.66^2}{2 \times 9.81}$$

= **0.00443**

Bend - 3 (horizontal)

u/s angle from horizontal , ά = 0.0

d/s angle from horizontal , β = 28° 30' 00"

Deflection angle , Δ = 28° 30' 00"

From fig 3 , Kb for Δ = 28° 30' 00" and r/D ratio 4 is = 0.055

Bend loss , Hb = $KbV^2/2g$

$$= \frac{0.055 \times 4.66^2}{2 \times 9.81}$$

= **0.061**

Wye

u/s angle from horizontal , α = 0.0

d/s angle from horizontal , β = 45° 00' 00"

Deflection angle , Δ 45° 00' 00"

From fig 3 , Kb for Δ = 45° 00' 00" and r/D ratio 4 is = 0.084

Bend loss , Hb $KbV^2/2g$

$$= \frac{0.084 \times 4.66^2}{2 \times 9.81}$$

= **0.0930**

Bend -4 (Feeder pipe)

Deflection angle , Δ = 45° 00' 00"

From fig 3 , Kb for Δ = 45° 00' 00" and r/D ratio 4 is = 0.084

Bend loss , Hb = $KbV^2/2g$

$$= \frac{0.084 \times 3.78^2}{2 \times 9.81}$$

= **0.0612**

Bend - 5 (Feeder pipe)

Deflection angle , Δ = 25° 18' 05"

From fig 3 , Kb for Δ = 45° 00' 00" and r/D ratio 4 is = 0.05

Bend loss , Hb = $KbV^2/2g$

$$= \frac{0.05 \times 3.78^2}{2 \times 9.81}$$

= **0.0364**

Loss in Manifold

Transition loss , hm = $KmV^2/2g$

Km = 0.80

$$= \frac{0.80 \times 4.66^2}{2 \times 9.81}$$

= **0.885**

The various losses in penstock are tabulated below

Item	Head (m)	Item	Head (m)
Frictional loss		**Bend loss**	
Penstock	3.901	Bend - 1	0.04427
Feeder pipe	0.168	Bend - 2	0.004
Trash rack loss	0.0044	Bend - 3	0.061
Entrance loss	0.111	Wye	0.0930
Gate loss	0.111	Bend - 4	0.0612
Manifold	0.885	Bend - 5	0.0364
Total	5.180		0.30012
Total Loss		=	**5.4805151**

CHAPTER - 10

ESTIMATE

10.1 General

The main civil works include construction of trench weir, power channel , Forebay, penstock, powerhouse, tailrace and facilities such as roads. The mechanical work includes the manufacture, fabrication and erection of gates. The electromechanical work includes erection and commissioning of 2, 3 MW capacity generating equipments, erection of EOT crane, auxiliary equipments for dewatering, cooling etc. and construction of transmission towers and lines.

The estimate is prepared based on revised PWD Schedule of Rates 2012. Total cost of Civil works comes to ₹ 30.08 crore. Total cost of Electrical works comes to ₹ 24.00 crore. Overall cost of the project comes to ₹ 54.08 crore.

GENERAL ABSTRACT OF ESTIMATE

	Direct Charges	Rs. lakhs
I	Works	
a)	Civil works	2857.58
b)	Electric works (including Establishment Charges, T&P)	2400.00
II	Establishment	
a)	Civil works	128.93
III	Tools and plant	
a)	Civil works	24.71
IV	Suspense	
V	Receipts and Recoveries	-3.15
	Total Direct Charges	5408.07
	GRAND TOTAL (Rs. lakhs)	**5408.07**
	Civil works	**3008.07**
	Electrical works	**2400.00**
	TOTAL (Rs. lakhs)	**5408.07**

MARIPUZHA SMALL HE SCHEME: 6MW
ABSTRACT OF CIVIL WORKS

			Rs. in Lakhs
A.	Preliminaries		21.92
B	Land		278.98
J	Power Plant Civil Works		2191.96
K	Buildings		9.27
M	Plantations		3.00
O	Miscellaneous		26.15
R	Communication		260.40
P	Maintenance during construction 1% of works less A , B,M and O		24.62
Q	Special Tools and Plant Capital cost of Spl. T&P(p)	0	
	Capital cost of inspection/transport vehicles(q)	21.00	
	Provision to be made under spl. tool and plant		21.00
	Environment & ecology		14.00
	Losses on stock		
	0.25% of work less A, B and Q		6.29
	Total		2857.58
II	Establishment on works @ 5%		128.93
III	Tools and Plants		
	1% on works		24.71
IV	Suspense		
V	Receipts and Recoveries		
	Resale value of special tools and plant		
	0.75 of 0.25p+ 0.2q	-3.15	
	Resale value of temporary buildings (15%)		
	0.00	0	-3.15
	Total direct charges		3008.07

A	**PRELIMINARIES**	**Rs. lakhs**
	Includes expenditure on investigation such as	
	detailed survey for final loacation	
	vehicles for site investigation	
	consultation fee (Geological survey of India)	
	(1% of Civil work)	**21.92**
B	**LAND**	
	Private Land :7.5 Ha @37.05 Lakhs per Ha	277.875
	Govt. Land : 1.10Ha @1 Lakhs per Ha	1.10
	Total cost of land	**278.98**
K	**BUILDINGS**	
	Buildings such as dormitory for operating personel	
	Temporary	
	150 Sq.m @ 5500 per Sqm.	9.00
	Miscellaneous @ 3% of building cost	0.27
	TOTAL	**9.27**
M	**Plantations:**	
1	Plantation in colonies and along approach roads 5 kms.	1.00
2	Landscaping and development of area around dams and power	2.00
	Total	**3.00**

E	**MISCELLANEOUS**	
	Capital Cost	
	i. Water supply- purification and distribution	3.00
	ii. Sewage disposal and storm water drainage works	0.60
	Maintenance & Services	
	i. Electrification	1.00
	ii. Water supply purification and distribution	0.50
	iii. Security arrangments	3.60
	iv. Fire fighting	1.00
	v. Inspection vehicles 2 Jeeps for 3 years	10.45
	vi. Compensation to workmen	5.00
	vii. Boundary pillars and stones, distance marks and bench	1.00
	TOTAL	**26.15**
R	**COMMUNICATION**	
	Access roads	
	Major part included in component structures	260.40
	Total	**260.40**

A.1.1.H Special Tools &Plants

Capital cost of special tools&plant				0
Capital cost of Inspection vehicles				
Jeep	3	Nos	5.00	15.00
Pickup van (3t)	1	Nos	6.00	6.00
Total				**21.00**

x Environment and Ecology:

		Rate	Amount
		Rs.	Rs. lakhs
1	Restoration of land in construction areas by levelling, filling of borrowpits landscaping etc		4.00
2	providing green belt and preventing soil erosion etc		3.00
3	supplying firewood		6.00
4	measures to prevent forest fire and enforcement of antipoaching laws etc		1.00
	Total		**14.00**

TOTAL ABSTRACT

A	Clearing the site	5.00
B	Trench Weir	215.00
C	Intake Chamber	49.77
D	Power Channel	761.00
E	Forebay	256.84
F	Overflow Channel	37.86
G	Penstock	290.00
H	Power house and Switch Yard	478.76
I	Tailrace Channel	97.73
	Grand Total cost	**2191.96**

MARIPUZHA SMALL HE SCHEME: 6MW (2x3.00 MW)

ABSTRACT OF ESTIMATE FOR CIVIL WORKS

Section	Sl.No	Name	Quantity		Rate Rs.	Amount Rs. Lakhs
A	1	**PART I -CLEARING THE SITE**				**5.00**
B	2	**PART II -CONSTRUCTION OF TRENCH WEIR**				
	2.1	**Coffer dam**				
	2.1.1	Excavation				
	2.1.1.1	Common excavation in all classes of soil including 40% ordinary soil and 60% ordinary rock.	45 cum	4276.54	/10cum	0.19
	2.1.1.2	Excavation in hard rock with jack hammer drilling and spoil disposing within 5 km by lorry conveyance.	80 cum	7857.66	/10cum	0.63
	2.1.2	R.R masonry in CM1:5 for cofferdam	90 cum	2365.52	/cum	2.13
	2.1.3	Putting bunds before construction of cofferdam and during plugging of sluice.	60 cum	2343.84	/10cum	0.14
	2.1.4	Dismantling of cofferdam	90 cum	832.42	/cum	0.75
	2.1.5	Excavating & removing temporary bunds	50 cum	647.02	/10cum	0.03
	2.1.6	Bailing out water	L.S			0.70
		Sub Total				**4.57**
		Contingencies @3% of above less L.S.	3%	3.87		0.12
		For rounding				0.01
		Coffer dam- Total				**4.70**
	2.2	**TRENCH WEIR**				
	2.2.1	Excavation				
	2.2.1.1	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers within initial leads and lifts .	510.00 cum	2325.56	/10cum	1.19
	2.2.1.2	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers including all leads and lifts within a distance of 5 km.	770.00 cum	3829.76	/10cum	2.95

2.2.1.3	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size by controlled and protected blasting in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in t	190.00 cum	8200.78	/10cum	1.56
2.2.1.4	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places poi	2530.00 cum	7857.66	/10cum	19.88
2.2.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	900 cum	910.46	/10cum	0.82
2.2.3	Wedging, barring, picking etc. on hard rock including loose rock wherever necessary and depositing the spoil within a distance of 5 km, including all charges as per the direction of departmental officers.	200 cum	17082.88	/10cum	3.42
2.2.4	Final foundation preparation for placing concrete including chisel dressing wherever required at all elevations and cleaning the surface with compressed air and water etc.and depositing the spoil at dump yard or at places pointed out by the departmental	360 sqm	2903.72	/10sqm	1.05
2.2.5	Providing anchor bars using 25 mm dia tor steel including drilling holes with jack hammer and grouting with cement grout including all labour charges, machinery, air, water cost and conveyance of cement and steel etc. complete as per the specifications a	880 kg	92.45	/1kg	0.81
2.2.6	Cement Concrete				
2.2.6.1	Cement concrete M 10 with graded aggregates of size 40mm and 20mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	65 cum	5126.12	/1cum	3.33
2.2.6.2	Cement concrete M 25 with 20 mm graded aggregates for diversion weir and connected structures laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	675.00 cum	5444.51	/1cum	36.75

2.2.6.3	Second stage concreting with cement concrete M 20 with 40 mm graded aggregates for diversion weir and connected structures laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding c	150.00 cum	5145.69	/1cum	7.72
2.2.7	Reinforcement for R.C.C work using tor steel bent, tied and placed in position including cost of all materials etc complete as per specification	640.00 Qtl	7289.23	/1 Qtl	46.65
2.2.8	Supplying and laying 600mm dia 45mm thick NP2 concrete pipe for diverting river water from upstream side for repair and maintenance work including all cost of conveyance and labour etc. complete.	32.00 m	2312.00	/1m	0.74
2.2.9	Back filling with sandy gravel and compacting in layers including labour charges etc. complete as per specification and as directed by the departmental officers.	325.00 cum	9831.54	/10cum	3.20
2.2.10	Supplying , Fabricting and installing metal works for Angles,plates and flats, etc. including cost of materials, fabrication and fixing charges etc. complete as per the drawings and as directed by the departmental officers.	125.00 QTL	14223.36	/1QTL	17.78
2.2.11	*Gabion matresses with dry rubble packing using deptl. Rubble issued (free of cost) including cost of materials, conveyance, labour charges etc. complete	145.00 cum	6665.12	/10cum	0.97
2.2.12	RR Masonry in CM 1:5 with deptl. Rubble issued (free of cost) including cost of materials, conveyance, labour charges, watering, curing etc. complete (excluding cost and conveyance of cement)	30.00 cum	2365.52	/1cum	0.71
2.2.13	Supply of cement at site including cost of all storage arrangements, charges for stacking and re-stacking if nescessery and all conveyance charges etc. complete	470.00 MT	7095.82	/1MT	33.35
2.2.14	Colgrouting masonry in CM 1:3 with deptl. Rubble issued (free of cost) including cost of materials, conveyance, labour charges, watering curing etc. complete (excluding cost and conveyance of cement)	500.00 cum	4218.75	/cum	21.09
	Sub Total				**203.95**
	Contingencies @3% of above.	3%	203.95		6.12
	Add extra for rounding				0.23
	TRENCH WEIR- Total				**210.30**
	SECTION - B TOTAL				**215.00**

C	3	**PART III - INTAKE CHAMBER**				
	3.1	Excavation				
	3.1.1	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers including all leads and lifts within a distance of 5 km.	1100.00 cum	3829.76	/10cum	4.21
	3.1.2	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places poi	700.00 cum	7857.66	/10cum	5.50
	3.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	315.00 cum	910.46	/10cum	0.29
	3.3	Wedging, barring, picking etc. on hard rock including loose rock wherever necessary and depositing the spoil within a distance of 5 km, including all charges as per the direction of departmental officers.	40.00 cum	17082.88	/10cum	0.68
	3.4	Providing anchor bars 25mm dia including drilling holes with jack hammer and grouting with cement grout including all labour charges, machinery, air, water cost and conveyance of cement and steel etc. complete as per the specifications and as directed by the departmental officers.	600.00 Kg.	92.45	/1Kg.	0.55
	3.5	Cement Concrete				
	3.5.1	Cement concrete M 10 with graded aggregates of size 40mm and 20mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	5.80 cum	5126.12	/cum	0.30
	3.5.2	Cement concrete M 25 with 20 mm graded aggregates for diversion weir and connected structures laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	175.00 cum	5444.51	/cum	9.53
	3.5.3	Second stage concreting with cement concrete M 20 with 20 mm graded aggregates laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	23.00 cum	7653.85	/cum.	1.76

3.6	Reinforcement for R.C.C work using tor steel bent,tied and placed in position including cost of all materials etc complete as per specification	145.00 Qtl	7289.23	/Qtl	10.57
3.7	Backfilling with earth and compacting in layers etc. complete as per specification and as directed by the departmental officers.	570.00 cum	1040.52	/10cum	0.59
3.8	Supplying and fixing deflushing pipe 300mm dia welded steel pipe 4mm thick including cost and conveyance of all material , labour charges etc. complete.	100.00 m	2488.00	/1 m	2.49
3.9	RR Masonry in CM 1:5 with deptl. Rubble issued (free of cost) including cost of materials, conveyance, labour charges, watering, curing etc. complete (excluding cost and conveyance of cement)	40.00 cum	2365.52	/1cum	0.95
3.10	Fabricating, supplying and installing Intake gate and hoist arrangements using approved quality structural steel works suitable to the opening in intake, embedded parts and guide ways including cost of materials, fabrication and transportation charges, erection charges, painting and including design of structural members, preparation of drawings etc. complete	1.80 MT	137052.66	/1MT	2.47
3.11	Furnishing and installing miscellaneous metal works such as hatch cover and frames, gratings, chequered plates, ladder, and rails, grills, embedded parts etc. using contractors materials in various floors including cost of materials, conveyance, painting with primer etc. complete as per specification and as directed by the departmental officers.	1500.00 Kg	71.53	/1Kg	1.07
3.12	Supplying and fixing best quality 300mm sluice valve of approved make for connecting with the desilting pipe including cost of valve, flanges, packing and transportation charges, installation and painting charges etc. complete.	1 No	74293.89	/1E	0.74
3.13	Supply of cement at site including cost of all storage arrangements , charges for stacking and re-stacking if necessary and all conveyance charges etc. complete	90.00 MT	7095.82	/1MT	6.39
	Sub Total				**48.09**
	Contingencies @3% of above.	3%	48.09		1.44
	Add extra for rounding				0.24
	Intake Chamber Total				**49.77**
	SECTION - C TOTAL				**49.77**

D 4 PART IV -POWER CHANNEL

4.1	Excavation				
4.1.1	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers within initial leads and lifts .	20520.00 cum	2325.56	/10cum	47.72
4.1.2	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers including all leads and lifts within a distance of 5 km.	13680.00 cum	3829.76	/10cum	52.39
4.1.3	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size by controlled and protected blasting in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places pointed out by departmental officers including all lead and lift within a distance of 5 km by head load / lorry conveyance, including cost of compressed air, jack hammer, water line etc complete.	2280.00 cum	8200.78	/10cum	18.70
4.1.4	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, oonveying and depositing the excavated spoil in to dump yard or any other places pointed out by departmental officers including all lead and lift within a distance of 5 km by head load / lorry conveyance, including cost of compressed air, jack hammer, water line etc complete.	22800.00 cum	7857.66	/10cum	179.15
4.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	11300.00 cum	910.46	/10cum	10.29
4.2.1	Wedging, barring, picking etc. on hard rock including loose rock wherever necessary and depositing the spoil within a distance of 5 km, including all charges as per the direction of departmental officers.	450.00 cum	17082.88	/10cum	7.69
4.3	Chiselling in hard rock and old concrete surface wherever necessary and depositing the spoil at the places pointed by the deptl. officers including all lead and lift etc. complete as per specifications	75 sqm	1462.80	/10sqm	0.11

4.4	Providing anchor bars using 20 mm tor steel including drilling holes with jack hammer and grouting with cement grout including all labour charges, machinery, air, water cost and conveyance of cement and steel etc. complete as per the specifications and a	1700.00 Kg.	92.45	/1Kg.	1.57
4.5	**Cement concrete**				
4.5.1	Cement concrete M 10 with graded aggregates of size 40mm and 20mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	480.00 cum	5126.12	/1cum.	24.61
4.5.2	Reinforced Cement concrete M 25 with 20 mm graded aggregates for R.C.C works of bottom plate, side wall etc. of fore bay at all elevations, laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. com	2100.00 cum	6646.37	/cum	139.57
4.5.3	Cement concrete M 20 with 20 mm graded aggregates laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	250.00 cum	6273.38	/cum	15.68
4.6	Supplying and laying 160 mm PVC perforated pipe to lines and levels including all charges etc., complete as per specification and as directed by the deptl. Officers	1193.00 m	483.50	/m	5.77
4.7	Supplying and laying 110 mm PVC pipe to lines and levels including all charges etc., complete as per specification and as directed by the deptl. officers	650.00 m	277.50	/m	1.80
4.8	Supplying and fixing 160/110 mm PVC Reducer Tee including cost of all material, labour etc.,complete	40.00 Nos	302.00	/E	0.12
4.9	Supplying and fixing 160 mm PVC bend / funnel including cost of all material, labour etc.,complete	50.00 Nos	555.00	/E	0.28
4.10	Supplying and fixing 110 mm PVC bend / funnel including cost of all material, labour etc.,complete	30.00 Nos	146.90	/E	0.04
4.11	Providing graded filter with 5 to 20mm graded aggregates including cost of all materials, labour charges etc. complete as per specifications, drawings and as directed by departmental officers.	540.00 cum	2218.92	/cum	11.98
4.12	Supply and laying good quality polythene sheet over the gravel filter layer	3700.00 sqm	70.00	/1 sqm	2.59

4.13	Reinforcement for R.C.C work using tor steel bent,tied and placed in position including cost of all materials etc complete as per specification	1377.00 Qtl.	7289.23	/Qtl	100.37
4.14	Back filling with uncompacted earth conveyed from dumping yard/ borrow pits as per specification and as directed by the departmental officers	5500.00 cum	1230.50	/10cum	6.77
4.15	DR Masonry for retaining wall with deptl. Rubble issued (free of cost) including cost of conveyance, labour charges, etc. complete	400 cum	1039.21	/cum.	4.16
4.16	RR Masonry in CM 1:5 with deptl. Rubble issued (free of cost) including cost of materials, conveyance, labour charges, watering, curing etc. complete (excluding cost and conveyance of cement)	210.00 cum	2365.52	/cum	4.97
4.17	Supplying and fixing standard water stopper for expansion joints in walls during concreting	170.00 m	290.54	/m	0.49
4.18	Furnishing and installing galvanised iron sheet 2mm thick in joints and at other locations as per standard specification and as per the direction of the departmental officers.	1000.00 kg	104.20	/1 kg	1.04
4.19	Providing and installing hand rails using GI pipes of 50mm and 32mm or nearest size including cost of bending, welding,painting etc., as per drawing and specification.	200.00 m	903.84	/m	1.81
4.20	Plastering with CM 1:3, 15mm thick floated hard and trowel led smooth 72 kg per 10m2 of plastering including cost of scaffolding, curing, cost and conveyance of materials, labour etc. complete but excluding cost of cement as per specification and as directed by the departmental officers.	3000.00 sqm	2054.81	/10sqm	6.16
4.21	Turfing the slopes with vetiver plants including trimming, dressing and lead up to 200m and lift upto 5m and watering as required until the turf properly takes root and in any case for a period not less than 1 month	10300 sqm	1052.42	/10 sqm	10.84
4.22	Supply of cement at site including cost of all storage arrangements, charges for stacking and re-stacking if nescessery and all conveyance charges etc. complete	1153.00 MT	7095.82	/MT	81.81
	Sub Total				**738.50**
	Contingencies @3% of above.	3%	738.50		22.15
	Add extra for rounding				0.35
	Power Channel- Total				**761.00**
	SECTION - D TOTAL				**761.00**

E	5	**PART V -FOREBAY**				
	5.1	Excavation				
	5.1.1	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers including all leads and lifts within a distance of 5 km.	3000.00 cum	3829.76	/10cum	11.49
	5.1.2	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places poi	2000.00 cum	7857.66	/10cum	15.72
	5.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	900.00 cum	910.46	/10cum	0.82
	5.3	Wedging, barring, picking etc. on hard rock including loose rock wherever necessary and depositing the spoil within a distance of 5 km, including all charges as per the direction of departmental officers.	220.00 cum	17082.88	/10cum	3.76
	5.4	Providing anchor bars including drilling holes with jack hammer and grouting with cement grout including all labour charges, machinery, air, water cost and conveyance of cement and steel etc. complete as per the specifications and as directed by the departmental officers.	1250.00 kg	92.45	/1 kg	1.16
	5.5	Cement Concrete				
	5.5.1	Cement concrete M 10 with graded aggregates of size 40mm and 20mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	50.00 cum	5126.12	/cum	2.56
	5.5.2	Cement concrete M 25 with 20 mm graded aggregates for R.C.C works of bottom plates side wall etc. at all elevations, laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost an	1040.00 cum	5444.51	/cum	56.62
	5.5.3	Reinforced Cement concrete M 20 with 20 mm graded aggregates for R.C.C works of Anchor/ Standing wall of forebay at all elevations, laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (ex	80.00 cum	5093.83	/cum	4.08

5.5.4	Second stage concreting with cement concrete M 20 with 20 mm graded aggregates laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	5.00 cum	7653.85	/cum	0.38
5.6	Reinforcement for R.C.C work using tor steel bent,tied and placed in position including cost of all materials etc complete as per specification	1125.00 Qtl.	7289.23	/1Qtl.	82.00
5.7	Furnishing and placing copper seiling strips in joints and at other locations as per drawings and specifications etc., complete including cost of all copper strips etc.,	700 kg	623.62	/kg	4.37
5.8	RR Masonry in CM 1:5 with deptl. Rubble issued (free of cost) including cost of materials, labour charges, watering, curing etc. complete (excluding cost and conveyance of cement)	480 cum	2365.52	/1cum	11.35
5.9	DR Masonry for retaining wall with deptl. Rubble issued (free of cost) including cost of conveyance, labour charges, etc. complete	320.00 cum	1039.21	/cum	3.33
5.10	Backfilling with earth and compacting in layers etc. complete as per specification and as directed by the departmental officers.	750.00 cum	1040.52	/10cum	0.78
5.11	Fabricating, supplying and installing Intake gate and hoist arrangements using approved quality structural steel works suitable to the opening in forebay, embedded parts and guide ways including cost of materials, fabrication and transportation charges, e	2.30 MT	137052.66	/MT	3.15
5.12	Fabricating, supplying and installing Trash rack metal works suitable to the trash rack opening in forebay, embedded parts and guideways including cost of materials, fabrication and transportation charges, erection charges, painting and including design of structural members, preparation of drawings etc. complete	5.00 MT	137052.66	/MT	6.85
5.13	Furnishing and installing miscellaneous metal works such as hatch cover and frames, gratings, chequered plates, ladder, and rails, grills, embedded parts etc. using contractors materials in various floors including cost of materials, conveyance, painting with primer etc. complete as per specification and as directed by the departmental officers.	5.00 Qtl	85076.82	/1MT	0.43

	5.14	Supplying and fixing DN 300 welded steel pipe 4mm thick (300mm dia) including cost and conveyance of all material , labour charges etc. complete.	35.00 m	2488.00	/1m	0.87
	5.15	Supplying and fixing best quality 300mm sluice valve of approved make for connecting with the desilting pipe including cost of valve, flanges, packing and transportation charges, installation and painting charges etc. complete.	1.00 No	74293.89	/E	0.74
	5.16	Turfing the slopes with vetiver plants including trimming, dressing and lead up to 200m and lift upto 5m and watering as required until the turf properly takes root and in any case for a period not less than 1 month	200 sqm	1052.42	/10sqm	0.21
	5.17	Supply of cement at site including cost of all storage arrangements , charges for stacking and re-stacking if necessary and all conveyance charges etc. complete	535 MT	7095.82	/1MT	37.96
		Sub Total				**248.63**
		Contingencies @3% of above.	3%	248.63		7.46
		Add extra for rounding				0.75
		FOREBAY- Total				**256.84**
		SECTION - E TOTAL				**256.84**
F	6	**PART VI -OVERFLOW CHANNEL AT FOREBAY**				
	6.1	Excavation				
	6.1.1	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers including all leads and lifts within a distance of 5 km.	460.00 cum	3829.76	/10cum	1.76
	6.1.2	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places poi	310.00 cum	7857.66	/10cum	2.44
	6.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	140.00 cum	910.46	/10cum	0.13

6.3	Wedging, barring, picking etc. on hard rock including loose rock wherever necessary and depositing the spoil within a distance of 5 km, including all charges as per the direction of departmental officers.	40.00 sqm	17082.88	/10sqm	0.68
6.4	Providing anchor bars 25mm dia including drilling holes with jack hammer and grouting with cement grout including all labour charges, machinery, air, water cost and conveyance of cement and steel etc. complete as per the specifications and as directed by the departmental officers.	180.00 Kg.	92.45	/1Kg.	0.17
6.5	Cement Concrete				
6.5.1	Cement concrete M 10 with graded aggregates of size 40mm and 20mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	44.00 cum	5126.12	/cum	2.26
6.5.2	Reinforced Cement concrete M 25 with 20 mm graded aggregates for R.C.C works of bottom plate, side wall etc. of forebay at all elevations, laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. comp	185.00 cum	5444.51	/1cum	10.07
6.6	Reinforcement for R.C.C work using tor steel bent,tied and placed in position including cost of all materials etc complete as per specification	125.00 Qtl	7289.23	/1 Qtl	9.11
6.7	Backfilling with earth and compacting in layers etc. complete as per specification and as directed by the departmental officers.	200.00 cum	1040.52	/10cum	0.21
6.8	RR Masonry in CM 1:5 with deptl. Rubble issued (free of cost) including cost of materials, conveyance, labour charges, watering, curing etc. complete (excluding cost and conveyance of cement)	75.00 cum	2365.52	/1cum	1.77
6.9	DR Masonry for retaining wall with deptl. Rubble issued (free of cost) including cost of conveyance, labour charges, etc. complete	85.00 cum	1039.21	/cum	0.88
6.10	Turfing the slopes with vetiver plants including trimming, dressing and lead up to 200m and lift upto 5m and watering as required until the turf properly takes root and in any case for a period not less than 1 month	300.00 sqm	1052.42	/10 sqm	0.32

6.11	Supply of cement at site including cost of all storage arrangements , charges for stacking and re-stacking if necessary and all conveyance charges etc. complete	97.00 MT	7095.82	/1 MT	6.88
	Sub Total				**36.68**
	Contingencies @3% of above.	3%	36.68		1.10
	Add extra for rounding				0.08
	Overflow Channel- Total				**37.86**
	SECTION - F TOTAL				**37.86**

G 7 PART VII -PENSTOCK

TRACK FORMATION, CONSTRUCTION OF ANCHORS & ROCKER SUPPORT, DRAINS, FABRICATION AND ERECTION OF PENSTOCK, ETC.

7.1 TRACK FORMATION

7.1.1 Excavation

7.1.1.2	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers within initial leads and lifts.	9600.00 cum	2325.56	/10cum	22.33
7.1.1.3	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size by controlled and protected blasting in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places pointed out by departmental officers including all lead and lift within a distance of 5 km by head load / lorry conveyance, including cost of compressed air, jack hammer, water line etc complete.	160.00 cum	8200.78	/10cum	1.31
7.1.1.4	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places pointed out by departmental officers including all lead and lift within a distance of 5 km by head load / lorry conveyance, including cost of compressed air, jack hammer, water line etc complete.	3280.00 cum	7857.66	/10cum	25.77
7.1.1.5	Earth work in hard soil and depositing on banks with initial lead up to 50m and lift upto 1.5m including breaking ,clods,watering ramming and sectioning of spoil bank etc. complete. For rocker support and anchors of penstock	240.00 cum	3251.63	/10cum	0.78
7.1.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	1550 cum	910.46	/10cum	1.41
7.1.3	Wedging, barring, picking etc. on hard rock including loose rock wherever necessary and depositing the spoil within a distance of 5 km, including all charges as per the direction of departmental officers.	40.00 cum	17082.88	/10cum	0.68
	Sub Total TRACK FORMATION				**52.29**

7.2 CONSTRUCTION OF ANCHORS

7.2.1	Providing anchor bars using 25 mm dia tor steel including drilling holes with jack hammer and grouting with cement grout including all labour charges, machinery, air, water cost and conveyance of cement and steel etc. complete as per the specifications and as directed by the departmental officers.	200 Kg.	92.45	/1 kg	0.18
7.2.2	Cement concrete M 20 with 20 mm graded aggregates for penstock support and connected structures laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	370.00 cum	5776.92	/1cum	21.37
7.2.3	Second stage concreting with cement concrete M 20 with 20 mm graded aggregates for penstock support and connected structures laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	15.00 cum	5690.83	/1cum	0.85
7.2.4	Reinforcement for R.C.C work using tor steel bent,tied and placed in position including cost of all materials etc complete as per specification	194 Qtl	7289.23	/1 Qtl	14.14
7.2.5	Turfing the slopes with vetiver plants including trimming, dressing and lead up to 200m and lift upto 5m and watering as required until the turf properly takes root and in any case for a period not less than 1 month	1500 m2	832.42	/10sqm	1.25
7.2.6	Supply of cement at site including cost of all storage arrangements, charges for stacking and re-stacking if necessary and all conveyance charges etc. complete	160.00 MT	7095.82	/1MT	11.35
	Sub Total CONSTRUCTION OF ANCHORS				**49.16**

7.3 FABRICATION OF PENSTCOK PIPES AND ACCESSORIES

7.3.1	Ultrasonic inspection of spirally welded steel penstock pipe (IS 2002 Grade II Steel) at place of delivery/fabrication site as per specification, approved drawings prior to fabrication of plates including all expenses for testing arrangements, labour charges etc. complete and as directed by the departmental officers.	123.00 MT	440.00	/1MT	0.54
7.3.2	Supplying spirally welded steel pipe of external dia 1.422m (56") with 8mm thickness,of length 6m pertaining to (IS 2002 Grade II Steel) of standard tested quality at the site as per specification, approved drawings including all expences etc.complete and as directed by the departmental officers.	123.00 MT	64058.39	/1MT	78.79

7.3.3	Fabrication of penstock using spirally welded pipes of 6m in length 1.422 dia making water tight , testing the welds by dye penetrant test as per specification including cost of structural steel welds etc. complete as per the directions of Engineer in charge.	123.00 MT	13525.00	/1MT	16.64
7.3.4	Fabrication of IS 2002 Grade II Steel liner for manhole, expansion joit, ring girder etc./ penstock making water tight ,testing the welds by Dye penetrant test as per specification including cost of structural steel welds etc. complete as per the directions of Engineer in charge.	24.00 MT	98315.10	/1MT	23.60
7.3.5	Loading and transporting of penstock pipes and its accessories including bifurcation piece, bends, H D straps, rocker supports, expansion joints, butterfly valve etc. from the pipe dump yard nearest location of erection including loading unloading and co	147.00	6062.76		8.91
7.3.6	Erection of penstock pipes, bends, expansion joints, bifurcation/trifurcation pieces, rocker supports, butterfly valves, accessories including handling, adjusting and positioning of pipes in lines and levels, welding joints using contractors own machineri	142.00 MT	31419.96	/1MT	44.62
7.3.7	Radiographic inspection of welds as per the specification including all expenses for testing arrangements and labour charges etc. complete and as directed by the departmental officers.				
a)	Field welds carried out at site	500.00 m	900.00	/1m	4.50
7.3.8	Culvert at penstock crossing the coup road	LS			0.80
	Sub Total: FABRICATION OF PENSTCOK PIPES AND ACCESSORIES				**178.39**
	PENSTOCK				
	Sub Total : TRACK FORMATION, CONSTRUCTION OF ANCHORS & ROCKER SUPPORT, DRAINS, FABRICATION AND ERECTION OF PENSTOCK, ETC.				279.84
	Contingencies @3% of above.	3%	279.04		8.37
	Add extra for rounding				1.79
	Sub Total : PENSTOCK				**290.00**
	SECTION - G TOTAL				**290.00**

H 8 PART VIII -POWER HOUSE AND SWITCH YARD

8.1 Power House

8.1.1 Excavation

8.1.1.1	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers ,within initail lead and lift.	1130.00 cum	2325.56	/10cum	2.63
8.1.1.2	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers including all leads and lifts within a distance of 5 km.	4510.00 cum	4732.28	/10cum	21.34
8.1.1.3	Common excavation in shafts, faults trenches, seams cut etc. and depositing the spoil at places pointed out by Deptl. Officers including all leads and lifts with in a distance of 5 KM.	175.00 cum	5658.35	/10cum	0.99
8.1.1.4	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places point	3708.00 cum	7857.66	/10cum	29.14
8.1.1.5	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size by controlled and protected blasting in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in t	752.00 cum	8200.78	/10cum	6.17
8.1.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	1692.00 cum	910.46	/10cum	1.54
8.1.3	Wedging, barring, picking etc. on hard rock including loose rock wherever necessary and depositing the spoil within a distance of 5 km, including all charges as per the direction of departmental officers.	50.00 cum	17082.88	/10cum	0.85
8.1.4	Chiselling in hard rock surface wherever necessary and depositing the spoil at the places pointed by the deptl. officers including all lead and lift etc. complete as per specifications	50.00 cum	5851.20	/1cum	2.93

8.1.5	Foundation preparation including cleaning of foundation using broom,compressed air .etc.. and removal of soil including depositing the same required for the filling area within the PH/Switch yard premises	200.00 sqm	639.76	/10sqm	0.13
8.1.6	Providing anchor bars of 25mm dia steel rod including drilling holes with jack hammer and grouting with cement grout including all labour charges, machinery, air, water cost and conveyance of cement and steel etc. complete as per the specifications and as directed by the departmental officers.	400.00 kg	92.45	/1kg	0.37
8.1.7	**Cement concrete**				
8.1.7.1	Cement concrete M20 with graded aggregates of size 12mm and 6mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete for thin slabs etc.. (excluding cost and conveyance of cement)	10.00 cum	6359.22	/1cum	0.64
8.1.7.2	Cement Concrete M10 MSA 40mm for levelling course below column footing	124.76 cum	5467.67	/1cum	6.82
8.1.7.3	Cement Concrete M25 MSA 20mm for column footing	38.00 cum	5404.57	/1cum	2.05
8.1.7.4	Cement Concrete M25 MSA 20mm for column upto level +464 & walls . Etc..	195.00 cum	10485.30	/1cum	20.45
8.1.7.5	Cement Concrete M25 MSA 20mm for beams, lintel etc.	47.00 cum	10665.71	/1cum	5.01
8.1.7.6	Cement Concrete M20 MSA 20 for column above +464.000m level	**51.10** cum	10485.30	/1cum	5.36
8.1.7.7	Cement Concrete M20 MSA 20 for slab & sunshade	14.50 cum	8679.84	/1cum	1.26
8.1.7.8	Cement concrete M20 MSA20 for mass concrete works	1225.00 cum	5890.69	/1cum	72.16
8.1.7.9	Cement concrete M20 with 20mm graded aggregates for precast slab, consolidating, curing, stacking etc. and transporting to site and laying to lines and levels after cleaning and compacting the surface including cost of	20.00 cum	7060.93	/1cum	1.41
8.1.7.10	Cement concrete M20 with 12mm & 6mm size broken stones	10.00 cum	6359.22	/1cum	0.64
8.1.7.11	Cement concrete M20 with 20mm broken stone for switchyard structures, power house yard construction works..etc..	223.00 cum	7311.46	/1cum	16.30
8.1.8	walls	**261.78** cum	6363.41	/1cum	16.66
8.1.9	M10 MSA 40 for floor concreting works	17.00 cum	5467.67	/1cum	0.93

8.1.10	Supplying & Fixing various size aluminium sliding sash glass window with 5mm thick glass as per specifications	49.00 sqm	2264.96	/1sqm	1.11
8.1.11	Supplying & Fixing in position aluminium doors of various size as per standard specifications	12.00 sqm	2644.46	/1sqm	0.32
8.1.12	Plasering with Cement Mortar 1:3, 9mm thick for ceiling plasering	127.00 sqm	2014.26	/10sqm	0.26
8.1.13	Plasering with Cement Mortar 1:4, 12mm thick for exposed faces of brick masonry	2538.98 sqm	2051.71	/10sqm	5.21
8.1.14	Dadoing wall with best quality white glazed tiles	18.00 sqm	1551.79	/1sqm	0.28
8.1.15	Supplying and fixing European type white glazed earthenware W C pan with trap	1.00 No	3493.24	/1E	0.03
8.1.16	White cement washing two coats on plastered surfaces	2477.00 sqm	707.86	/10sqm	1.75
8.1.17	Painting with water proof cement paint of approved colour and quality, two coats	2350.00 sqm	757.14	/10sqm	1.78
8.1.18	Reinforcement for RCC works bent,tied and placed in position ..etc.. complete	1200.00 Qtl	7289.23	/1 Qtl	87.47
8.1.19	Chemical treatment to the out side face of wall with a flexible elastic water proofing and protection	310.00 sqm	816.50	/1sqm	2.53
8.1.20	Fabricating and installing miscellaneous inside metal works such as frames, covering ladder etc. including cost of painting	75.00 Qtl	110.03	/1kg	8.25
8.1.21	Supplying and fixing electrically operated rolling shutters of approved make	24.00 sqm	3083.16	/1sqm	0.74
8.1.22	Supplying and fixing rolling shutter cover of approved make	5.00 m	653.00	/1m	0.03
8.1.23	Supplying and fixing best quality ceramic tiles of approval quality	88.00 sqm	7144.96	/10sqm	0.63
8.1.24	Providing and fixing anodised aluminium hand rails over steal railing with necessary protection works	110.00 kg	279.85	/1 kg	0.31
8.1.25	Supplying and fixing 550 x 400 mm size wash basin of white glazed earthern best quality	2.00 Nos	3109.79	/1 E	0.06
8.1.26	Supplying ,threading, laying and jointing 50mm nominal dia GI pipe(B class) and specials with clamps including cutting and making good the wall painting the exposed surface of the pipe as per specification and as directed by the departmental officers	25.00 m	464.37	/1 m	0.12

8.1.27	Supplying, threading, laying and painting 75mm nominal dia GI pipe (B class)and specials with clamps including cutting and making good the wall painting the exposed surface of the pipe as per specification and as directed by the departmental officers	15.00 m	656.09	/1m	0.10
8.1.28	Supplying , threading, laying and painting 15 mm nominal dia GI pipe (B class) and specials with clamps including cutting and making good the wall painting the exposed surface of the pipe as per specification and as directed by the departmental officers	25.00 m	161.80	/1m	0.04
8.1.29	Supplying and fixing pasted type 110mm dia PVC down water pipe including necessary fittings such as clamps, screws etc. fixing the pipe to the wall with iron clamps and screws to teak wood plug embedded in CM, cutting masonry/concrete wherever necessary,	105.00 m	221.22	/1m	0.23
8.1.30	Supplying and fixing 40 mm dia PVC pipe (6 kg/sq cm) pasted type with fittings such as Tee, bend, elbow, checknuts etc. including all other accessories for internal water supply as per specification.	100.00 m	44.80	/1m	0.04
8.1.31	Supplying and fixing 20 mm dia PVC pipe (12 kg/ sq cm) pasted type with fittings such as Tee, bend, elbow, checknuts etc. including all other accessories for internal water supply as per specification.	50.00 m	26.92	/1m	0.01
8.1.32	Supplying and fixing lipped urinal of size 430 x 230 x 350 mm or nearest size of white glazed earthenware as per specification and as directed by the Deptl. Officers	1.00 No	1926.92	/1 E	0.02
8.1.33	DR masonry for retaining wall with departmental rubble issued free of cost iscluding conveyance, labour charges etc.	800.00 cum	1039.21	/1cum	8.31
8.1.34	RR Masonry in CM 1:5 with Deptl. Rubble issued (free of cost) including cost of materials,conveyance, labour charges, watering, curing etc. complete (excluding cost and conveyance of cement)	250.00 cum	2365.52	/1cum	5.91
8.1.35	Back filling with sandy gravel and compacting in layers including labour charges etc. complete as per specification and as directed by the departmental officers.	120.00 cum	9162.12	/10cum	1.10
8.1.36	Supplying and filling with ballast and compacting in layers etc. complete as per specification and as directed by the deparmental officers.	100.00 cum	1541.17	/1cum	1.54

8.1.37	Back filling with uncompacted earth conveyed from dumping yard as per specification and as directed by the departmental officers	300.00 cum	910.80	/10cum	0.27
8.1.38	Supplying, stacking and spreading 40 mm broken stone at switch yard for a thickness of 15 cm including cost of materials and labour charges	400.00 sqm	2556.88	/10sqm	1.02
8.1.39	Supplying, stacking and Spreading sand at switch yard area for a thickness of 8 cm	400.00 sqm	1566.29	/10sqm	0.63
8.1.40	Providing M.S grills for compound gates including all labour charges for fabricating and cost of materials and applying a coat of iron primer etc. complete	300.00 kg	110.03	/1Kg	0.33
8.1.41	Supplying and fixing 1000 ltr PVC storage watertank of ISI Standard	1.00 No	5650.00	/1 E	0.06
8.1.42	Painting iron works with two coats of approvad quality colour paint over a coat of iron primer after rubbing with emery paper and clearing the surface including cost of materials, labour charges etc.	150.00 sqm	970.78	/10sqm	0.15
8.1.43	Supplying and laying non metalic floor hardner of approved colours for floors of Power House, store and such other places using premixed powder containing selective hard aggregates hardness 7-8 on Moh's having abrasion resistance less than 0.75 mg/cycle	347.00 sqm	3960.37	/10sqm	1.37
8.1.44	Fabricating, supplying and installing embedded parts ,stop log gate, gate slot, draft tube, guideways including cost of materials, fabrication and transportation charges, erection charges, painting and including design of structural members, preparation o	4.80 MT	127758.75	/1MT	6.13
8.1.45	Supply, fabrication and erection of roof girders, roof trussers, gantry girders etc. at all elevation including painting one coat of iron primer etc. complete	22.00 MT	93908.79	/1 MT	20.66
8.1.46	Supplying and fixing GI strip (50x5mm) for laying earth mat at appropriate location.	20.00 Qtl	5836.82	/1 Qtl	1.17
8.1.47	Supplying and fixing standard water stopper for expansion joints in walls during concreting	100.00 m	290.54	/1m	0.29
8.1.48	Supplying and fixing copper plates including bending, folding to shapes etc. for expansion joints in walls & slabs	100.00 m	5762.39	/1m	5.76

8.1.49	Furnishing and installing PVC water stops in construction joints at all elevation	100.00 m	1733.45	/1m	1.73
8.1.50	Roofing with prepainted galvanized trapezoidal sheet with bolt ,nut and bitumen washers, including necessary overlap of 150mm at ends etc. complete as per specification	400.00 sqm	6921.02	/10sqm	2.77
8.1.51	Supplying and fixing plain galvanized ridge 225mm with 22G sheets or available size including crank bolts & nuts and washers etc.	32.00 m	3669.23	/10m	0.12
8.1.52	Providing pre painted galvanized plain sheet 1mm thick partition works for power house building outer walls above 5mtr height including M.S fabrication works for fixing the partitions etc. complete	24.00 sqm	5310.79	/10sqm	0.13
8.1.53	Supplying and fixing turbo air extractor of approved quality including all cost for fixing at power house roof top etc complete.	6.00 Nos	12500.00	/1 E	0.75
8.1.54	Supply of cement at site including cost of all storage arrangements, charges for stacking and re-stacking if nescessery and all conveyance charges etc. complete	850.00 MT	7095.82	/1 MT	60.31
8.1.55	For sanitary and water supply items	LS			2.00
8.1.56	Protective works	LS			5.00
	Sub total				**454.62**
	Contingencies @3% of above less LS.	3%	447.62		13.43
	Add extra for rounding				0.71
	Total for POWER HOUSE				**468.76**
8.2	**Switch yard**	LS			**10.00**
	SECTION - H- TOTAL				**478.76**
9	**TAIL RACE CHANNEL**				
9.1	**Excavation**				
9.1.1	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers including all leads and lifts within a distance of 5 km.	840.00 cum	3829.76	/10cum	3.22

9.1.2	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack. hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places poi	1960.00 cum	7857.66	/10cum	15.40
9.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	882.00 cum	910.46	/10cum	0.80
9.3	**Cement concrete**				
9.3.1	Cement concrete M 10 with graded aggregates of size 40mm and 20mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	42.00 cum	5126.12	/cum	2.15
9.3.2	Reinforced Cement concrete M 25 with 20 mm graded aggregates for R.C.C works of bottom plate, side wall etc. of forebay at all elevations, laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. comp	480.00 cum	6646.37	/cum	31.90
9.4	Reinforcement for R.C.C work using tor steel bent,tied and placed in position including cost of all materials etc complete as per specification	325.00 Qtl.	7289.23	/1Qtl.	23.69
9.5	Rough stone dry packing for aprons and revetments with Deptl. Rubble issued (free of cost) including conveyance, labour charges etc. complete.	25.00 cum	1110.90	/1cum	0.28
9.6	Furnishing and installing pvc water stops in constructions joints	74.00 m	1733.45	/1m	1.28
9.7	Supply of cement at site including cost of all storage arrangements , chrges for stacking and re-stacking if necessary and all conveyance charges etc. complete	220.00 Qtl.	7095.82	/1Qtl.	15.61
	Sub Total				**94.34**
	Contingencies @3% of above.	3%	94.34		2.83
	Add extra for rounding				0.56
	Tailrace Channel- Total				**97.73**
	SECTION -I - TOTAL				**97.73**

J 10

ACCESS ROAD TO POWER HOUSE

10.1	Excavation				
10.1.1	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers within initial leads and lifts.	530.00 cum	2325.56	/10cum	1.23
10.1.2	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size by controlled and protected blasting in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in t	140.00 cum	8200.78	/10cum	1.15
10.1.3	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places poi	200.00 cum	7857.66	/10cum	1.57
10.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	153.00 cum	910.46	/10cum	0.14
10.3	Backfilling with earth and compacting in layers etc. complete as per specification and as directed by the departmental officers.	780.00 cum	364.18	/10cum	0.28
10.4	Rough stone dry packing for pitching the sides of the road with deptl rubble(free of cost) including all labour charges etc. complete	65.00 cum	1110.90	/1cum	0.72
10.5	DR Masonry for retaining wall with deptl. Rubble issued (free of cost) including cost of conveyance, labour charges, etc. complete	170.00 cum	1039.21	/1cum	1.77
10.6	RR Masonry in CM 1:5 with deptl. Rubble issued (free of cost) including cost of materials, conveyance, labour charges, watering, curing etc. complete (excluding cost and conveyance of cement)	32.00 cum	2365.52	/1cum	0.76
10.7	**Cement concrete**				
10.7.1	Cement concrete M 10 with graded aggragates of size 40mm and 20mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	20.00 cum	5126.12	/1cum	1.03

10.7.2	Cement concrete M 15 with 20 mm graded aggregates for concrete pipe, pad and at other locations laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cemen	30.00 cum	5458.13	/1cum	1.64
10.7.3	Cement concrete M 20 with 20 mm graded aggregates laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	2.00 cum	5458.13	/1cum	0.11
10.8	Supplying 60mm graded metal (proportion of 7:3 of 60mm and 36mm by volume) and stacking in standard heaps for measurements including cost, conveyance, labour etc. complete	60.00 cum	1364.04	/cum	0.82
10.9	Supplying 36mm broken stone and stacking in standard heaps for measurements including cost and conveyance of materials and labour charges etc. complete	55.00 cum	1467.22	/1cum	0.81
10.10	Supplying 12mm hard blue granite broken stone and stacking in standard heaps for measurements including cost , conveyance, labour charges etc. complete	15.00 cum	1808.22	/1cum	0.27
10.11	Supplying 6mm hard blue granite broken stone and stacking in standard heaps for measurements including cost, conveyance, labour charges etc. complete	5.00 cum	1482.62	/1cum	0.07
10.12	Sectioning up to 150mm and forming the surface for new roads including all charges as per the direction of the departmental	600.00 sqm	260.13	/10sqm	0.16
10.13	Metalling the roadway, 100mm spread thickness compacted to 75mm using deptl. broken stone (graded in the ratio of 7:3 of 60mm and 36mm size respectively) 1m3/10m2 and deptl. blinding material (0.20m3/10m2) bed rolling, spreading broken stones to template,	600.00 sqm	1113.47	/10sqm	0.67
10.14	Metalling the roadway 100mm spread thickness compacted to 75 mm using 36mm departmental broken stone (1 m3/10m2) and depl. blinding material (0.15m3/10m2), spreading broken stone to template, rolling dry to compaction, watering profusely and rolling unti	550.00 sqm	1113.47	/10sqm	0.61

	10.15	Providing 20mm pre-mixed chipping carpet over WBM surface with departmental broken stone after thoroughly cleaning the base with wire brush, brass grooms and applying a priming coat 7.50 Kg of bitumen per 10m2 and spreading the hot pre-mix (formed 0.27m	520.00 sqm	2288.35	/10sqm	1.19
	10.16	Reinforcement for R.C.C work using tor steel bent,tied and placed in position including cost of all materials etc complete as per specification	21.00 Qtl	7289.23	/1Qtl	1.53
	10.17	Turfing the slopes with vetiver plants including trimming, dressing and lead up to 200m and lift upto 5m and watering as required until the turf properly takes root and in any case for a period not less than 1 month	640.00 sqm	1052.42	/10sqm	0.67
	10.18	Supply of cement at site including cost of all storage arrangements, charges for stacking and re-stacking if nescessery and all conveyance charges etc. complete	18.50 MT	7095.82	/1MT	1.31
		Sub Total				**18.51**
		Contingencies @3% of above.	3%	18.51		0.56
		Add extra for rounding				0.51
		Access Road to Power house				**19.58**
		SECTION - J- TOTAL				**19.58**
K	11	**ACCESS ROAD TO WEIR SITE**				
	11.1	Excavation				
	11.1.1	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers within initial leads and lifts.	7850.00 cum	2325.56	/10cum	18.26

11.1.2	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size by controlled and protected blasting in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in t	525.00	cum	8200.78	/10cum	4.31
11.1.3	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places poi	4725.00	cum	7857.66	/10cum	37.13
11.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	2363.00	cum	910.46	/10cum	2.15
11.3	Backfilling with earth and compacting in layers etc. complete as per specification and as directed by the departmental officers.	300.00	cum	364.18	/10cum	0.11
11.4	Rough stone dry packing for pitching the sides of the road with deptl rubble(free of cost) including all labour charges etc. complete	160.00	cum	1110.90	/1cum	1.78
11.5	DR Masonry for retaining wall with deptl. Rubble issued (free of cost) including cost of conveyance, labour charges, etc. complete	325.00	cum	1039.21	/1cum	3.38
11.6	Cement concrete M 10 with graded aggragates of size 40mm and 20mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	38.00	cum	5126.12	/1cum	1.95
11.7	RR Masonry in CM 1:5 with deptl. Rubble issued (free of cost) including cost of materials, conveyance, labour charges, watering, curing etc. complete (excluding cost and conveyance of cement)	55.00	cum	2365.52	/1cum	1.30
11.8	Cement concrete M 15 with 20 mm graded aggregates for concrete pipe, pad and at other locations laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cemen	55.00	cum	5458.13	/1cum	3.00
11.9	Cement concrete M 20 with 20 mm graded aggregates laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	12.00	cum	5458.13	/1cum	0.65

11.10	Supplying 60mm graded metal (proportion of 7:3 of 60mm and 36mm by volume) and stacking in standard heaps for measurements including cost, conveyance, labour etc. complete	135.00	cum	1364.04	/cum	1.84
11.11	Supplying 36mm broken stone and stacking in standard heaps for measurements including cost and conveyance of materials and labour charges etc. complete	130.00	cum	1467.22	/1cum	1.91
11.12	Sectioning up to 150mm and forming the surface for new roads including all charges as per the direction of the departmental officers.	1400.00	sqm	260.13	/10sqm	0.36
11.13	Metalling the roadway, 100mm spread thickness compacted to 75mm using deptl. broken stone (graded in the ratio of 7:3 of 60mm and 36mm size respectively) 1m3/10m2 and deptl. blinding material (0.20m3/10m2) bed rolling, spreading broken stones to template,	1400.00	sqm	1113.47	/10sqm	1.56
11.14	Metalling the roadway 100mm spread thickness compacted to 75 mm using 36mm departmental broken stone (1 m3/10m2) and depl. blinding material (0.15m3/10m2), spreading broken stone to template, rolling dry to compaction, watering profusely and rolling unti	1300.00	sqm	1113.47	/10sqm	1.45
11.15	Reinforcement for R.C.C work using tor steel bent,tied and placed in position including cost of all materials etc complete as per specification	44.00	Qtl	7289.23	/1Qtl	3.21
11.16	Providing gabion matresses for supporting the side slopes and river edges including all cost of conveyance and materials etc. complete.	1200.00	cum	6665.12	/10 cum	8.00
11.17	Turfing the slopes with vetiver plants including trimming, dressing and lead up to 200m and lift upto 5m and watering as required until the turf properly takes root and in any case for a period not less than 1 month	2300.00	sqm	1052.42	/10sqm	2.42
11.18	Supply of cement at site including cost of all storage arrangements, charges for stacking and re-stacking if nescessery and all conveyance charges etc. complete	37.00	MT	7095.82	/1MT	2.63
	Sub Total					**97.38**
	Contingencies @3% of above.		3%	97.38		2.92
	Add extra for rounding					0.75
	Access Road to Wier site- Total					**101.05**
	SECTION - K - TOTAL					**101.05**

L 12 POWER HOUSE BRIDGE

12.1 Excavation

12.1.1	Common excavation in all classes of soil including boulders up to 500 dm3 in size and depositing the excavated spoil at places pointed out by the departmental officers including all leads and lifts within a distance of 5 km.	380.00 cum	3829.76	/10cum	1.46
12.1.2	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size by controlled and protected blasting in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in t	114.00 cum	8200.78	/10cum	0.93
12.1.3	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places poi	456.00 cum	7857.66	/10cum	3.58
12.2	Stacking useful rubble obtained from rock excavation including all charges etc.complete for measurements	256.50 cum	910.46	/10cum	0.23
12.3	Wedging, barring, picking etc. on hard rock including loose rock wherever necessary and depositing the spoil within a distance of 5 km, including all charges as per the direction of departmental officers.	30.00 cum	17082.88	/10cum	0.51
12.4	Back filling with sandy gravel and compacting in layers including labour charges etc. complete as per specification and as directed by the departmental officers.	118.00 cum	9831.54	/10cum	1.16
12.5	Backfilling with earth and compacting in layers etc. complete as per specification and as directed by the departmental officers.	120.00 cum	1040.52	/10cum	0.12
12.6	Cement concrete				
12.6.1	Cement concrete M 10 with graded aggregates of size 40mm and 20mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	55.00 cum	5126.12	/1cum	2.82
12.6.2	Boulder Cement concrete M15 with MSA 40 including 30% boulder pieces up to 150mm size (available at site) but excluding cost of cement	180.00 cum	3118.58	/1cum	5.61

12.6.3	Reinforced Cement concrete M 25 with 20 mm graded aggregates for R.C.C works of bottom plate, side wall etc. of forebay at all elevations, laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. comp	330.00 cum	5444.51	/1cum	17.97
12.6.4	Cement concrete M 20 with 20 mm graded aggregates laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	21.00 cum	6273.38	/1cum	1.32
12.6.5	Cement concrete M 20 with 40 mm graded aggregates laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	210.00 m	5145.69	/1cum	10.81
12.7	Reinforcement for R.C.C work using tor steel bent,tied and placed in position including cost of all materials etc complete as per specification	285.00 Qtl	7289.23	/1 Qtl	20.77
12.8	RR Masonry in CM 1:5 with deptl. Rubble issued (free of cost) including cost of materials, conveyance, labour charges, watering, curing etc. complete (excluding cost and conveyance of cement)	240.00 cum	2365.52	/1 cum	5.68
12.9	Rough stone dry packing for aprons and revetments with Deptl. Rubble issued (free of cost) including conveyance, labour charges etc. complete.	30.00 cum	1110.90	/1 m3	0.33
12.10	Supply of cement at site including cost of all storage arrangements , charges for stacking and re-stacking if necessary and all conveyance charges etc. complete	310.00 MT	7095.82	/1 MT	22.00
	Sub Total				**95.31**
	Contingencies @3% of above.	3%	95.31		2.86
	Add extra for rounding				0.09
	Power House Bridge- Total				**98.26**
	SECTION - L - TOTAL				**98.26**
M 13	**BRIDGE AT WEIR SITE**				
13.1	Excavation				
13.1.1	Excavation in hard rock/ sheet rocks and boulders above 500 dm3 in size in wet / dry condition at all elevations using modern explosives with jack hammer etc. drilling, conveying and depositing the excavated spoil in to dump yard or any other places poi	80.00 cum	7857.66	/10cum	0.63

13.2	Wedging, barring, picking etc. on hard rock including loose rock wherever necessary and depositing the spoil within a distance of 5 km, including all charges as per the direction of departmental officers.	30.00 cum	17082.88	/10cum	0.51
13.3	Providing anchor bars using 25mm dia tor steel including drilling holes with jack hammer and grouting with cement grout including all labour charges, machinery, air, water cost and conveyance of cement and steel etc. complete as per the specifications an	480.00 kg	92.45	/1kg	0.44
13.4	Cement concrete				
13.4.1	Cement concrete M 10 with graded aggregates of size 40mm and 20mm laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	6.00 cum	5126.12	/1cum	0.31
13.4.2	Reinforced Cement concrete M 25 with 20 mm graded aggregates for R.C.C works of bottom plate, side wall etc. of forebay at all elevations, laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. comp	205.00 cum	5444.51	/1 cum	11.16
13.4.3	Cement concrete M 20 with 20 mm graded aggregates laying to lines and levels, consolidating, curing etc. including cost of all form work, labour, materials etc. complete (excluding cost and conveyance of cement)	5.00 cum	5093.83	/1cum	0.25
13.5	Reinforcement for R.C.C work using tor steel bent,tied and placed in position including cost of all materials etc complete as per specification	165.00 Qtl	7289.23	/1 Qtl	12.03
13.6	RR Masonry in CM 1:5 with deptl. Rubble issued (free of cost) including cost of materials, conveyance, labour charges, watering, curing etc. complete (excluding cost and conveyance of cement)	80.00 cum	2365.52	/1cum	1.89
13.7	Supplying and fabricating steel bridge	4.70 MT	127758.75	/1MT	6.00
13.8	Painting new iron works with two coats of approved quality colour paint over a priming coat of iron primer after rubbing with emery paper, cleaning the surfaces including cost of all materials, labour charges, etc. complete.	100.00 sqm	970.78	/10sqm	0.10
13.9	Supply of cement at site including cost of all storage arrangements , charges for stacking and re-stacking if necessary and all conveyance charges etc. complete	99.00 MT	7095.82	/1MT	7.02
	Sub Total				**40.35**
	Contingencies @3% of above.	3%	40.35		1.00
	Add extra for rounding				0.16
	Weir site Bridge- Total				**41.51**
	SECTION - M- TOTAL				**41.51**

COST ESTIMATE OF ELECTROMECHANICAL EQUIPMENTS FOR 6 MW (2 x 3 MW) MARIPUZHA S.H.E.P.

Sl. No.	Items	Unit	Quantity	Rate (Rupees in lakhs)	Amount (Rupees in lakhs)
I	**ELECTROMECHANICAL EQUIPMENTS**				
1	Preliminary Expenses	LS			10.00
2	Butterfly Valve	Nos	2	60.00	120.00
3	Horizontal Francis Turbine complete	Nos	2	200.00	400.00
4	Electronic Governor System	Nos	2	15.00	30.00
5	Synchronous Generator, 11kV, 3MW	Nos	2	220.00	440.00
6	Excitation System	Nos	2	15.00	30.00
7	Generator CT with LAVT & NG cubile	Nos	2	10.00	20.00
8	Unit Control, Protection & Metering system complete	Nos	2	16.00	32.00
9	Synchronizing panel	Nos	1	7.00	7.00
10	EOT crane complete	Nos	1	60.00	60.00
11	11kV Switchgear Complete (3 panel) with link	Set	1	30.00	30.00
12	Transformer Control,Protection &Metering System	Nos	1	10.00	10.00
13	Cooling water, Dewatering & Drainage system	LS		25.00	25.00
14	OPU, LOS & other Mechanical Auxillaries	LS		70.00	70.00
15	11kV / 415V, 250 kVA Auxillary transformer	Nos	1	6.00	6.00
16	11/33 kV, 8 MVA transformer	Nos	1.00	90.00	90.00
17	33 kV Circuit breaker	Nos	1.00	5.00	5.00
18	33 kV Current Transformer	Nos	3.00	0.50	1.50
19	33 kV Potential Transformer	Nos	3.00	0.50	1.50
20	33 kV Lightning Arrestor	Nos	6.00	0.25	1.50
21	33kV Line Isolator with Earth switch	Nos	1.00	1.00	1.00
22	33 kV Neutral CT	Nos	1.00	0.50	0.50
23	Switchyard structures including conductors,insulators,clampsand hardware etc.	LS		15.00	15.00
24	Station Grounding System	LS		20.00	20.00
25	Electrical Auxillaries including DC and AC System	LS		25.00	25.00
26	Fire Protection System	LS		10.00	10.00
27	Air conditioning & Air Ventilation System	LS		4.00	4.00
28	Power house &yard lighting and communication	LS		5.00	5.00
29	Power cables & control cables	LS		40.00	40.00
30	Spares	LS			120.00
	Sub total				**1630.00**
31	Erection, testing & commissioning @10%	LS			163.00
32	Establishment,audit and accounts @5%	LS			81.50
33	Transportation, storage & insurance @2%	LS			32.60
34	Miscellaneous				2.90
I	**Total**				1910
	Power Evacuation				
35	Total power evacuation cost considering the proposed projects also in the region(P.T.O for details)	LS		980.00	980.00
II	**Apportioned cost for power evacuation from Maripuzha SHEP (50% of 980)**	LS		490.00	490
	Total E&M Cost (I + II)				**2400.00**

C.V.NANDAN
Chief Engineer
Projects- Electrical Designs

P.T.O

Power evacuation for the subject scheme consists of the following

a Construction of 33KV Single circuit feeder from Maripuzha SHEP to Location CKT-47 through Narsingachodu and Anakkampoyil for a length of 8.8kM

b Construction of 33 KV Double Circuit Feeder from Thambalamanna substation to Location CKT-47 along existing 33KV Chembukadavu line route with 110kV DC line parameters using existing RoW(Right of Way) for a length of 7kM

c Dismantling of 7 Km Single Cirrcuit line using A pole with maximum span of 55Mtrs (Chembukadavu - Thambalamanna line)

d Construction of 33KV feeder bay in 110kV parameter at 33KV substation Thambalamanna.

CHAPTER - 11

FINANCIAL VIABILITY

11.1. Project Cost

The Maripuzha Small HE scheme envisages an installation of 6MW with an average annual generation of 15.31 Mu. The overall cost of the project is estimated as ₹54.08crores (2012 schedule of rates). The cost per MW installed capacity works out to be ₹ 9.01 crores. The cost of energy at the transmission end works out to be ₹6.40 /unit. In Hydro Power Schemes the cost of fuel is nil. Hence the scheme is cheaper compared to other sources of energy.

11.2. Financial Assistance

11.2.1 MNRE grant

The Ministry of Non-Conventional and Renewable Energy (Government of India) is providing financial assistance for the development of Small Projects up to 25MW. This project can also be posed for financial assistance from MNRE, Government of India. As per sixteenth report of study Committee energy (2011 – 12) support to new SHP projects in state is ₹ 2.5 crore for 1st MW + ₹ 40 lakh / Mw for each additional MW. MNRE grant is obtained as ₹ 4.5 crore.

The eligible financial support will be released in four instalments as follows:-

1. 25% on signing of the contract agreement.
2. 30% on completion of 25% of work.
3. 35% on completion of 50% work.
4. Balance 10% on completion of the project.

11.3 Annual Fixed Charges

For calculating annual fixed charges the following items are included as per SERC guidelines.

11.3.1 Interest rate on Loan Capital.

An interest rate of 13% has been reckoned for I D C calculation and for the dept for working out financial return. Interest during construction is capitalised.

11.3.2 Depreciation

The straight-line method of depreciation has been adopted. The life of the components of the project has been taken as per the guidelines of S E R C. Annual Depreciation is worked out as 2.29%.

11.3.3 Source of financing

As per S E R C guidelines, debt equity ratio of 70:30 is considered for the same. Hence 70% of the project cost is to be met from debt for which an interest rate of 13% is provided. Equity of 30 % of the project cost is to be met by KSE Board. Also 15.5% of annual return on equity is considered for financial analysis as per the guidelines. The loan repayment period is taken as12 years. Interest rate of 11% is considered on working capital.

The cost of the project is phased as given below.

1st half year	10%
2nd half year	15%
3rd half year	25%
4th half year	25%
5th half year	25%

11.3.4 Operation and maintenance charges.

1.5% of the capital cost has been allowed for operation and maintenance charges.

11.4. Financial analysis as per 'SERC' Guidelines

Financial analysis has been done as per 'SERC' guidelines. Accordingly, the project is proposed to be financed in the debt equity ratio 70:30. The construction of the project can be completed in a period of $2^{1/2}$ years. The total cost of the project at the time of commissioning along with13% IDC will come to ₹54.41 crores. Details are given in table11 -1. An interest rate of 13% on debt and 15.5% return on equity is considered. Interest rate of 11% is considered on working capital.

11.5 Pay back period

The project will pay back the capitalised cost in 11 years. The details are given in Table 11- 2

11.6 Internal Rate of Return

The project will have an IRR of 12.21%. The details are given in Table 11 – 3.

11.7 Net Present value

NPV for the project is ₹ 1.29 Crores with a discounting factor of 12%. Hence the project is economically viable. The details are given in Table 11 – 4.

11.8 Levellised Tariff

Levellised Tariff at discounting rate of 12% for the project is ₹ 4.92 /unit. The details are given in Table 11- 5.

Financial Evaluation of Maripuzha S H E Project

Name of the project	Maripuzha S H E P	
Installed Capacity	**6.00**	MW
Annual Energy	**15.31**	MU
Auxiliary consumption	0.50%	
Total capital cost (2012- schedule of rates)	**54.08**	Rs. Cr
MNRE grant	4.50	Rs. Cr
Period of construction	30	months
Life of the project (Hydel)	35	years
Assumptions		
(as per CERC norms for tariff calculation)		
Debt: Equity	70:30	
Interest on loan	13%	
Loan repayment period	12	years
Return on Equity	15.5%	
Depreciation rate (with life 35 years)	**2.29%**	of capital cost
O&M cost (base year)	1.50%	of capital cost
O&M cost escalation (for subsequent years)	4%	
Average tariff realization @Rs5.16 during 2008-09escalated at 5%once in 2 years		
Working capital		
(a) O&M expense for one month		
(b) Maintenance of spares @1% of the historical cost escalated @6% per annuam		
(c) Receivable equivalent to two months fixed charge		
Interest on loan for WC (short term loan)	**11.00%**	
Discount rate (for arriving levelised tariff)	**12%**	
Tariff		
Tariff on the 1st year after Commercial Operation	**6.40**	Rs/kWh
Levelised Tariff	**4.92**	Rs/kWh
Pay back period	**11**	Years

Table 11-1

Maripuzha S H E P

Total cost of Construction Including IDC

Total cost excluding IDC **54.08** RsCrores

MNRE Grant 1*2.5+5*.4 **4.50** Cr

Interest rate **13.00%**

Total Capital cost including IDC

Half year	Phasing of investment	Half Yearly investment (Rs.Cr)	Allotment of MNRE subsidy	Net Investment	Equity (30%)	Total Debt including IDC			Cumulative capital cost (Rs. Cr)
						Debt (70%)	Interest during construction for Debt	Total debt including IDC (Rs. Cr)	
1	10%	5.41	1.13	4.28	1.28	3.00	0.10	3.10	4.38
2	15%	8.11	1.35	6.76	2.03	4.73	0.36	5.09	11.50
3	25%	13.52	1.58	11.95	3.58	8.36	0.80	9.17	24.25
4	25%	13.52	0	13.52	4.06	9.46	1.44	10.90	39.20
5	25%	13.52	0.45	13.07	3.92	9.15	2.13	11.28	54.41
Total	100%	54.08	4.50	49.58	14.87	34.71	4.83	39.53	

Total cost including IDC **54.41** Crores

Table 11-2							
Maripuzha S H E P							
Payback period							
	Cash outflow				Cash inflow	cash surplus available for payback	Cumulative cash surplus
Year	Interest	O&M cost	Interest on WC	Total outflow	Average tariff realisation @Rs 5.16 (Rs.3.97,increased 30%) during 2012-13 escalated at 5%once in 2 years		
	(Rs.Cr)	(Rs. Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	
1	5.14	0.82	0.25	6.20	8.67	2.47	2.47
2	4.71	0.85	0.24	5.80	9.10	3.30	5.77
3	4.28	0.88	0.24	5.40	9.10	3.70	9.46
4	3.85	0.92	0.24	5.01	9.56	4.55	14.01
5	3.43	0.95	0.23	4.62	9.56	4.94	18.95
6	3.00	0.99	0.23	4.22	10.03	5.81	24.76
7	2.57	1.03	0.23	3.83	10.03	6.20	30.96
8	2.14	1.07	0.23	3.44	10.54	7.09	38.06
9	1.71	1.12	0.23	3.06	10.54	7.48	45.53
10	1.28	1.16	0.23	2.67	11.06	8.39	53.92
11	**0.86**	**1.21**	**0.23**	**2.29**	**11.06**	**8.77**	**62.69**
12	0.43	1.26	0.23	1.91	11.62	9.70	72.40
13	0.00	1.31	0.23	1.54	11.62	10.08	82.48
14	0.00	1.36	0.24	1.60	12.20	10.60	93.08
15	0.00	1.41	0.25	1.66	12.20	10.54	103.61
16	0.00	1.47	0.26	1.73	12.81	11.08	114.69
17	0.00	1.53	0.27	1.80	12.81	11.01	125.70
18	0.00	1.59	0.28	1.87	13.45	11.58	137.28
19	0.00	1.65	0.29	1.94	13.45	11.50	148.78
20	0.00	1.72	0.30	2.02	14.12	12.10	160.88
21	0.00	1.79	0.32	2.11	14.12	12.01	172.89
22	0.00	1.86	0.33	2.19	14.82	12.63	185.52
23	0.00	1.93	0.35	2.28	14.82	12.54	198.07
24	0.00	2.01	0.36	2.37	15.57	13.19	211.26
25	0.00	2.09	0.38	2.47	15.57	13.09	224.35
26	0.00	2.18	0.40	2.57	16.34	13.77	238.12
27	0.00	2.26	0.42	2.68	16.34	13.67	251.79
28	0.00	2.35	0.44	2.79	17.16	14.37	266.16
29	0.00	2.45	0.46	2.90	17.16	14.26	280.42
30	0.00	2.55	0.48	3.02	18.02	15.00	295.42
31	0.00	2.65	0.50	3.15	18.02	14.87	310.29
32	0.00	2.75	0.53	3.28	18.92	15.64	325.93
33	0.00	2.86	0.55	3.42	18.92	15.50	341.43
34	0.00	2.98	0.58	3.56	19.87	16.31	357.74
35	0.00	3.10	0.61	3.71	19.87	16.16	373.90

Table 11-3

Maripuzha S H E P

Internal Rate of Return

Year	Loan at the beginning of the Year	Loan repayment during the year	Interest	Return on equity	Depreciation	O&M cost	Interest on WC	Total annual cost excl. ROE& Depreciation	Average tariff realisation @Rs 5.16 (Rs.3.97,increased 30%) during 2012-13 escalated at 5%once in 2 years	Final Net cash flow
	(Rs.Cr)	(Rs. Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs. Cr)	(Rs.Cr)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)=(d)+(g)+(h)	(j)	
										-54.41
1	39.53	3.29	5.14	2.31	1.25	0.82	0.25	6.20	**8.67**	2.47
2	36.24	3.29	4.71	2.31	1.25	0.85	0.24	5.80	**9.10**	3.30
3	32.94	3.29	4.28	2.31	1.25	0.88	0.24	5.40	**9.10**	3.70
4	29.65	3.29	3.85	2.31	1.25	0.92	0.24	5.01	**9.56**	4.55
5	26.35	3.29	3.43	2.31	1.25	0.95	0.23	4.62	**9.56**	4.94
6	23.06	3.29	3.00	2.31	1.25	0.99	0.23	4.22	**10.03**	5.81
7	19.77	3.29	2.57	2.31	1.25	1.03	0.23	3.83	**10.03**	6.20
8	16.47	3.29	2.14	2.31	1.25	1.07	0.23	3.44	**10.54**	7.09
9	13.18	3.29	1.71	2.31	1.25	1.12	0.23	3.06	**10.54**	7.48
10	9.88	3.29	1.28	2.31	1.25	1.16	0.23	2.67	**11.06**	8.39
11	6.59	3.29	0.86	2.31	1.25	1.21	0.23	2.29	**11.06**	8.77
12	3.29	3.29	0.43	2.31	1.25	1.26	0.23	1.91	**11.62**	9.70
13				2.31	1.25	1.31	0.23	1.54	**11.62**	10.08
14				2.31	1.25	1.36	0.24	1.60	**12.20**	10.60
15				2.31	1.25	1.41	0.25	1.66	**12.20**	10.54
16				2.31	1.25	1.47	0.26	1.73	**12.81**	11.08
17				2.31	1.25	1.53	0.27	1.80	**12.81**	11.01
18				2.31	1.25	1.59	0.28	1.87	**13.45**	11.58
19				2.31	1.25	1.65	0.29	1.94	**13.45**	11.50
20				2.31	1.25	1.72	0.30	2.02	**14.12**	12.10
21				2.31	1.25	1.79	0.32	2.11	**14.12**	12.01
22				2.31	1.25	1.86	0.33	2.19	**14.82**	12.63
23				2.31	1.25	1.93	0.35	2.28	**14.82**	12.54
24				2.31	1.25	2.01	0.36	2.37	**15.57**	13.19
25				2.31	1.25	2.09	0.38	2.47	**15.57**	13.09
26				2.31	1.25	2.18	0.40	2.57	**16.34**	13.77
27				2.31	1.25	2.26	0.42	2.68	**16.34**	13.67
28				2.31	1.25	2.35	0.44	2.79	**17.16**	14.37
29				2.31	1.25	2.45	0.46	2.90	**17.16**	14.26
30				2.31	1.25	2.55	0.48	3.02	**18.02**	15.00
31				2.31	1.25	2.65	0.50	3.15	**18.02**	14.87
32				2.31	1.25	2.75	0.53	3.28	**18.92**	15.64
33				2.31	1.25	2.86	0.55	3.42	**18.92**	15.50
34				2.31	1.25	2.98	0.58	3.56	**19.87**	16.31
35				2.31	1.25	3.10	0.61	3.71	**19.87**	16.16
			Internal Rate of Return							**12.21%**

Table 11- 4

Maripuzha S H E P

NET PRESENT VALUE

Year	Loan at the beginning of the Year	Loan repayment during the year	Interest	Return on equity	Depreciation	O&M cost	Interest on WC	Total annual cost excl. ROE& Depreciation	Average tariff realisation @Rs 5.16 (Rs.3.97,increased 30%) during 2012-13 escalated at 5%once in 2 years	Final net cash flow	Discounted Cash flow
	(Rs.Cr)	(Rs. Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs. Cr)	(Rs.Cr)	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)=(d)+(g)+(h)	(j)	K	l
										-54.41	
1	39.53	3.29	5.14	2.31	1.25	0.82	0.25	6.20	**8.67**	2.47	2.20
2	36.24	3.29	4.71	2.31	1.25	0.85	0.24	5.80	**9.10**	3.30	2.63
3	32.94	3.29	4.28	2.31	1.25	0.88	0.24	5.40	**9.10**	3.70	2.63
4	29.65	3.29	3.85	2.31	1.25	0.92	0.24	5.01	**9.56**	4.55	2.89
5	26.35	3.29	3.43	2.31	1.25	0.95	0.23	4.62	**9.56**	4.94	2.80
6	23.06	3.29	3.00	2.31	1.25	0.99	0.23	4.22	**10.03**	5.81	2.94
7	19.77	3.29	2.57	2.31	1.25	1.03	0.23	3.83	**10.03**	6.20	2.81
8	16.47	3.29	2.14	2.31	1.25	1.07	0.23	3.44	**10.54**	7.09	2.86
9	13.18	3.29	1.71	2.31	1.25	1.12	0.23	3.06	**10.54**	7.48	2.70
10	9.88	3.29	1.28	2.31	1.25	1.16	0.23	2.67	**11.06**	8.39	2.70
11	6.59	3.29	0.86	2.31	1.25	1.21	0.23	2.29	**11.06**	8.77	2.52
12	3.29	3.29	0.43	2.31	1.25	1.26	0.23	1.91	**11.62**	9.70	2.49
13	0.00	3.29	0.00	2.31	1.25	1.31	0.23	1.54	**11.62**	10.08	2.31
14				2.31	1.25	1.36	0.24	1.60	**12.20**	10.60	2.17
15				2.31	1.25	1.41	0.25	1.66	**12.20**	10.54	1.92
16				2.31	1.25	1.47	0.26	1.73	**12.81**	11.08	1.81
17				2.31	1.25	1.53	0.27	1.80	**12.81**	11.01	1.60
18				2.31	1.25	1.59	0.28	1.87	**13.45**	11.58	1.51
19				2.31	1.25	1.65	0.29	1.94	**13.45**	11.50	1.34
20				2.31	1.25	1.72	0.30	2.02	**14.12**	12.10	1.25
21				2.31	1.25	1.79	0.32	2.11	**14.12**	12.01	1.11
22				2.31	1.25	1.86	0.33	2.19	**14.82**	12.63	1.04
23				2.31	1.25	1.93	0.35	2.28	**14.82**	12.54	0.93
24				2.31	1.25	2.01	0.36	2.37	**15.57**	13.19	0.87
25				2.31	1.25	2.09	0.38	2.47	**15.57**	13.09	0.77
26				2.31	1.25	2.18	0.40	2.57	**16.34**	13.77	0.72
27				2.31	1.25	2.26	0.42	2.68	**16.34**	13.67	0.64
28				2.31	1.25	2.35	0.44	2.79	**17.16**	14.37	0.60
29				2.31	1.25	2.45	0.46	2.90	**17.16**	14.26	0.53
30				2.31	1.25	2.55	0.48	3.02	**18.02**	15.00	0.50
31				2.31	1.25	2.65	0.50	3.15	**18.02**	14.87	0.44
32				2.31	1.25	2.75	0.53	3.28	**18.92**	15.64	0.42
33				2.31	1.25	2.86	0.55	3.42	**18.92**	15.50	0.37
34				2.31	1.25	2.98	0.58	3.56	**19.87**	16.31	0.35
35				2.31	1.25	3.10	0.61	3.71	**19.87**	16.16	0.31
										SUM	55.69

NET PRESENT VALUE = 1.29 CRORES

Table 11-5

MARIPUZHA S H E PROJECT

	Yearly Tariff & Levelised Tariff										
	Year	Loan at the beginning of the Year	Loan repayment during the year	Interest	Return on equity	Depreciation	O&M cost	Interest on WC	Total annual cost	Net Annual Cost	Cost of energy
		(Rs.Cr)	(Rs. Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)	(Rs.Cr)		(Rs/kWh)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)= (d)+(e)+(f) +(g)+(h)	i- j	(j)
1	1	39.53	3.29	5.14	2.31	1.25	0.82	0.25	9.75	9.75	6.40
1	2	36.24	3.29	4.71	2.31	1.25	0.85	0.24	9.35	9.35	6.14
1	3	32.94	3.29	4.28	2.31	1.25	0.88	0.24	8.96	8.96	5.88
1	4	29.65	3.29	3.85	2.31	1.25	0.92	0.24	8.56	8.56	5.62
1	5	26.35	3.29	3.43	2.31	1.25	0.95	0.23	8.17	8.17	5.36
1	6	23.06	3.29	3.00	2.31	1.25	0.99	0.23	7.78	7.78	5.10
1	7	19.77	3.29	2.57	2.31	1.25	1.03	0.23	7.39	7.39	4.85
1	8	16.47	3.29	2.14	2.31	1.25	1.07	0.23	7.00	7.00	4.59
1	9	13.18	3.29	1.71	2.31	1.25	1.12	0.23	6.61	6.61	4.34
1	10	9.88	3.29	1.28	2.31	1.25	1.16	0.23	6.23	6.23	4.09
1	11	6.59	3.29	0.86	2.31	1.25	1.21	0.23	5.84	5.84	3.84
1	12	3.29	3.29	0.43	2.31	1.25	1.26	0.23	5.46	5.46	3.59
1	13				2.31	1.25	1.31	0.23	5.09	5.09	3.34
1	14				2.31	1.25	1.36	0.24	5.15	5.15	3.38
1	15				2.31	1.25	1.41	0.25	5.21	5.21	3.42
1	16				2.31	1.25	1.47	0.26	5.28	5.28	3.47
1	17				2.31	1.25	1.53	0.27	5.35	5.35	3.51
1	18				2.31	1.25	1.59	0.28	5.42	5.42	3.56
1	19				2.31	1.25	1.65	0.29	5.50	5.50	3.61
1	20				2.31	1.25	1.72	0.30	5.58	5.58	3.66
1	21				2.31	1.25	1.79	0.32	5.66	5.66	3.71
1	22				2.31	1.25	1.86	0.33	5.74	5.74	3.77
1	23				2.31	1.25	1.93	0.35	5.83	5.83	3.83
1	24				2.31	1.25	2.01	0.36	5.93	5.93	3.89
1	25				2.31	1.25	2.09	0.38	6.02	6.02	3.95
1	26				2.31	1.25	2.18	0.40	6.13	6.13	4.02
1	27				2.31	1.25	2.26	0.42	6.23	6.23	4.09
1	28				2.31	1.25	2.35	0.44	6.34	6.34	4.16
1	29				2.31	1.25	2.45	0.46	6.46	6.46	4.24
1	30				2.31	1.25	2.55	0.48	6.58	6.58	4.32
1	31				2.31	1.25	2.65	0.50	6.70	6.70	4.40
1	32				2.31	1.25	2.75	0.53	6.83	6.83	4.48
1	33				2.31	1.25	2.86	0.55	6.97	6.97	4.57
1	34				2.31	1.25	2.98	0.58	7.11	7.11	4.67
1	35				2.31	1.25	3.10	0.61	7.26	7.26	4.77

Levelised tariff (at discounting rate- 12%) (Rs/kWh) **4.92**

Table 12-6					
Maripuzha S H E P					
Depreciation					
Sl No	**Items**	**Life in Years**	**Cost (in Rs. Lakhs)**	**Depreciation factor (As per CERC norms)**	**Annual depreciation (Rs. Lakhs)**
1	Weir, Intake chamber, Power channel, Forebay & over flow channel	50	1320.47	1.80%	23.77
2	Penstock	35	290.00	2.57%	7.46
3	Power house & Switch yard	35	478.76	2.57%	12.31
4	Tail race channel	35	97.73	2.57%	2.51
5	Buildings	50	9.27	1.80%	0.17
6	Roads & Bridges	50	260.40	1.80%	4.69
8	Other items	50	24.88	1.80%	0.45
	Total		2221.11		50.90
	Weighted average depreciation		**2.29%**		

CHAPTER - 12

CONSTRUCTION

12.1General

The main civil works include construction of trench weir , power channel, penstock, powerhouse, tailrace and facilities such as roads. The mechanical work includes the manufacture, fabrication and erection of gates. trash rack and intake, butterfly valve for penstock, stop log gate for power house etc. The electromechanical work includes erection and commissioning of 2, 3.0 MW capacity generating equipments, erection of EOT crane, auxiliary equipments for dewatering, cooling etc. and construction of transmission towers and lines

12.2 Communication Facilities

Power House road and bridge

The length of power house road is 165m and the formation width is 5.50m. This road crosses Iruvanjipuzha between Ch. 101 and Ch. 126. A 25m long bridge is required to cross the river. Bore hole No. 2 was drilled up to a depth of 23.95m and shows no rock deposits. A multiple box type bridge with a bottom raft and cutoff wall is provided. Initial 100m length of road is passing through tribal colony in a convenient location so as to avoid any interference to inhabitants.

Weir site road and bridge

The length of weir site road is 334m and consists of one steel bridge of span 10m and two culverts of span 5m and 4m respectively. The steel bridge is proposed to abut on two large boulders situated in the upstream side of Pottankayam. The stability of structure on these boulders shall be ascertained before construction. 1 in 10 gradient is adopted for the road. The maximum excavation depth for this road is 16m. Gabion retaining walls are provided to retain the soil. The excavation activities shall be arranged during non monsoon period to minimize the saturated soil pressure. The stability analysis of this excavation slopes shall be determined. An alternate location for access road to weir site is available near the suspension bridge site at Mainavalavu. But the length of bridge and road will be more and this alignment will be costlier than the above.

12.3 Availability of Construction Materials

12.3.1 Rubble

The Surface rock deposits can be seen between Ch. 568m to 625m in Power Channel. Even though the rock level in Forebay and Power House is more or less same as the foundation level, the core drilling log shows the presence of large boulders. Rubble for the project is manufactured from the department rubble excavated and stacked in the dumping yard. Provision for stacking rubble at dumping yard is provided.

12.3.2 Broken stone

Broken stone can be procured from Mukkam which is about 20km from site.

12.3.3 Sand

Sand can be collected from Areacode which is about 35 km from site.

12.3.4 Cement and steel

Cement and steel required for the scheme is proposed to be supplied by the contractor. The cement and reinforcement steel can be procured in bulk from Thiruvambadi (15km).

12.3.5 Penstock plates

IS 2002 Grade-2 Steel is used for fabricating penstock shells. The plate of 8mm is required for fabricating penstock pipe. IS 2002 sheets are manufactured by SAIL and sourced from SAIL yard at Thripunithara (257 Km). The penstock plates are to be supplied by the contractor. Since cost of IS 2002 plates are not available in SOR, the cost of TMT steel is taken instead.

CONVEYANCE STATEMENT

Sl. No:	Materials	Unit	Conveyance		Lorry Conveyance in km		Head load Conveyance in m	Lorry Conveyance in Rs.		Head load Conveyance in Rs.
			From	To	Plain	Hill		Plain	Hill	Hill
1	Cement	MT	Thiruvambady	Project site	8	7	100	346	54.05	59.80
2	Sand	M^3	Areakode	Project site	28	7	100	582	128.80	123.05
3	Tor steel	MT	Thiruvambady	Project site	8	7	100	346	54.05	59.80
4	Structural steel	MT	Kozhikode	Project site	42	7	100	582	56.35	59.80
5	TMT steel for penstock	MT	Thripunithura SAILyard	Project site	250	7		2038	56.35	-
6	M. S. rod	MT	Thiruvambady	Project site	8	7	100	346	54.05	59.80
7	Rubble	M^3	Mukkam	Project site	13	7	100	342.00	128.80	123.05
8	36 mm metal	M^3	Mukkam	Project site	13	7	100	342.00	128.80	123.05
9	40 mm metal	M^3	Mukkam	Project site	13	7	100	342.00	128.80	123.05
10	20 mm metal	M^3	Mukkam	Project site	13	7	100	342.00	128.80	123.05
11	12 mm metal	M^3	Mukkam	Project site	13	7	100	342.00	128.80	123.05
12	6 mm metal	M^3	Mukkam	Project site	13	7	100	342.00	128.80	123.05
13	60 mm metal	M^3	Mukkam	Project site	13	7	100	342.00	128.80	123.05
14	Bricks 19 x 9 x 9	1000 Nos.	Feroke	Project site	46	7	100	1070.00	152.95	163.30
15	Paving tiles	1000 Nos.	Feroke	Project site	46	7	100	1070.00	152.95	163.30
16	Flooring tiles	1000 Nos.	Kozhikode	Project site	42	7	100	994.00	152.95	163.30
17	32 mm G.I. Sheet	MT	Kozhikode	Project site	42	7	100	582.00	56.35	59.80
18	G.I. Pipe, G.I strip	MT	Kozhikode	Project site	42	7	100	582.00	56.35	59.80
19	Welded mesh	MT	Kozhikode	Project site	42	7	100	582.00	56.35	59.80
20	Asphalt/bitumen	MT	Ambalamugal	Project site	217	7	100	1807.00	56.35	59.80
21	Copper sealing strip	MT	Kozhikode	Project site	42	7	100	582.00	56.35	59.80
22	Asphalted wooden slab	MT	Kozhikode	Project site	42	7	100	582.00	56.35	59.80
23	Aluminium sheet 3 mm thick	MT	Kozhikode	Project site	42	7	100	582.00	56.35	59.80
24	Gravel/Blasted rubble	M^3	Local	Project site		5	100		250.70	123.05
25	Red earth	M^3	Local	Project site		5	100		250.70	123.05
26	Asphalt felt	MT	Kozhikode	Project site	42	7	100	582.00	56.35	59.80
27	Steel pipe 4 mm thick	MT	Kozhikode	Project site	42	7	100	582.00	56.35	59.80
28	Timber	M^3	Kozhikode	Project site	42	7	100	582.00	56.35	59.80

12.4 Project implementation

The construction activities are proposed to execute through contract agencies. KSEB has sufficient know how and expertise for successful implementation of hydroelectric projects.

12.4.1 Construction phases

The implementation of Maripuzha S.H.E.P is divided into the following three phases.

Phase – I

Phase – I involves construction of access roads and bridges to various project components.

Phase – II

This phase involves the construction of major hydraulic structures, penstock and power house building.

Civil work consist of construction of Trench weir, Diversion weir, Intake channel, Intake chamber, Feeder conduit, Feeder channel, , Power channel, Forebay, Escape channel, Power house, Tail race chamber, Tail race channel, Switch yard, Retaining walls, Compound walls and Miscellaneous CD works.

Mechanical work consists of Fabrication and erection of steel penstock & accessories, Trash racks, Intake gates, Stop log gates and hoisting arrangements.

Phase – III

The final phase consists of Electro Mechanical works and Transmission line work.

The E&M package consists of supply and erection of EOT crane, butterfly valves, turbines, synchronizing generators, governors, pressure relies valves, draft tubes, protection and metering, switch yard equipments, cabling, fire protection, lighting, commissioning and performance testing.

The transmission line work consists of erecting 33kv single circuit line between Maripuzha power house site to Anakkampoyil power house site and double circuit line between Anakkampoyil power house to Nellipoyil where the existing Chembukadavu – Thambalamanna 33kv line passes.

12.5 Resource utilization

This project is designed to utilize the optimum usage of available resources so as to save cost, time and environment. The power house building is planned as a composite structure of RCC and Steel. RCC structure is proposed up to 4m from service bay level and steel structure is proposed above this level for speedy construction. The penstock diameters are so chosen to avoid material wastage at the maximum extent. The curves in RCC power channel is of same radius at all bend points for enabling the reuse of curved shuttering.

12.6 Time frame

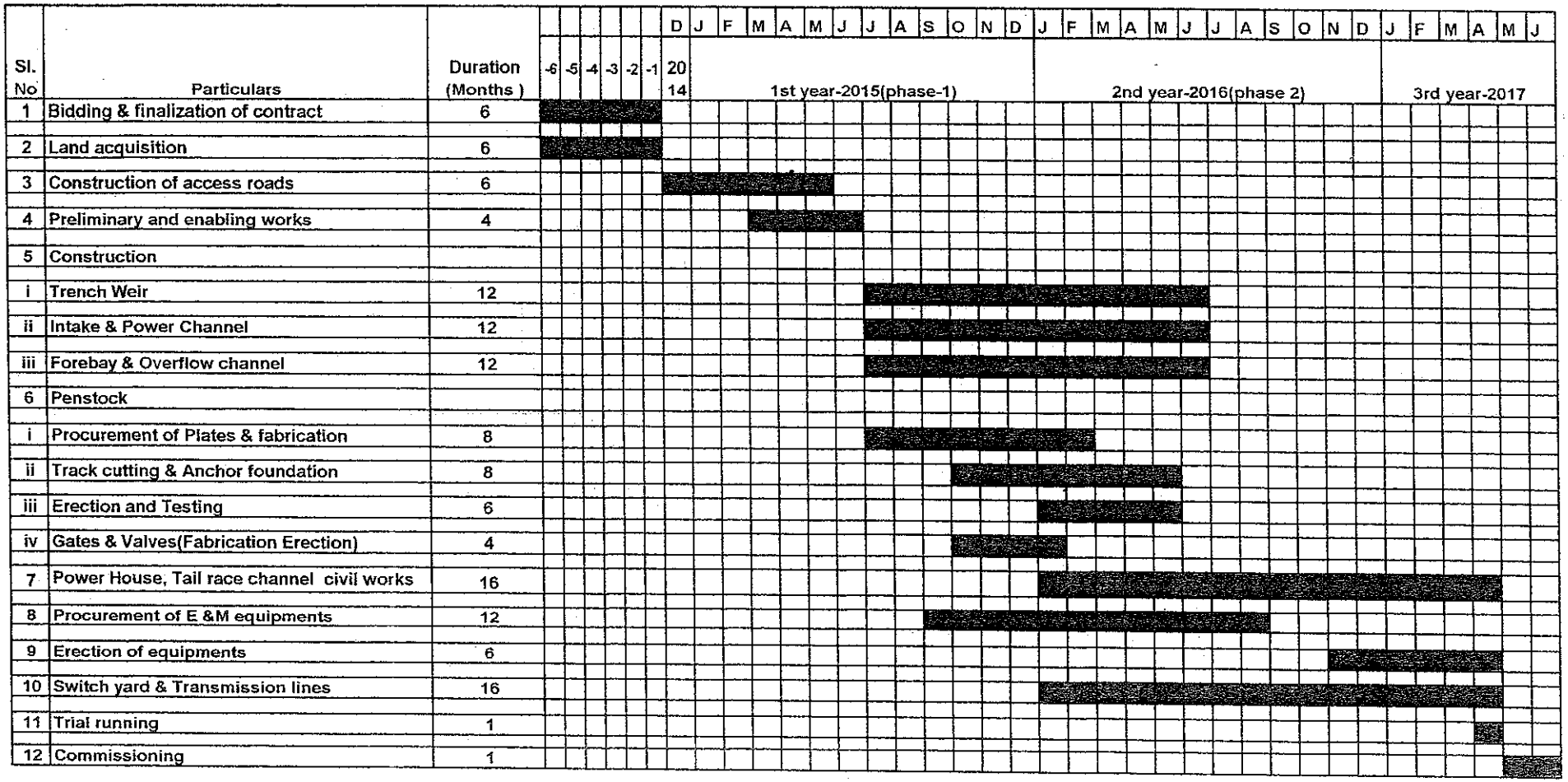
The best time to start the construction activities at Maripuzha is December onwards. The first phase is assumed to be starting from March 2015. The time lag between first and second phase is arranged to occur during the monsoon of 2015. Since major structures will be ready before 2016 monsoon, the heavy rain will not affect the remaining work. The project is scheduled to be finished by September 2016. Test running and performance testing can be completed in October and the plant will be ready for commercial operation by June 2017.

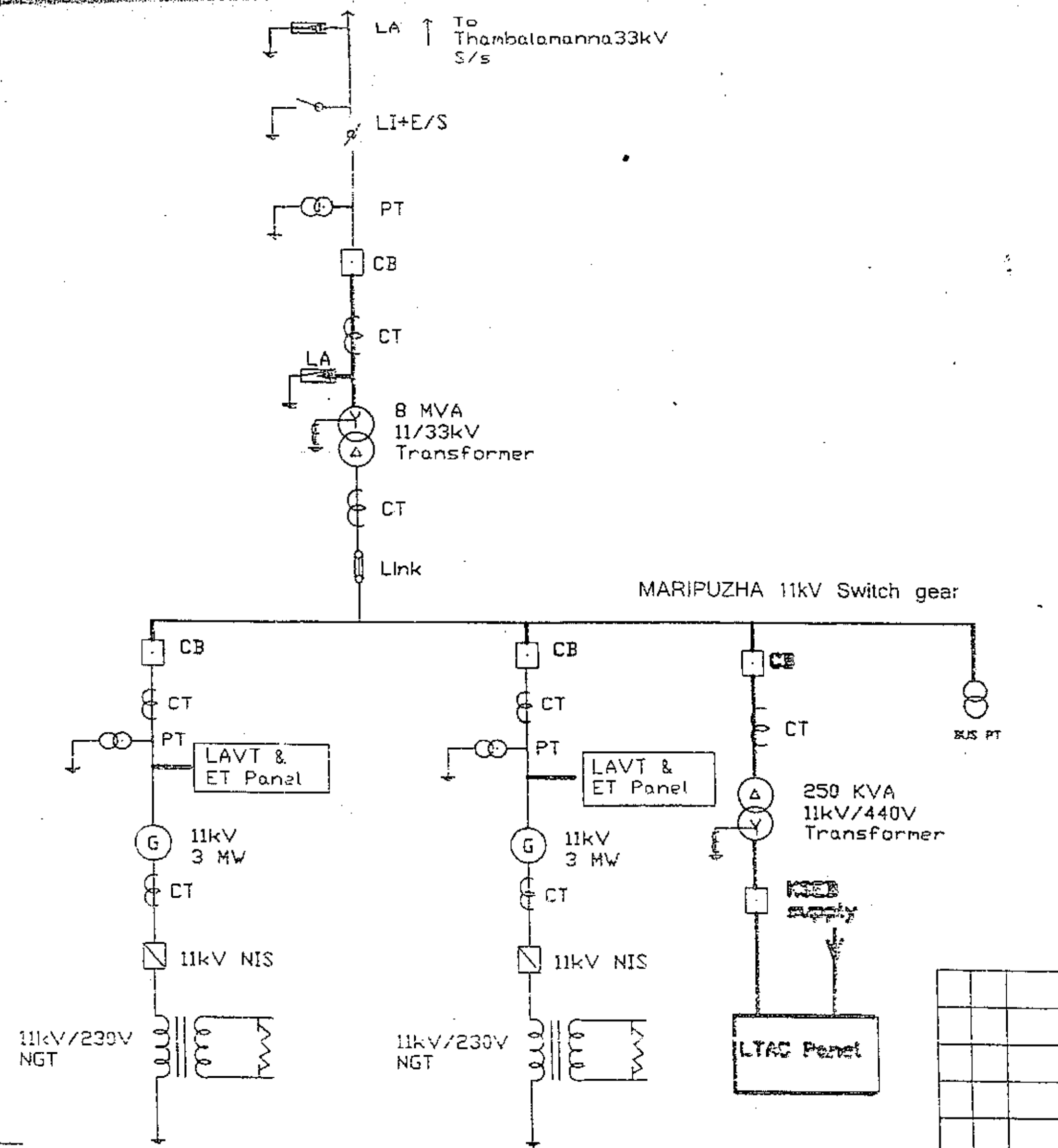
12.7 Construction program

A detailed construction program for Maripuzha S.H.E.P is prepared with monthly and half yearly cash flow statements covering all major activities in different stages of project implementation. The IDC is calculated based on this cash flow statement. The construction program bar chart is shown overleaf.

MARIPUZHA SHEP - BAR CHART
CONSTRUCTION PROGRAM

Sl. No	Particulars	Duration (Months)
1	Bidding & finalization of contract	6
2	Land acquisition	6
3	Construction of access roads	6
4	Preliminary and enabling works	4
5	Construction	
i	Trench Weir	12
ii	Intake & Power Channel	12
iii	Forebay & Overflow channel	12
6	Penstock	
i	Procurement of Plates & fabrication	8
ii	Track cutting & Anchor foundation	8
iii	Erection and Testing	6
iv	Gates & Valves(Fabrication Erection)	4
7	Power House, Tail race channel civil works	16
8	Procurement of E &M equipments	12
9	Erection of equipments	6
10	Switch yard & Transmission lines	16
11	Trial running	1
12	Commissioning	1





KERALA STATE ELECTRICITY BOARD

For Tender Purpose Only

MARIPUZHASHEP (2 X 3MW)

PROPOSED SINGLE LINE DIAGRAM

Asst. Engineer | Asst. Exe. Engineer | Exe. Engineer | Date: | Drawing No: | Scale: NTS | Sheet: 1 of 1

Rev | Date | Description | Initial | Dy. CE (PED) | Chief Engineer (PED)

ANNEXURE

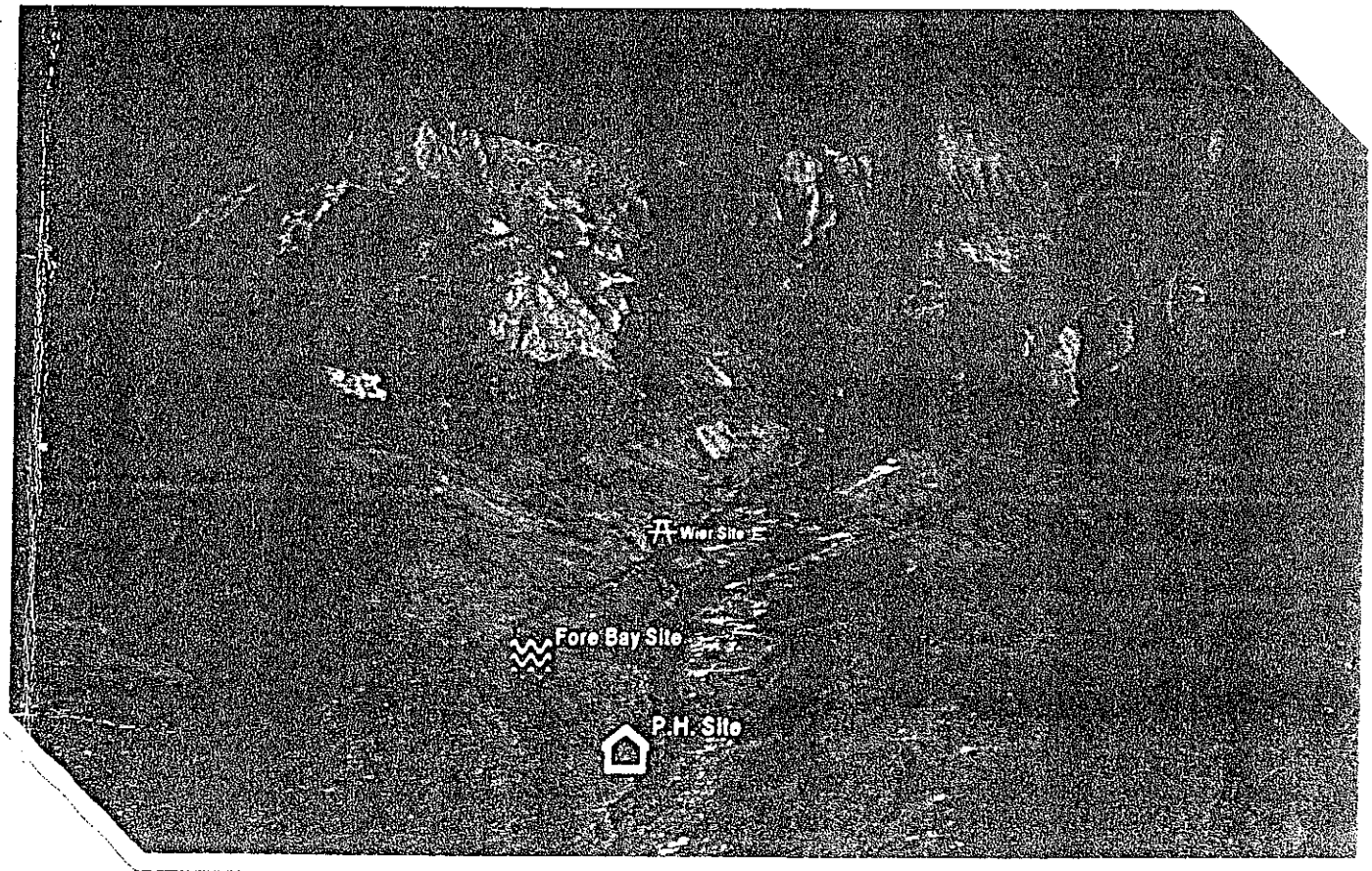
REPORT ON THE PRELIMINARY STAGE GEOTECHNICAL INVESTIGATION OF MARIPUZHA

REPORT ON THE PRELIMINARY STAGE GEOTECHNICAL INVESTIGATION OF MARIPUZHA HYDROELECTRIC PROJECT

KOZHIKODE DISTRICT, KERALA

(FIELD SEASON : 2010 - 12)

(EG/C/SR/TNPK/2010/055)



K .Aravind, Senior Geologist

&

Abhishek Kumar, Geoloigst

ENGINEERING GEOLOGY DIVISION

GEOLOGICAL SURVEY OF INDIA

STATE UNIT: TAMIL NADU & PUDUCHERRY

C-2, B WING, RAJAJI BHAVAN, BESANT NAGAR

CHENNAI - 600 090

SEPTEMBER 2012

REPORT ON PRELIMINARY STAGE GEOTECHNICAL INVESTIGATION OF
MARIPUZHA HYDRO ELECTRIC PROJECT
KOZHIKODE DISTRICT, KERALA

(Field Season 2010-2012)
(EG/C/SR/TNP/2010/055)

K.ARAVIND, Senior Geologist
&
ABHISHEK KUMAR, Geologist

Contents

List of Plates

List of Tables

List of Annexure

List of Figures

REPORT ON PRELIMINARY STAGE GEOTECHNICAL INVESTIGATION OF MARIPUZHA HYDRO ELECTRIC PROJECT KOZHIKODE DISTRICT, KERALA

(Field Season 2010-2012)

(EG/C/SR/TNP/2010/055)

K.ARAVIND
Senior Geologist
&
ABHISHEK KUMAR
Geologist
Geological Survey of India

ABSTRACT

Maripuzha Small Hydro Electric Project envisages diverting waters from Iruvanjipuzha river, of Chaliyar Basin, by constructing a trench weir in Maripuzha to generate 2X 2500 KW of electricity, utilizing a gross head of 125.25 m. Preliminary stage geotechnical investigation of the project site was carried out, involving feasibility assessment of the component site, and logging of exploratory drill cores.

charnockite of Archaean age is the principal rock type at the project site, with E-W trending foliation. The site falls in the Seismic Zone –III of the Seismic Zoning Map of India and marked by E-W trending lineaments.

The project site is in general marred by thick overburden material with scanty outcrops. Blocks of rocks within the overburden material are common on the hill slopes, as seen along the power channel and the penstock route alignment. Single bore hole drilled at the proposed trench weir revealed no recovery of insitu rock down to the drilled depth of 23.94 m, warranting further probe by drilling. The site around the de-silting chamber lies along the sloping ground mass. Preliminary investigation of the site indicated that the bed rock along the entire length of the power duct may be at greater depth. Excavations through the head race channel alignment needs utmost precaution since modification of the natural slope may trigger minor land slide. Suitable design for the penstock anchors has been recommended in view of thick overburden. The power house site near the river bank exposed fresh rock, suitable for foundation. Provision of boulder trap at the upstream of the weir is recommended.

REPORT ON PRELIMINARY STAGE GEOTECHNICAL INVESTIGATION OF MARIPUZHA HYDRO ELECTRIC PROJECT KOZHIKODE DISTRICT, KERALA

(Field Season 2010-2012)
(EG/C/SR/TNP/2010/055)

K.ARAVIND
Senior Geologist
&
ABHISHEK KUMAR
Geologist
Geological Survey of India

I. INTRODUCTION:

In order to meet the ever increasing demand for power, the Kerala State Electricity Board (KSEB) proposes Maripuzha Hydro Electric Project, to utilise the waters of Iruvanjipuzha river of Chaliyar Basin to generate 12.97 Mu (2 x 2500 KW), utilising a gross head of 125.25 m.

The proposal is to divert waters from Iruvanjipuzha river, by constructing a trench weir, directing water to feeder conduit through an intake channel and intake chamber and desilting chamber , to fore bay and from there through penstock to the powerhouse, proposed on the right bank.

Preliminary stage geotechnical investigations were carried out at the site during 26th and 27th July 2011 in response to a request from the Dy. Chief Engineer, Investigation Circle, Thrissur (vide letter no.ICN/135/TSR/Marippuzha dated 01.06.11) . Geological and geotechnical studies have been carried out along the power channel alignment, fore bay site, penstock alignment, power house site, etc. Besides, drill cores have been logged to a cumulative depth of 187.63 m from 9 nos. of bore holes drilled at various components of project.

II. LOCATION and ACCESSIBILITY:

The project site is located in Nellipoyil village of Kodencheri Panchayat, Kozhikode Distt., Kerala, falling in the Survey of India toposheet no. 58 A/3 (Plate – 1). It is located 49 kms from Kozhikode (via) Thiruvambady- Anakkampoyil-Muthappanpuzha. The Weir Site Coordinate is Latitude - 11° 27' 02"N and Longitude 76° 05' 57.50" E.

III. SALIENT FEATURES:

1. Hydrology

i) Catchment area -15.92 sq km

ii) Average monsoon discharge -73.08 Mm^3

iii) Average annual rainfall -6696.65 mm

2. Head

i) Gross head -125.25 m

ii) Net head -118 m

3. Weir – I

i) Type - Trench weir

ii) F.S.L - +588.00 m above m.s.l

iii) H.F.L - +589.500 m above m.s.l (after construction)

iv) Lowest bed level - +587.045 m above m.s.l

v) Length of weir - 18 m

vi) Width - 2.10m

vii) Depth - 1.50m to 1.86m below FSL

viii) Bedslope - 1in50

ix) Free board - 0.25 (Average)

4. Weir – II

i) Type - Trench weir

ii) F.S.L - +588.00 m above m.s.l

iii) Lowest bed level - +587.045 m above m.s.l

iv) Length of weir - 4 m

v) Width - 1.00 m

vi) Depth - 2.07 m to 2.11 m below FSL

5. Intake Channel

i) Type - RCC Box shaped channel

ii) Location - Trench Weir to intake chamber

iii) Main weir to auxilliary - 39 m

iv) Auxilliary to intake chamber - 9 m

v) Width - 2.10 m

vi)Height - 1.68 to 2.20 below FSL

vii) Free board - 0.50 m

6. Intake Chamber

i) Intake Chamber - 4m x 4m x 8.25m top open

ii) Service gate - 1.50m x 1.50m

iii) Flushing pipe - 300mm dia, 60m long

iv)Auxilliary to intake chamber - 9 m

v) F.S.L - +587.85 m above m.s.l

vi)Centre line of distributory - +585.00 m above m.s.l

7. Feeder Conduit

i) Size - 1.50m x 1.50m

ii) Type - Concrete box shaped

iii) Longitudinal slope - 1 in 100

iv) Length - 175 m

8. Feeder Channel & Surplus Weir

i) Width - 3m

ii) Depth - 3.00 m (average)

iii) Total Length - 19m

iv) Surplus weir length - 7 m

v) Surplus channel width - 2.40m

vi) Depth - 1.20m + 0.75m free board

9. Desilting Chamber

i) Size - 21m x 5m x 4.75m

ii) Type - Hoper bottom intermittent flushing

iii) Lowest removal size - 0.50 mm

iv) Inlet transition - 6 m long (3m to 5m)

v) Outlet transition - 3m long (5m to 2.50m)

vi) Deflusing pipe - 300mm dia 3 Nos M.S

10. Head Race Channel

i) Type Size - Rectangular R.C Channel 2.50 x 1.50 + (0.75 free board)

ii) Length Longitudinal slope - 913m (desilter to forebay) 1 in 750

11. Fore Bay Tank

i)	Type	-	Rectangular Reinforced concrete
ii)	Size	-	28m x 12m x 2.50 to 10.50
iii)	Live storage	-	762 m^3, for 130 seconds
iv)	M.W.L	-	+586.00 m above m.s.l
v)	F.S.L	-	+585.50 m above m.s.l
vi)	M.D.D.L	-	+582.50 m above m.s.l
vii)	Top level	-	+586.50 m above m.s.l
viii)	Lowest bed level	-	+576.00 m above m.s.l
ix)	Trash rack	-	1.90x1.35, 3 panels in each slot
x)	No. of slots	-	3
xi)	Slope	-	1H: 4V
xii)	Raking	-	Manual

12. Penstock

i)	Number of Penstock pipes	-	1 No.
ii)	Length of penstock	-	310 m
iii)	Chainage	-	8 to 295 m
iv)	Diameter of penstock	-	1.30 m
v)	Thickness of steel plate	-	8mm 120.89m length 10mm 122.26m length 12mm 61.90m length
vi)	Design discharge	-	5.862 m^3/s
vii)	Design velocity	-	4.39 m/s
viii)	Diameter of bifurcation pipe	-	1.30 ~ 0.98m
ix)	Number of feeder pipes	-	2 Nos
x)	Diameter of feeder pipes	-	0.98 m

13. Anchor Block

i)	Anchor block – 1	-	Ch. 8.00. El: +578.00 m
ii)	Anchor block – 2	-	Ch. 120.000 El: +534.00 m
iii)	Anchor block – 3	-	Ch. 235.000 El: +493.00 m
iv)	Anchor block – 4	-	Ch. 290.000 El: +467.00 m

14. Power House

i)	Type	-	Overground
ii)	Overall dimension	-	27.40 m x 11.10 m,
iii)	Type of Turbine	-	2 Nos 2500 kW Horizontal Francis Turbine
iv)	Normal tail water level	-	+461.00 m above m.s.l.
v)	Minimum tail water level	-	+460.40 m above m.s.l.
vi)	Machine floor level	-	+460.80 m above m.s.l.
vii)	Service bay level	-	+464.00 m above m.s.l.
viii)	Yard level	-	+463.50 m above m.s.l.
ix)	Control room	-	8.80 x 5.90 x 4.00 m
x)	Switch gear room	-	8.80 x 5.45 x 4.00 m

15. Tail Race Pool & Channel

i)	Tail race pool	-	13.00 x 12.50 x 6.90m
ii)	Length of tail race channel	-	30 m
iii)	Channel size	-	3m x 1m water depth
iv)	Lined channel	-	RCC box channel 6.05 m
v)	Unlined Channel	-	23.95 m

IV. GEOLOGICAL FRAME WORK OF THE PROJECT:

A. Regional Geology:

The major rock types exposed in the area belong to the Wayanad Group (WG), Charnockite Group (CG) of Archaean age, Peninsular Gneissic Complex – II (PGC-II) of Archaean to Palaeo Proterozoic age and Acid Intrusives of Neo-Proterozoic age and basic intrusives of Meso-Proterozoic age. Meta pyroxenite, meta gabbro, amphibolite, magnetite quartzite and garnet biotite gneiss are the principal restites belonging to the

WG. The dominant rock type is charnockite, which occupies most of the area (Plate-2). It is flanked on either side by biotite hornblende gneiss of PGC-II. Pegmatite and quartz veins are the acid intrusives and metagabbro is the basic intrusives of Proterozoic age. Mesozoic dolerite and gabbro dykes are the youngest basic intrusives. Extensive lateritisation of migmatite is seen in the southeast. The mineral assemblage indicates granulite facies of metamorphism in charnockite and upper amphibolite to granulite facies in the Supracrustal rocks. Some of the grains of hornblende in the gneisses show relict cleavage of pyroxenes indicating retrograde metamorphism.

The foliation trend varies between NE – SW to NW – SE in most parts. In the northwest, central and eastern parts, the trend of foliation is N – S with steep dips on either side. E – W trend is also seen in some parts of north and south. Minor shears are noticed in charnockite and biotite gneiss.

Placer gold is widely reported from the riverbeds of Kanjirapuzha and Chaliyarpuzha. Gold is also reported in the laterite and quartz veins near Nilambur. Charnockite and biotite gneiss are extensively quarried for road metal at various places in the Nilambur valley.

B. Geology of the Project Site:

At the proposed weir site, no sizeable exposures are observed on either side of the river due thick overburden, except some patchy outcrops of Charnockite on the river banks (Plate- 2). However, accumulations of huge boulders were common all along the river, especially at the Trench Weir site. Since the site was not approachable during the site visit, the attitude of lithologies could not be taken. However, foliation at the project site is trending E-W with steep dip towards south, as measured on rough planes.

C. Seismotectonic Evaluation:

In the Seismic Zoning Map of India, the project lies in Seismic Zone –III (Plate-3), which implies that occurrence of earthquakes up to a magnitude of 6 (Intensity –VII) cannot be ruled out. Seimotectonic map of India shows that, within 100 km radius from the project site, one major earthquake of magnitude 5 was

recorded by IMD and USGS on 29.07.1972, near Coimbatore. The location is roughly 100 km SE of the project site. There is no other major event reported near the project site, however, some of the lower magnitude events are listed in Table- I.

Three minor lineaments of undefined status are marked near the project site, trending in E – W to ENE – WSW direction. In general the project site exhibits low to moderate seismicity. In view of the above factors, it is opined that the project components may require suitable seismic resistant design to withstand earthquakes of moderate magnitude.

Table – I: List of Earth Quake Events within 100 km radius

S_No	Date	Latitude	Longitude	Magnitude	Depth	Source
1	27/12/2006	10.698	76.140	3.00	10.00	ASC
2	27/12/2006	10.657	76.221	3.70	5.00	ISC
3	21/12/2006	10.670	76.310	3.00	10.00	ISC
4	20/12/2006	10.700	76.140	2.80	10.50	ASC
5	20/12/2006	10.609	76.125	3.40	10.00	ISC
6	29/07/1972	11.000	77.000	5.00	N.A	IMD
7	29/07/1972	11.000	77.000	5.00	N.A	USGS
8	N.A	11.300	75.800	4.30	N.A	ASC
9	02/08/1900	10.700	76.700	6.00	N.A	USGS
10	02/08/1900	10.800	76.800	6.00	N.A	USGS
11	24/06/1865	11.000	76.940	N.A	N.A	OLD
12	24/06/1865	11.000	76.950	N.A	N.A	USGS
13	20/12/2006	10.557	76.201	2.80	22.80	KSEB
14	25/08/2001	10.484	76.121	3.10	15.00	ISC

V. GEOTECHNICAL EVALUATION:

1. Trench Weir Site:

Since, the monsoon had already set in, during the inspection, the site for the trench weir could not be assessed. The bore hole no.1, drilled near the Trench Weir site, has not shown any core recovery down to the drilled depth 23.94m. This would, possibly, represent a condition where the hole has penetrated through a thick pile of overburden mass, along its entire depth, while assuming that quality of drilling was normal. This would require further confirmation of the stated fact, by drilling one more hole at this site.

Moreover, from the observation at the site, it is evident that the trench weir area comprises

boulder accumulations (Fig.1). Hence, suitable boulder trap need to be planned in the upstream side, which can take care of huge boulders blocking the trench weir.

Fig.1 – Photograph of Trench Weir Site – with huge boulders

2. Intake Channel - Surplus weir - Feeder Conduit:

The area between Intake Channel and up to the end of Feeder Conduit could not be inspected, due to bad weather condition and non-approachability during rains. Moreover, Bore holes were not drilled in this area during the time of inspection, hence geotechnical assessment of this portion could not be undertaken.

3. De-silting Chamber:

Hopper Bottom Intermittent Flushing type De-silting chamber is proposed at the end of the Feeder Conduit, of the size 21m x 5m x 4.75 m (Plate – 4). The area around de-silting chamber has been inspected and found to be on a sloping ground mass. Outcrop of charnockitic gneiss has been observed only in the stream section at this site. However, due to absence of drilling data, exact depth of fresh rock level could not be ascertained.

4. Head Race Channel (De-silter to Forebay):

A 913 m long Head Race Channel of size 2.50 m x 1.50 m (+0.75m free board) has been proposed after De-silting chamber, with a slope of 1 in 750. Most parts of the

channel alignment fall at the base of hill slope, parallel to the river course, and show signs of soil creep as evident by tilted trees (Fig.2), a process induced by river toe cutting. All along its route, a few isolated blocks of weathered rock are seen (rolled boulders – Fig.3).

Fig.2: Slanting Tree sapling off the alignment near ch. 570 m

Excavation on this sloping ground, along the channel alignment would require utmost precaution, since modification of the natural slope may disturb the slope equilibrium. Preliminary investigation and assessment of site conditions could not ascertain bed rock depth, and it is quite likely that most part of the channel alignment would have to be cut through overburden. The structure should therefore be designed accordingly.

To obviate pore pressure development created by water saturation in soil, suitable drainage arrangement may be considered in the design.

Fig.3: Rolled Boulder along the power channel alignment near ch. 612 m

5. Fore Bay Tank:

A rectangular concrete, Forebay tank of live storage 762 m^2 (for 130 sec.) has been proposed at the end of the Head Race Channel, (Plate-4) with M.W.L +586.00 m and M.D.D.L. +582.50 m . The site condition is similar (Fig. 4), to the one discussed for the proposed head race channel. However, the bore hole (B.H.9.) drilled at Fore Bay location intercepted fresh rock around 10.20 m (El. 577.635 m). Since, the bed level of the Fore Bay is kept at EL+576.00, rock is likely to be met at the foundation grade. However, during excavation, surprises cannot be ruled out, since a single bore hole cannot represent the entire area

6. Penstock:

A single Penstock of 1.30 m dia., for length of 310 m is proposed from the Fore Bay, with a design discharge capacity of 5.862 m^3/s. Four nos. of anchor blocks were planned along the penstock alignment. No rock exposures observed along the alignment as the area is densely forested and marks overburden material (Fig 5 and Plate – 5)

Fig.4: Fore Bay Site

Fig.5: Overburden along the Penstock alignment

The summarized litho log (Table –II & Fig.6), indicates 5 m to 8.05 m thick, over burden along the penstock alignment. Suitable anchor foundation may therefore be designed, accordingly (Fig.4).

Table –II : Abstract Litho-log of Maripuzha S.H.E. Project

B.H. No.	Location of B.H.	Total Depth Drilled (m)	Over Burden (m)	Fresh Rock Level (m)	Rock Type
1	Weir Site	23.94	23.94	---	---
2	Bridge Site	23.95	23.95	---	---
3	P.H Site (6.30 m d/s of CC block)	20.58	9.40	9.50	Granite Gneiss
4	Penstock Bifurcation	17.75	5.25	6.35	Granite Gneiss
5	P.H. Tail Race Pool 21.50 m d/s of PH CC block	22.35	10.3	11.05	Granite Gneiss
6	Penstock – Anchor -3	19.68	7.75	8.05	Pyroxene Granulite
7	Penstock – Anchor -2	19.80	7.60	7.70	Pyroxene Granulite
8	Penstock – Anchor -1	17.35	5.00	5.10	Pyroxene Granulite
9	Fore Bay	22.23	9.80	10.20	Pyroxene Granulite

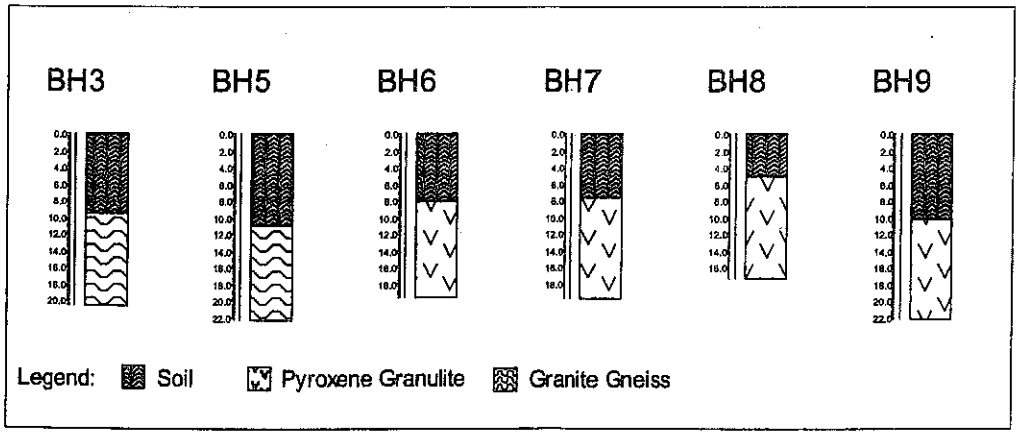


Fig.6: Bore Litholog of B.H.3, 5, 6, 7, 8 & 9

7. Power House:

Surface Power House of capacity 2 x 2500 kW (Horizontal Francis Turbine) has been proposed along the right bank of Iruvanji puzha River.(Plate – 3)

Two bore holes, B.H. no. 3 & 5 have been drilled around P.H site (Fig.7), have indicated an overburden of 9.40 & 10.30 m, respectively, overlying granite gneiss (Fig.6). Fresh rock is intercepted at 9.50 m (455.60m), while the machine floor level is +460.80 m. The design Foundation may either be revised considering the interpreted bed rock level or the possibility of shifting towards the hill slope may be explored.

Fig.7: Power House Site near the river bank

VI. CONCLUSION AND RECOMMENDATIONS:

1. Preliminary stage geotechnical investigation has been carried out for the head race channel, desilting chamber, power channel, fore bay, penstock alignment and power house site of Maripuzha Small H.E.P.

2. The project site is located in a metamorphic terrain, comprising Charnockite as the principle rock type. Outcrops were not generally noticed in the area. Rolled blocks of rocks within the overburden material were common on the hill slopes. The penstock alignment is covered by fairly thick overburden.

3. The project site falls in the Seismic Zone –III of the Seismic Zoning Map of India and marked by E-W trending lineaments. It is therefore required to design seismic resistant structure to withstand earthquakes of moderate magnitude.

4. The proposed trench weir site could not be investigated due to inaccessibility. Only one B.H. and no core recovery down the drilled depth 23.94 m is the limitation to arrive at any decision. Hence, further probe by drilling to decide the depth of excavation and to assess foundation condition is suggested.

5. Suitable boulder trap is suggested in the upstream side, since the trench weir area comprises bouldery river bed.

6. The site around de-silting chamber is on a sloping ground mass. Outcrop of charnockitic gneiss has been observed only in the stream section. Exact depth of fresh rock level could not be known, due to absence of drilling data.

7. It is inferred that the entire length of the power duct is occupied by a medium of thick overburden, consisting of huge boulders embedded in sandy matrix. Preliminary investigation and site condition indicates bed rock to be at greater depth.

8. Negotiating through the head race channel alignment, needs utmost precaution, since modification of the natural slope may provoke destabilization of slope. Suitable design measures may have to be adopted, for effective diversion of natural drainage, such that pore pressure created by water saturation in soil, does not affect the proposed structure.

9. Foundation grade rock is likely to be encountered at designed level of the fore bay site.

10. Suitable anchor foundation may be designed, for the penstock anchors, in view of overburden thickness varying from, 5 m to 8.05 m, along the penstock alignment.

11. Fresh rock at power house site was intercepted at 9.50 m (455.60m), while the machine floor level is +460.80 m. The design foundation level may therefore be fixed

accordingly, since availability of foundation grade rock may be at further depth.

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By

Sd/- 26-09-12
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MARIPUZHA SMALL HYDRO ELECTRIC PROJECT

Bore Hole No.: **BH 3**

Ground Elevation: 465.100 m

Location: PH (6.30 m D/S from PH cc block)

Total Depth Drilled: = 20.58 m

Depth Drilled		Run	Core Recovery		RQD	Structure	Lithology	Remarks
From	To	Length	Length	%				
0.00	9.40	9.40	-	-	-	-	Silty Sandy soil	
9.40	10.60	1.20	1.07	89.16	69.16	Joint - 50° , planar, rough iron stained	Grey biotite granite gneiss	
10.60	11.60	1.00	0.88	88.00	76.00	Joint - 50° , Fol. prominenet vertical	Grey biotite granite gneiss	
11.60	12.50	0.90	0.67	74.44	44.44	Joint- 65°, ion stained	Grey biotite granite gneiss	
12.50	13.90	1.40	1.35	96.43	65.00	joint- 20°, Fol is vertical	Grey biotite granite gneiss	
13.90	14.90	1.00	0.96	96.00	62.00	Joint- 20°, 65°, ion stained	Grey biotite granite gneiss	
14.90	16.10	1.20	1.15	95.83	71.66	Joint- 40°, Fol. is vertical	Grey biotite granite gneiss	
16.10	16.60	0.50	0.50	100.00	100.00	Foliation is sub vertical	Grey biotite granite gneiss	one long single core
16.60	17.40	0.80	0.75	93.75	76.25	No joints, Fol is vertical	Grey biotite granite gneiss	
17.40	18.45	1.05	0.99	94.29	61.90	-	Upto 18.30 m Grey biotite granite gneiss then pink granite gneiss	
18.45	19.00	0.55	0.47	85.45	52.72	Joint- 65°, no foliation	Pink granite gneiss	
19.00	19.84	0.84	0.78	92.86	61.90	Joint- 60°	Upto 19.32 pink granite gneiss then grey biotite granite gneiss	Joints are closely spaced
19.84	20.58	0.74	0.70	94.59	32.43	Joint- 60°, Fol is vertical	Grey biotite granite gneiss	

Conclusion: Core recovery is from 74.44 to 100 % and RQD is from nil to 100 in rock. Foliation is gnerally steep to vertical . Fresh rock is available from 9.50 m depth.

MARIPUZHA SMALL HYDRO ELECTRIC PROJECT

Bore Hole No.: **BH 4**

Ground Elevation: 466.72 m

Location: Penstock Bifurcation- Anchor 4 - Ch.29 m

Total Depth Drilled: = 17.75 m

Depth Drilled		Run	Core Recovery		RQD	Structure	Lithology	Remarks
From	To	Length	Length	%				
0.00	2.00	2.00	-	-	-	-	Silty Sandy soil with few boulders	
2.00	3.00	1.00	-	-	-	-	Silty Sandy soil with few boulders	
3.00	3.6	0.60	-	-	-	-	Silty Sandy soil with few boulders	
3.60	5.25	1.65	-	-	-	-	Silty Sandy soil with few boulders	
5.25	6.35	1.10	1.00	90.91	51.82	Foliation not prominent ,Joint - 50° , planar, rough iron stained	Moderately to slightly weathered granite gneiss	
6.35	7.35	1.00	0.94	94.00	69.00	Foliation not prominent ,Joint - 30° , planar	Slightly weathered to fresh granite gneiss	
7.35	8.60	1.25	1.22	97.60	84.80	Foliation- Vertical ,Joint - 75° , planar	Fresh granite gneiss	
8.60	9.88	1.28	1.27	99.22	80.47	Foliation- Vertical ,Joint -25°, 65° , planar	Fresh pink granite gneiss	
9.88	10.80	0.92	0.91	98.91	58.70	Foliation Joint -80° with iron stain	Fresh pink grnaite gneiss and from 10.1 m Biotite gneiss	
10.80	11.95	1.15	1.12	97.39	96.52	Foliation- Vertical	fresh granite gneiss	
11.95	13.10	1.15	1.07	93.04	62.61	Foliation- Vertical	granite gneiss upto 12.36m and then pink gnraite	
13.10	14.50	1.40	0.67	47.86	10.71	Joint -75°	upto 13.31 m - Pink granite; from 13.31 to 13.73m - granite gneiss; from 13.31 m - Biotite gneiss	
14.50	16.15	1.65	1.50	90.91	67.88	-	upto 14.93 m - Biotite rich; from 14.93 to 15.28m - pink granite; from 15.28 m - granite gneiss	
16.15	17.75	1.60	1.47	91.87	76.25	Joint -30°	granite gneiss	

Conclusion: Core recovery is from 47.86 to 99.22 % and RQD is from 10.71 to 96.52 in rock. Foliation is gnerally steep to vertical . Fresh rock is available from 6.35 m depth.

MARIPUZHA SMALL HYDRO ELECTRIC PROJECT

Bore Hole No.: **BH 5**

Ground Elevation: 463.835 m

Location: P.H. Tail Race Pool - Ch.21.50 m d/s from P.H. CC block

Total Depth Drilled: = 17.75 m

Depth Drilled		Run	Core Recovery		RQD	Structure	Lithology	Remarks
From	To	Length	Length	%				
0.00	2.00	2.00	-	-	-	-	Silty Sandy soil	
2.00	3.50	1.50	-	-	-	-	Silty Sandy soil with few boulders	
3.50	5.00	1.50	-	-	-	-	Silty Sandy soil with few boulders	
5.00	6.00	1.00	-	-	-	-	Silty Sandy soil with few boulders	
6.00	7.40	1.40	-	-	-	-	Silty Sandy soil with few boulders	
7.40	8.95	1.55	-	-	-	-	Silty Sandy soil with few boulders	
8.95	10.30	1.35	-	-	-	-	Silty Sandy soil with few boulders	
10.30	11.40	1.10	0.99	90	13	Foliation Joint - 65°, Joint - 20°	Slightly weathered to fresh granite gneiss	
11.40	12.30	0.90	0.55	61	18	Joint - 80°, Iron stained	fresh granite gneiss	
12.30	14.00	1.70	1.57	92	72	Foliation - 80°; Joint - 30°- iron stained	fresh granite gneiss	
14.00	15.40	1.40	1.22	87	65	Joint - 80°	fresh granite gneiss	
15.40	17.50	2.10	1.21	58	22	Joint -85°	granite gneiss	
17.50	19.00	1.50	1.41	94	92	Joint -15° & 20°	fine grained granite gneiss	
19.00	20.70	1.70	1.60	94	59	Joint -80°	granite gneiss	
20.70	22.35	1.65	1.56	95	47	Foliation - Vertical; Joint -85°	granite gneiss	

Conclusion: Core recovery is from 58 to 95 % and RQD is from 13 to 92 in rock. Foliation is dipping 65° to vertical . Fresh rock is available from11.35 m depth

MARIPUZHA SMALL HYDRO ELECTRIC PROJECT

Bore Hole No.: **BH 6**

Ground Elevation: 505.625 m

Location: Penstock Route Anchor 3, Ch. 200 m

Total Depth Drilled: = 19.68 m

Depth Drilled		Run Length	Core Recovery		RQD	Structure	Lithology	Remarks
From	To		Length	%				
0.00	7.75	7.75	-	-	-	-	Soil	
7.75	9.45	1.70	1.64	96.47	79.41	sub horizontal joints	Granulite	
9.45	10.95	1.50	1.01	67.33	9.00	Joint- 35° & 50°	Do	
10.95	12.40	1.45	1.23	84.83	25.86	Joints- horizontal, 50° and vertical	Do	
12.40	14.00	1.60	1.55	96.88	83.12	Joint- 45°, no foliation	Do	
14.00	15.60	1.60	1.53	95.63	85.62	Joints- 15° & sub vertical, feeble sub vertical joints	Do	
15.60	16.90	1.30	0.40	30.77	-	Joints- 70°	Do	silicification is prominent
16.90	18.50	1.60	1.27	79.37	33.75	Do	Do	
18.50	19.68	1.18	1.12	94.92	77.96	sub horizontal joints	Do	

recovery is from 30.77 to 96.88 % and RQD is from 9 to 85.62 in rock. Joints are sub horizontal to vertical and foliation is feebly developed. Fresh rock is available

MARIPUZHA SMALL HYDRO ELECTRIC PROJECT

Bore Hole No.: **BH 7**

Ground Elevation: 539.380 m

Location: Penstock Route Anchor 2, Ch. 110 m

Total Depth Drilled: = 19.80 m

Depth Drilled		Run	Core Recovery		RQD	Structure	Lithology	Remarks
From	To	Length	Length	%				
0.00	7.60	7.60	-	-	-	-	Soil	
7.60	9.10	1.50	1.4	93.33	93.33	Joint- 30°, no foliation	Pyroxinite	Malenocratic, with greenish blackn minerals.
9.10	10.60	1.50	1.42	94.67	82.00	Joint- 55°, no foliation	Do	
10.60	11.20	0.60	0.54	90.00	90.00	Joint- 60°, sub horizontal joints.	Do	
11.20	12.60	1.40	1.07	76.43	58.57	Joint- 35°, sub horizontal joints.	Upto 11.20 m pyroxinite then pink granite gneiss	ion stained
12.60	13.85	1.25	1.23	98.40	58.40	Joint- 35°, 70° & sub horizntal joint	Pink granite gneiss	ion stained (J- 70°), clay filled (J-35°)
13.85	15.85	2.00	1.63	81.50	71.00	Joint- 30° & sub horizontal joint	Upto 14.31 m pink granite gneiss then granulite	silicification is prominent
15.85	17.70	1.85	1.67	90.27	90.27	No joint	Granulite	
17.70	19.80	2.10	1.08	51.43	47.14	No joint	Granulite	Rock is good and no joints is observed but 1 m core is missing.

:lusion: Core recovery is from 51.43 to 98.40 % and RQD is from 47.14 to 93.33 in rock. Joints are sub horizontal to 70°with no foliation. Fresh rock is available from 7.70 m d

MARIPUZHA SMALL HYDRO ELECTRIC PROJECT

Bore Hole No.: **BH 8**

Ground Elevation: 579.645 m

Location: Penstock Anchor 1; Ch 10.00

Total Depth Drilled: = 17.35 m

Depth Drilled		Run	Core Recovery		RQD	Structure	Lithology	Remarks
From	To	Length	Length	%				
0.00	5.00	5.00	-	-	-	-	Silty Sandy soil	
5.00	6.60	1.60	1.55	96.88	95.62	Joint- 65°, ion stained	Silty Sandy soil with few boulders	
6.60	8.20	1.60	1.55	96.88	95.00	Joint- 20°,50° and feeble foliation	Silty Sandy soil with few boulders	ion stained
8.20	9.80	1.60	1.54	96.25	96.25	Joint- 65°, ion stained, no foliation	Silty Sandy soil with few boulders	
9.80	11.55	1.75	1.04	59.43	42.85	Joint- 65°,	Silty Sandy soil with few boulders	ion stained
11.55	13.15	1.60	1.54	96.25	93.75	-	Silty Sandy soil with few boulders	no joint and foliation
13.15	14.85	1.70	1.52	89.41	87.05	Joint- 65°	Silty Sandy soil with few boulders	ion stained and clay filled
14.85	16.35	1.50	1.49	99.33	99.33	-	Slightly weathered to fresh granite gneiss	no joint and single long core
16.35	17.35	1.00	0.89	89.00	86.00	Joint- 65°	fresh granite gneiss	chlorite filling in joint.

: Core recovery is from 59.43 to 96.88 % and RQD is from 42.85 to 99.33 in rock. Foliation is not well developed and joints are dipping 65°. Fresh rock is available from 5

MARIPUZHA SMALL HYDRO ELECTRIC PROJECT

Bore Hole No.: **BH 9**

Ground Elevation: 587.835 m

Location: Forebay

Total Depth Drilled: = 22.23 m

Depth Drilled		Run	Core Recovery		RQD	Structure	Lithology	Remarks
From	To	Length	Length	%				
0.00	9.80	9.80	-	-	-	-	Soil	
9.80	11.35	1.55	1.26	81.29	27.74	Joint - 75° & 65°, Iron stained	Hornblende gneiss	open joint with clay filling
11.35	12.75	1.40	1.18	84.26	73.57	Joint- 55°, no foliation	Do	
12.75	14.50	1.75	1.32	75.43	51.42	Joint- 60°	Upto 14 m hornblende gneiss then more hard rock.	
14.50	15.55	1.05	1.04	99.05	99.04	No joints	Hornblende gneiss	single long core
15.55	17.05	1.50	1.44	96.00	96.00	No joints	Do	single long core
17.05	18.65	1.60	1.5	93.75	84.37	Joint- 25° & sub vertical	Do	garnet observed
18.65	20.25	1.60	1.55	96.86	88.75	Joint- 80°	Do	sulphide mineralisation
20.25	22.23	1.98	1.36	68.69	45.45	Joint- 65° & 80°	Do	Box work filling

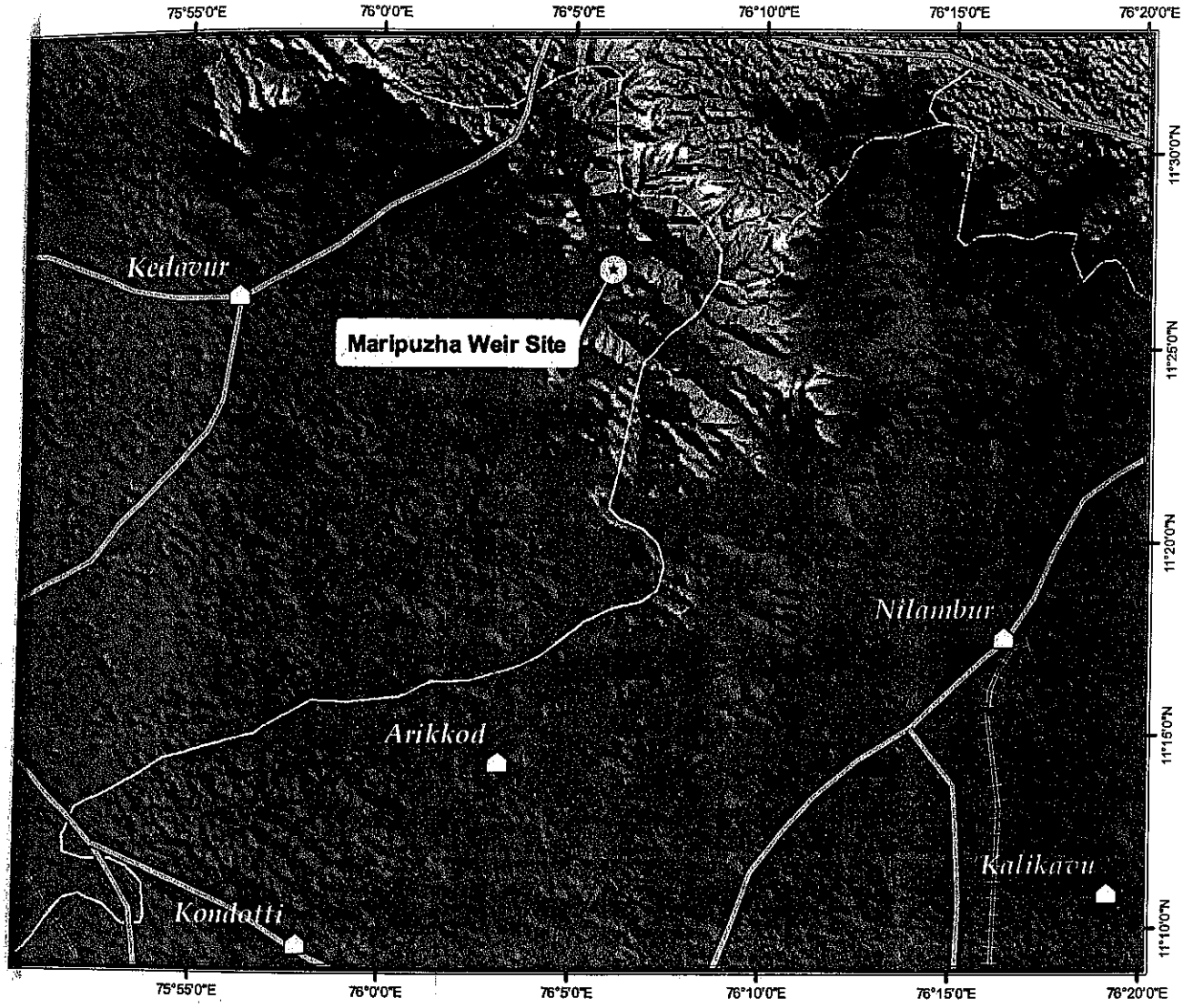
ı: Core recovery is from 68.69 to 99.05 % and RQD from 27.74 to 99.04 in rock. Joints is dipping 55° to 80° and no foliation is obseved. Fresh rock is available from10

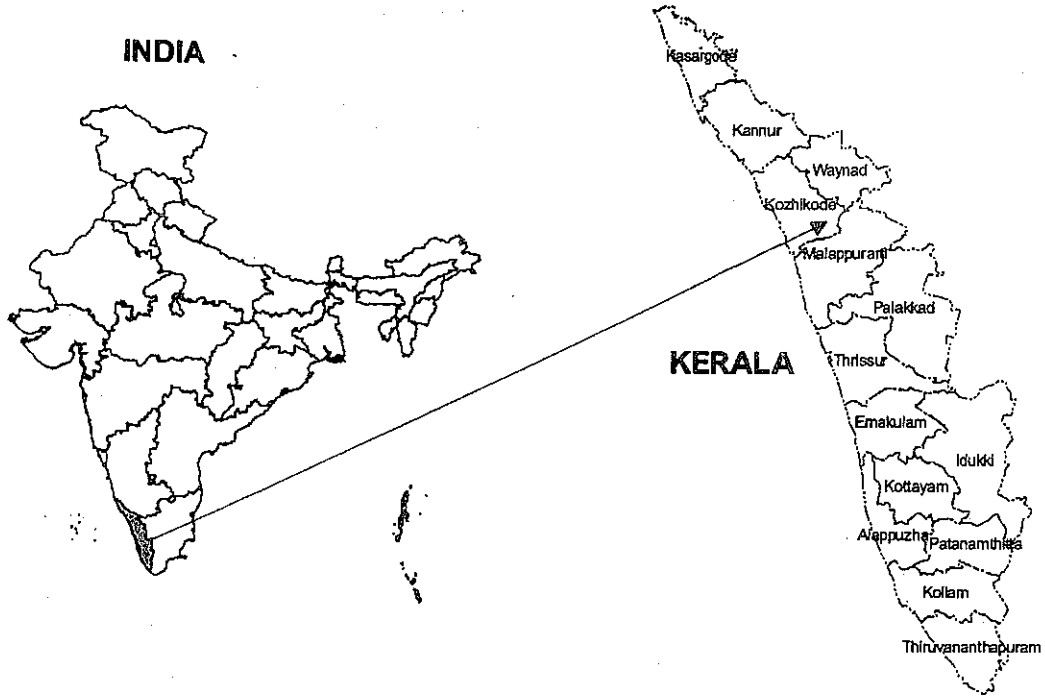
Plate - 1

LOCATION MAP

Scale

0 4 8 16 Km





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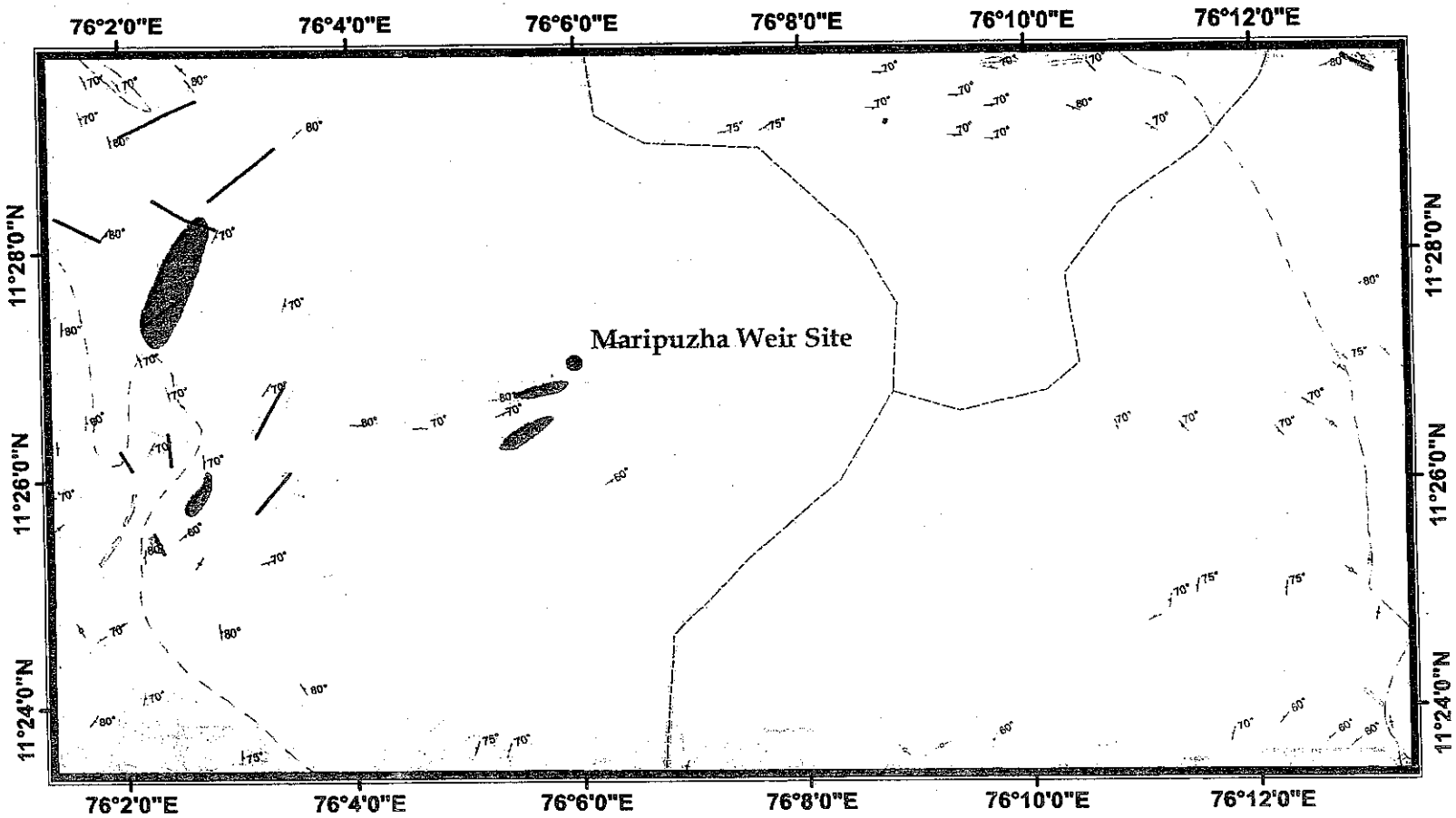
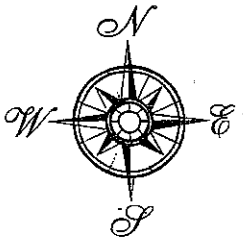
REGIONAL GEOLOGICAL MAP

Plate - 2

0 1.5 3 6 Km





INDEX

- Quartz vein
- Pegmatite
- Hornblende-biotite gneiss/ composite gneiss
- Charnockite (Unclassified)
- Sillimanite-kyanite-quartz schist
- Banded iron formation / magnetite quartzite
- Basic Dykes
- Inclined Foliation
- Vertical Foliation
- Inclined Joint
- Vertical Joint
- Lineation

Geology after:
A.R.Sawarkar - 1964-65
K.Balakrishan Nair - 1969-70
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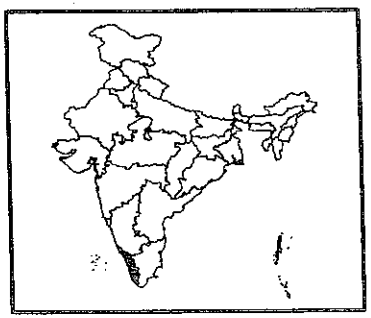

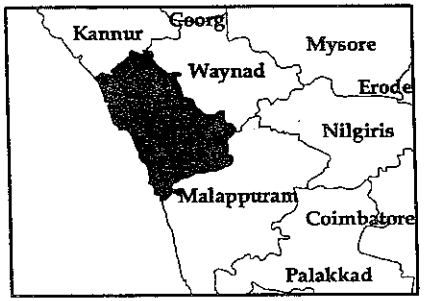

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PLATE - 3

SEISMOTECTONIC MAP OF KERALA AND TAMIL NADU SHOWING SEISMIC ZONES

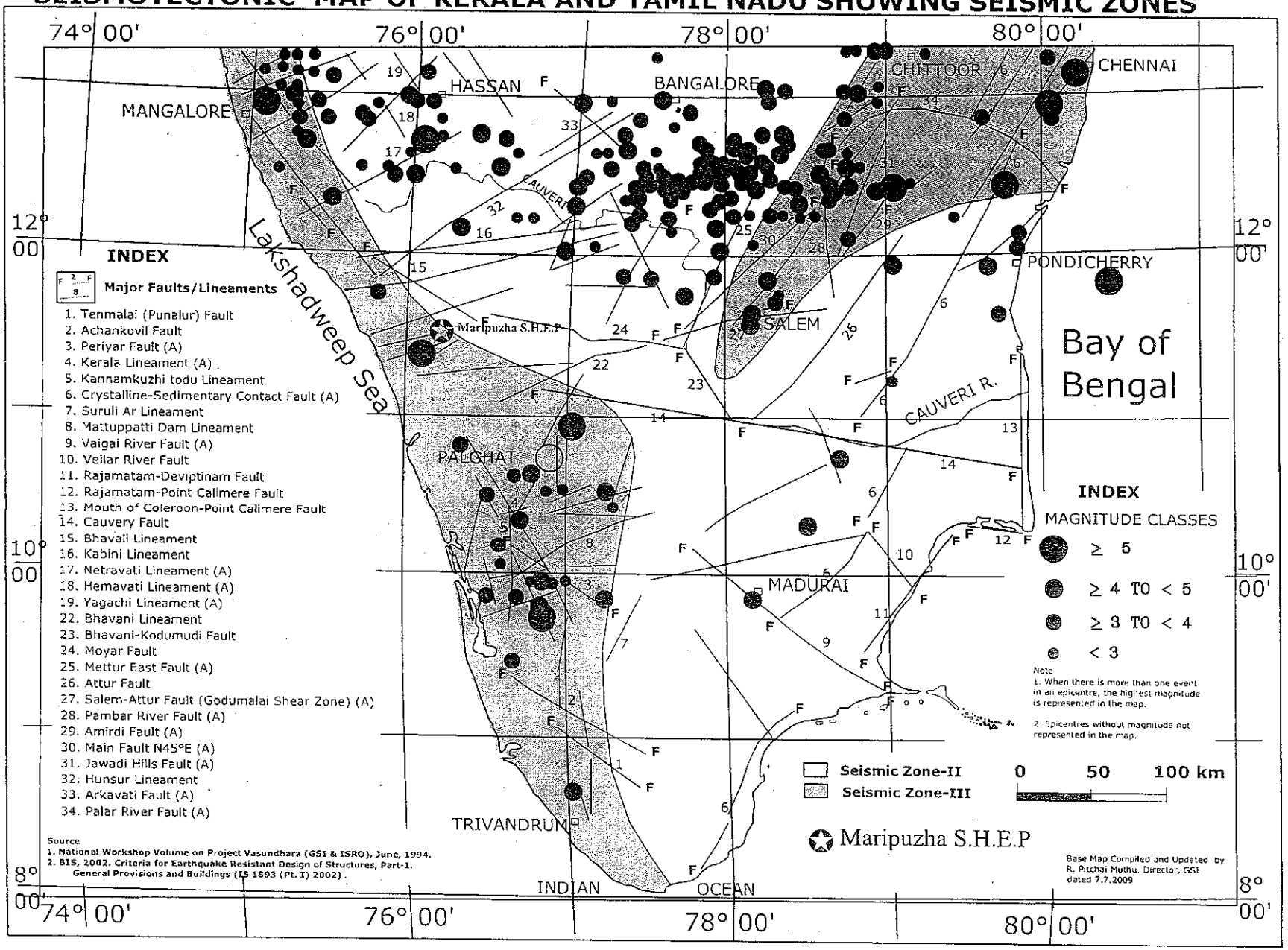
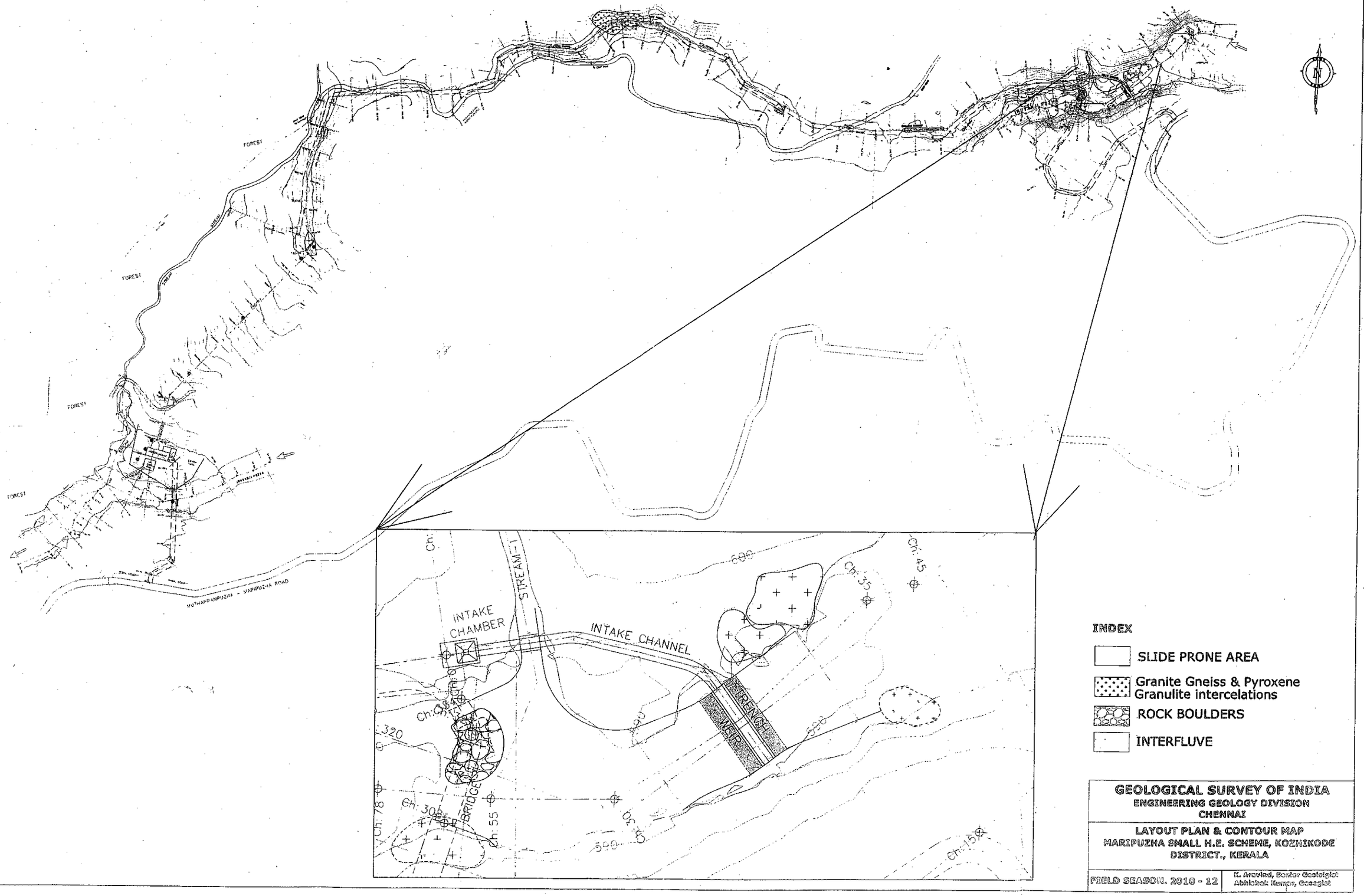


Plate - 4



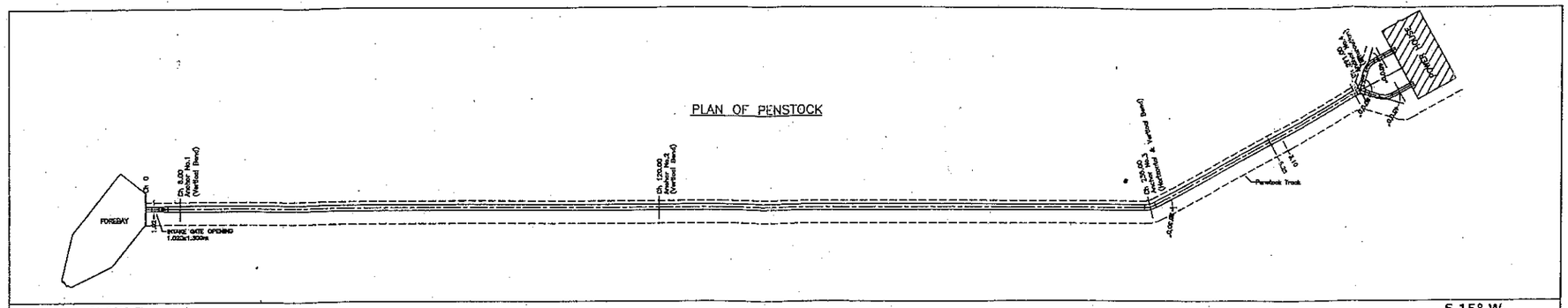
GEOLOGICAL SURVEY OF INDIA
ENGINEERING GEOLOGY DIVISION
CHENNAI

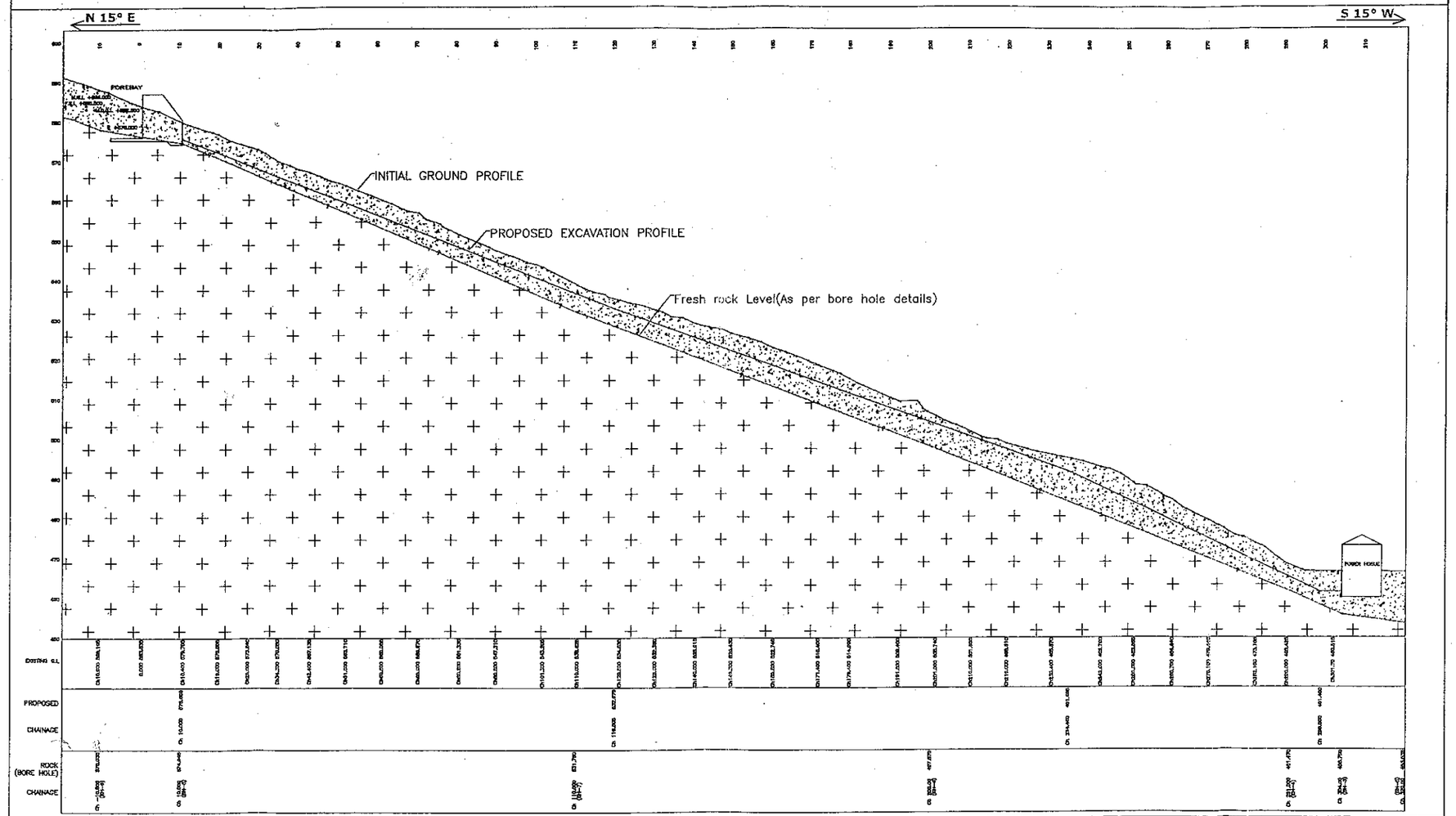
LAYOUT PLAN & CONTOUR MAP
MARIPUZHA SMALL H.E. SCHEME, KOZHIKODE DISTRICT., KERALA

FIELD SEASON: 2010 - 12

K. Aravind, Senior Geologist
Abhishek Kumar, Geologist

Plate-5





INDEX

- Overburden/ Soil Cover
- Granite Gneiss & Pyroxene Granulite intercelations
- Fresh Rock Level (Inferred from Bore Hole Log)

GEOLOGICAL SURVEY OF INDIA
ENGINEERING GEOLOGY DIVISION
CHENNAI

LONGITUDINAL SECTION OF PENSTOCK ROUTE MARIPUZHA SMALL H.E. SCHEME, KOZHIKODE DISTRICT., KERALA

FIELD SEASON. 2010 - 12	K. Aravind, Senior Geologist Abhishek Kumar , Geologist