



KERALA STATE ELECTRICITY BOARD LIMITED

IDUKKI EXTENSION SCHEME

“Preparation of Feasibility Study Report / Detailed Project Report, obtaining all statutory clearances for execution including preparation of Bid & Allied documents for selection of an EPC contractor for execution of project”



FEASIBILITY STUDY REPORT

CONSULTANT: WAPCOS LIMITED



WAPCOS Ltd.,
76-C, Institutional Area, Sector-18, Gurugram, Haryana, India
Pin: 122015
E-mail: amitabh@wapcosindia.com

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Prepared for	Kerala State Electricity Board Limited. (KSEB),
Represented by	Office of the Chief Engineer (Civil-Investigation & Construction Central)

CONSULTANT TEAM

CED & Environmental Team Leader	Mr. Aman Sharma
Group Leader	Mr. Amitabh Tripathi,
Civil Team Leader	Mr. Mehak Jeet Singh Deol
Electrical & Mechanical Team Leader	Mr. Gaurav Kumar
Geology & Geo-Tech Team Leader	Mr. Prasanta Mishra
Hydrology Expert	Mr. D.K. Kaushik
Hydro-Mechanical Expert	Mr. R.K.Mishra
Concrete/RCC Dam and Spillways Expert	Mr. M. M.Madan
Geologist	Mr. Sanjay Sharma
Sr. Project Engineer	Mr. Rajeev Singh
Project Engineer	Mr. Vinay Shankar

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TABLE OF CONTENTS

CONTENTS

CHAPTER-1	13
1. EXECUTIVE SUMMARY	13
1.1 Introduction	13
1.2 Project Background	14
1.3 Project Location	15
1.4 Access to the Project	16
1.5 Scope of Work	17
1.6 Topography & General Climate	17
1.7 Hydrology	19
1.8 Geology	19
1.9 Seismicity of the Area	21
1.10 Installed Capacity and Power Generation	21
1.11 Land Requirement	22
1.12 Estimates of the Cost	23
1.13 Financial Aspects	23
1.14 Salient Features	24
CHAPTER- 2	30
2. ECONOMIC SCENE OF KERALA	30
2.1 Introduction	30
2.2 Economic Parameters	32
2.2.1 GSDP/NSDP	32
2.2.2 Foreign Direct Investment (FDI) inflow & Investments	32
2.3 Agriculture	33
2.4 Horticulture	35
2.5 Irrigation	36
2.6 Forest Resources	37
2.7 Fisheries	39
2.8 Livestock	40
2.9 Industry	41
2.10 Information Technology	43
2.11 Service Sector	43
2.12 Power	44

CHAPTER - 3.....	47
3. POWER SCENARIO	47
3.1 Introduction.....	47
3.2 Installed Generating Capacity in India	49
3.2.1 Capacity Addition Targets and Achievements in the 12th Plan, 2017-18, 2018-19 and 2019-20.....	54
3.2.2 All India Electrical Energy Requirement, Peak Electricity Demand & Electrical Energy Consumption Projections for 2016-17 to 2026-27	56
3.3 Power Sector in Kerala.....	60
3.3.1 Introduction.....	60
3.3.2 Kerala State Electricity Board Limited (KSEBL) - Overview	61
3.3.3 Existing Power Scenario of Kerala	62
3.3.4 Idukki Hydro Electric Project (Existing).....	67
3.3.5 Demand and Supply Scenario.....	68
3.3.6 Transmission.....	69
3.3.7 Distribution.....	70
3.4 Hydro Power – A Flexible Solution	72
3.4.1 Importance of Hydro in Present Scenario.....	74
3.4.2 Hydro Potential and its Development.....	76
3.4.3 Growth of Installed Capacity.....	79
3.4.4 Share of Hydroelectric Installed Capacity & Generation	79
3.5 Necessity and Justification.....	84
CHAPTER – 4.....	88
4. HYDROLOGY	88
4.1 General	88
4.2 River Basin	88
4.3 Objective of Hydrological Study	90
4.4 Project Proposal	91
4.5 Catchment Area.....	92
4.6 Hydro-meteorological data availability	93
4.6.1 Data Consistency Check.....	93
4.7 Hydrological Studies	94
4.7.1 Water Availability	94
4.7.2 Diversion Flood.....	96

4.7.3	Design Flood	96
4.8	Conclusion.....	96
CHAPTER – 5.....		102
5. GEOLOGICAL AND CONSTRUCTION MATERIAL STUDIES		102
5.1	Introduction.....	102
5.2	Objective of Study	103
5.3	Regional Geomorphology and Geology.....	103
5.3.1	Seismicity.....	108
5.3.2	Geomorphology and Geology of the Project Area	110
5.4	Geology of Civil Components.....	112
5.4.1	Intake.....	112
5.4.2	Intake Gate Shaft.....	113
5.4.3	Head Race Tunnel	113
5.4.4	Surge Shaft	114
5.4.5	Pressure Shaft	114
5.4.6	Powerhouse& Transformer Cavern	115
5.4.7	Trail race Tunnel.....	115
5.5	Construction Material.....	116
5.6	Conclusions and Recommendations.....	117
CHAPTER – 6.....		122
6. POWER POTENTIAL & INSTALLED CAPACITY		122
6.1	Introduction.....	122
6.2	Objective of the Study	122
6.3	Assessment of peaking hours for optimization of Potential of Idukki reservoir	123
6.4	Reservoir Parameters.....	125
6.4.1	Full Reservoir Level	125
6.4.2	Minimum Draw Down Level	125
6.4.3	Tail Water Level.....	125
6.4.4	Reservoir Elevation-Area -Capacity Characteristic.....	125
6.4.5	Water Conductor Losses.....	125
6.4.6	Rated Head.	125
6.4.7	Evaporation Losses.	126
6.5	Generating Units Efficiency	126
6.5.1	Turbine Efficiency.....	126

6.5.2	Generator Efficiency	126
6.5.3	Combined Efficiency	126
6.6	Power Potential Studies	126
6.7	Conclusion.....	128
CHAPTER – 7.....		134
7. DESIGN OF CIVIL STRUCTURES.....		134
7.1	The Existing Idukki H.E.Project.....	134
7.2	The Proposed Idukki Extension Scheme.....	135
7.3	Present Proposal.....	135
7.4	Alternative Layout Studies	136
7.5	Determination of Discharge Carrying capacity of Thodupuzha River	138
7.6	Comparison and Selection of Best Alternative	144
7.7	Idukki Reservoir	144
7.8	Design of Civil Components	146
7.8.1	Intake Structure	146
7.8.2	Intake Gate Shaft.....	148
7.8.3	Water Conductor System (WCS).....	149
7.8.4	Surge tank	150
7.8.5	Pressure Shaft (Steel Lined)	152
7.8.6	Underground Power House Cavern and Underground Transformer Cavern .	152
7.8.7	Machine Cavern	153
7.8.8	Tail Race Tunnel (Concrete Lined) and Tail Race Channel.....	153
CHAPTER – 8.....		166
8. DESIGN OF ELECTRO-MECHANICAL EQUIPMENTS		166
8.1	General	166
8.1.1	Layout Plan of Electro-Mechanical Equipment.....	166
8.2	Electro-Mechanical Equipment	167
8.2.1	Turbine	167
8.2.2	Basic Hydraulic System.....	168
8.2.3	Governor	169
8.3	Generator.....	169
8.4	Excitation System and AVR.....	170
8.5	Insulated Phase Bus Duct (IPBD) and Associated Equipment.....	171

8.6	Generator Transformers.....	172
8.7	Neutral Grounding Resistor	172
8.8	220 kV GIS and outdoor Pothead Yard	173
8.9	Control and Protection System	173
8.10	Computerized Control System (CCS)	174
8.11	Mechanical Auxiliaries	174
8.11.1	EOT Crane	174
8.11.2	Oil Pressure System	174
8.11.3	Low Pressure Compress Air System	175
8.11.4	Dewatering and Drainage System.....	175
8.11.5	Cooling Water System.....	175
8.11.6	Air Conditioning and Ventilation System.....	176
8.11.7	Oil Handling System	176
8.11.8	Fire Fighting System.....	176
8.11.9	Potable Water and Sanitary System	177
8.11.10	Lifts	177
8.11.11	Mechanical Workshop	177
8.12	Electrical Auxiliaries	178
8.12.1	LT/HT AC Station Supply	178
8.12.2	DC Supply System	180
8.12.3	Power, Control & Instrumentation Cables	180
8.12.4	Illumination System.....	180
8.12.5	PLCC Equipment.....	181
8.12.6	Communication & Surveillance System.....	181
8.12.7	Electrical Equipment & Testing Laboratory	181
8.12.8	Lightning and Grounding Protection system	181
8.12.9	Diesel Generating Sets.....	182
CHAPTER – 9		187
9. CONSTRUCTION PROGRAMME AND SCHEDULE		187
9.1	General	187
9.2	Main Components of the Project.....	187
9.2.1	Main Structure/ Components.....	187
9.2.2	Target Schedule	188
9.3	Infrastructure Facilities	188

9.4	Coffer Dam at intake	190
9.5	Power Intake	190
9.6	Headrace, Surge Shaft & Pressure shaft	190
9.7	Tailrace Tunnel	191
9.8	Tailrace Channel	191
9.9	Underground Powerhouse/ Transformer Caverns	191
9.10	Electro-Mechanical Works	191
CHAPTER – 10		194
10. ENVIRONMENTAL ASPECT		194
10.1	General	194
10.2	Study Area.....	194
10.3	Environmental Baseline Status	194
10.3.1	Climate	195
10.3.2	River System.....	195
10.4	Prediction of impacts	196
10.4.1	Impacts on environment.....	196
10.4.1.1	Construction phase	196
10.4.1.2	Operation phase	197
10.4.2	Impacts on environment.....	197
10.4.2.1	Construction Phase.....	197
10.4.2.2	Operation Phase.....	200
10.4.3	Impacts on Noise Environment	200
10.4.3.1	Construction phase	200
10.4.3.2	Operation phase	203
10.4.4	Impacts on Land Environment.....	204
10.4.4.1	Construction phase	204
10.4.4.2	Operation Phase.....	205
10.4.5	Impacts on Terrestrial Flora.....	206
10.4.5.1	Construction Phase.....	206
10.4.5.2	Operation Phase.....	207
10.4.6	Impact on Terrestrial fauna.....	207
10.4.6.1	Construction Phase.....	207
10.4.6.2	Operation Phase.....	208
10.4.7	Impacts on Socio-Economic Environment.....	208

10.4.7.1	Construction Phase.....	208
10.4.7.2	Operation Phase.....	210
10.5	Environmental Management Plan.....	210
10.5.1	Facilities in labour camps.....	210
10.5.2	Solid waste management from labour camps.....	210
10.5.3	Provision of free fuel	211
10.5.4	Muck Disposal.....	211
10.5.5	Compensation for Acquisition of Forest Land	212
10.5.6	Wildlife Conservation	212
10.5.7	Greenbelt Development	213
10.5.8	Public Health Delivery System	213
10.5.9	Maintenance of Water Quality	214
10.5.10	Control of Noise	214
10.5.11	Control of Air Pollution.....	216
10.6	Resettlement and Rehabilitation Plan	218
10.7	Infrastructure Development under Local Area Development Committee (LADC)..	219
10.8	Environmental Monitoring Programme	219
10.9	Cost Estimates.....	221
CHAPTER – 11		225
11. POWER EVACUATION.....		225
11.1	Introduction.....	225
11.2	Power Evacuation Arrangement	225
11.3	Proposed construction of Transmission lines:	225
CHAPTER – 12		228
12. COST ESTIMATE.....		228
12.1	Project Cost.....	228
12.2	Basis of Estimate.....	228
12.3	Classification of Civil Works into Minor Head/Sub Heads	229
12.3.1	Direct Charges	230
12.3.2	Indirect Charges	234
12.4	Electro-Mechanical Works	235
CHAPTER – 13		238
13. ECONOMIC EVALUATION.....		238
13.1	General	238

13.2	Project Benefits.....	238
13.3	Capital Cost.....	238
13.4	Mode of Financing.....	238
13.5	Phasing of Expenditure	238
13.6	Financial Analysis.....	239
13.6.1	Basic and Normative Parameters	239
13.6.2	Assessment of Tariff	240
CHAPTER – 14		244
14. CONCLUSION AND RECOMMENDATION		244
14.1	Technical Merits of the Project:.....	244
14.2	Need of Idukki Extension Scheme.....	245

CHAPTER-1: EXECUTIVE SUMMARY

CHAPTER-1

1. EXECUTIVE SUMMARY

1.1 Introduction

India is a fast-growing economy experiencing rapid industrialization, irrigation development, urbanization, improved village infrastructure etc. The demand for power which is one of the basic inputs for the economic growth of a country is therefore, on the rise in India. The chief sources of energy which are utilized for generation of electricity are: Fuel in all forms i.e. solid, liquid and gaseous, water energy and nuclear energy. The other sources of energy are sun (solar photo-voltaic etc.), wind and tides.

Hydro-power is a renewable, economical, non-polluting and environmentally benign source of energy. Hydropower stations have inherent ability for instantaneous starting and stopping, to help in improving reliability of power system and to meet the peak demand. Hydroelectric projects have long useful life and help in conserving scarce fossil fuels.

The State of Kerala is endowed with as many as 44 rivers and abundant rainfall which in together have hydro power potential of about 6000 MW. Out of which only 2124.92 MW (about 35%) has been harnessed as yet. On the other hand, number of consumers and the energy requirement has been increasing very fast. Further, over the years, consumption of energy which accounts to about 46% of the total energy consumption at the domestic sector at the highly subsidized rate is also been increased, resulting in increasing the peak demand to almost twice the off-peak demand. This forced more investment in the power system to meet the peak demand and purchase of thermal energy from outside the state.

Further, the system statistics of state reveals that the demand of power in the state is increasing at an alarming rate and the rate of increase of demand is disproportionate with the capacity addition. The most reliable and affordable power in the State is the one which is generated from hydro sources. State depends greatly on hydroelectric

generation to meet its power demand even though the vagaries of monsoon seriously disrupt its reliability in certain years.

To meet the increased peak/off peak demand in the state, accelerating development of Hydro Power Projects in the State as well as to achieve an efficient electricity generation and supply system in the state having mostly Hydel predominant Power Generation, KSEBL in early 2000, explored the concept and implementation of Extension Schemes/Capacity Addition etc. in an environmentally benign manner.

1.2 Project Background

KSEBL after undertaking a reconnaissance study of various options at its disposal and its existing installations spread across the State has now indentified to first to explore possibility of tapping the available resources at its largest power station viz. IDUKKI Hydro Electric Project located in IDUKKI District of Kerala State due to ideal natural topography. Option of an “Extension Scheme” to the existing scheme seems possible.

To implement the Extension scheme of IDUKKI HEP, Kerala state Electricity Board Limited has appointed WAPCOS for preparation of Feasibility Study Report (FSR)/ Detailed Project Report (DPR) vis-à-vis, obtaining all statutory clearances for Execution, Including Preparation of Bid & Allied Documents for Selection of EPC Contractor for the construction of IDUKKI Extension Hydro-Electric Project and Chief Engineer (Civil- Investigation & Construction Central), issued an Loa vide. letter No. CE (C-I &CC)/ TA/ GEN/2020/147 to WAPCOS for undertaking the above mentioned services for IDUKKI Extension Hydro-Electric Project, in Kerala.

The work on Feasibility Study report started immediately after award of work and a multi disciplinary team of experts of WAPCOS undertook the project site visit from 25th to 29th September 2020 to have first-hand information regarding the site and layout feasibility. During the site visit team has got the chance to meet project officials and had technical discussions on different Project configurations and alignments as well as major issues, objectives, criteria, and investigation programmes. The Team collected the earlier study reports and as per Clause no. 4

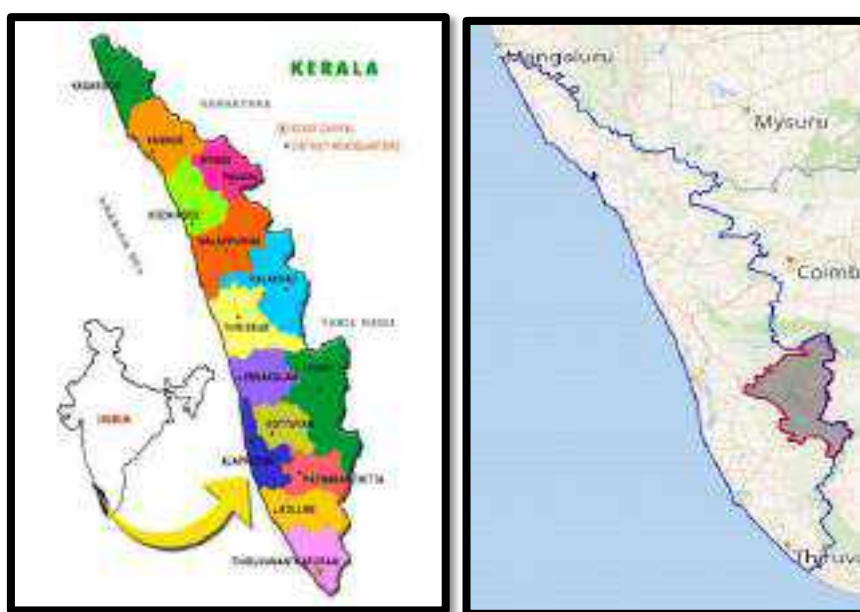
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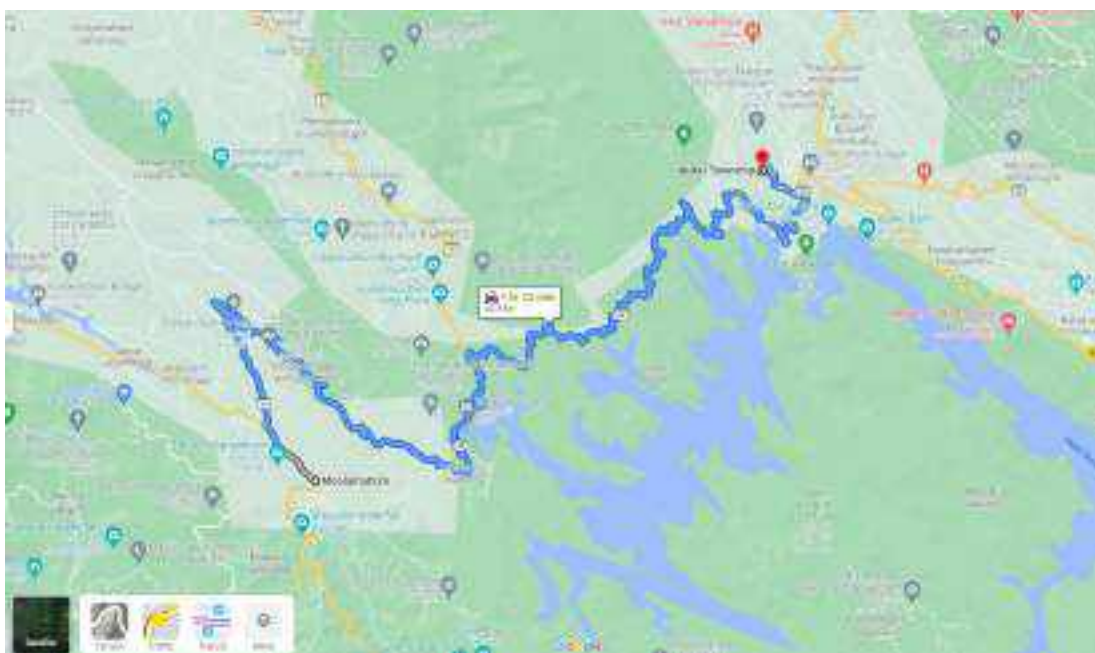
Further after receipt of various data from KSEB, various alternatives for the extension scheme were firmed up. As a part of the preparation of the "Feasibility Study Report (FSR) and also in order to kick off the topographical survey works and allied field investigations works, a joint site visit of KSEBL and WAPCOS officials was undertaken during 26th to 28th August 2021.

The Feasibility Study Report for Idukki Extension Scheme has been prepared as part of the assignment. The Feasibility report will help for preparation of Detailed project report of Idukki Extension project in Kerala to strengthen the power position and flexibility to control the frequency of the power grid and power requirement of the state and utilisation of generated power during peak hours of power demand.

1.3 Project Location

The proposed Idukki Extension Project is located at Moolamattom of Idukki district of Kerala, India (**Figure 1: Location Map**). The project falls in the Lat. N 9° 49' 42" and Long. E 76° 48' 12". It is located 20 KM towards south from District headquarters. The Power house is located at 550m away from the existing Idukki Hydro Electric Project. The Index Map of the Project has been presented at **Annexure-1.1**.





Source: - Google Earth

Fig. - 1 : Location Map

1.4 Access to the Project

a) Roadways

NH-49 Madurai-Kochi (280 km.) passes through the District starting from Kundannur and terminating at Bodim, thus covering 167.6 km. in the District. The Cochin-Munnar road, Kottayam-Kumily road, Thodupuzha- IDUKKI road and Kumily-Munnar road are the major roads in the District. Access to the site is through Thodupuzha – Muttam – Moolamatom.

The roads in IDUKKI are part of Ghat roads. The major roads connect the city of Kochi to Tamil Nadu. The KK road (Kumili - Kottayam), the PT road (Puliyanmala - Thodupuzha State Highway-33) are some of the other busy roads.

b) Railways

At present, there is no railway in and to IDUKKI district of Kerala. The nearest railway stations are Kottayam (65 km) (station code – KTYM), Aluva (76 km) (Alwaye, station code – AWY), Ernakulam South (82 km) (Ernakulam Jn., station code – ERS) and Ernakulam North (Ernakulam Town, station code – ERN).

c) Airport

Nearest airport is Nedumbasseri airport of Ernakulum district which is 76 km away from project site. The nearest International airport to IDUKKI is Cochin International Airport and Coimbatore Airport..

1.5 Scope of Work

The project is envisaged to be Conventional Hydro Electric Scheme utilising water from existing Idukki Reservoir in addition to the existing operational hydro electric scheme. The water conductor system will connect the Idukki reservoir to tail race exit in Thodupuzha River through an underground power house.

The scope of work envisages preliminary studies for:

- Collection of hydrological/meteorological data and assessment of water availability for the project.
- Use of existing Idukki reservoir of gross capacity **1996.3 MCM** created by three dams across periatr river.
- Selection of an underground power house with numbers of pump-turbines of a particular capacity along with an auxiliary system. Working out the tentative orientation of the powerhouse on preliminary geotechnical, engineering and hydraulic aspects.
- An underground Transformer Cavern with number of Power Transformers for each machine.
- Preliminary geological, geotechnical and engineering appraisal of Head Race Tunnel (Concrete Lined), pressure shaft (steel lined) and Tail Race Tunnel for conveyance of water.
- Power potential studies on the line of present power scenario and future demands.
- Tentative projection of cost and benefits of the project.

1.6 Topography & General Climate

Idukki has an area of 4,358 km² (1,683 sq mi) and is the second-largest district of Kerala. It is one of the mountainous district of Kerala with high hills and deep valleys,

has a plateau like structure. Rugged mountains and forests cover about 97 per cent of the total area of the district. The district consists of five taluks: Thodupuzha, Devikulam, Idukki, Udumbanchola, and Peerumedu. The district borders the Kerala districts of Pathanamthitta in the south, Kottayam in the southwest, Ernakulam in the northwest, and Thrissur in the north. IDUKKI also shares borders with Coimbatore, Dindigul, small parts of Tenkasi, Tiruppur, Theni, and Virudhunagar districts of Tamil Nadu in the east.

The proposed Idukki Extension Scheme comes under the Periyar River Basin. This region slopes towards the West, except the North-East where its slopes towards the East. It is part of Central Kerala Coast and on the basis of topography, geology, soils, climate and natural vegetation, It is sub-divided into 5 Micro Regions viz., Anamalai Forested Hills, Marayoor Forested Hills, Cardamom Hills, Periyar River Basin and Thekkedy Forested Hills.

The Periyar river Basin region lies in the central and the Western parts of the District and makes its boundaries with Anamalai Forested Hills in the North, Cardamom Hills in the East, Thekkedy Forested Hills in the South and Meenachil - Kanjirappally Upland and Periyar-Muvattupuzha Rolling Plain in the West. This region is the catchment area of the Periyar River and is structurally controlled towards the North-West. This region is having below 1000 m. in height and slopes towards the West. However, the maximum height (1,194 m.) lies at Udumbannoor Village of Thodupuzha Taluk and the minimum height (118 m.) in its Western part at Pannorkara of Udumbannoor Village of Thodupuzha Taluk. The average height of this region is between 850 m. and 900 m. It has a number of escarpments in its central and Western parts. 'V' shaped valleys formed by the Kudayatturpuzha and the Kaliyar Rivers are identifiable landmarks in this region. This region has thick ever-green forests, teak, rubber and tea plantations and cultivations like pepper, cashew, tapioca, etc.

The climate of Idukki district varies considerably from the rest of the State due to its peculiar topography. The highland region is having a comparatively cold climate. In the places above an elevation of El. 2400m, the temperature at times falls down to

freezing point in the winter. Occurrence of mist is usual in the highland regions lying over an elevation of El. 1300m above mean sea level. The western part of the district comprising midland area experiences moderate climate, temperature varying between 21⁰ to 27⁰ degree with minimum variation. The eastern parts of the district located in the highland have a comparatively cold climate with temperature varying between -1⁰ C to 15⁰ C in November/January and 5⁰ C to 15⁰ C during March/ April.

Idukki district also has the benefit of the south-west monsoon (Edavapathi) during June to September and the north-east monsoon (Thulavarsham) during October and November, the former is more prominent. The eastern and the north-eastern regions of the district get very low rainfall in contrast to the other areas. Marayoor, Kanthalloor, Vattavada and Thalayar regions come under this group. Marayoor and Kanthalloor are virtually rain- shadow areas, lying in the eastern side of the Western Ghats

1.7 Hydrology

The proposed project is located on Periyar River and the source of water for this scheme is water stored in existing Idukki reservoir. The catchment area of Idukki dam is 675.89 sq.km. The average rainfall in Idukki catchment is 3549 mm. The average water availability inflow into reservoir in Idukki reservoir is 1687.23 MCM. The FRL of this reservoir is El. 732.43 m. Moreover, the proposed scheme do not envisage any change in existing operating levels of the reservoir. No structural modifications/interface are required in existing dam structure. The elevation area capacity curves as available are being recommended for utilization since the quantum of water being used for proposed hydroelectric project study is miniscule. The tail water from Idukki Extension scheme is also discharging to the same river as that of existing scheme.

1.8 Geology

The project area is surrounded by hilly terrain and the predominant landforms in the project area are structural and denudational hills. Physio-graphically the state can be divided into four domains from east to west, viz., the Western Ghats, the foothills, the

midland and the coastal low- land. Kerala is drained by 44 rivers, many of which originate from the Western Ghats. Except Kabini, Bhavani and Pambar which are east - flowing, the rest of rivers are west- flowing and join the Arabian Sea. A few of them drain into the backwaters of the Arabian Sea. Most important rivers (with their length in km in parenthesis of the state, are Chandragiri (105), Valapatnam (110), Achankovil (120) Kallada (121), Uvattupuzha (121), Chalakudy (130), Kadalundi(130), Chaliyar (169), Pampa (176),Bharathapuzha(209) and Periyar (244).

The hills are formed of Precambrian basement rocks and have a soil cover. A major part of the district falls in the hill ranges of Western Ghats except for Thodupuzha block and western part of Elamdesam block which fall in the mid land region of the State. The average elevation of the mid land region ranges from 40 – 60 m AMSL. The mid land area is characterized by rugged topography formed by small hillocks separated by deep valleys. The general slope of the area is towards west. The hill ranges can be subdivided into foot hills, plateau region and high ranges. The foot hill region is a narrow strip of land where midland region grades into the plateau regions. The elevation of this region ranges from 80 to 500m AMSL and slope is very steep, ranging from 30 to 50% and occasionally up to 80%. The width of the foot hill ranges from 2 to 8 km. Plateau region is the most important physiographic unit of the district and is characterized by moderately sloping large land mass with a slope of less than 30 % and an elevation of less than 1500m AMSL. Major part of the district fall in this region. The region is incised by a number of deep cut streams. Presence of two former planation surfaces were deciphered on the basis of the maturity of the landscape, accordance of summits and the residual cover over them. The older surface has an elevation of more than 1200m whereas the younger one has between 900 and 1200m. Along the western margin, valley flats are developed due to dissection by the rivers. Major part of the district is drained by Periyar River. Northeastern and western parts are drained by Pambar and Muvattupuzha rivers respectively. Anaimudi (2695m) the highest peak of South India is along the northeastern part of the district. Other peaks are Kewarikkat mala (2523m) and Chunduvurai mala (2525m). The area in the north eastern part of the district is characterized by high mountains with elevation more than 1500 m AMSL. The highest

peak in South India, Anamudi (2693 m AMSL) is in the north central part of the district. There are several steep falls within the region. The details of preliminary geological study at FSR level is presented in chapter 5 of this report.

1.9 Seismicity of the Area

Idukki Extension Scheme Hydroelectric Project is located within metamorphic terrain comprises of pyroxene granulite, magnetite quartzite and charnockite among which the charnockite is dominant and widespread. Pyroxene granulite and magnetite quartzite occur as linear bands of a few metre width and a few tens of metre in length within the gneissic terrain. They are aligned generally parallel to the trend of foliation. Charnockite occurs as continuous rock unit covering the hilly region in the south and northwest. It is mostly massive but gneissic varieties are also seen, with intermediate to acidic in composition. These are belongs from Archaean to Proterozoic age. A series of NW-SE, NE-SW & NNW-SSE trending lineaments (shear, fault) are also present in the area as reflected on District Resource Map of GSI on 1:2,50,000 scale.

The area falls under seismic zone-III(Fig.4)as per Seismic Zonation Map of India(IS: 1893-2002, Part-1).

1.10 Installed Capacity and Power Generation

The power potential studies have been carried out for power potential with idduki reservoir and can be optimized upto 1580 MW based on the 25 years of hydrological data. The carryover reservoirs simulation studies carried out for FRL at El. 732.43 m, MDDL at El. 694.94 m and maximum TWL ot El. 49.3 m.

The studies indicate that the project would afford a firm power of 271.6 MW cont. on 90% dependable basis with an installed capacity of 1580 MW. The details of the study are presented in Chapter 6 of this report.

Further, as existing Idukki Hydroelectric project is operating at 780 MW with 6 nos. of unit of 130 MW each. Therefore Idduki Extension Scheme is proposed to have an Installed Capacity of 800 MW wherein 4 nos. units is recommended with unit size of

200 MW each with Tecno-economic consideration. Based on the study, the key details of the scheme are summarized below:

Installed Capacity (MW)	800
No of units	4
Unit Size (MW)	200
Head (min) (m)	629.58
Net Rated Head (m)	654.57
Head (max) (m)	677.07
Daily (min) Peaking hours in lean flow (for simultaneour operation of both existing and proposed scheme)	4 Hours 8 minutes (4.13 Hours)
Annual Energy Generation (GWh) from proposed scheme	1301.27
Annual Energy Generation (GWh) from both schemes	2569.70

1.11 Land Requirement

The total land to be acquired for the project is approximately 127 Ha. Based on the site visit, most of the land required lies in forest area. The clearance and acquisition of land will be as per the land guidelines. Suitable site will be selected for muck disposal at DPR stage. The various components of the land required is shown in Table below:

S. No.	Appurtenance	Area (Ha.)
1.	Project Component	101
2.	Roads	6
3.	Muck Disposal/ Quarry Site	15
4.	Contractor's facility	5
	Total	127

1.12 Estimates of the Cost

The estimated project cost is ₹ 2669.67 Crores at August, 2021 price levels. The preliminary cost estimate of the project has been prepared as per guidelines of CEA / CWC. The Abstract Summary of the cost estimates is given below:

Item	Estimated Cost (₹ Crores) (August. 2021)
Civil Works	₹ 1309.67
Electro-mechanical Works	₹ 1360.00
Total	₹ 2669.67

1.13 Financial Aspects

The estimated cost of the project is ₹ 2669.67 Crores at August, 2021 price levels and annual energy generation of 1301.27 GWh per year and is proposed to be completed in a period 5 years.

The tariff has been worked out considering a debt-equity ratio of 70:30, and interest rate of 9.0 % on the loan component for the financial analysis of the project.

Based upon the parameters given above, the first year and levellised tariff is indicated below.

Table 1:1

Sl. No.	First Year Tariff (₹/kWh)	40-year Levellized Tariff (₹/kWh)
1	5.19	4.67

1.14 Salient Features

1. LOCATION	
Country	India
State	Kerala
District	Idukki
River	Periyar
Access to the Project	
Road	Cochin airport to Moolamattom – 77 km Moolamattom to Kulamavu dam – 18 km
Airport	Cochin airport – 92 km
Railhead (with unloading facilities)	Angamali - 90 km Ettumanoor – 70 km
Port	Cochin Port
2. PROJECT	
Type	Hydro Electric Project
Installed Capacity	4 x 200 MW
3. HYDROLOGY	
Average Annual Rainfall	3549 mm (for 1995 to 2020)
4.0 CIVIL STRUCTURE	
4.1 Intake Structure	
Location	Left bank of Kulamavu Dam
Lat-Long	76° 53' 10.24" E, 09° 48' 03.50" N
Centre line level of Intake	EL. 680.79m
Type	Trapezoidal type with anti-vortex louver
4.2 Headrace Tunnel (Concrete Lined)	
Length	1900 m
Size & Shape	7.00m dia., Modified Horse Shoe Shape
4.3 Surge Shaft (Concrete Lined)	
Type	Restricted Orifice
Inner Dia of Orifice	3.5m
Diameter of Surge Shaft	10.0 m
Adit to Bottom of Surge Shaft	325m long, D-Shaped, Size 7x7 m

4.4 Pressure Shaft (Steel Lining)	
Type	Underground Inclined Pressure Shaft
Number of lines	2
Total Length	850m
Diameter	3.90m
Adit to Inclined Pressure shaft	
Length	455m
Size & Shape	7x7 m, D-Shape
After Bifurcation (D x L x No. of line)	2.80 m x 55 m x 4 line
4.5 Tailrace	
Tail Race Tunnel Length	1465m
Size & Shape	7.50 x 7.50 m, D-Shape
Tail Race Channel Length	730m
Bottom Width of Channel	10m
Side Slope of Channel	1 H : 8 V
Longitudinal Slope of Channel	1:1000
Tail Race Exit Lat-Long	76° 50' 40.37" E, 09° 47' 37.20" N
4.6 Powerhouse	
Type	Underground Cavern
Size	146m x 22m x 44.5m
4.7 Transformer Room	
Type	Underground Cavern
Size	146m x 16m x 26.5m
4.8 Auxiliary Tunnel	
Main Access Road Tunnel	D-Shaped,
Length	1050 m
Size & Shape	8 x 8 m, D-Shape
MAT Entrance Lat-Long	76° 51' 24.32" E, 09° 47' 23.62" N
Cable Tunnel	605m long, 7 x 7 m, D-Shape
4.9 Switch Yard	
Type	

Outgoing Bay Incoming Feeder	Outdoor Pothead Yard 6 Nos. 4 Nos.
5.0 Electromechanical Equipment	
5.1 Turbine	
Type	Vertical Pelton
Number of unit	4
Rated Turbine Head	654.57 m
Turbine Output at Rated Head	203.04 MW
Rated Turbine Discharge	34.48 cumecs
Synchronous Speed	375 rpm
5.2. Generator	
Type	Suspended Type
Number of unit	4
Rated Output	200MW
Generation Voltage	18kV
Power Factor	0.85 lagging
Rated Frequency	50 Hz - 5% to + 3 %
Rated Speed	375 rpm
Over Load Capacity	10%
5.3 Main Transformer	
Numbers	13 nos (including 1 spare)

Rated Capacity	87 MVA
Rated Voltage	H.V. Side 220 kV; LV Side 18 kV
Type of cooling	ODWF/OFWF
Cooling medium	Mineral oil
Tapping	Off-Load Type ($\pm 5\%$ in steps of 2.5%)
5.4 Gas Insulated Switchgear	
Type	Indoor GIS
Number of Bays	11
Rated Voltage	245 kV
5.5 EOT Crane	
Number of Unit	2
Rated Capacity	250/40/10 T
5.6 Land	
Private Land	16 Ha.
Forest Land	111 Ha.
6 Project Cost	
Cost of Civil Works including H&M	₹. 1309.67 Cr.
Cost of E & M Works	₹. 1360.00 Cr.
IDC	₹. 392.41 Cr.
Total Cost of The Project	₹. 3062.08 Cr.
7. Project Benefit's	
Levelized tariff	4.67 (₹/kWh)
First year tariff	5.19 (₹/kWh)

Annexure-1.1

CHAPTER-2:

ECONOMIC SCENE OF KERALA

CHAPTER- 2

2. ECONOMIC SCENE OF KERALA

2.1 Introduction

Kerala is a state on the Malabar Coast of India. It was formed on 1 November 1956, following the passage of the States Reorganisation Act, by combining Malayalam-speaking regions of the erstwhile regions of Cochin, Malabar, South Canara, and Travancore. The State is covered an area of 38,863 sq.km. It is the twenty-first largest Indian state by area. The State is bounded by Karnataka to the north and northeast, Tamil Nadu to the east and south, and the Lakshadweep Sea to the west. The State is divided into 14 districts with the capital being Thiruvananthapuram. Malayalam is the most widely spoken language and is also the official language of the state.

Kerala is blessed with a unique set of geographical features that have made it one of the most important tourist destinations in Asia. A long shoreline with serene beaches, tranquil stretches of emerald backwaters, lush hill stations and exotic wildlife is the wonder of Kerala. The State is divided into three geographical regions. Highlands, which slope down from the Western Ghats onto the Midlands of undulating hills and valleys into an unbroken 580 km long coastline with many picturesque backwaters, interconnected with canals and rivers. The wild lands are covered with dense forests, while other regions lie under tea and coffee plantations or other forms of cultivation. Most of the state is engulfed in rich greenery which ensures a very calming experience at all times.

The State ranks second in the Investment Climate Index followed by Karnataka as per a policy research working paper by the World Bank. The state stands second due to its world-class infrastructure and well-trained human resource pool. Kerala's traditional industries include handloom, cashew, coir, and handicrafts.

At current prices, Kerala's total GSDP stood at Rs. 876,283 crore (US\$ 119.93 billion) in 2021-22, an increase of 1% over FY20. The state's GSDP is expected to grow at a CAGR of 11.72% between 2015-16 and 2020-21. The state's per capita GSDP stood

at Rs. 245,323 (US\$ 3,329) in 2019-20. According to the Department for Promotion of Industry and Internal Trade (DPIIT), cumulative FDI inflow in Kerala was valued at US\$ 269.61 million between October 2019 and March 2021. Exports from the state stood at US\$ 3.94 billion in FY21. The growth rate of GSVA is only 2.58 per cent in 2019-20 compared to 6.2 per cent in 2018-19.

In terms of population, Kerala is the thirteenth largest Indian state by population. The total population of the State is 33 million as per the 2011 census. Kerala has the highest literacy rate and ranks first in the country with literacy rate of 93.91 % and closely followed by Lakshadweep (92.28 %) and Mizoram (91.58 %) as per Census of India, 2011. Kerala's literacy rate, which was only 47.18 % in 1951 became doubled by 2011 and the male-female literacy gap which was 22 % in 1951 has narrowed down to 4.04 % in 2011. Kerala holds the first place in the country in female literacy with 92 % as per Census of India, 2011. It is the second most urbanised state in the country with 47.7% urban population according to the 2011 Census of India. The state topped in the country to achieve the Sustainable Development Goals according to the annual report of NITI Aayog published in 2019.

Kerala has a forest area of 11,125 sq km, which covers almost 29 percent of the total land area of the state and spread over the Western Ghats which is one of the world's hot spots of bio-diversity. It is rich in a wide variety of rare and endangered flora and fauna. Kerala lies closer to the equator but is bestowed with a pleasant and equable climate throughout the year. Because of that reason, there are so many wildlife sanctuaries in Kerala. These forests are the ultimate paradise for the nature lovers and others who are interested in wildlife.

As per the land use data of 2019-20, out of a total geographical area of 38.86 lakh hectare (ha), total cultivated area is 25.89 lakh ha (66.64 %) and the net area shown is 20.26 lakh ha (52.13 %). Non-agricultural land stands at 11.73 % and forest area is 27.83 %. Forests of Kerala are broadly classified into 5 major categories such as Tropical Wet Evergreen Forest, Tropical Moist Deciduous Forests, Tropical Dry Deciduous Forests, Mountain Sub Tropical Forests and Plantations. As per India State of Forest Report 2019, the forest cover of the State has increased during the

second consecutive assessment period and thereby enabling the State to occupy third position in terms of increase in forest cover.

The production of pepper and natural rubber contributes significantly to the total national output. In the agricultural sector, coconut, tea, coffee, cashew and spices are important. Around 1.1 million people in the state are dependent on the fishery industry which contributes 3% to the state's income. Kerala is one of the prominent tourist destinations of India, with coconut-lined sandy beaches, backwaters, hill stations, Ayurvedic tourism and tropical greenery as its major attractions.

Under SEZ Act, 2005, Kerala has 29 formally approved SEZs, 25 notified SEZs and 19 exporting SEZs. The state has a techno park in Thiruvananthapuram which has been instrumental in attracting global electronics manufacturers, an info park in Kochi, and a cyber park in Kozhikode

2.2 Economic Parameters

2.2.1 GSDP/NSDP

Kerala's total GSDP stood at Rs. 876,283 crore (US\$ 119.93 billion) at current prices in 2021-22, an increase of 1% over FY 2020-2021. The state's GSDP is expected to grow at a CAGR of 11.72% between 2015-16 and 2020-21. The state's per capita GSDP stood at Rs. 245,323 (US\$ 3,329) in 2019-20. According to the Department for Promotion of Industry and Internal Trade (DPIIT), cumulative FDI inflow in Kerala was valued at US\$ 269.61 million between October 2019 and March 2021. Exports from the state stood at US\$ 3.94 billion in FY21. The growth rate of GSVA is only 2.58 per cent in 2019-20 compared to 6.2 per cent in 2018-19.

2.2.2 Foreign Direct Investment (FDI) inflow & Investments

Kerala is one of the most scenic and popular tourist destinations in India. It is also famous for its special ayurvedic therapies and its backwaters. Kerala also leads other states in Industrial development and per capita income. Kerala is a major exporter of coir, spices, marine products, cashew, coffee and pickles. Two-thirds of the state's export income comes from food processing industry.

With a coastline of nearly 590 km, Kerala has a major port at Kochi (with a cruise terminal) and 16 smaller ports along the coast. The state is very close to global maritime trade route passing through the Indian Ocean region with Kochi International Container Trans-shipment Terminal (ICT) at Vallarpadam, which is India's first ICT. Kerala is the first state in India to have four international airports, namely in Kochi, Kozhikode, Thiruvananthapuram and Kannur.

The state's unique heritage and cultural diversity have attracted tourists from all over the world. Its strategic location on the trans-national trade corridor, rich natural resources, and simple and transparent procedures make the state appropriately suited for investments in major sectors such as tourism, IT/ITeS, manufacturing and mining.

Kerala has the highest human development index with the highest literacy rate, life expectancy and the highest ratio of females to males in the country. Foreign Direct Investments have brought-in technological advancement in various industrial sectors and resulted in a growth in export production.

The state's GSDP was about Rs 8.76 trillion (US\$ 125.27 billion) in 2019-20. According to Department for Promotion of Industry and Internal Trade (DPIIT), during April 2000 to June 2019, FDI inflows into Kerala, including Lakshadweep, totalled to US\$ 2.24 billion. Total merchandise exports from Kerala stood at US\$ 9.77 billion during 2018-19.

2.3 Agriculture

Agriculture sectors hold a significant role in the development process. It is a pivotal sector of the economy to achieve the Sustainable Development Goals (SDG) of no poverty, zero hunger, and good health and well-being. With decline in the size of land holdings in agriculture, the State has to focus on production, productivity, and profitability to attain the SDG targets and sustainability in agriculture. Crops, livestock, fishing, and forestry contributed 8.03 % to Kerala's Gross State Value Added (GSVA) in 2019-20 (constant prices). The agricultural sector in Kerala has undergone significant structural changes in the form of decline in share of Gross State Domestic Product (GSDP) indicating a shift from the agrarian economy.

Gross cropped area in Kerala has declined from 29, 33,000 hectares in 1970-71 to 25, 79,000 hectares in 2017-18, registering a decline of about 12 per cent. As of 2017-18, the gross cropped area in Kerala stands at 25, 79,000 hectares while the net sown area is 20, 40,000 hectares. However, the gross irrigated area stands at only 21 per cent of the gross cropped area and has increased at a very slow pace from 3,81,000 hectares (13 % of GCA) in 1980-81 to 5,40,000 hectares (21 % of GCA) in 2017-18. The slow growth in irrigated area has a major bearing on production and productivity in agriculture sector in the state.

The total cropped area of the State has been declining consistently from 30 lakh hectare in 2000 to 25.79 lakh hectare in 2017-18. Net sown area has recorded a slight decline of 8.64 %, and the area sown more than once has declined by 30.29%. Current fallows have decreased 7.5 % whereas the “fallow other than current fallows” as well as “cultivable waste land” have recorded an increase of 63.38% and 71% respectively. Thus the land that is fit for cultivation but is not being cultivated is the rise signalling the tendency of people to keep land fallow for various reasons.

While the gross area under rice cultivation has declined to almost one-fifth of the area cultivated between 1970-71 and 2017-18, the area cultivated under rubber has trebled and that under coconut has increased, although not at a considerable pace. The area under pulses has registered the highest rate of decline and at present, only 2,000 hectares are under pulses cultivation. The area under rice and pulses which in 1970-71 constituted 31% of the Gross Cropped area, has come down to 7.4 % in 2017-18. Since pulses are a rich source of protein and are water-efficient, promoting cultivation of pulses would augur well for nutrition security and food security of the state.

A major change of land use pattern has been made in Kerala. The major change was the shift from cultivation of food crops to non-food crops and increase in area under land put to non-agricultural use. Changes in land use and cropping pattern in Kerala pose a challenge not only to food security but also to the ecological sustainability of the State.

2.4 Horticulture

Horticulture sector in Kerala, encompasses wide range of crops namely fruit crops, vegetable crops, potato and tuber crops, ornamental crops, medicinal & aromatic crops, spices and plantation crops has grown in a faster pace than agriculture, making Kerala a major horticulture hub. Horticulture has emerged an indispensable part of agriculture, offering a wide range of choice to the farmers for crop diversification. It also provides ample opportunities for sustaining large number of agro-industries which generate substantial employment opportunities. Increase of the area and production under Horticultural crops has put Kerala in a stronger position in terms of attracting investments from private sectors. The returns from Horticulture per unit of land are higher as compared to Agriculture. The horticulture is climate resilient and involving less risk that assures higher income to farmers so these became a sustainable and viable venture for the small and marginal farmers.

Besides, the sector has also started attracting entrepreneurs for taking up horticulture as a commercial venture. There is a great scope for the horticulture industry to grow and flourish. Due to changing socioeconomic profile and increasing middle class coupled with higher per capita income this sector has more potential as food habits are changing and people are becoming more health conscious.

The state is located in the southern tip of India and bordered by Arabian Sea, the extensive network of azure backwaters, rivers and streams, boast of an agrarian economy. The abundance of water due to the 34 lakes and other small streamlets, innumerable backwaters and water bodies and 49 rain fed rivers flowing over the terrain and the adequate rainfall of 300 mm received by the state probably facilitated horticulture to a great extent.

The state is the second largest producers of fruits and vegetables and largest producer and consumers of cashew nut, tea spices, cocoanut, rubber, coffee, banana plants etc and hence the economy of the state is dominated by horticulture. The Horticulture sector contributes around 28% of the GDP from about 13.08% of the area and 37% of the total export of agricultural commodities.

Government of Kerala has also initiated Kerala Horticulture Development Programme (KHDP) in 1993 with financial support of the European Union to attract Self Help Group for promoting fruits and vegetable production in Kerala and the activities were first launched in the districts of Thiruvananthapuram, Ernakulam and Kottayam and other to rise up to the new and emerging challenges in the horticulture sector by the farmers.

2.5 Irrigation

Irrigation development plays an important role in the agricultural production because of uncertain, inadequate and uneven rainfall in the state of Kerala. The average annual rainfall of the state is 3000mm and the bulk of which (70%) is received during the South-West monsoon and sets in by June and extends upto September. The state also gets some rains from the North-East monsoon during October to December but the remaining period from December to May is practically dry. Though the State has got 41 west-flowing and 3 east-flowing rivers originating from the Western Ghats and the total annual yield from these rivers together is 78.041 Million Cubic Meters (MCM) of which 70,323 MCM is in Kerala. But due its peculiarity of the rivers flowing across Kerala most of the rain water received during monsoon period flows to sea within 48 hours of rainfall due to the character of the geographic terrain of the state. Therefore, the irrigation is must for the successful cultivation of crops in Kerala.

Though there are various methods for providing irrigation water but the best and the most reliable method that was used by the State is the construction of storage reservoirs for impounding water during the monsoon and utilizing the water in the reservoir for critical periods of the crops when there is insufficiency. The State Irrigation Development has taken up major and medium projects for cultivation of a major portion of the cultivable land by making ayacut under these projects. Irrigation Development not only correlates to Agriculture but also to other Socio-Economic aspects like industry, navigation, hydropower, pisciculture, water supply etc.

The oldest irrigation project in Kerala is the Peechi Irrigation Project, built across Manali river in Thrissur district. This straight concrete gravity dam, completed in 1959, serves as irrigation dam for nearly 17555 Ha of land and also caters to the drinking

water needs of the population. The dam has a vast catchment area with extensive botanical gardens and cascading fountains and offers numerous inviting avenues for tourists. Other projects like the Vazhani, Wayalar, Malampuzha, Mangalam, Gayathri, Pothundy, Neyyar Irrigation Projects were taken up by the Department for enhancing the irrigation potential of the State. Neyyar Irrigation Project in Thiruvananthapuram district is one of the major irrigation projects taken up in Kerala under the first five year plan and completed in 1976 and the project envisages irrigating an ayacut of 11740 Ha and now it become an integral part of the lives of people in Neyyatinkara taluk and its surroundings as it is the main source of water for agriculture and drinking purpose, Tourist attractions are the Lion Safari park, boating service, Crocodile Rehabilitation and Research Centre, miniature wild life sanctuary, Lake Garden etc.

Others irrigation projects are also constructed for cultivation of the land in the state but considering the present situation almost all projects are being converted into multipurpose projects in order to maximize the utilization of existing resources. In order to improve the Irrigation potential, innovative MI Schemes have also been implemented in almost all parts of the state.

Groundwater is also used for irrigation in the state from wells and tube wells but in most parts of the state do not provide a favourable environment for intensive use of this resources. The ground water potential of Kerala is very low as compared to that of many other states in the country. The estimated ground water balance is 5590Mm³. The ground water fulfils the irrigation needs of around 50 percent of irrigated area. The total Annual ground water availability in Kerala State has been computed as 6.620 Billion Cubic Meter (BCM) and the net ground water availability in the entire state is 6.029 BCM. The rainfall recharge about 82 % of the annual recharge.

2.6 Forest Resources

The State of Kerala is largely spread over the Western Ghats which border the state. The Western Ghats represent one of the World's 18 hot spots of bio-diversity and is considered to be a repository of endemic, rare and endangered flora and fauna. In tune with the National Forest Policy, the Government of Kerala developed a vision and strategy for the management of forest resources with an endeavour to reconcile the

disparate demands on forests, to conserve the bio-diversity on the one hand and to meet the demands of the society on the other.

The geographical area of the State is 38,852 sq km, which is 1.18% of the geographical area of the country. Physiographical, the State can be divided into coastal, midland and highland zones. The important rivers of the State are Periyar, Kaloda and Attingok which drain into the Arabian Sea. Climate of the State is humid with mean temperature ranging from 19.8°C to 36.7°C and the average annual rainfall from 1,520 mm to 4,075 mm. The State has 14 districts out of which 10 districts are hill and 9 districts are tribal. The recorded forest area in Kerala is 11,125.59 sq.kms. The percentage of forest cover in Kerala is 28.90 which is higher than the national coverage of 19.50. This includes 9157.10 sq. kms reserve forests, 214.31 sq.km proposed reserve and 1754.18 sq. km vested forest. Out of the total of 11,125 sq.km. of recorded forest area, the effective (actual) forest area in Kerala is only 9400 sq.km.

Kerala forest fall in two biogeography provinces, viz Western Ghats and the Western Coast, and are rich in biodiversity and vital for environmental protection and considered to be a repository of rare and endangered flora and fauna. The pressure on India's forests is very high because of high population. The rapid growth in the economy of the country in the last one decade has put additional demands on forest for infrastructure development. Forest plays an important role in the country's ecological stability and economic development. The national forest policy in India, since 1952 has set a goal of bringing one-third area of the country under forest cover. India aims at maintaining a minimum of 33% of country's geographical area under forest and tree cover.

Though the state is small in size with comparatively small area under forest cover, Kerala is the medley of a variety of vegetations and forest types. The forest types of Kerala include Tropical Wet Evergreen Forests, Tropical Moist Deciduous Forests, Tropical Dry Deciduous Forests, Mountain Sub Tropical, Rolling Grasslands, Shola Forest, Thorny Scrub Forest, high Sholas etc.. This wide range of forest types enables the growth of a rich variety of flora. The trees of the Tropical Dense Evergreen Forests are - White Pine, Kuntharekka Pine, Punnappa, Bhadraksham, Palai, VEDIPLAVU,

Maravuri, Vayana etc. The Moist Deciduous Forest include trees such as Teak, Maruthi, Karimaruthi, Rosewood, Venteak, Vengal, Chadachi, Mazhukanjiram, Bamboo etc.. The only south Indian coniferpodocarpus wallichianus grows in the region around the Periyar Reserve. Apart from the trees the states forests are also home to thousands species of flowering and non-flowering plants, orchids and medicinal plants.

Forest plantations constitute the major source of raw material to the forest based industries. Teak is the major species planted, followed by mixed plantations and eucalypts. Major forest produce includes timber, bamboo, reeds and firewood.

2.7 Fisheries

Fisheries and Aquaculture is an important sector for economic development of both national and State economies. It contributes not only to GDP and employment but also stimulates growth in a number of subsidiary industries. Kerala, by virtue of its geographical location is blessed with rich and varied fisheries resources and marine fisheries play an important role in the coastal economy of Kerala. The coastline of the State bordered by the Arabian Sea runs to a length of about 590 km., 400,000 hectares of inland water resources and approximately 220,000 active fishermen of Kerala is one of the leading producers of fish in India. According to 2003–04 reports, about 1.1 million people earn their livelihood from fishing and allied activities such as drying, processing, packaging, exporting and transporting fisheries. The annual yield of the sector was estimated as 608,000 tons in 2003–04. This contributes to about 3% of the total economy of the state. In 2006, around 22% of the total Indian marine fishery yield was from Kerala. In year 2018-19 the total fish production was 13.75 Million Metric Tonnes (MMT) with a contribution of 9.58 MMT from inland sector and 4.15 MMT from marine sector. Inland fish production constitutes 70 % of the total fish production in the country. Among the top ten countries with the largest aquaculture production, India occupies second position next to China. The sector has been one of the major contributors of foreign exchange. In 2019-20, the export of marine products from India stood at 12, 89,651 metric tonnes valued at Rs. 46,662.85 crore. The share of fisheries sector in the total GSVA (at constant price) in 2019-20 constitutes 0.82 %

and accounts for 0.72 % of GSDP. Fisheries and Aquaculture contributes 9.7 % of the Gross State Value Added (GSVA at constant prices 2019-20 (Q)) from the primary sector. The total fish production of Kerala in 2019-20 is 6.8 lakh metric tonnes with a contribution of 4.75 lakh metric tonne from marine sector and 2.05 lakh metric tonne from inland sector. Total fish production in Kerala, which had been declining since 2015-16, witnessed a significant increase in 2018-19.

According to Census 2011, out of total population in Kerala, the fisher folk population is estimated to be around 3.13 %. They reside in 222 marine fishing villages and 113 inland fishing villages of the State. The Government of Kerala has so far completed the construction work of 18 fishing harbours and the works of another 7 are progressing. Total revenue collected from fishing harbours and fish landing centres had shown a sharp increase from Rs. 302.54 lakh in 2016-17 to Rs. 849.08 lakh in 2017-18. But slightly declined to Rs. 726.45 lakh in 2019-20.

2.8 Livestock

Animal Husbandry is a vital sector for ensuring a more inclusive and sustainable agriculture system and plays a pivotal role in the economic development of the country by enhancing farmers' income. It also provides gainful employment in the rural sector particularly among the landless farmers, small and marginal farmers, women, and weaker sections. It acts as both a supplementary and complementary enterprise.

The livestock sector contributes substantially to the economy. About 20.5 million people depend upon livestock for their livelihood. The sector contributes 16 % of the income of small farm households as against an average of 14 % for all rural households and provides livelihood to two-third of the rural community. It also provides employment to about 8.8 % of the population in India and percentage of area used for all types of livestock farming was 1.69 %. Our country has vast livestock resources and contributes 4.11 % of GDP and 25.6 % of total agricultural GDP. The rural women play a significant role in animal rearing and are involved in operations namely, feeding, breeding, management, and health care. The livestock sector has emerged as one which generates employment and income security to women through micro enterprises. Women constitute 71 % of the labour force in livestock farming.

In Kerala, the livestock sector is prominent and one of the fastest growing sectors of the rural economy. The share of livestock in Gross State Value Added (GSVA) at constant prices from the agriculture sector shows a marginal decrease from 26.97 % in 2018-19 to 26.67 % in 2019-20. Though GSVA at constant prices from the sector has increased in absolute numbers, its share in total GSVA of the State has declined marginally from 2.38 % in 2018-19 to 2.14 % in 2019-20. India's livestock sector is one of the largest in the world and plays a crucial role in improving the socio- economic conditions of the rural masses. As per 20th Livestock Census (2019), the total livestock population of the country is 535.78 million showing an increase of 4.6 % over Livestock Census (2012).

2.9 Industry

Industrial development is one of the major components of economic development of the State. The manufacturing sector in Kerala is relatively small in size. The manufacturing sector accounted for a share of only 12.5 % of Kerala's Gross State Value Added (GSVA) (at constant 2011-12 prices) in 2019-20. In comparison, the manufacturing sector accounted for 17.4 % of India's GDP in 2019-20. According to data from Annual Survey of Industries, Kerala's share in gross value added by India's factory sector increased from 1.2 per cent in 2014-15 to 1.5 per cent in 2017-18.

The Government is taking steps to modernise the traditional industries in the State, including coir, cashew and handloom. As already noted, these industries continue to employ a substantial part of the State's total workforce. Modernisation of traditional industries will include (but not limited to) mechanisation of production processes in these industries. Moreover, with modernisation, Kerala's traditional industries will strive to diversify into new products (such as geo-textiles in the coir sector), and evolve effective marketing and distribution strategies. Rather than displacing workers (a strategy involving mechanisation alone may result in this), modernisation will lead to overall expansion of the industry and the creation of greater value addition per worker.

In Kerala, there is very high potential for growth in the garment sector. Kerala has a large and sophisticated market for all types of garments. In addition to the large home market, garment firms in Kerala can also take advantage of the demand for Kerala-

specific designs from a sizeable export market comprising non-resident Keralites. The other advantage is the large availability in Kerala of skilled workers and professionals in the garment and fashion sector. The industry should work closely with fashion and design institutes in Kerala. The garment sector should take good advantage of online marketing strategies.

Kerala is yet to take advantage of its huge potential in the food and beverages sectors. There are enormous possibilities in the State in the storage, processing, and value addition of vegetables, fruits, fish, and meat. There exists huge potential, in particular, for the processing of coconut, jackfruit, banana, pineapple, and tapioca. Wood and bamboo based industries can also be developed in selected regions of the State. A relatively large market for food and agro-based products exists within Kerala. However, a good part of this domestic demand is met by imports from other Indian States and countries. Kerala's industries, especially food and agro-based industries, can tap into this domestic market.

The growth of traditional, food and agro-based industries and of tourism can go hand in hand in Kerala, feeding on each other to create a globally recognised niche for the State in these sectors. Kerala can learn lessons from countries such as Thailand, Malaysia, and Vietnam in successfully combining agriculture, agro-based industries and tourism.

The State Government has decided to make business friendly amendments to the relevant laws and regulations. In order to strengthen the sector, the Government of Kerala has come up with the Kerala Investment Promotion and Facilitation Act, 2018 which envisages mandatory approval within a period of 30 days if applications are submitted with necessary documents. The Act seeks to avoid delays in granting various licenses, permissions, approvals, and clearances required under the various enactments and make the State investor friendly.

Facilitation Act, 2019 and the rules made there in, under Section 14 of the Act, dated January 6, 2020 vide G.O. (P)No.2/2020/ID is one of the key initiatives under the Ease of Doing Business Reforms of the Industries Department for establishing and operating MSME units. This forms part of the online single window clearance

mechanism which covers central inspection system for compliance inspections, introduction of self-certification regime, parallel processing of applications by various departments, deemed approvals post the mandated timelines, elimination of redundant clearances, and spot approval for registration through nodal agencies which are revamped single window Board at State, District, and Industrial Parks.

The Kerala Government has engaged handloom cooperative societies in Kerala to supply cloth for the School Uniform Scheme of the Government to revive the sector to some extent. Many workers who had left handloom weaving because of lack of opportunities have returned to work in this sector.

2.10 Information Technology

Kerala has focused more attention towards growth of Information Technology sector with formation of Technopark, Thiruvananthapuram which is one of the largest IT employer in Kerala. It was the first technology park in India and with the inauguration of the Thejaswini complex on 22 February 2007, Technopark became the largest IT Park in India. Software giants like Infosys, Oracle, Tata Consultancy Services, Capgemini, HCL, UST Global, NeST and Suntec have offices in the state. The state has a second major IT hub, the Infopark centred in Kochi with "spokes" (it acts as the "hub") in Thrissur and Cherthala, Alappuzha. As of 2014, Infopark generates one-third of total IT Revenues of the state with key offices of IT majors like Tata Consultancy Services, Cognizant, Wipro, UST Global, IBS Software Services etc. and Multinational corporations like KPMG, Ernst & Young, EXL Service, Etisalat DB Telecom, Nielsen Audio, Xerox ACS, Tata ELXSI etc. Kochi also has another major project SmartCity under construction, built in partnership with Dubai Government. A third major IT Hub is under construction centred around Kozhikode known as Cyberpark. Kerala is the first Indian state to make Internet access a basic right. As on 2019, Kerala's Internet penetration rate is the second highest in India only after Delhi.

2.11 Service Sector

The services sector is not only the dominant sector in India's GDP, but has also attracted significant of foreign investment. This sector has contributed significantly to

export and has provided large scale employment. India's services sector covers a wide variety of activities such as trade, hotel and restaurants, transport, storage and communication, financing, insurance, real estate, business services, community, social and personal services, and services associated with construction.

Share of the services sector accounted for 55.39% of the total GVA in FY21. India's services sector GVA increased at a CAGR of 11.43% to Rs. 101.47 trillion (US\$ 1,439.48 billion) in FY20, from Rs. 68.81 trillion (US\$ 1,005.30 billion) in FY16. Between FY16 and FY20, financial, real estate and professional services augmented at a CAGR of 11.68% (in Rs. terms), while trade, hotels, transport, communication and services related to broadcasting rose at a CAGR of 10.98% (in Rs. terms). According to RBI, in April 2021, service exports stood at US\$ 21.17 billion, while imports stood at US\$ 10.61 billion.

The state's service sector accounts for around 65% of its revenue and is mainly based upon its Hospitality industry, Tourism, Ayurveda & Medical Services, Pilgrimage Information technology, Transportation, Financial sector, and Education. Major initiatives under the industrial sector include Cochin Shipyard, Oil refinery, Shipbuilding, Software Industry, Coastal mineral industries, food processing, marine products processing, and Rubber based products. The primary sector of the state is mainly based upon Cash crops. Kerala produces a significant amount of national output of the cash crops such as Coconut, Tea, Coffee, pepper, Natural rubber, Cardamom, and Cashew in India. The cultivation of food crops began to reduce since 1950's. The Migrant labourers in Kerala are a significant workforce in its industrial and agricultural sectors. Being home to only 1.18% of the total land area of India and 2.75% of its population, Kerala contributes more than 4% to the Gross Domestic Product of India.

2.12 Power

Power sector is a critical infrastructure element required for the smooth functioning of the state economy. The availability of reliable, quality and affordable power helps in all over development and the overall economy of the State. It is one of the vital infrastructural inputs for the socioeconomic development of any nation, either in the

form of finite resources such as coal, oil and gas or in renewable forms such as hydroelectric, wind, solar and biomass, or its converted form of electricity.

Kerala is the first State in the country to attain 100 per cent house hold electrification. Electricity is being provided throughout the State 24x 7 x 365 without any power cut or load shedding.

Power development activities in the State are carried out mainly through four agencies, namely, Kerala State Electricity Board Limited (KSEBL), Agency for Non-conventional Energy and Rural Technology (ANERT), Electrical Inspectorate, and Energy Management Centre (EMC).

The total available power including the installed generation capacity of Kerala state is 5753.50 MW (up to 31/01/2021). The portion of hydro power energy of the state is about 1856.50 megawatt (MW) and renewable energy of the state is about 486.54 megawatt (MW).

The Power scenario of the State has been explained in the subsequent chapters.

CHAPTER-3: POWER SCENARIO

CHAPTER - 3

3. POWER SCENARIO

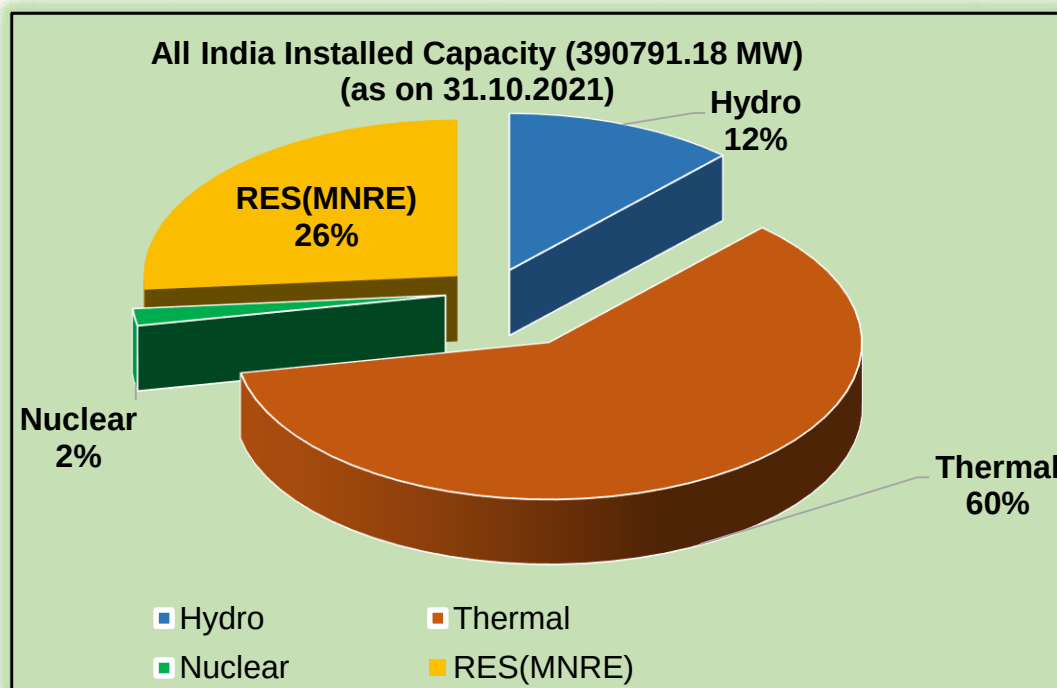
3.1 Introduction

If India is to maintain high rates of growth and provide universal and sustainable access to electricity, the power sector needs to grow and reform faster in all the three constituent areas of generation, transmission and distribution. India has considerable hydro power potential, which being a renewable source of energy can play a key role in reducing the carbon footprint of the Indian power sector and efforts are being set afoot in this direction. A hydroelectric project has a long useful life extending to well over 50 years and helps in conserving scarce fossil fuels. Development of hydro projects is important to meet the objective of sustainable development and for energy security of the country.

8% (percent) GDP growth requires 6% (percent) growth in energy supply from all sources. Development of hydro power projects also provides the added advantage of opening up avenues for development of remote and backward regions of the country. Hydro power stations have the inherent ability for instantaneous starting, stopping and managing load variability which helps in improving reliability of the power system. Hydro Electric Projects are ideal for meeting the peak requirement and the balancing requirement arising due to variability of renewable energy sources.

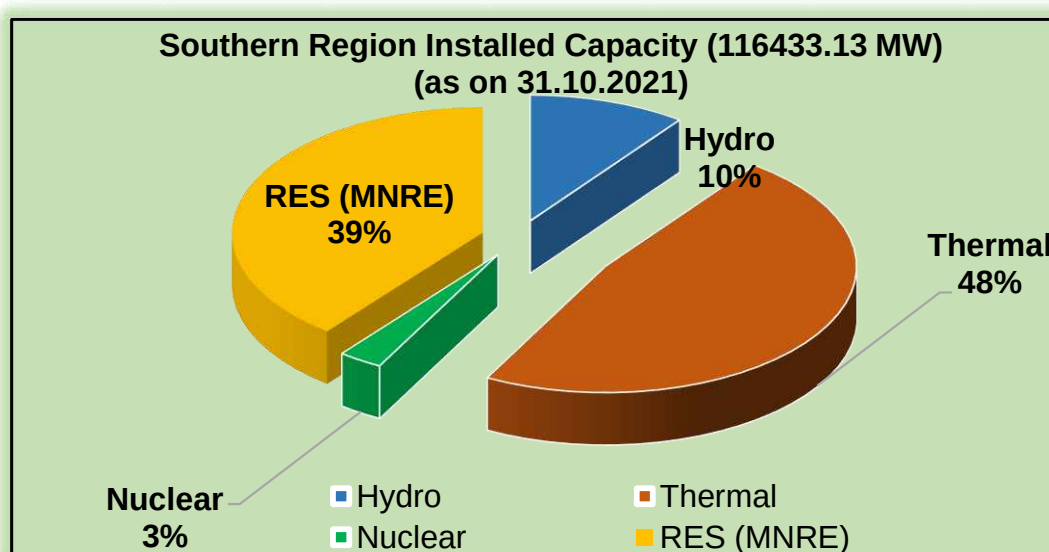
As per review carried out by CEA, as on 31.03.2017 the actual capacity addition during 12th five year plan (2012-2017), from conventional sources is 99209.5 MW (Thermal – 91730.5 MW, Hydro - 5479 MW and Nuclear - 2000 MW) against target of 88537 MW. This is about 112% of the target, but 55% of total capacity addition during 12th Plan has come from private sector. There has been considerable slippage against the capacity addition target in respect of Hydro (5418 MW) and Nuclear (3300 MW) during 12th Plan period.

As on 31.10.2021 India achieved at total installed capacity 1,49,567.47 MW from Renewable energy source. The country has revised its renewable energy capacity target to 175 GW by the year 2021-22 including 10GW through Small hydro power projects



Source: Central Electricity Authority (CEA)

Fig.3.1 - All India Installed Capacity (Type wise)



Source: CEA

Fig.3.2 – Southern Region Installed Capacity (Type wise)

The projected peak demand is 226 GW and energy requirement is 1566 BU at the end of 2021-22 and peak demand is 299 GW and energy requirement is 2047 BU at the end of the year 2026-27, as per the 19th Electric Power Survey report.

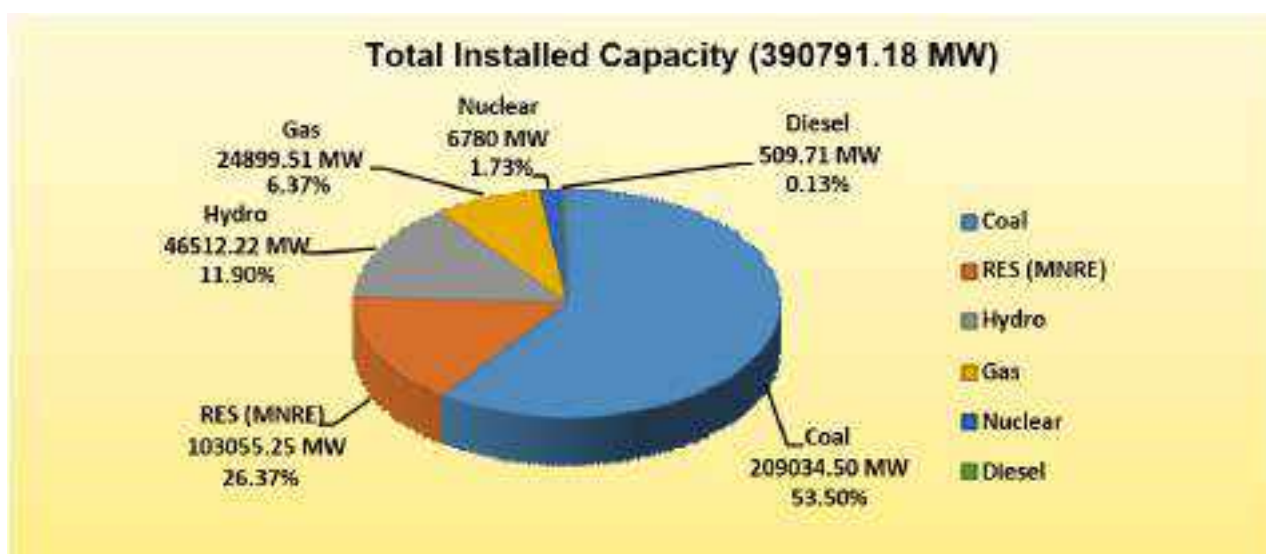
Total energy savings due to implementation of various energy saving measures during the years 2021-22 and 2026-27 are estimated to be 249 BU and 337 BU respectively.

Considering the capacity addition (19th EPS. CAGR 6.18%) from Gas 406 MW, Hydro 6823 MW, Nuclear 3300 MW, RES 117756 MW and likely retirement of 22716 MW (5927 MW-old and inefficient units + 16789 MW completing 25 years by 2022 and without FGD space) of coal based capacity during 2017-22, the study result reveals that coal based capacity addition of 6445 MW is required during the period 2017-22. However, a total capacity of 47855 MW coal based power projects are currently under different stages of Construction and are likely to yield benefits during the period 2017-22. Thereby, the total capacity addition during 2017-22 is likely to be 176140 MW.

Considering the demand projections for the year 2026-27, as per the 19th EPS, coal based capacity addition of 47855 MW already under construction for benefits during 2017-22, committed capacity addition of Nuclear 6800 MW, Hydro 12000 MW, RES 100000 MW and likely retirement of 25572 MW of coal based capacity (which will be completing more than 25 years of age by 2027) during 2022-27, the study results reveal that capacity addition of 46420 MW is required during the period 2022-27. This capacity addition required during 2022-27, as shown in the results is, in fact, the peaking capacity requirement to be met in the grid. This capacity requirement can be met from any conventional source of energy but preferably from peaking power plants like Hydro, Gas or Energy Storage Devices

3.2 Installed Generating Capacity in India

The mode wise total installed capacity in the country as on 31st October, 2021 (as per CEA) is 3,90,791.18 MW and given below:



Source: CEA

Fig.3.3 - Total Installed Generating Capacity as on 31st October, 2021

The state-wise distribution of the total installed capacity in southern region is given in the **Table 3.1**:

Table 3:1 Total Installed Capacity (in MW) in Southern Region

As on 31st October, 2021
(*Above 25 MW Projects)

INSTALLED CAPACITY (IN MW) OF POWER UTILITIES IN THE STATES/UTS LOCATED IN SOUTHERN REGION INCLUDING ALLOCATED SHARES IN JOINT & CENTRAL SECTOR UTILITIES										
State	Ownership/ Sector	Mode wise breakup								Grand Total
		Thermal					Nuclear	Hydro	RES (MNRE)	
		Coal	Lignite	Gas	Diesel	Total				
Andhra Pradesh	State	5010.00	0.00	235.40	0.00	5245.40	0.00	1673.60	56.18	6975.18
	Private	3873.88	0.00	3831.32	36.80	7742.00	0.00	0.00	8869.33	16611.34
	Central	1546.83	180.23	0.00	0.00	1727.06	127.27	0.00	250.00	2104.33
	Sub-Total	10430.71	180.23	4066.72	36.80	14714.46	127.27	1673.60	9175.51	25690.84
Telangana	State	5972.50	0.00	0.00	0.00	5972.50	0.00	2479.93	41.22	8493.65
	Private	1389.45	0.00	831.82	0.00	2221.27	0.00	0.00	4423.67	6644.94
	Central	1806.85	210.57	0.00	0.00	2017.42	148.73	0.00	10.00	2176.15
	Sub-Total	9168.80	210.57	831.82	0.00	10211.19	148.73	2479.93	4474.89	17314.74
Karnataka	State	5020.00	0.00	0.00	0.00	5020.00	0.00	3631.60	193.89	8845.49
	Private	1948.50	0.00	0.00	25.20	1973.70	0.00	0.00	15540.41	17514.11
	Central	2877.80	471.90	0.00	0.00	3349.70	698.00	0.00	0.00	4047.70

	Sub-Total	9846.30	471.90	0.00	25.20	10343.40	698.00	3631.60	15734.29	30407.29
Kerala	State	0.00	0.00	0.00	159.96	159.96	0.00	1856.50	180.90	2197.36
	Private	1047.50	0.00	174.00	0.00	1221.50	0.00	0.00	399.01	1620.51
	Central	1011.42	314.20	359.58	0.00	1685.20	362.00	0.00	50.00	2097.20
	Sub-Total	2058.92	314.20	533.58	159.96	3066.66	362.00	1856.50	629.91	5915.07
Tamil Nadu	State	4320.00	0.00	524.08	0.00	4844.08	0.00	2178.20	122.70	7144.98
	Private	4487.67	250.00	503.10	211.70	5452.47	0.00	0.00	15442.59	20895.06
	Central	3025.32	1517.30	0.00	0.00	4542.62	1448.00	0.00	231.90	6222.52
	Sub-Total	11832.99	1767.30	1027.18	211.70	14839.17	1448.00	2178.20	15797.19	34262.56
NLC	State	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Central	0.00	166.00	0.00	0.00	166.00	0.00	0.00	0.00	166.00
	Sub-Total	0.00	166.00	0.00	0.00	166.00	0.00	0.00	0.00	166.00
Pondicherry	State	0.00	0.00	32.50	0.00	32.50	0.00	0.00	0.00	32.50
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.52	11.52
	Central	140.80	111.80	0.00	0.00	252.60	86.00	0.00	0.00	338.60
	Sub-Total	140.80	111.80	32.50	0.00	285.10	86.00	0.00	11.52	382.62
Central - Unallocated		1426.00	418.00	0.00	0.00	1844.00	450.00	0.00	0.00	2294.00
Total (Southern Region)	State	20322.50	0.00	791.98	159.96	21274.44	0.00	11819.83	594.88	33689.15
	Private	12747.00	250.00	5340.24	273.70	18610.95	0.00	0.00	44686.53	63297.48
	Central	11835.02	3390.00	359.58	0.00	15584.60	3320.00	0.00	541.90	19446.50
	Grand Total	44904.52	3640.00	6491.80	433.66	55469.99	3320.00	11819.83	45823.31	116433.13

Source: CEA

The Southern Region has an installed capacity of 116433.13 MW as on 31st October, 2021 consisting of 55469.99 MW thermal, 11819.83 MW hydro and 45823.31 MW from renewable energy sources. The Southern Grid faced energy shortage of 0% and peaking shortage of 0% during the year 2020-21 as compared to energy and peak shortage of 0% and 0.2% respectively during the previous year i.e. 2019-20.

The Hydro installation of 11819.83 MW in overall installation of 116433.13 MW in Southern Region is only 10.15% which is much below the optimum hydro thermal mix of 40:60. Thus there is an urgent need to take up more hydro projects with an aim to achieve optimum hydro thermal mix in the region.

The total energy requirement in the country during 2020-21 was 1275534 Million Units (MUs) as against 1291010 MUs during the previous year, registering a decrease of 1.2%. The total energy supplied in the country during 2020-21 was 1270663 MUs as against 1284444 MUs during the previous year, registering a decrease of 1.07%.

The energy not supplied during the year 2020-21 was 4871MUs (0.4%) against 6566 MUs (0.5%) during the previous year. The peak demand during the year 2020-21 was 190198 Mega Watt (MW) as against 183804 MW during the previous year, registering an increase of 3.48%. The peak demand met during 2020-21 was 189395 MW as against 182533 MW during the previous year, registering an increase of 3.76%. The demand not met during the year 2020-21, decreased from 1271 MW (0.7%) to 802 MW (0.4%) as compared to previous year.

It may be noted that, as a practice, additional peak and energy available to KSEB is traded, sold to other utilities in the state and country also. Consequently, KSEB may witness an increase in revenues from trading of power over the coming years.

The power supply position in the Country and in the Southern Region are given in the **Table 3.2 Table 3.3 and Table 3.4** respectively.

Table 3:2 Power Supply Position (Energy) in the Country

Year	Energy Requirement (MU)	Energy Supplied (MU)	Energy	
			Energy not Supplied	
			(MU)	(%)
2014-15	1068923	1030785	38138	3.6
2015-16	1114408	1090850	23558	2.1
2016-17	1142928	1135332	7596	0.7
2017-18	1213326	1204697	8629	0.7
2018-19	1274595	1267526	7070	0.6
2019-20	1291010	1284444	6566	0.5
2020-21	1275534	1270663	4871	0.4

Source: CEA

Table 3:3 Power Supply Position (Peak) in the Country

Peak				
Year	Peak Demand (MW)	Peak Met (MW)	Demand not Met	
			(MW)	(%)
2014-15	148166	141160	7006	4.7
2015-16	153366	148463	4903	3.2
2016-17	159542	156934	2608	1.6
2017-18	164066	160752	3314	2.0
2018-19	177022	175528	1494	0.8
2019-20	183804	182533	1271	0.7
2020-21	190198	189395	802	0.4

Source: CEA

Table 3:4 Power Supply Position (Energy & Peak) in the Southern Region for April 2020- March 2021

Energy					Peak			
State/ Region	Energy Requirement (MU)	Energy Supplied (MU)	Energy not Supplied		Peak Demand (MW)	Peak Met (MW)	Demand not Met	
			(MU)	(%)			(MW)	(%)
Andhra Pradesh	62080	62076	4	0	11193	11193	0	0
Telangana	66998	66994	4	0	13688	13688	0	0
Karnataka	68851	68831	19	0	14367	14367	0	0
Kerala	25118	25102	16	0.1	4275	4269	6	0.1
Tamil Nadu	101194	101189	5	0	16263	16263	0	0
Pondicherry	2644	2644	0	0	429	429	0	0
Lakshadweep	56	56	0	0	11	11	0	0
Southern Region	326885	326836	48	0	58395	58395	0	0

Source: CEA

3.2.1 Capacity Addition Targets and Achievements in the 12th Plan, 2017-18, 2018-19 and 2019-20

Table 3:5: Capacity Addition Targets and Achievements in the 12th Plan

Sector	Thermal		Hydro		Nuclear		Total	
	Target	Ach.	Target	Ach.	Target	Ach.	Target	Ach.
Central	14878	15869	6004	2584	5300	2000	26182	20453
State	13922	22201	1608	2276	0	0	15530	24477
Private	43540	53661	3285	619	0	0	46825	54280
All India	72340	91730	10897	5479	5300	2000	88537	99209

(Figures in MW) Source: Executive Summary Report February'2021, CEA

Table 3:6: Capacity Addition Target and Achievement for 2017-18

Sector	Thermal		Hydro		Nuclear		Total	
	Target	Ach.	Target	Ach.	Target	Ach.	Target	Ach.
Central	4880	3170	800	390	500	0	6180	3560
State	3546	1760	300	200	0	0	3846	1960
Private	2940	3780	205	205	0	0	3145	3985
All India	11366	8710	1305	795	500	0	13171	9505

(Figures in MW) Source: Executive Summary Report February'2021, CEA

Table 3:7: Capacity Addition Target and Achievement for 2018-19

Sector	Thermal		Hydro		Nuclear		Total	
	Target	Ach.	Target	Ach.	Target	Ach.	Target	Ach.
Central	2760	1960	710	110	0	0	3470	2070
State	4506	2850	130	30	0	0	4636	2880
Private	0	972	0	0	0	0	0	972
All India	7266	5782	840	140	0	0	8106	5922

(Figures in MW) Source: Executive Summary Report February'2021, CEA

Table 3:8: Capacity Addition Target and Achievement for 2019-20

Sector	Thermal		Hydro		Nuclear		Total	
	Target	Ach.	Target	Ach.	Target	Ach.	Target	Ach.
Central	6040	3940	600	300	700	0	7340	4240
State	4256.15	2780	210.99	0	0	0	4467.14	2780
Private	0	45	379	0	0	0	379	45
All India	10296.15	6765	1189.99	300	700	0	12186.14	7065

(Figures in MW)

Source: Executive Summary Report February'2021, CEA

Table 3.9: Estimated Energy Capacity in 2030 (MW)

Year	GDP Growth	
	6%	9%
2022-2023	316,148	352,778
2023-2024	327,850	371,467
2024-2025	342,316	391,249
2025-2026	354,549	412,212
2026-2027	368,054	434,455
2027-2028	383,630	458,082
2028-2029	397,443	483,211
2029-2030	413,385	509,967

Source: Strategic Analysis Report by Future Directions International (FDI)

Table 3.10: Estimated Energy Demand and Availability in India to 2030

Year	6% GDP Growth		9% GDP Growth	
	Met (MW)	Requirement (MW)	Met (MW)	Requirement (MW)
2022-2023	184,651	198,660	201,428	213,059

2023-2024	191,910	206,017	211,575	222,895
2024-2025	199,347	213,539	222,450	233,367
2025-2026	206,964	221,226	234,055	244,477
2026-2027	214,900	229,199	246,253	256,109
2027-2028	223,154	237,458	259,321	268,499
2028-2029	231,591	245,884	273,121	281,528
2029-2030	240,348	254,598	287,791	295,318.1

Source: Strategic Analysis Report by Future Directions International (FDI)

3.2.2 All India Electrical Energy Requirement, Peak Electricity Demand & Electrical Energy Consumption Projections for 2016-17 to 2026-27

The 19th Electric Power Survey (EPS) Report, covering electricity demand projection of Distribution Companies, States/UT's, Regions and the all-India Electricity demand projection has been brought out by Central Electricity Authority (CEA). The Report covers year-wise electricity demand projection for the years 2016-17 to 2026-27 for Discoms, States/UT's, Regions and for the country. The report also covers perspective electricity demand projection for States/UT's, Regions and for the country for the years 2031-32 and 2036-37.

The electricity consumption on all-India basis during the year 2016-17, 2021-22 and 2026-27 has been assessed as 921 BU, 1300 BU and 1743 BU respectively. The electrical energy requirement on all-India basis during the year 2016-17, 2021-22 and 2026-27 has been assessed as 1160 BU, 1566 BU and 2047 BU respectively.

The peak electricity demand has been estimated as 162 GW during the year 2016-17; 226 GW during 2021-22 and 299 GW during the year 2026-27.

The electricity consumption on all-India basis during the year 2031-32 and 2036-37 has been assessed as 2192 BU and 2672 BU respectively. The electrical energy

requirement on all India basis during the year 2031-32 and 2036-37 has been assessed as 2531 BU and 3049 BU respectively. The peak electricity demand has been estimated as 370 GW during the year 2031- 32 and 448 GW during the year 2036-37.

The Electrical Energy Consumption, electrical energy requirement and peak electricity demand for the years 2016-17, 2021-22 and 2026-27 is summarized in successive tables.

Table 3:11: All India State/UT Wise Electrical Energy Requirement at Power Station Bus Bars (Utilities)

(2022-23 to 2026-27)

State/UT/Region	2022-23	2023-24	2024-25	2025-26	2026-27
Delhi	38997	40224	41557	42904	44267
Haryana	66747	70333	75110	80239	85743
Himachal Pradesh	12360	12876	13417	13983	14576
Jammu & Kashmir	19963	21161	22433	23795	25254
Punjab	76826	81369	86027	90789	95658
Rajasthan	95782	101200	108808	117219	126290
Uttar Pradesh	159412	167731	176477	185674	195323
Uttarakhand	20687	22029	23438	24920	26480
Chandigarh	2388	2475	2566	2659	2756
Northern Region	493162	519399	549833	582182	616345
Goa	5855	6120	6389	6660	6932
Gujarat	144186	152475	160989	169732	178693
Chhattisgarh	40155	42661	45315	48146	51088
Madhya Pradesh	104772	109727	114765	120027	125394
Maharashtra	200288	211307	223171	235949	249628
D. & N. Haveli	9920	10513	11120	11741	12373
Daman & Diu	2855	3006	3166	3337	3517
Western Region	508032	535810	564915	595591	627624
Andhra Pradesh	84429	90794	97181	104072	111485
Telangana	881301	91836	95776	99945	104345
Karnataka	90381	95042	99916	105017	110368
Kerala	32861	34393	35964	37582	39357
Tamil Nadu	144145	152357	161349	170822	180989
Puducherry	3809	3959	4114	4279	4448

Southern Region	443754	468380	494301	521717	550992
Bihar	41208	43926	46735	50717	54363
Jharkhand	32209	33850	35544	37354	39252
Orissa	331721	34163	35219	36326	37453
West Bengal	72222	75264	78463	81915	85590
Sikkim	669	702	737	773	810
Eastern Region	179480	187906	196698	207085	217468
Assam	15164	16355	17631	18998	20462
Manipur	2300	2515	2760	3020	3300
Meghalaya	2667	2771	2900	3036	3177
Nagaland	1200	1275	1356	1441	1524
Tripura	1661	1731	1796	1866	1930
Arunachal Pradesh	1669	1863	2081	2326	2601
Mizoram	937	1013	1095	1181	1307
North Eastern Region	25598	27523	29619	31869	34301
Andaman & Nicobar Islands	504	535	566	598	632
Lakshadweep	64	66	68	70	73
All India	1650594	1739618	1836001	1939111	2047434

In Million Units

Source: 19th Electric Power Survey of India (EPS), CEA

Table 3:12: All India State/UT Wise Peak Electricity Demand at Power Station Bus Bars (Utilities)

(2022-23 to 2026-27)

State/UT/Region	2022-23	2023-24	2024-25	2025-26	2026-27
Delhi	7712	7954	8217	8482	8751
Haryana	12819	13501	14415	15398	16451
Himachal Pradesh	1977	2059	2146	2236	2331
Jammu & Kashmir	3332	3585	3859	4157	4482
Punjab	15654	16431	17217	18009	18809
Rajasthan	15176	16048	17282	18651	20131
Uttar Pradesh	25331	26658	28053	29522	31064
Uttarakhand	3420	3675	3945	4232	4538
Chandigarh	509	527	546	566	587
Northern Region	77929	82017	86776	91835	97182
Goa	904	951	999	1047	1096
Gujarat	22730	24079	25471	26908	28387

Chhattisgarh	6613	7050	7513	8006	8518
Madhya Pradesh	16445	17223	18014	18840	19682
Maharashtra	30725	32717	34911	37269	39828
D. & N. Haveli	1385	1483	1584	1689	1798
Daman & Diu	449	473	498	525	553
Western Region	75275	79748	84502	89528	94825
Andhra Pradesh	12731	13690	14656	15698	16820
Telangana	15338	16086	16885	17738	18653
Karnataka	15033	15834	16674	17554	18481
Kerala	5513	5770	6034	6305	6603
Tamil Nadu	21471	22784	24225	25750	27392
Puducherry	606	630	655	681	708
Southern Region	66710	70579	74666	79002	83652
Bihar	7054	7521	8003	8681	9308
Jharkhand	5450	5733	6013	6326	6626
Orissa	5517	5691	5878	6073	6273
West Bengal	13318	13873	14435	15065	15680
Sikkim	179	187	197	206	216
Eastern Region	29500	30895	32319	34031	35674
Assam	2979	3271	3590	3868	4166
Manipur	453	499	553	611	667
Meghalaya	508	528	552	578	605
Nagaland	250	266	284	303	322
Tripura	411	432	452	474	495
Arunachal Pradesh	309	345	386	431	482
Mizoram	185	199	213	229	252
North Eastern Region	4891	5319	5790	6235	6710
Andaman & Nicobar Islands	103	109	115	122	129
Lakshadweep	12	12	13	13	13
All India	238899	252288	266844	282418	298774

In Mega Watts

Source: 19th EPS, CEA

Table 3.13 All India & Regional Summary of Long Term Forecast (Utilities Only)

Electrical Energy Requirement at Power Station Bus Bars (MU)			
Region	2026-27	2031-32	2036-37
Northern Region	616345	758701	917617

Western Region	627624	782039	932817
Southern Region	550992	680149	824657
Eastern Region	217468	263665	317567
North-Eastern Region	34301	45114	55787
Andaman & Nicobar Islands	632	777	932
Lakshadweep	73	86	101
All India	2047434	2530531	3049478
Peak Electricity Demand at Power Station Bus Bars (MW)			
Region	2026-27	2031-32	2036-37
Northern Region	97182	118844	144161
Western Region	94825	119277	142355
Southern Region	83652	104900	128655
Eastern Region	35674	42968	51420
North-Eastern Region	6710	8373	10007
Andaman & Nicobar Islands	129	153	177
Lakshadweep	13	16	18
All India	298774	370462	447702
Electrical Energy Consumption (MU)			
Region	2026-27	2031-32	2036-37
Northern Region	510941	646737	794572
Western Region	543036	685483	825499
Southern Region	477932	595712	728039
Eastern Region	183157	226116	275804
North-Eastern Region	27384	37598	47587
Andaman & Nicobar Islands	518	660	802
Lakshadweep	67	79	93
All India	1743036	2192305	2672302

Source: 19th EPS, CEA

3.3 Power Sector in Kerala

3.3.1 Introduction

Power Growth of power sector is a requisite for overall growth of an economy. The availability of reliable, quality and affordable power is vital for rapid growth in agriculture, industry and for overall economic development of a State. An efficient,

resilient and financially healthy power sector is an essential requirement for growth of a State and economic empowerment of the common man.

The Kerala State Electricity Board Limited is the successor entity of Kerala State Electricity Board which was constituted by the Government of Kerala, as per order no. EL1-6475/56/ PW dated 07.03.1957 of the Kerala State Government, under the Electricity (Supply) Act, 1948 for carrying out the business of Generation, Transmission and Distribution of electricity in the state of Kerala. The Kerala State Electricity Board Limited has been incorporated under the Companies Act, 1956 on 14th January' 2011 and started operations as independent company with effect from 1st November' 2013

3.3.2 Kerala State Electricity Board Limited (KSEBL) - Overview

Over the last fifty nine years, the KSEBL has grown from a total installed capacity of 109 MW to an installed capacity of 2182.76 MW and created Transmission and Distribution networks of over 10404 and 272480 circuit kilometers respectively. At present, the KSEBL caters to the needs of over 1.3 crore consumers spread over the urban and rural areas of the State. This incremental growth in the power system brought several changes in the characteristics of the system. The input cost structure and revenue composition have undergone significant changes. Until the recent past, the hydroelectric plants owned by the Board supplied a major portion of the energy requirement of the state. However, after the promulgation of the Forest Conservation Act in 1980, the implementation of new hydroelectric projects had been seriously affected and more costly thermal energy had to be generated / purchased to meet the increasing demand.

Over the years, the consumption of heavily subsidised domestic sector has been increasing and now, it accounts for approximately 46% of the total energy consumed. As a consequence, the peak demand in the state has increased to almost twice the off-peak demand. This forced more investment in the power system to meet the peak demand and purchase of thermal energy from outside the State. But the capacity so created for meeting the peak demand remains under-utilised during the off-peak periods. KSEBL had been supplying electricity at lowest price in

the country for several decades. Because of this KSEBL had to resort to heavy borrowings to meet the expenses. Though KSEBL was statutorily enjoined to function as a commercial institution, it continued to function mainly with service orientation providing infrastructure facility, reliefs and concessions to other sectors like industry, agriculture and so on. Now, the State Commission insists upon to perform strictly on commercial considerations

Vision & Mission

- KSEB Limited envision to be the best power utility in India.
- KSEB Limited mission is to provide quality electricity to customers adequately, safely, sustainably at affordable cost.

3.3.3 Existing Power Scenario of Kerala

3.3.3.1 Generation of Electrical Energy

The State Electricity Department was formed in 1933, the year in which the works for the first hydro electric power station in Kerala began at Pallivasal, a village situated on the south western part of Idukki district. On March 19, 1940, Sir C P Ramaswamy Aiyer, the Dewan of Travancore inaugurated the first stage of the Pallivasal project, which had an initial installed capacity of 13.5 MW. It was the first Hydro Electric Project in Kerala, set up to serve the power needs of the general public. The Pallivasal project, at present, has a capacity of 37.5 MW (3x5+3x7.5). The renovation of the project was completed in 2002. In order to fully utilize the available water, a new project of 60 MW Pallivasal Extension Scheme (PES) is now under construction.

Fourteen years after the commissioning of Pallivasal, the second powerhouse of the state of Kerala, the Sengulam power house with an installed capacity of 48 MW (4x12MW), was commissioned. The 300 MW Sabarigiri Hydro Electric Project, which was added to the Kerala System in 1966, enjoyed the special status of having a capacity higher than the capacities of all the other projects (including Sholayar which was also in the final stages of commissioning in 1966), in the Kerala system put together. Since then, project after project was added to the Kerala power system till

1976, when the first stage of Idukki HEP, with a capacity of 390 MW (3x130MW) was commissioned. When the stage II of Idukki, with a capacity of 390 MW was also added in 1986, Idukki HEP became the largest project in Kerala, with a total capacity of 780 MW. The Idukki project continues to be the largest project, hydro or otherwise, of the KSEBL till date.

After the commissioning of Idukki HEP in 1986, the Hydro Electric Projects which gave significant contribution to the capacity addition were the 75 MW Idamalayar, the 150 MW Kuttiyadi Extension Schemes, the 180 MW Lower Periyar and the 50 MW Kakkad project. KSEB focused on small Hydel projects and commissioned 15 projects in this time. At present, implementation of 11 small Hydel projects is at various stages of construction.

KSEB also commissioned two Thermal Stations based on Diesel/LSHS at Brahmapuram and Kozhikode to meet the ever increasing demand for power. The Brahmapuram Diesel Power Plant (BDPP), with a capacity of 106.6 MW (5x21.32MW) was commissioned in 1997-98 and the 128 MW (8X16MW) Kozhikode Diesel Power Project (KDPP) of capacity 128 MW(8X16MW) was commissioned in 1999. Recently two units each of BDPP and KDPP were decommissioned due to ageing. One 2.025 MW wind farm was also set up by KSEB at Kanjikode during 1995.

The installed capacity of KSEBL as on as on 30.08.2021 is 2182.76 MW. Moreover, the total generating capacity of Kerala including all generating agencies/owners is 3136.54 MW as of 30.08.2021.

Apart from the KSEBL owned stations, a number of power stations (hydel, thermal and wind/solar farm) were also set up by private agencies for which Power Purchase Agreement has been executed by KSEB. A 359.58 MW Thermal Power Plant was set up by M/s. NTPC at Kayamkulam during 1998-1999 and KSEB has executed PPA for the purchase of power.

At present KSEBL relies on the Central share, the power purchased from the Kayamkulam Thermal Power Plant and other private stations in addition to its own stations for meeting the demand.

Details of Thermal, Wind/Solar and Hydro Power stations being operated in Kerala is given in the Table 3.14, 3.15 & 3.16 respectively as of 30.08.2021.

Table 3:14: Hydro Plants in Kerala by KSEB

Sl.No	Name of Station	Installed Capacity of the plant		Firm annual Gen.Capability	Annual Generation Designed MU
		No. of Generators. X Capacity in (MW)	Plant Capacity in (MW)	MU	
I	HEPs				
1	Idukki	6 x 130	780	2398	2398
2	Sabarigiri	4 x 55 + 2x 60	340	1338	1338
3	Idamalayar	2 x 37.5	75	380	380
4	Sholayar	3x18	54	233	233
5	Pallivasal	3 x 5+ 3x7.5	37.5	284	284
6	Kuttiyadi	3x25	75	566	268
7	Kuttiyadi Extension	1x50	50		75
8	Kuttiyadi Additional Exten.Scheme	2x50	100		223
9	Neriamangalam	3 x17.55	52.65	237	237
10	Lower Periyar	3 x 60	180	493	493
11	Poringalkuthu	4x9	36	191	191
12	Sengulam	4 x 12.8	51.2	182	182
13	Kakkad	2x25	50	262	262
14	Panniar	2 x 16.2	32.4	158	158
15	Neriamangalam Extn Scheme	1x25	25	58.27	58.27
	Sub Total (HEP)		1938.75	6780.27	6780.27

Small HEPs					
1	Kallada	2x7.5	15	65.00	65
2	Malankara	3x3.5	10.5	65.00	65
3	PLBE	1x16	16	74.00	74
4	Peppara	1x3	3	11.50	11.5
5	Madupatty	1x2	2	6.40	6.4
6	Malampuzha	1x2.5	2.5	5.60	5.6
7	Lower Meenmutty	(1x0.5 + 2x1.5)	3.5	7.63	7.63
8	Chembukadavu - 1	3x0.9	2.7	6.59	6.59
9	Chembukadavu - 2	3x1.25	3.75	9.03	9.03
10	Urumi -1	3x1.25	3.75	9.72	9.72
11	Urumi -2	3x0.8	2.4	6.28	6.28
12	KTR	3x1.25	3.75	17.01	15
13	Poozhithode	3 x 1.6	4.8	10.97	10.97
14	Ranni-Perinadu	2x2	4	16.73	16.73
15	Peechi	1x1.25	1.25	3.21	3.21
16	Vilangad	3x2.5	7.5	22.63	22.63
17	Chimmony	1x2.5	2.5	6.70	6.7
18	Adyanpara	2x1.5+0.5	3.5	9.01	9.01
19	Barapole	3x5	15	36.00	36
20	Poringalkuthu Micro (Screw Turbine)	1x 0.011	0.011	0.082	0.082
21	Vellathooval	2x1.8	3.6	12.170	12.17
22	Perunthenaruvi	2x3	6	25.770	25.77
23	Kakkayam SHEP	2x1.5	3		10.39
24	Chathankottunada Stage-II	3x2	6		
Sub Total (SHEP)			126.011	427.03	435.412
Total (Hydel)			2064.76	7207.30	7215.68

Table 3:15: Thermal, Wind & Solar Plants in Kerala by KSEB

Sl.No	Name of Station	Installed Capacity of the plant		Firm annual Gen.Capability	Annual Generation Designed MU
		No. of Generators. X Capacity in (MW)	Plant Capcity in (MW)	MU	
<u>Thermal Plants</u>					
1	BDPP	3x21.32		363.6	

2	KDPP	6x16	96	672	672
	Sub Total (Thermal)		96.00	1035.60	672.00
Wind farm					
1	Kanjikode Wind Farm	9x0.225	2.025	4	4
Solar (Grid Connected)					
1	Kanjikode Solar Project(Gr. mount)	1	1	1.63	1.63
2	Kollangode S/s	1	1		
3	Idayar S/s	1.25	1.25		
4	Thalakulathoor, Kozhikode	0.65	0.65		
5	Manjeswaram, ground mounted	0.5	0.5		
6	Kuttippuram	0.5	0.5		
7	Peermedu	0.5	0.5		
8	Pezhakkappally, Muvattupuzha	1.25	1.25		
9	Pothencode	2	2		
10	Kottiyam-Kollam	0.6	0.6		
11	Barapole canal Bank Grid connected	1	1		
	KSEB Variuos locations - Groud mounted type total	10.25	10.25		
1	Palakkad Tribal Colonies (DDG)-off grid	0.065	0.065		
2	Solar- Chaliyoor colony	0.096	0.096	0.15	
3	Barapole canal top	3	3		
4	Solar- flower, fountain,canopy-Banasura Sagar reservoir	0.003372	0.00337		
5	Padinjarethara - Dam top	0.4	0.4		
6	Banasurasagar reservoir (floating Solar)	0.51	0.51		
7	Buildings under Generation wing (Roof Top)	0.7	0.7		
8	Solar-Poringalkuthu (Roof top)	0.05	0.05	0.06	
9	Vydyuthi Bhavanam, Pattom (Roof top)+4th floor top	0.03	0.03		
10	Buildings under Trans. wing(Roof top)	0.91	0.91		
11	Buildings under Dist. wing (Roof top)	0.46	0.46		
12	KSEBL roof top -IPDS (23 locations)	0.495	0.495		
13	Ponnani ,Malappuram	0.5	0.5		
14	Govt.Institutions south -4 locations	0.495	0.495		

15	LSGD Wayanad (Mattil,ThavinjalGP,Disrt Hospital mananthavady	0.072	0.072		
16	Municipal Corporation kozhikkode (Govt schools nadakkavu & Iranjikkal	0.024	0.024		
17	Attingal municipality,NCSS,Buffullo farm Kuriottumala	0.0575	0.0575		
18	Jilla Panchayath,Tvpm(4 nos.)	0.121	0.121		
19	Jilla Panchayath,Kasargode 2nd phase (5 nos.)	0.335	0.335		
20	Jilla Panchayath,Kannur 1st phse(29 nos)	0.67	0.67		
21	Jilla Panchayath,Kozhikkode(44 nos)	0.48	0.48		
22	Kerala University of Health Sciences(KHUS)	0.25	0.25		
	Roof Top and others (solar)		9.72387		
	Sub Total (Solar)		19.9739		
	TOTAL (KSEB)	KSEB owned stations (incl. Hydro)	2182.76	8246.90	

Table 3:16: Power Plants in Kerala by IPP

Sl.No	Name of Station	Installed Capacity of the plant		Firm annual Gen.Capability	Annual Generation Designed MU
		No. of Generators. X Capacity in (MW)	Plant Capcity in (MW)	MU	
II	IPP/CPP/ Private IN THE STATE				
	SHEPs-IPP and owner of the plant				
1	Maniyar - (Carborandum Universal Ltd.)	3x4	12	36	36
2	Kuthungal - (INDSIL Hydro Power & Manganese Ltd.)	3x7	21	79	79
3	Ullunkal -(EDCL Power Projects Ltd.)	2x3.5	7	32.22	32
4	Iruttukanam - (Viyyat Power Pvt.Ltd.)	3 x 1.5	4.5	15.86	13



वापकोस लिमिटेड
WAPCOS LIMITED
 (एनएसई एन.एस.एसई)
 50% एफडी ईएनएसई
 A Joint Venture of India & Germany
 (Incorporated in India)

	Thermal-KERALA		632.38		
	Wind Total -KERALA		70.275		
	Solar total-KERALA		298.46		
	GRAND TOTAL -KERALA		3136.54		

3.3.4 Idukki Hydro Electric Project (Existing)

Idukki Hydro Electric Project (IHEP) is the largest hydro electric project in Kerala. Installed capacity of this project is 780 MW. The powerhouse has six generators of 130 MW capacity each. The project was completed with aid from the Government of Canada and the technical consultancy was M/s Surveyor, Nenniger and Chenevert. The project was dedicated to the nation on 12th February'1976 by the then Prime Minister of India, Mrs. Indira Gandhi. There are three Dams associated with this project. They are:

- Idukki Arch Dam (Height is 168.91 meters, Length of the dam at top is 365.85 meters and width at top is 7.32 meters).
- Cheruthoni Dam (Height is 138.38 meters and length at top is 650.9 meters).
- Kulamavu Dam (The height is 100 meters and the length is 385.06 meters).

The salient features of this reservoir are listed below:

Water Spread Area	60 Sq. Km.
Catchment Area	640 Sq. Km.
Average Rainfall	3000 mm
Full Reservoir Level (FRL)	2403 Ft (Above MSL)
Minimum Drawdown level (MDDL)	2280 Ft (Above MSL)
Effective Storage at FRL	1459.5 MCM
Energy Equivalent at FRL	2145.47 MU
Average head at power house	660 m

This Underground Power Station is a technological achievement in many aspects. The powerhouse cavern with length of 141 meters, 20 meters in width and 34.5 meters in height is the biggest of its kind in the country. The entry to this cavern is through an access tunnel, 599 meters in length. Vertical Pelton turbines are used in

the station. There are six generating units each of 130 MW capacity. The 220 KV switchyard is situated outside the powerhouse cavern and it is from here that power generated in the station is transmitted to load centers. There are seven 220KV feeders for this purpose, including the Inter-state Idukki-Udumalpet feeder. The power generated in the powerhouse is taken to the switchyard through 220 KV oil filled cables. After power generation, water from the power station is released to the Thodupuzha River through an underground tunnel, 1220 meters in length. This tail race water is used for power generation in the Malankara Small Hydro Electric Station and also for irrigation purpose with the help of Irrigation dam at Malankara.

Place	Moolamattom
Village	Arakulam
Taluk	Thodupuzha
District	Idukki
Installed capacity	780 MW (6 X 130 MW)
Firm annual generation capability	2398 MU
Prime mover	Vertical Pelton Turbine

3.3.5 Demand and Supply Scenario

The Kerala power system recorded a maximum peak demand of 4316.278 MW on 13.4.2019, where as the morning demand rose to 3464.7 MW on 23.05.2019. The daily consumption of the state reached a maximum of 88.34 MU on 23.5.2019. A notable change in the load pattern of the Kerala power system is the flattening of the load curve during the recent years.

The Kerala power system recorded a maximum Peak demand of 4316.278 MW on 13.4.2019, where as the Morning demand (6 AM to 8 AM) rose to 3464.7 MW on 23.05.2019 and Day demand (8 AM to 6 PM) to 3933.3 MW on 23.05.2019. The daily consumption of the state reached a maximum of 88.34 MU on 23.05.2019. A notable change in the load pattern of the Kerala power system is the flattening of the load curve during the recent years.

The energy requirement of Kerala during FY 2016-17 was 24622 MU and in the FY 2020-21 it would be 31371 MU as per projection made in the 19th EPS of India due

to rapid increase in power demand for all types of present and future customers (Domestic, Commercial, Irrigation, Industries, Railway traction and others).

Table 3.17 (A): Southern Region & Kerala Electrical Energy Requirement (MU) at power station bus bars (Utilities)

State/Region	2016-17	2021-22	2026-27	2031-32	2036-37
Kerala	24622	31371	39357	45788	55630
Southern Region	307047	420753	550992	680149	824657

Source: 19th EPS, CEA

Table 3.17 (B)
Southern Region & Kerala Peak Electricity Demand (MW) at power station bus bars (Utilities)

State/Region	2016-17	2021-22	2026-27	2031-32	2036-37
Kerala	4131	5263	6603	7972	9478
Southern Region	44782	62975	83652	104900	128655

Source: 19th EPS, CEA

3.3.6 Transmission

Transmission network, the backbone of any power system enables transfer of bulk power from the generating stations to the load centers. Over the years the intra state transmission infrastructure in Kerala has grown substantially with the addition of more and more EHT substations and lines. The Kerala grid is presently connected to the national grid mainly through three 400 kV double circuit lines viz. Udumalpett-Madakkathara, Thirunelveli - Pallippuram (Trivandrum).

The transmission sector of KSEB Ltd is geographically divided in to two zones - the North Zone headquartered at Kozhikode and the South Zone headquartered at Thiruvananthapuram. Each zone is headed by a Chief Engineer. In addition to the above, the System Operations wing which performs the real time management of Kerala Power System also comes under the Transmission SBU. The System Operations wing is headed by a Chief Engineer and is headquartered at Kalamassery.

The Kerala grid has grown considerably during the recent years. We have as many as 418 Substations spread across the state as on 01.12.2019. Also the total length of our transmission network is 12845.55 C km. The total power transfer capacity of our Substations stands at 20933.4 MVA as on 30.09.2019. An abstract view of the transmission system of the State is given in the table 3.18 below.

Table 3.18 Transmission System of the State

Sl. No.	Voltage	No of Substations	Line length in Circuit kms
1.	400 kV	1 + 5*	947.96
2.	220 kV	22	2910.98
3.	110 kV	162	4803.28
4.	66 kV	70	2100.64
5.	33 kV	158	2082.69

(*Substations and Lines owned by PGCIL)

Source: KSEBL

With the objective of ensuring 24x7 quality power to the consumers in the State and to enable constraint-free transportation of bulk power from generating stations and ISTS nodes by minimizing the transmission losses, KSE Board had approved a Long Term Transmission Plan (LTTP) up to the year 2023 in December 2014. Considering the peculiar geographical shape of the State, a 400 kV backbone transmission network from the northern part of the State to the southern part was proposed in the plan with intermediate substations at 220 kV and 110 kV voltage levels to cater to the load requirement of various load centers.

3.3.7 Distribution

The Strategic Business Unit-Distribution of Kerala State Electricity Board Limited is responsible for the distribution of electricity in the State of Kerala except in Thrissur Municipal Corporation, Munnar (Kannan Devan Hills) areas and in the areas of seven other licensees which are mainly small industrial parks. The SBU-D of KSEBL comprises four distribution regions namely South, Central, North and North Malabar.

The South region, headed by the Chief Engineer (Distribution South) with head quarters at Thiruvananthapuram, has a consumer strength of 34,60,642. This region

consists of 7 Electrical Circles, 20 Electrical Divisions, 63 Electrical Sub-Divisions and 216 Electrical Sections, as on November 2019.

The Central region is headed by the Chief Engineer (Distribution Central) with head quarters at Ernakulam, has a consumer strength of 38,53,643 and consists of 7 Electrical Circles, 24 Electrical Divisions, 69 Electrical Sub-Divisions and 235 Electrical Sections, as on November 2019.

The Northern region, with its head quarters at Kozhikode is headed by the Chief Engineer (Distribution North). This region has a consumer strength of 36,35,986 and consists of 7 Electrical Circles, 19 Electrical Divisions, 52 Electrical Sub-Divisions and 212 Electrical Sections, as on November 2019.

The North Malabar Region, with its head quarters at Kannur is headed by the Chief Engineer (Distribution North Malabar). The region has a consumer strength of 17,76,188 and consists of 4 Electrical Circles, 8 Electrical Divisions, 27 Electrical Sub-Divisions and 108 Electrical Sections, as on November 2019.

Table 3.19: KERALA 19th Electric Power Survey Projection

Electrical Energy Consumption, Energy Requirement and Peak Electricity Demand Category Year Wise (Utilities only)

2021-22 to 2026-27

Consumption Categories	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27
Domestic	13805	14537	15293	16073	16877	17805
Commercial	4786	5087	5399	5723	6062	6414
Public Lighting	543	574	605	637	670	703
Public Water Works	452	468	484	501	517	534
Irrigation	348	356	365	374	382	391
Industries LT	1281	1324	1369	1414	1462	1510
Industries HT	3558	3638	3717	3794	3868	3940

Railway Traction	270	281	292	304	319	335
Bulk Supply	1679	1759	1839	1921	2003	2086
Total Energy Consumption (MU)	26722	28024	29363	30740	32160	33718
T&D losses (MU)	4170	4336	4504	4675	4848	5038
T&D losses (%)	13.50	13.40	13.30	13.20	13.10	13.00
Energy Requirement (MU)	30893	32360	33868	35415	37008	38756
Annual Load Factor (%)	67.00	67.00	67.00	67.00	67.00	67.00
Peak Electricity Demand (MW)	5263	5513	5770	6034	6305	6603
Pattern of Utilisation						
Category	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27
Domestic	51.7	51.9	52.1	52.3	52.5	52.8
Commercial	17.9	18.2	18.4	18.6	18.9	19.0
Irrigation	1.3	1.3	1.2	1.2	1.2	1.2
Industries	18.1	17.7	17.3	16.9	16.6	16.2
Others	11.0	11.0	11.0	10.9	10.9	10.9
Total	100	100	100	100	100	100

Source: 19th EPS, CEA

3.4 Hydro Power – A Flexible Solution

Hydropower is a renewable energy resource because it uses the earth's water cycle to generate electricity. The movement of flowing water during its course from upper to lower topography on earth's surface creates kinetic energy and same can be converted into electricity. The artificially created storage dams also are used as potential source of hydropower. Hydro power projects are broadly divided in two groups:

- Conventional Hydropower Projects
- Pumped Storage Projects

The first category allows water to flow into the river itself after power generation and the second category utilizes gravitational potential to store energy, having two bodies of water, at different elevations. There is a general pattern all over the world to define Conventional Hydro power as Small & Major Hydro on the basis of Power Output. Small hydro projects (SHPs), in general, include Micro/Mini/Small categories of Hydro projects.

The power system operation stability requires the system to minimize fluctuations between demand and supply. This encompasses, for example, short term reserves (generation, storage, demand response) to cover potential incidents, which decrease power supply to the system, or to respond to short-term variations in demand and generation. Hydropower therefore provides an ideal solution for the challenges of a transitioning power system.

Hydropower brings a strong contribution to flexibility in the power system today filling the gap between supply and demand that has been induced by the non-dispatchable variability of RES. The storage capabilities of many hydropower plants make them a perfect instrument for optimizing the use of variable RES over shorter and longer periods. Hydropower also provides a number of ancillary services which are needed in order to manage a transmission system in a way that secures system stability and security of supply. Moreover, during power system restoration, such as in the case of an extreme event (e.g. blackout), auxiliary loads of conventional thermal and nuclear power plants need external power source, which can be provided quickly by hydropower.

Hydropower plants with reservoirs reduce the dependency on the variability of the natural inflow and enable adjustments of power generation to the variability in demand. These plants are operated on a scheduled basis taking into account data regarding water flow forecast and consumption patterns. They are commonly used for intense load following and to meet peak demand. The generation of peak-load energy from reservoir type hydropower plants allows the optimization of base-load power generation from other less flexible electricity sources, such as nuclear and thermal power plants. Besides contributing to water management activities (flood control, irrigation, drinking water, etc.), hydropower plants with reservoirs also

introduce unique benefits to the electricity system. There are different types of hydropower plants with reservoirs.

Storage hydro plant (or conventional reservoir-type hydropower plant) takes advantage of large reservoirs with natural inflow of water and the possibility to reduce or increase the water outflow instantaneously. The water is stored in the reservoir and no pumps are needed. Pumped storage power plants store energy by pumping water from a lower to a higher reservoir and converting the potential energy back into electricity. These reservoirs can be natural or artificial.

Both types of storage plants enable the power system to receive and store energy in periods of low demand or excessive generation, and generate electricity in times of higher demand. Storage possibilities combined with the instant start and stop of generation make hydropower plants very flexible. Storage hydro with peak generation are able to cope with high generation driven fluctuations and can provide active power within a short period of time.

Conventional reservoir-type hydropower plants can provide the full range of grid stabilising services in view of their ability to follow demand or generation fluctuations within only a few minutes.

3.4.1 Importance of Hydro in Present Scenario

There are several different ancillary services or grid stabilising services of hydropower, thus facilitating the integration of variable RES into the power system and providing a key tool to maintain a stable and balanced grid:

- **Back-up and reserve:** hydropower plants have the ability to enter load into an electrical system from a source that is not on-line. Hydropower can provide this service while not consuming additional fuel, thereby ensuring minimal emissions.
- **Quick-start capability:** Hydropower plant has the quick-start capability takes just a few minutes.

- **Black start capability:** Hydropower plants have the capability to run at a zero load. When loads increase, additional power can be delivered rapidly to the system in order to meet demand.
- **Regulation and frequency response:** Hydro plants contribute towards maintaining the frequency within the given margins through continuous modulation of active power and to address moment-to moment fluctuations in system power requirements. Hydropower's fast response ability makes it especially valuable in covering steep load gradients (ramp rates) through its fast load-following.
- **Voltage support:** Hydropower plants have the ability to control reactive power, thereby ensuring that power will flow from generation to load. They also contribute to maintain voltage by injecting or absorbing reactive power to the System/Grid.
- **Spinning reserve:** Hydropower supports the dynamic behavior of the grid operation. Hydropower plants can provide spinning reserve - additional power supply that can be made available to the transmission system within a few seconds in case of unexpected load changes in the grid.

Hydropower plants with a small reservoir are sometimes also called pondage plants. These are designed to modulate generation on a daily or weekly basis. Pondage plants can provide flexibility services mainly through balancing power. They also provide frequency and voltage control as ancillary services.

Run-of-river hydro plants have little or no storage capacity. They therefore offer short-term storage possibilities (few minutes dynamic cycle), thus allowing for some adaptation to demand, especially for ancillary services, such as frequency and voltage control.

To sum up, flexibility solutions of hydropower include:

- Accommodating large variations in residual demand (to counter variability of RES, as sun does not always shine and wind does not blow constantly),

- Providing increasing ramp rates in real time, caused by sudden changes of generation, and
- Offsetting unexpected variations in production due to forecast errors in the intra-day markets or in the form of balancing power or ancillary services.

3.4.2 Hydro Potential and its Development

An assessment was made of the economically exploitable hydro power potential in the country by CEA during the period 1978-1987, based on observed basic data on topographic features of river basins, discharge characteristics of rivers at a large number of sites, geological and other information. According to the assessment, the total Hydro Electric Power potential in the country was assessed as 84044 MW (at 60% load factor) from a total of 845 number of identified H.E. Schemes which when fully developed would result in an installed capacity of about 148701 MW on the basis of probable average load factor. The total hydro energy potential is assessed as 600 billion units per year.

The identified potential of H.E. schemes above 25 MW installed capacity works out to be 145320 MW from a total of 592 H.E. schemes.

The basin-wise details of hydroelectric potential development in terms of Installed Capacity are indicated in the Fig. 3.4.

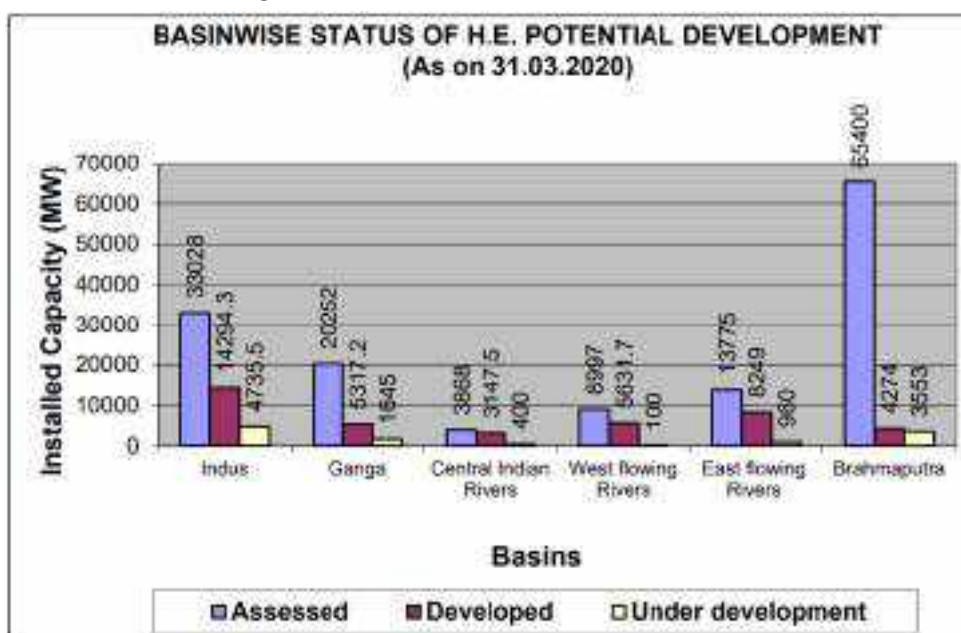


Fig. 3.4 - Basin-wise Hydro Electric Potential Development as on 31.03.2020

(CI = Central Indian, WF = West Flowing, EF = East Flowing, R = River Systems)

Source: Annual Report of CEA 2019-20, CEA

As on 31.03.2020, the hydroelectric schemes in operation account for only 27.95% (46512.22 MW) and those under execution for 8.71% (12663.50 MW) of the total potential in terms of installed capacity. Thus, the bulk of the potential (59.60%) remains to be developed. For Southern region, 58.27% has been depeveloped and 35.43% potential is yet to be developed.

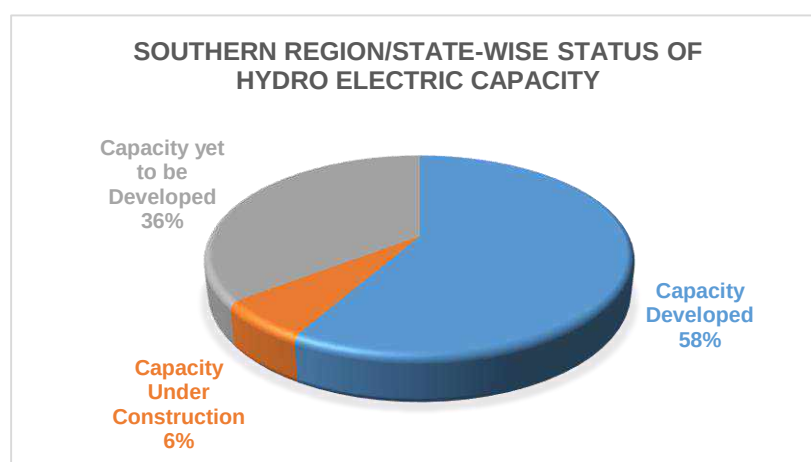


Fig. 3.5 – Southern Region-Status of Hydro Electric Capacity as on 31.10.2021

Table 3.20: Status of Hydro Electric Capacity

As on 31st October, 2021

(In terms of Installed Capacity-above 25 MW)

SOUTHERN REGION/STATE-WISE STATUS OF HYDRO ELECTRIC CAPACITY								
Region/State	Identified Capacity as per reassessment study (MW)		Capacity Developed		Capacity Under Construction		Capacity yet to be Developed	
	Total (MW)	Above 25 MW	(MW)	(%)	(MW)	(%)	(MW)	(%)
Southern Region (SR)								
Andhra Pradesh	3355	3311	1673.60	50.55	960.0	28.99	677.4	20.46
Telangana	1339	1339	800	59.75	0.0	0.00	539	40.25
Karnataka	6798.2	6598.2	3698.2	56.05	0.0	0.00	2900	43.95
Kerala	3898	3668	1856.5	50.61	100.0	2.73	1711.5	46.66

Tamil Nadu	2267	1913	1778.2	92.95	0.0	0.00	134.8	70.47
Sub Total (SR)	17657.2	16829.2	9806.5	58.27	1060.0	6.30	5962.7	35.43
All INDIA	148701	145320	46512.22	27.95	12663.50	8.71	87044.28	59.90

Source: CEA

The Great Indus, the Ganga and the Brahmaputra rivers with their innumerable tributaries originating from the Himalayas constitute about 70% of the country's assessed hydropower potential. In addition to above, a sizable potential was identified by CEA for development of micro, mini and small hydro schemes on rivulets and canal drops. 1512 nos. of small hydro-electric schemes having aggregate installed capacity of above 6782 MW on canal falls/rivers have been identified. The matter relating to H.E. Projects up to 25 MW is being looked after by MNRE and the potential of small H.E. Projects has been assessed by MNRE as 19749 MW.

3.4.3 Growth of Installed Capacity

A small Hydro-Electric Plant (130 KW) established near Darjeeling in 1897 ushered the beginning of hydro-electric power development in the country. The hydel installed capacity which was only 508 MW in 1947 with 12 H.E. Stations, 51 units and the maximum unit size of 22 MW at Bhira H.E. station under Tata, has risen to 46512.22 MW (as on 31.10.2021) from H.E. stations above 25 MW capacity. The maximum unit size now is 250 MW at Koyna Stage-IV under MAHAGENCO, Nathpa Jhakri under SJVNL, Tehri under THDC and Karcham Wangtoo of JSW Energy. Contribution of electricity generation from Hydro Electric Power Stations was 2.2 BU during 1947 and was 150.3 BU in 2020-21.

3.4.4 Share of Hydroelectric Installed Capacity & Generation

The installed capacity of Hydro-Electric Stations vis-à-vis total capacity, the contribution in generation by hydro-electric plants and trend of hydro capacity & generation over the years are indicated in Table - 3.28 and at fig. 3.6, 3.7 and 3.8. From Table 3.28, it may be observed that the overall share of hydro in terms of installed capacity in the country rose from 37.3% at the end of 1947 to 50.6% during

1962-63. However, thereafter, the share of hydro progressively declined and is presently 11.90% at the end of 2020-21. The generation from hydro stations during the year 2020-21 accounted for 12.26% of the total energy generation in the country.

Table 3.21: Hydro-Electric Capacity & Generation viz-à-viz Total Capacity & Generation

Year	Installed Capacity			Generation		
	Total (MW)	Hydro (MW)	Hydro as % of Total	Total (MU)	Hydro (MU)	Hydro as % of Total
1947	1362	508	37.30	4072	2194	53.88
1950	1713	560	32.63	5106	2519	49.33
1955-56	2886	1061	36.76	9145	4295	46.97
1960-61	4653	1917	41.20	16937	7837	46.27
1962-63	5801	2936	50.61	22365	11805	52.78
1965-66	9027	4124	45.68	32890	15225	46.29
1968-69	12957	5907	45.59	47434	20723	43.69
1973-74	16664	6966	41.80	66689	28972	43.44
1978-79	26680	10833	40.60	102523	47159	46.00
1979-80	28448	11384	40.02	104627	45478	43.47
1984-85	42585	14460	33.96	156859	53948	34.39
1989-90	63636	18307	28.77	245437	62116	25.31
1991-92	69065	19194	27.79	287028	72757	25.35
1996-97	85795	21658	25.24	395889	68901	17.40
1997-98	89203	21904	24.58	421748	74582	17.68
1998-99	92269	22479	24.10	447464	82923	18.53
1999-00	97837	23857	24.37	481128	80755	16.78
2000-01	101450	25153	24.75	499429	74362	14.89
2001-02	105046	26269	25.01	515066	73759	14.32
2002-03	107877	26767	24.81	531607	63834	12.01
2003-04	112684	29507	26.19	558113	73775	13.22
2004-05	118419	30936	26.12	587416	84495	14.38
2005-06	124287	32326	26.01	624631	101293	16.22
2006-07	132321	34662	26.19	659513	113359	17.19
2007-08	143061	37002	25.86	704469	123424	17.52
2008-09*	147917	36846	24.91	714653	109840	15.37
2009-10*	159398	36863	23.13	763429	103916	13.61
2010-11*	173626	37567	21.64	805532	114257	14.18
2011-12*	199877	38990	19.51	871602	130510	14.97
2012-13*	223344	39491	17.68	907262	113720	12.53
2013-14*	243029	40531	16.68	961552	134848	14.02
2014-15*	267637	41267	15.42	1043665	129244	12.38
2015-16*	302088	42783	14.16	1102578	121377	11.01
2016-17*	326849	44478	13.61	1154524	122378	10.60
2017-18*	344002	45293	13.17	1201528	126123	10.50
2018-19*	356100	45399	12.75	1244930	134894	10.84

2019-20*	370106.46	45699.22	12.35	1389120.93	155769.12	11.21
2020-21*	390791.18	46512.22	11.90	1225840	150300	12.26

* Capacity above 25 MW only has been considered.

Source: CEA

Table 3.22: Future Hydro Projects - KSEBL

Sl. No	Name of Project	Installed Capacity (MW)	Annual Energy (MU)	District
ONGOING PROJECTS				
1.	Bhoothathankettu	24.0	83.50	Ernakulam
2.	Sengulam Augmentation	-	85.00	Idukki
3.	Thottiyar	40.0	99.00	Idukki
4.	Upper Kallar	2.0	5.14	Idukki
5.	Poringalkuthu	24.0	45.02	Thrissur
6.	Chinnar	24.0	76.45	Idukki
7.	Pallivasal Extension Scheme	60.0	153.90	Idukki
8.	Pazhassi Sagar SHEP	7.5	25.16	Kannur
9.	Chathankottunada II	6.0	14.76	Kozhikode
10.	Peruvannamuzhy	6.0	24.70	Kozhikode
	TOTAL	193.5	612.63	
FUTURE PROJECTS				
1	Mankulam	40.0	82.000	Idukki
2	Anakkayam	7.5	22.830	Malappuram
3	Olikkal	5.0	10.260	Kozhikode
4	Poovaramthode	3.0	5.880	Kozhikode
5	Upper Sengulam	24.0	53.220	Idukki
6	Ladrum	3.5	12.130	Idukki
7	Marmala	7.0	23.020	Kottayam
8	Valanthode	7.5	15.291	Malappuram
	TOTAL	97.5	224.631	

Source: KSEBL

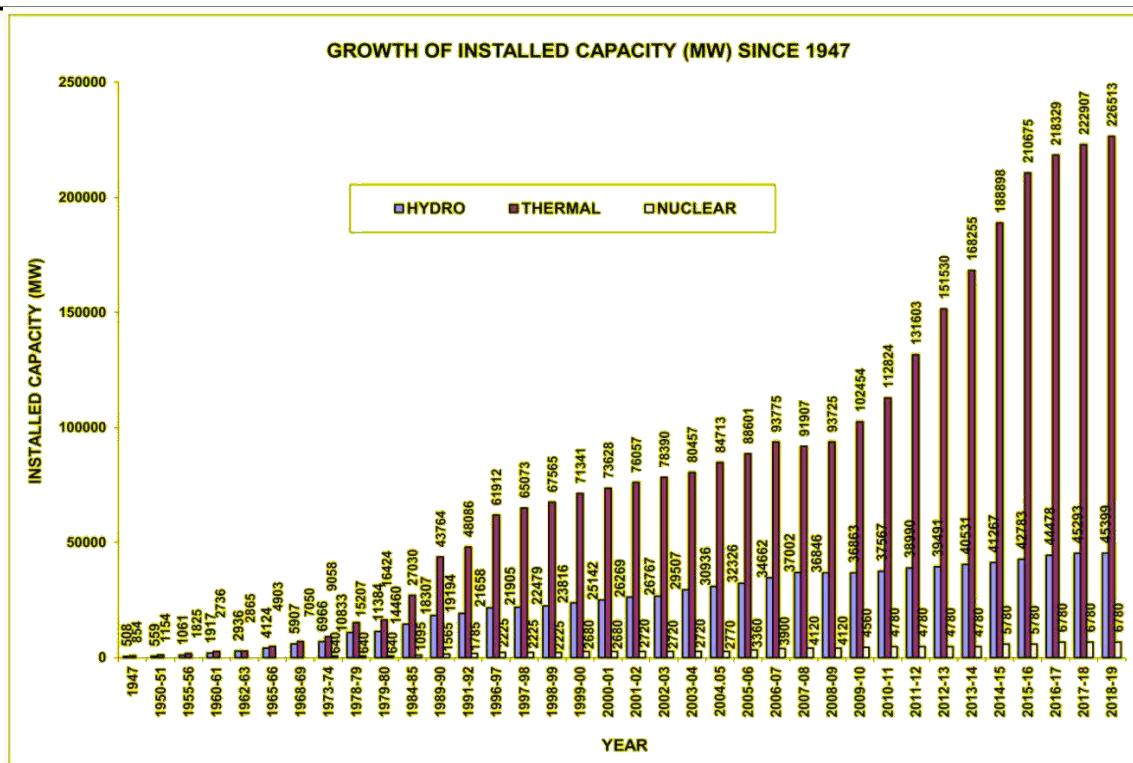


Fig. 3.6 - Growth of Installed Capacity

Source: CEA

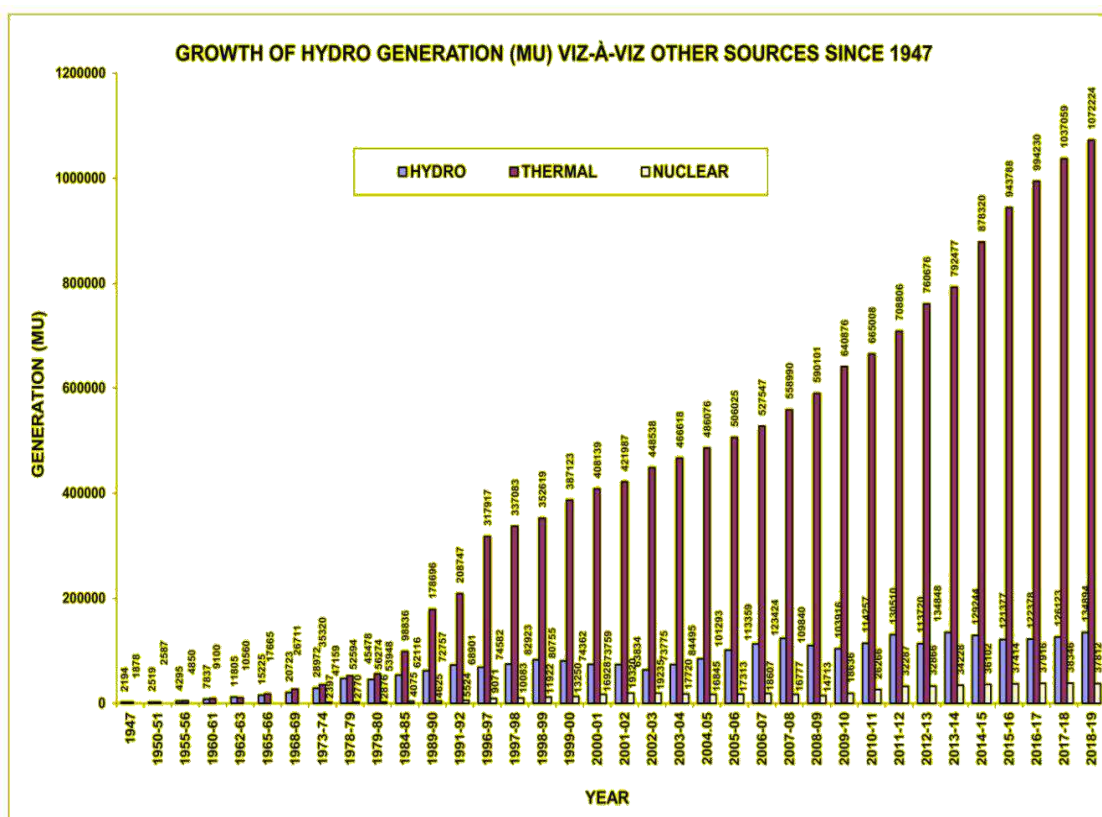


Fig. 3.7 - Growth of Hydro Generation (MU) viz-à-viz other sources since 1947

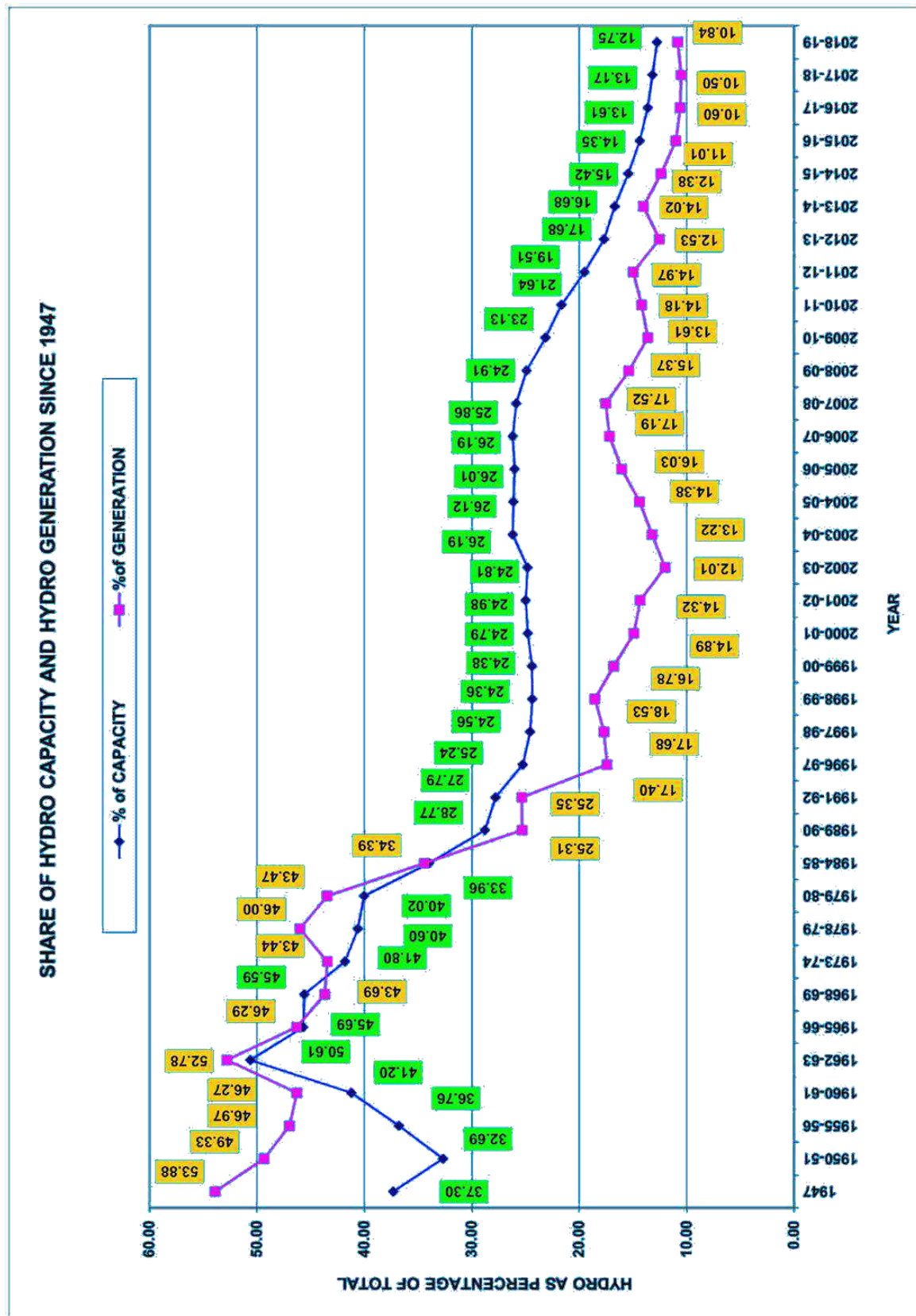


Fig. 3.8 - Share of Hydro Capacity & Generation since 1947

3.5 Necessity and Justification

Necessity

It is observed that expansion of estimated power requirement during the period of 13th five year plan (1st April 2017 to 31st March 2022) and estimated power requirement in 2030, KSEBL can take part in this integration of power generation of the country.

As per forecast of 12th and 13th (National 5 Year Plan), the Electrical Energy Requirement of Southern Zone for the period 2026-27 is estimated to be 550992 MU and for the period 2036-37 is estimated to be 824657 MU. Requirement of Peak Electricity Demand at power station Bus bars has been estimated as 83652 MW for the period 2026-27 and 128655 MW and for the period 2036-37.

As per review of forecast of all India and state wise electrical energy consumption (MU) and CAGR of Actual and Forecast, peak electricity demand in Kerala in 2036-37 will be 9478 MW against 6603 MW in 2026-27. Increase of generation of KSEBL is needed to cope up with the forecast of demand as stated above. Installation of Hydro Electric Project is suitable according to the present trend of world power scenario to meet up therefore peak demand as well as to avoid use of fossil fuel and to avail the opportunity of god gifted geological condition.

Proposal for Extension Scheme of 800 MW (4x200 MW) Idukki Hydro Electric Project is very much essential to fulfil peak power demand and justified in consideration with the requirement of excess 2875 MW peak electricity demand at Southern Zone in 2036-37 in comparison to 2026-27. To maintain Indian standard frequency 50 cycles/sec and Grid balancing by generation of power, Hydro Storage Project Projects are very much effective.

There is a big scope to keep up this ratio with the installation of a Hydro Electric Project as well as to add generation according to need of the grid which will ensure the active participation in expansion of power generation of the country in coming years.

The Idukki Extension Scheme H.E. Project (4 x 200 MW) is proposed as a hydroelectric peaking station by sharing the daily water drawl from the existing Idukki reservoir. The off-peak generation of the existing Moolamattom power station is planned to be reduced and the water thus saved will be utilized at the Idukki Extension scheme during peak hours. Thus an additional capacity of 800 MW can be achieved during peak hours, resulting in the corresponding power purchase at higher rates during peak time. The Idukki Extension Scheme will generate 1301 Mu of electricity annually. The advantages of Idukki Extension Scheme are as follows.

- 1) KSEB Ltd can increase the share of Peak Hour demand by in house hydro generation, thus reducing the expenditure for peak hour power purchase
- 2) Since no additional reservoir is formed, the environmental issues are less and hence the statutory clearances will be a comparatively easier task.
- 3) The extension power house operation is in line with the Load Curve of the State Grid. Cost of head works is eliminated since existing dam and reservoir are used.
- 4) Less time for completion.
- 5) The proposed scheme does not affect the functioning of downstream dams.
- 6) More availability of machines for crisis management.
- 7) Gives flexibility for shut down for planned and forced shut downs
- 8) To meet the power demand during morning peak & evening peak.
- 9) To meet the requirement of flywheel effect during power system disturbances
- 10) To provide reactive power when the solar power generation increases considerably.
- 11) Easy variation of the power from 10 % to 100 % by using Pelton Wheel.
- 12) As a redundant station when Idukki Power Station goes for total renovation

CHAPTER-4: HYDROLOGY

CHAPTER – 4

4. HYDROLOGY

4.1 General

Hydrological inputs play a vital role in planning, execution, operation and ever expansion of existing water resource developmental projects. Such studies are carried out at all stages of development process starting from pre-feasibility, Feasibility and Detailed Project Report (DPR) stage. Such studies involve estimation of water inflows its time distribution etc. for a period of at least 10 years for hydro power projects. However, as a general rule, the longer the data length, the better the results and would be near to reality. The estimation of water availability, design pattern and sediment deposition for storage projects are crucial which results in lots of storage with passage of time. For existing projects, the design flood is not an issue as the structure is existing and with stood during its long period of existence.

4.2 River Basin

The Periyar River is 244 km in length and the longest river of Kerala and drains an area of 5,398 sq km. The basin lies between latitude $9^{\circ} 15'N$ to $10^{\circ} 20'N$ and Longitude $76^{\circ} 10'E$ to $77^{\circ} 30'E$. It rises at the forest land Sivagiri peak 80 km south of Devikulam at an elevation of 2,438m above msl and traverses the steep mountainous terrain before it is joined by the Mullaiyar, 16 km downstream. The river then turns west and continues to flow in the direction for about 16 km in a sandy bed. After a winding course of about 13 km, the river reaches Vandiperiyar and passes through a second narrow gorge below which the Perumthura joins it. Further down, it is joined by six tributaries of which the important tributary Edmala joins the Periyar. Passing Malayattur and thereafter taking a meandering course, the river reaches Alwaye where it divides itself into two branches. The upper branch joins the Chalakudi River at Punthenvelikara and then expands into a broad sheet of water at Munambham. The other branch taking a southerly course is broken up into a number of small channels, which fall into the Vembanad Lake as Varapuzha. During this journey, Periyar passes through Periyar Tiger Reserve. The river drains

Idukki, Ernakulam and Thrissur districts of Kerala and Coimbatore districts in Tamilnadu. About 1500 Km² is covered by forests.

Mullaperiyar dam is constructed at the confluence of Periyar and Mullayar River to from the Periyar Thappady Lake and reserve. From this lake, some water is diverted to Tamil Nadu via a tunnel. The diverted water after hydropower generation in let into Vougai River (tributary). The Periyar River flows down for 35 Km and after existing from Periyar Tiger reserve reaches Idukki reservoir formed by the Idukki, Cheruthoni and Kulamavu dams. Idukki dam is the longest hydro-electric project in the state and located on Periyar River with an installed capacity of 780 MW (6 x 130 MW) through an underground power house at Moolamattom. The tail water is diverted into Thodupuzha tributary of Muvathupuzha River. There exists a number of hydro-power projects in the basin along with Periyar Valley irrigation Project in Ernakulum district besides supplying water for drinking and industrial uses. Fig 4.1 shows Hydropower development in Periyar River Basin along with adjacent river basin.

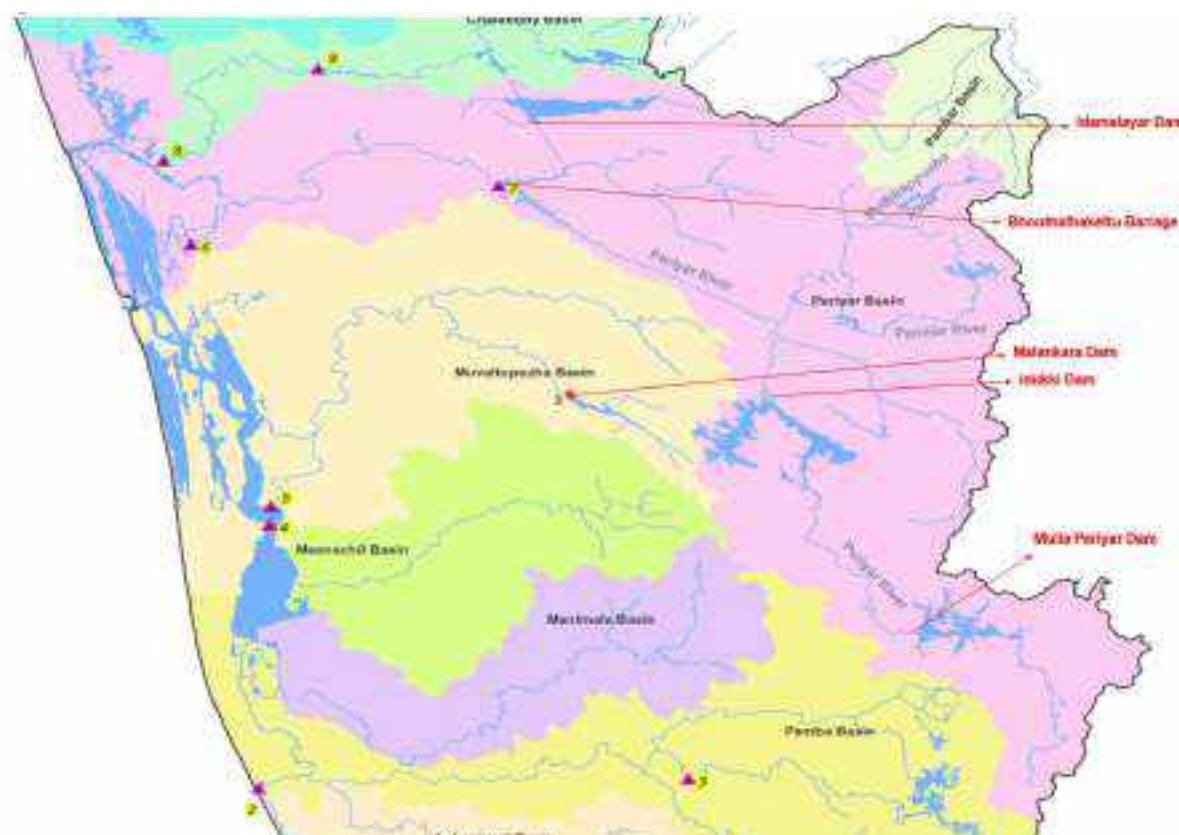


Fig 4.1: Hydropower Development in Periyar and its adjacent river basin

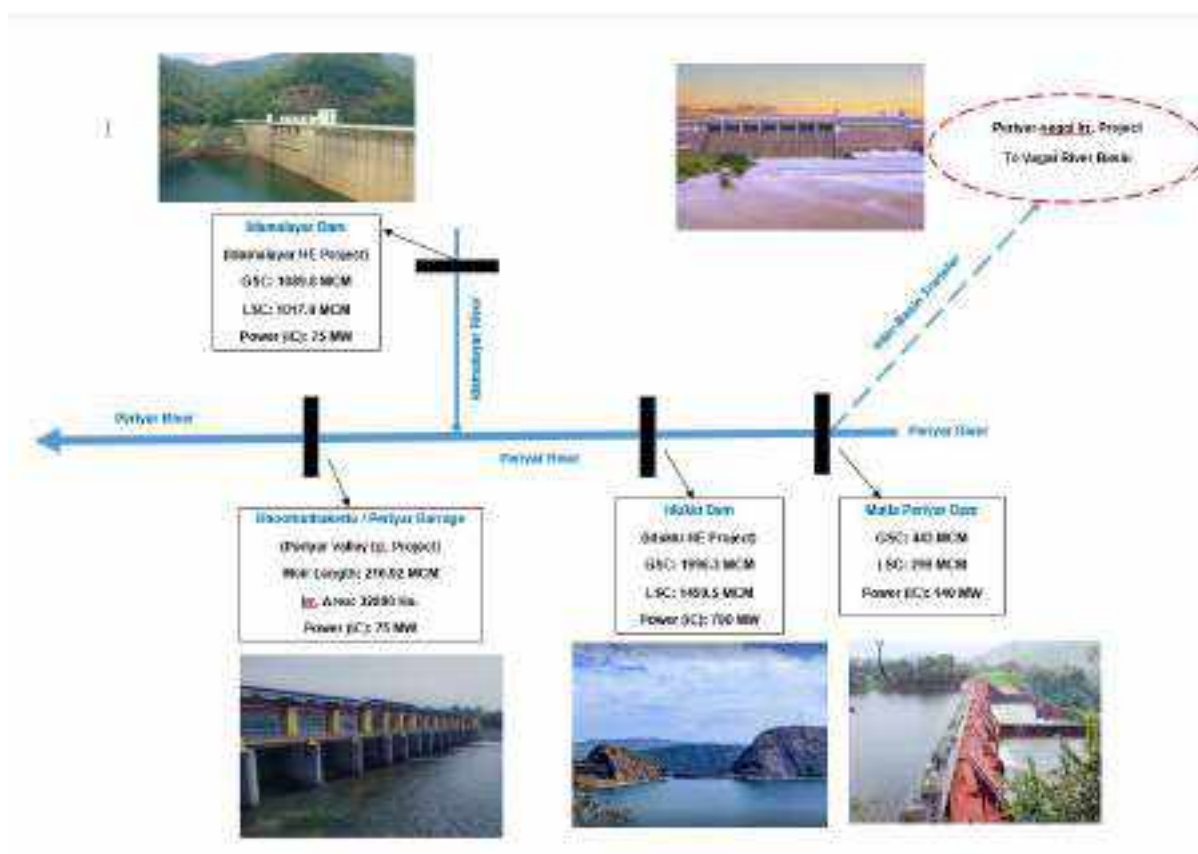


Fig 4.2: Line Diagram of Projects in Periyar River

4.3 Objective of Hydrological Study

The objective of the study is to assess the availability of peaking power from existing Idukki Reservoir project by installing additional units of 800 MW (4 x 200) at / or near to the existing power house through a new scheme named “Idukki Extension Scheme”. The scheme would entail change of operational policy of Idukki project from base/peaking station in tandem with new proposed scheme. The water that was being utilised by existing operational powerhouse during peak as well as off-peak hours, will be now utilised exclusively for peak operation by both the schemes in tandem. The water to be drawn would be from existing Idukki reservoir project only. No additional unit structure is envisaged except structure of water withdrawal from Idukki reservoir.

In nut shell, the earlier operating scheme for running existing Idukki hydro-power projects for 24 hours or less would be calculated to seen tributaries scheme viz.

4.4 Project Proposal

A Google image of the existing Idukki reservoir and proposed project structure is at Fig 4.3 below.

Malankara Dam
FRL: EL. 42 m
Gross Storage: 37 Mcm

Kulamavu Dam

Thodupuzha River

Cheruthoni Dam

Idukki Main Arch dam
River : Perriyar
FRL: EL. 732. 62 m

Idukki Reservoir
Surface Area: 59.83 Sq. Km
Gross: 1996.3 Mcm
Live: 1459.5 Mcm
Average Annual Yield : 1687.23 Mcm

Moolamatam Existing Underground PH
(6 x130 MW)

Fig 4.3: Google Earth Image showing Idukki Reservoir

4.5 Catchment Area

The catchment area intercepted for the existing projects is calculated using ARC GIS.10 and the details are as under:

- i. Gross CA of Cheruthoni – Idukki 1307.7 km²
- ii. Gross CA of Kulamaver reservoir 7.79 km²
- iii. Total gross CA of Idukki reservoir 1315.49 km²
- iv. Gross CA of Mullaperiyar dam 639.6 km²
- v. Net CA of Idukki reservoir 675.89 km²

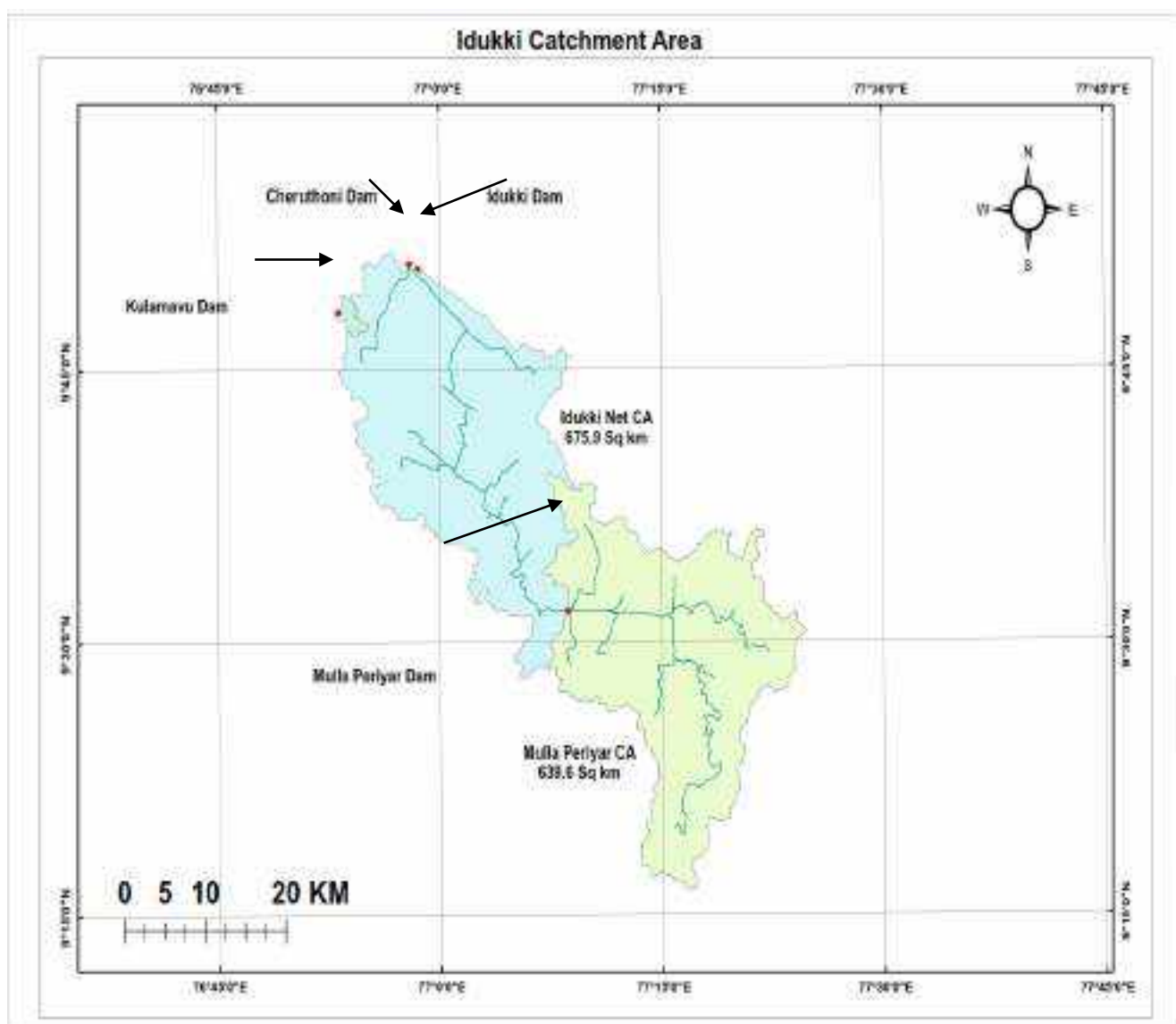


Fig 4.4: Catchment Area of Idukki Reservoir

4.6 Hydro-meteorological data availability

The Kerala State Electricity Board (KSEB) which is the operating project authorities for the Idukki Reservoir and existing hydroelectric scheme have maintained the Idukki Reservoir operational data. The daily rainfall, inflow, storage levels, daily power house usages, reservoir losses, elevation-average-capacity etc. for the Idukki existing project for the period January 1995 to December 2020 has been provided. The Details of the data as available at Idukki H.E. Project for carrying out hydrological studies is tabulated in **Table 4.1** under:

Table 4.1: List of Hydrological Data

.L.	Type of Data	Period	Provided By
1.	Idukki Reservoir Water Level in feet.	January 1995 to December 2020	KSEBL
2.	Idukki Reservoir Gross Storage in (MCM)	-do-	-do-
3.	Gross Inflow in Idukki Reservoir in (MCM)/day	-do-	-do-
4.	Releases from Power House in (MCM)/day	-do-	-do-
5.	Rainfall in mm	-do-	-do-

4.6.1 Data Consistency Check

The existing Idukki project is in operation and its daily inflow data since January 1995 upto December 2020 is available by project authorities i.e KSEBL. The project authorities estimate the inflow into the existing Idukki reservoir based on two method viz.

- Observed daily reservoir water levels converted into storage and then inflow based on the rating curve. The evaporation loss is considered using the evaporative loss rate.
- Power generated through the machines is utilised to back calculate the inflow into the machines.

The KSEB / project authorities thus ensured the data reliability before supplying it. In view of the same, the data supplied is considered as consistent and reliable for studies.

4.7 Hydrological Studies

4.7.1 Water Availability

The daily inflow into existing Idukki reservoir for the period January 1995 to December 2020 are available. No additional inflow water is contemplated. Moreover, only operating outflow is due to powerhouse generation in addition to evaporation losses. Out of three dams enclosing Idukki Reservoir, only Cheruthoni Dam has been provided with spillway. As per the historical records, Cheruthoni spillway shutters have been opened only thrice i.e. during 1981, 1992 and 2018 for flood control.

The present proposed scheme entails utilisation of water reservoir in tandem with the project so as to generate hydro-power for peaking purposes only. Thus water for both the power houses would be drawn simultaneously. Thus simulation studies would be carried out in power potential chapter to ensure hydro-power generation. The area capacity elevation table and Calculated 10 Daily inflows in Idukki Reservoir is given in **Annexure: 4.1 & Annexure 4.2** respectively. The Annual Yield at Idukki is Tabulated as Under. The Annual Rainfall and Inflows are presented in Table 4.2 and Table 4.3 Respectively.

**Table 4.2: Observed Annual Rainfall at Idukki Reservoir (in mm)
(1995 to 2020)**

S.L.	Year	Annual Rainfall in mm	S.L.	Year	Annual Rainfall in mm
1	1995	4105.6	14	2008	2992.8
2	1996	3569.4	15	2009	3438
3	1997	3584.6	16	2010	3359.6
4	1998	4276.28	17	2011	3449.44
5	1999	3657.28	18	2012	2483.6

6	2000	3513.7	19	2013	4483.8
7	2001	3998	20	2014	4156.6
8	2002	3104.8	21	2015	2901
9	2003	2856.3	22	2016	2612
10	2004	3453.7	23	2017	3201.8
11	2005	4438.6	24	2018	5112.8
12	2006	3644.9	25	2019	2764.3
13	2007	3978.1	26	2020	3137.60
Average Annual Rainfall in mm					3549.02

The Monthly Rainfall Data for the Period of 1995 onwards are presented at **Annexure-4.3**. The Evaporation losses considered in the study is presented at **Annexure-4.4**

Table 4.3: Observed Inflows at Idukki Reservoir (in MCM)

S.L.	Year	Yield in MCM	S.L.	Year	Yield in MCM
1	1995-96	1776.85	14	2008-09	1326.66
2	1996-97	1704.67	15	2009-10	1511.93
3	1997-98	1595.67	16	2010-11	1824.37
4	1998-99	2263.64	17	2011-12	1852.76
5	1999-00	1627.08	18	2012-13	905.81
6	2000-01	1581.25	19	2013-14	2334.33
7	2001-02	1907.68	20	2014-15	1905.54
8	2002-03	1088.22	21	2015-16	1357.32
9	2003-04	1083.99	22	2016-17	864.62
10	2004-05	1464.85	23	2017-18	1451.62
11	2005-06	2175.45	24	2018-19	3113.68
12	2006-07	1621.25	25	2019-20	1447.49
13	2007-08	2329.99	Average Annual Yield in MCM		1684.67

4.7.2 Diversion Flood

No new structure is proposed except an intake structure for withdrawing water from existing Idukki reservoir. As such, diversion flood is not envisaged except construction of a small coffer dam near to the proposed intake structure in the reservoir for carrying out the construction activities.

4.7.3 Design Flood

No fresh dam is proposed to be constructed under the present scheme. The existing Idukki dam, Cheruthoni dam and Kulamavu dam are existing since last four decades and have with stood with time. As such design flood is not an issue and accordingly no fresh studies are contemplated..

4.8 Conclusion

The project does not cause any impact on the existing hydrologic regime as the proposal involves sharing of available storage between existing Idukki Hydroelectric Scheme and the newly proposed Idukki Extension Scheme. No additional diversion is proposed in the scheme. The tail water from Idukki Extension scheme is also discharging to the same river as that of existing scheme.

Annexure - 4.1

Idukki Reservoir - Elevation Vs. Storage & Water Spread Area

Water level in feet	Water level in m	Water spread area in Sq km	Storage in Mcft	Storage in Mm ³	Remarks
1900.0	579.12	0.00	0.5	0.01	1 MCFT
1920.0	585.22	0.01	1.9	0.05	=
1940.0	591.31	0.06	8.8	0.25	0.028317
1960.0	597.41	0.17	33.2	0.94	MCM
1980.0	603.50	0.23	75.9	2.15	
2000.0	609.60	0.36	138.5	3.92	
2020.0	615.70	0.50	231.1	6.54	
2040.0	621.79	0.71	361.4	10.23	
2060.0	627.89	0.98	541.6	15.33	
2080.0	633.98	1.29	783.3	22.18	
2100.0	640.08	1.61	1093.3	30.96	
2120.0	646.18	2.67	1548.6	43.85	
2140.0	652.27	3.69	2230.0	63.15	
2160.0	658.37	4.91	3152.0	89.25	
2180.0	664.46	6.62	4389.0	124.28	
2200.0	670.56	9.06	6076.0	172.05	
2220.0	676.66	11.70	8304.0	235.14	
2240.0	682.75	14.59	11127.0	315.08	
2260.0	688.85	17.97	14625.0	414.13	
2280.0	694.944	22.35	18957.0	536.802	MDDL
2281.0	695.25		19206.0	543.85	
2282.0	695.55		19454.0	550.88	
2283.0	695.86		19703.0	557.93	
2284.0	696.16		19951.0	564.95	
2285.0	696.47		20200.0	572.00	
2286.0	696.77		20460.0	579.36	
2287.0	697.08		20720.0	586.73	
2288.0	697.38		20980.0	594.09	
2289.0	697.69		21240.0	601.45	
2290.0	697.99		21500.0	608.81	
2291.0	698.30		21768.0	616.40	
2292.0	698.60		22036.0	623.99	
2293.0	698.91		22304.0	631.58	
2294.0	699.21		22572.0	639.17	
2295.0	699.52		22840.0	646.76	
2296.0	699.82		23128.0	654.91	

Idukki Reservoir - Elevation Vs. Storage & Water Spread Area

Water level in feet	Water level in m	Water spread area in Sq km	Storage in Mcft	Storage in Mm ³	Remarks
2297.0	700.13		23416.0	663.07	
2298.0	700.43		23703.0	671.19	
2299.0	700.74		23991.0	679.35	
2300.0	701.04	27.17	24279.0	687.50	
2301.0	701.34		24601.0	696.62	
2302.0	701.65		24922.0	705.71	
2303.0	701.95		25244.0	714.83	
2304.0	702.26		25566.0	723.95	
2305.0	702.56		25887.0	733.04	
2306.0	702.87		26209.0	742.16	
2307.0	703.17		26531.0	751.27	
2308.0	703.48		26852.0	760.36	
2309.0	703.78		27174.0	769.48	
2310.0	704.09		27496.0	778.60	
2311.0	704.39		27817.0	787.69	
2312.0	704.70		28139.0	796.81	
2313.0	705.00		28460.0	805.90	
2314.0	705.31		28782.0	815.02	
2315.0	705.61		29104.0	824.13	
2316.0	705.92		29425.0	833.22	
2317.0	706.22		29747.0	842.34	
2318.0	706.53		30069.0	851.46	
2319.0	706.83		30390.0	860.55	
2320.0	707.14	32.69	30712.0	869.67	
2321.0	707.44		31089.0	880.34	
2322.0	707.75		31466.0	891.02	
2323.0	708.05		31844.0	901.72	
2324.0	708.36		32221.0	912.40	
2325.0	708.66		32598.0	923.07	
2326.0	708.96		32975.0	933.75	
2327.0	709.27		33352.0	944.42	
2328.0	709.57		33730.0	955.13	
2329.0	709.88		34107.0	965.80	
2330.0	710.18		34484.0	976.48	
2331.0	710.49		34861.0	987.15	
2332.0	710.79		35238.0	997.83	

Idukki Reservoir - Elevation Vs. Storage & Water Spread Area

Water level in feet	Water level in m	Water spread area in Sq km	Storage in Mcft	Storage in Mm ³	Remarks
2333.0	711.10		35616.0	1008.53	
2334.0	711.40		35993.0	1019.21	
2335.0	711.71		36370.0	1029.88	
2336.0	712.01		36747.0	1040.56	
2337.0	712.32		37124.0	1051.23	
2338.0	712.62		37502.0	1061.94	
2339.0	712.93		37879.0	1072.61	
2340.0	713.23	37.43	38256.0	1083.29	
2341.0	713.54		38690.0	1095.58	
2342.0	713.84		39124.0	1107.87	
2343.0	714.15		39557.0	1120.13	
2344.0	714.45		39991.0	1132.42	
2345.0	714.76		40425.0	1144.71	
2346.0	715.06		40859.0	1157.00	
2347.0	715.37		41293.0	1169.29	
2348.0	715.67		41726.0	1181.55	
2349.0	715.98		42160.0	1193.84	
2350.0	716.28		42594.0	1206.13	
2351.0	716.58		43028.0	1218.42	
2352.0	716.89		43462.0	1230.71	
2353.0	717.19		43896.0	1243.00	
2354.0	717.50		44329.0	1255.26	
2355.0	717.80		44763.0	1267.55	
2356.0	718.11		45197.0	1279.84	
2357.0	718.41		45631.0	1292.13	
2358.0	718.72		46064.0	1304.39	
2359.0	719.02		46498.0	1316.68	
2360.0	719.33	43.23	46932.0	1328.97	
2361.0	719.63		47433.0	1343.15	
2362.0	719.94		47935.0	1357.37	
2363.0	720.24		48436.0	1371.55	
2364.0	720.55		48938.0	1385.77	
2365.0	720.85		49439.0	1399.96	
2366.0	721.16		49941.0	1414.17	
2367.0	721.46		50442.0	1428.36	
2368.0	721.77		50944.0	1442.57	

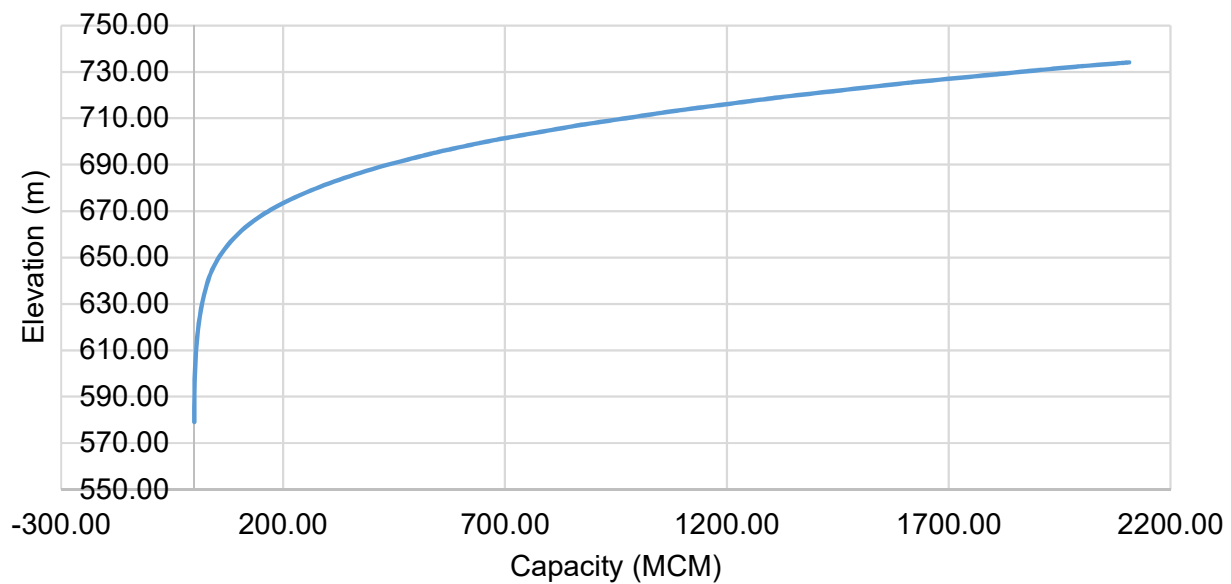
Idukki Reservoir - Elevation Vs. Storage & Water Spread Area

Water level in feet	Water level in m	Water spread area in Sq km	Storage in Mcft	Storage in Mm ³	Remarks
2369.0	722.07		51445.0	1456.76	
2370.0	722.38		51947.0	1470.98	
2371.0	722.68		52448.0	1485.16	
2372.0	722.99		52950.0	1499.38	
2373.0	723.29		53451.0	1513.56	
2374.0	723.60		53953.0	1527.78	
2375.0	723.90		54454.0	1541.97	
2376.0	724.20		54956.0	1556.18	
2377.0	724.51		55457.0	1570.37	
2378.0	724.81		55959.0	1584.58	
2379.0	725.12		56460.0	1598.77	
2380.0	725.42	50.09	56962.0	1612.98	
2381.0	725.73		57546.5	1629.54	
2382.0	726.03		58131.0	1646.09	
2383.0	726.34		58715.5	1662.64	
2384.0	726.64		59300.0	1679.19	
2385.0	726.95		59885.0	1695.75	
2386.0	727.25		60469.5	1712.31	
2387.0	727.56		61054.0	1728.86	
2388.0	727.86		61638.5	1745.41	
2389.0	728.17		62223.0	1761.96	
2390.0	728.47		62807.0	1778.50	
2391.0	728.78		63391.5	1795.05	
2392.0	729.08		63976.0	1811.60	
2393.0	729.39		64560.5	1828.15	
2394.0	729.69		65145.0	1844.70	
2395.0	730.00		65730.0	1861.27	
2396.0	730.30		66314.5	1877.82	
2397.0	730.61		66899.0	1894.37	
2398.0	730.91		67483.5	1910.92	
2399.0	731.22		68068.0	1927.47	
2400.0	731.52	58.56	68652.0	1944.01	
2401.0	731.82		69268.0	1961.45	
2402.0	732.13		69884.0	1978.89	
2403.0	732.43	59.57	70500.0	1996.34	FRL
2404.0	732.74		71209.0	2016.41	

Idukki Reservoir - Elevation Vs. Storage & Water Spread Area

Water level in feet	Water level in m	Water spread area in Sq km	Storage in Mcft	Storage in Mm ³	Remarks
2405.0	733.04		71918.0	2036.49	
2406.0	733.35		72627.0	2056.57	
2407.0	733.65		73336.0	2076.64	
2408.0	733.96		74045.0	2096.72	
2408.5	734.11		74400.0	2106.77	MWL

Area Capacity Curve of Idukki Reservoir



Annexure - 4.2

Idukki Reservoir 10-Daily inflow Water Year (in MCM)																												
10-Daily	No. of Days	1994 - 95	1995 - 96	1996 - 97	1997 - 98	1998 - 99	1999 - 2000	2000 - 2001	2001 - 2002	2002 - 2003	2003 - 2004	2004 - 2005	2005 - 2006	2006 - 2007	2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015	2015 - 2016	2016 - 2017	2017 - 2018	2018 - 2019	2019 - 2020	2020 - 2021
June I	10		20.0	14.4	6.6	10.0	70.6	91.6	34.0	22.2	6.8	61.4	16.9	66.1	12.2	15.1	33.3	24.7	138.9	12.4	31.8	25.4	14.0	28.3	14.3	51.6	12.6	23.1
June II	10		93.9	87.1	6.9	23.7	175.5	78.6	92.8	43.6	10.9	211.0	52.9	22.6	35.2	30.4	19.9	124.4	129.3	40.4	145.7	46.8	30.4	49.2	23.8	225.3	17.5	29.9
June III	10		81.0	70.1	19.6	160.8	69.0	76.0	168.0	67.6	61.4	62.5	83.5	104.0	181.7	64.2	33.0	77.5	75.2	50.1	244.9	87.7	208.5	63.6	121.1	109.2	25.0	42.3
July I	10		125.8	21.5	82.1	156.6	49.9	130.1	323.6	55.4	47.6	76.1	120.5	109.5	277.9	59.8	142.4	89.7	58.8	77.9	183.2	45.7	66.5	81.4	54.5	90.2	26.9	58.2
July II	10		175.5	106.2	123.5	105.1	108.3	87.6	144.6	75.5	74.6	77.1	120.5	179.0	274.3	41.2	241.2	102.4	136.4	55.3	203.4	196.9	79.1	122.9	36.2	400.7	47.8	45.1
July III	11		108.5	340.1	206.6	154.2	209.4	33.2	60.6	66.7	67.2	83.5	389.0	93.2	131.3	167.9	85.8	162.2	150.1	67.4	244.2	151.2	142.1	74.6	52.9	308.7	98.7	64.9
Aug I	10		95.4	80.7	136.2	148.2	155.2	48.2	109.8	116.7	49.1	234.4	292.1	40.5	152.8	115.6	57.7	76.0	161.0	37.1	325.3	261.4	48.9	50.7	103.9	196.9	243.6	398.5
Aug II	10		58.5	142.4	62.9	153.9	62.3	92.6	60.8	171.3	68.5	87.8	66.4	154.4	112.8	157.0	57.8	99.2	114.8	83.6	108.1	89.3	94.8	60.2	63.7	872.2	216.3	123.7
Aug III	11		171.5	89.5	127.1	106.5	48.2	435.8	110.3	69.1	115.3	47.7	45.0	64.2	73.3	72.4	60.0	143.0	138.7	68.1	70.2	124.8	41.3	48.8	147.4	233.7	110.5	32.7
Sep I	10		346.8	65.2	57.7	100.9	42.6	77.9	37.3	30.4	50.1	30.4	228.0	33.5	80.3	111.1	160.1	80.5	151.3	106.2	76.2	162.4	40.9	30.8	112.1	79.1	169.5	40.2
Sep II	10		76.0	59.0	53.2	106.2	21.8	34.2	26.1	23.3	21.7	35.2	162.0	80.1	136.5	123.0	63.8	72.2	96.0	51.9	149.8	58.3	41.2	23.6	158.7	31.0	74.3	105.9
Sep III	10		46.1	103.1	59.7	82.3	26.9	55.4	47.9	14.9	14.1	49.4	51.8	83.7	182.9	34.8	50.9	72.9	42.5	28.1	102.4	47.2	50.9	29.6	90.2	55.5	50.6	181.5
Oct I	10		42.4	74.0	38.9	72.2	57.4	49.0	87.2	30.5	120.2	65.3	33.7	61.8	58.7	25.3	136.1	114.4	21.2	18.9	44.2	45.0	77.5	18.2	52.3	70.2	35.4	48.6
Oct II	10		33.2	106.1	31.5	240.7	102.7	36.5	59.2	60.3	78.9	66.6	42.4	89.0	70.9	29.3	42.6	70.3	47.7	39.9	57.4	49.3	56.2	23.8	61.0	77.1	32.4	118.1
Oct III	11		31.4	53.5	54.5	66.2	126.5	24.4	99.8	42.1	52.9	37.7	49.8	52.8	150.1	77.7	22.3	61.7	63.7	31.6	69.7	104.7	27.0	18.5	53.2	73.0	77.5	53.5
Nov I	10		47.0	30.7	101.1	66.1	40.3	14.3	95.7	33.5	23.7	29.8	38.9	70.3	91.5	26.8	45.7	43.1	69.6	23.7	28.2	90.5	37.9	15.7	50.1	30.2	51.6	43.5
Nov II	10		30.5	20.3	121.7	85.9	20.4	8.1	75.8	25.9	15.4	26.6	59.0	65.7	46.6	18.1	52.0	49.0	32.8	14.5	30.1	40.9	44.1	6.6	26.1	34.2	26.8	28.4
Nov III	10		19.9	21.1	59.9	34.0	29.7	19.6	35.3	16.5	11.9	15.0	36.9	76.1	25.0	21.2	23.7	75.8	27.1	13.0	33.6	22.8	40.1	5.4	14.5	24.2	12.8	21.7
Dec I	10		12.4	14.1	48.2	27.4	15.4	11.5	20.3	12.2	10.0	10.6	27.2	14.5	13.6	13.9	16.0	40.9	24.8	7.8	17.4	15.0	44.7	3.5	27.9	14.4	11.4	25.4
Dec II	10		8.3	16.5	34.7	80.6	10.5	6.9	13.1	8.7	6.9	5.9	25.2	11.0	17.3	9.7	16.1	19.5	13.8	5.1	12.1	14.1	29.2	2.6	18.2	9.3	6.5	13.6
Dec III	11		14.9	11.3	25.8	20.7	9.1	13.5	13.8	5.3	4.2	5.4	14.0	2.6	18.2	7.5	12.7	15.6	13.8	5.1	6.4	11.4	18.2	5.7	9.7	4.9	6.6	12.4
Jan I	10	2.7	10.9	12.7	11.4	12.5	10.5	11.7	12.1	5.7	4.5	7.1	8.6	10.4	7.4	4.0	8.1	18.5	12.0	5.1	4.7	8.8	8.6	3.4	7.4	5.9	5.5	
Jan II	10	9.1	9.5	10.6	10.4	8.0	9.7	4.0	9.6	3.3	6.4	8.7	8.3	7.8	7.1	3.3	7.5	10.0	9.6	1.6	12.3	7.8	7.3	2.6	5.8	6.9	4.9	
Jan III	11	15.6	4.4	7.8	8.9	4.2	6.8	3.1	7.5	3.2	7.9	9.9	3.4	5.3	12.4	4.9	5.9	3.6	6.9	2.4	6.7	6.6	6.9	4.0	6.1	6.7	5.1	
Feb I	10	4.1	7.1	7.3	3.8	15.0	10.8	9.8	8.6	2.3	7.7	9.2	8.7	6.6	12.2	3.5	2.4	8.2	6.8	2.6	5.4	4.2	8.3	3.7	6.1	6.7	4.9	
Feb II	10	1.4	8.2	12.2	9.4	10.7	7.2	8.7	11.0	5.8	4.9	5.7	8.6	3.0	11.1	1.7	7.5	9.7	8.5	2.1	4.0	6.4	6.6	2.8	3.9	6.6	3.2	
Feb III	8	0.2	6.5	7.7	7.8	7.4	18.0	6.8	5.8	5.1	3.2	3.0	4.5	4.6	5.7	4.1	7.1	15.9	5.6	1.4	4.0	2.4	6.0	5.0	4.7	3.2	2.3	
Mar I	10	10.5	5.6	7.5	7.4	5.8	13.7	5.9	9.2	8.7	3.1	10.5	5.5	9.2	11.0	7.0	8.6	8.2	9.3	4.4	11.9	10.7	6.3	9.3	10.0	4.0	4.5	
Mar II	10	12.9	7.3	10.6	4.5	7.6	10.3	4.8	9.5	14.1	3.8	9.5	12.4	9.0	14.6	9.6	6.6	5.6	8.5	6.3	5.7	3.5	5.3	8.7	8.8	9.1	3.6	
Mar III	11	11.0	8.6	15.9	4.6	10.8	8.8	12.0	14.0	7.4	6.8	10.0	15.4	9.6	19.6	8.9	9.0	17.5	13.7	8.9	8.6	10.8	10.2	8.6	7.9	9.7	4.0	
Apr I	10	10.8	9.2	15.5	9.4	14.0	16.2	9.8	11.5	5.1	5.9	10.8	9.6	9.5	14.4	7.5	9.0	12.3	11.4	6.8	8.1	9.2	11.2	6.2	6.3	6.9	8.2	
Apr II	10	14.3	19.6	12.0	10.9	10.2	11.2	22.8	9.4	5.8	8.3	11.6	20.1	14.5	13.4	6.8	10.1	14.8	8.4	5.8	5.2	29.6	8.3	10.8	10.7	6.1	7.3	
Apr III	10	12.8	14.3	9.7	10.0	13.7	10.4	14.8	15.5	4.8	6.2	12.3	14.5	16.3	16.9	6.8	10.7	34.8	13.7	7.3	13.9	39.7	5.8	8.4	12.4	14.6	10.1	
May I	10	40.5	8.9	22.5	10.7	15.1	11.9	8.8	15.7	9.4	22.0	17.0	15.8	9.0	9.5	8.8	14.6	19.2	11.0	4.8	24.7	24.2	7.1	7.8	12.6	11.8	6.9	
May II	10	69.0	6.5	16.4	14.4	15.4	16.0	14.0	23.9	8.8	32.4	10.7	15.9	12.8	16.5	10.6	14.5	14.2	9.6	3.6	17.2	27.3	13.8	13.1	21.9	9.8	10.8	
May III	11	25.2	11.6	9.5	13.5	111.1	14.1	19.5	28.4	7.4	49.6	9.7	68.9	19.2	15.3	17.4	17.4	16.8	10.3	4.7	17.9	23.9	12.2	6.5	35.4	14.4	12.0	

Annexure - 4.3

Monthly Rainfall at Idukki Reservoir (in mm)

Year/ Month	January	February	March	April	May	June	July	August	September	October	November	December	Total Annual Rainfall (mm) ³
1995	46.40	21.00	84.00	223.20	467.00	617.60	803.20	825.60	585.00	235.80	196.80	0.00	4105.60
1996	20.20	25.60	0.00	209.80	39.40	752.80	1042.50	538.30	449.80	312.00	113.40	65.60	3569.40
1997	0.00	0.00	51.80	75.90	203.60	419.20	1116.10	744.90	212.10	269.20	436.30	55.50	3584.60
1998	0.80	46.90	0.00	147.10	138.80	920.30	924.00	812.88	636.80	447.00	158.30	43.40	4276.28
1999	0.00	99.60	40.00	137.30	569.00	515.00	1105.70	449.20	149.58	519.40	67.50	5.00	3657.28
2000	2.50	136.10	3.00	66.50	202.90	1032.00	464.20	1121.80	256.30	128.00	70.00	30.40	3513.70
2001	31.00	23.60	6.60	212.80	164.10	1000.40	1009.90	618.50	157.00	598.90	130.20	45.00	3998.00
2002	0.00	8.20	71.00	60.40	334.80	534.80	793.40	689.80	108.30	395.40	105.70	3.00	3104.80
2003	0.00	28.00	91.40	149.00	113.60	467.20	634.60	640.40	162.80	528.20	38.50	2.60	2856.30
2004	0.00	4.20	77.40	110.50	545.60	766.90	698.40	665.50	284.10	245.30	55.80	0.00	3453.70
2005	25.80	14.00	79.30	198.20	145.00	545.70	1382.00	633.30	833.30	245.50	275.50	61.00	4438.60
2006	10.80	0.00	87.10	104.40	434.60	586.00	883.30	516.60	484.70	314.30	223.10	0.00	3644.90
2007	2.00	0.00	26.80	126.60	127.00	711.70	1155.60	575.50	713.10	419.30	71.50	49.00	3978.10
2008	0.00	46.90	230.50	105.40	15.30	547.30	656.20	661.00	404.60	287.80	37.80	0.00	2992.80
2009	9.20	77.00	109.80	65.80	154.40	411.50	1010.20	472.70	515.40	306.60	246.50	58.90	3438.00
2010	18.40	0.00	24.30	180.70	150.80	674.80	767.20	552.00	310.00	401.60	270.20	9.60	3359.60
2011	65.20	40.50	1.40	210.90	73.70	835.60	718.30	724.24	313.60	306.80	126.60	32.60	3449.44
2012	1.80	0.00	31.00	172.20	68.20	386.80	614.80	646.40	258.20	149.40	154.80	0.00	2483.60
2013	0.00	42.20	13.00	127.40	55.00	1202.40	1158.60	842.00	542.00	313.00	181.60	6.60	4483.80
2014	0.00	18.20	35.60	61.40	198.00	557.40	1093.80	1030.00	541.00	427.20	136.00	58.00	4156.60
2015	1.00	24.80	38.40	265.90	165.00	601.90	617.60	417.00	251.20	193.40	203.20	121.60	2901.00
2016	0.00	1.40	40.40	9.80	268.80	614.40	795.00	529.80	192.40	144.40	3.20	12.40	2612.00
2017	9.80	0.00	156.60	19.40	210.60	600.20	432.40	914.40	495.60	258.40	72.60	31.80	3201.80
2018	0.80	28.60	6.60	111.60	250.20	827.60	1594.40	1710.60	229.20	200.40	152.00	0.80	5112.80
2019	6.80	9.00	12.00	131.00	9.80	247.00	603.50	886.20	465.00	224.30	169.10	0.60	2764.30
2020	0.00	0.00	9.00	148.00	102.20	416.40	497.00	937.80	635.00	275.20	91.80	25.20	3137.60

Annexure - 4.4

Idukki Reservoir Annual Evaporation Loss (Given by KSEB in MCM)		
	Non-Leap Year	Leap Year
Jan	5.80	5.80
Feb	6.02	6.24
Mar	7.56	7.56
Apr	6.06	6.06
May	4.81	4.81
Jun	3.87	3.87
Jul	3.66	3.66
Aug	3.91	3.91
Sep	3.90	3.90
Oct	4.50	4.50
Nov	4.35	4.35
Dec	5.30	5.30
Total Annual (MCM)	59.73	59.94

Evaporation Loss as per CWC Booklet (Evaporation Control in Reservoirs 2006)			
Month	Daily Loss (mm)	Day	Monthly (mm)
Jan	5	31	155
Feb	5	29	145
Mar	6	31	186
Apr	5	30	150
May	5	31	155
Jun	5	30	150
Jul	4	31	124
Aug	5	31	155
Sep	4	30	120
Oct	4	31	124
Nov	4	30	120
Dec	4	31	124
	Total (mm annually)		1708

CHAPTER-5: GEOLOGICAL STUDIES

CHAPTER – 5

5. GEOLOGICAL AND CONSTRUCTION MATERIAL STUDIES

5.1 Introduction

The Idukki Hydroelectric Project is the biggest Hydroelectric Project on Periyar River Basin in Kerala. It comprises of three dams, namely Idukki, Cheruthony and Kulamavu with interconnecting reservoirs. The 169m high Idukki dam is the first arch dam in India and other two dams of Idukki reservoir system are concrete gravity dams. The water is drawn from Kulamavu Reservoir through the power intake of the existing HE project. KSEBL in early 2000 explored the concept of Extension Schemes/Capacity Addition on eco-friendly manner to meet the increased peak/off peak demand in the state. Idukki extension scheme falls in toposheet no. 58 C/13 and the project area is bounded by Lat. N 9°45'to N 9°50'and Long. E 76°30' to 77°10' (**Fig-5.1**). In this regards, a PFR was prepared by KSEBL keeping this Extension scheme parallel and close vicinity of the existing project, but doubting the combined discharge capacity of Thodupuzha River, a long TRT (about 8Km) was proposed to discharge the tail water at the Malankara Reservoir created across Thodupuzha River at the downstream. The newly proposed hydroelectric extension scheme envisages construction of a head race tunnel, butterfly valve chamber, surge shaft, pressure shaft, an underground powerhouse (UGPH) TRT and TRC . The diverted water from UGPH will be collected at the existing Malankara Reservoir located at lower reaches through a tailrace tunnel and channel. The Full Reservoir Level of existing Idukki Reservoir is at El.732.43 m and Dead Storage level at El.694.94m. The proposed project will generate 800 MW of power by utilizing net design head of 654.57m. KSEBL has allotted the work to WAPCOS for preparation of FR and DPR.

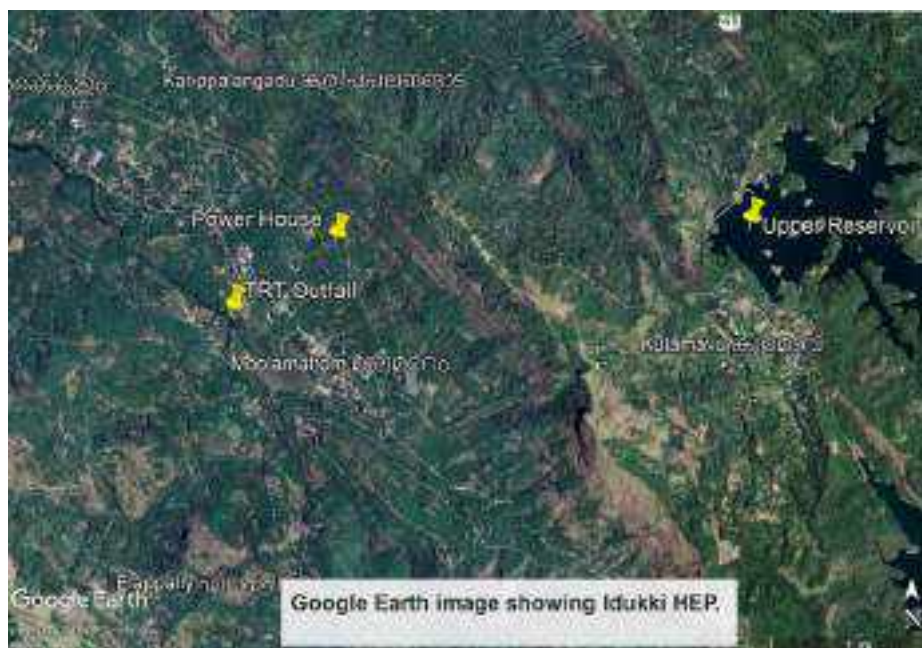


Fig.5.1. Google Earth image showing the proposed project area of Idukki HEP

5.2 Objective of Study

The aim of this report is to study the geological feasibility of the project components from District Resource Map for preparation of FSR and DPR for construction of the project for perspective development.

5.3 Regional Geomorphology and Geology

The project area is surrounded by hilly terrain and the predominant landforms in the project area are structural and denudational hills. Physio-graphically the state can be divided into four domains from east to west, viz., the Western Ghats, the foothills, the midland and the coastal low- land. Kerala is drained by 44 rivers, many of which originate from the Western Ghats. Except Kabini, Bhavani and Pambar which are east - flowing, the rest of rivers are west- flowing and join the Arabian Sea. A few of them drain into the backwaters of the Arabian Sea. Most important rivers (with their length in km in parenthesis of the state, are Chandragiri (105), Valapatnam (110), Achankovil (120) Kallada (121), Uvattupuzha (121), Chalakudy (130), Kadalundi(130), Chaliyar (169), Pampa (176),Bharathapuzha(209) and Periyar (244).

The hills are formed of Precambrian basement rocks and have a soil cover. A major part of the district falls in the hill ranges of Western Ghats except for Thodupuzha block and western part of Elamdesam block which fall in the mid land region of the State. The average elevation of the mid land region ranges from 40 – 60 m AMSL. The mid land area is characterized by rugged topography formed by small hillocks separated by deep valleys. The general slope of the area is towards west. The hill ranges can be subdivided into foot hills, plateau region and high ranges. The foot hill region is a narrow strip of land where midland region grades into the plateau regions. The elevation of this region ranges from 80 to 500m AMSL and slope is very steep, ranging from 30 to 50% and occasionally up to 80%. The width of the foot hill ranges from 2 to 8 km. Plateau region is the most important physiographic unit of the district and is characterized by moderately sloping large land mass with a slope of less than 30 % and an elevation of less than 1500m AMSL. Major part of the district fall in this region. The region is incised by a number of deep cut streams. Presence of two former planation surfaces were deciphered on the basis of the maturity of the landscape, accordance of summits and the residual cover over them. The older surface has an elevation of more than 1200m whereas the younger one has between 900 and 1200m. Along the western margin, valley flats are developed due to dissection by the rivers. Major part of the district is drained by Periyar River. Northeastern and western parts are drained by Pambar and Muvattupuzha rivers respectively. Anaimudi (2695m) the highest peak of South India is along the northeastern part of the district. Other peaks are Kewarikkat mala (2523m) and Chunduvurai mala (2525m). The area in the north eastern part of the district is characterized by high mountains with elevation more than 1500 m AMSL. The highest peak in South India, Anamudi (2693 m AMSL) is in the north central part of the district. There are several steep falls within the region (**Fig.5.2**).

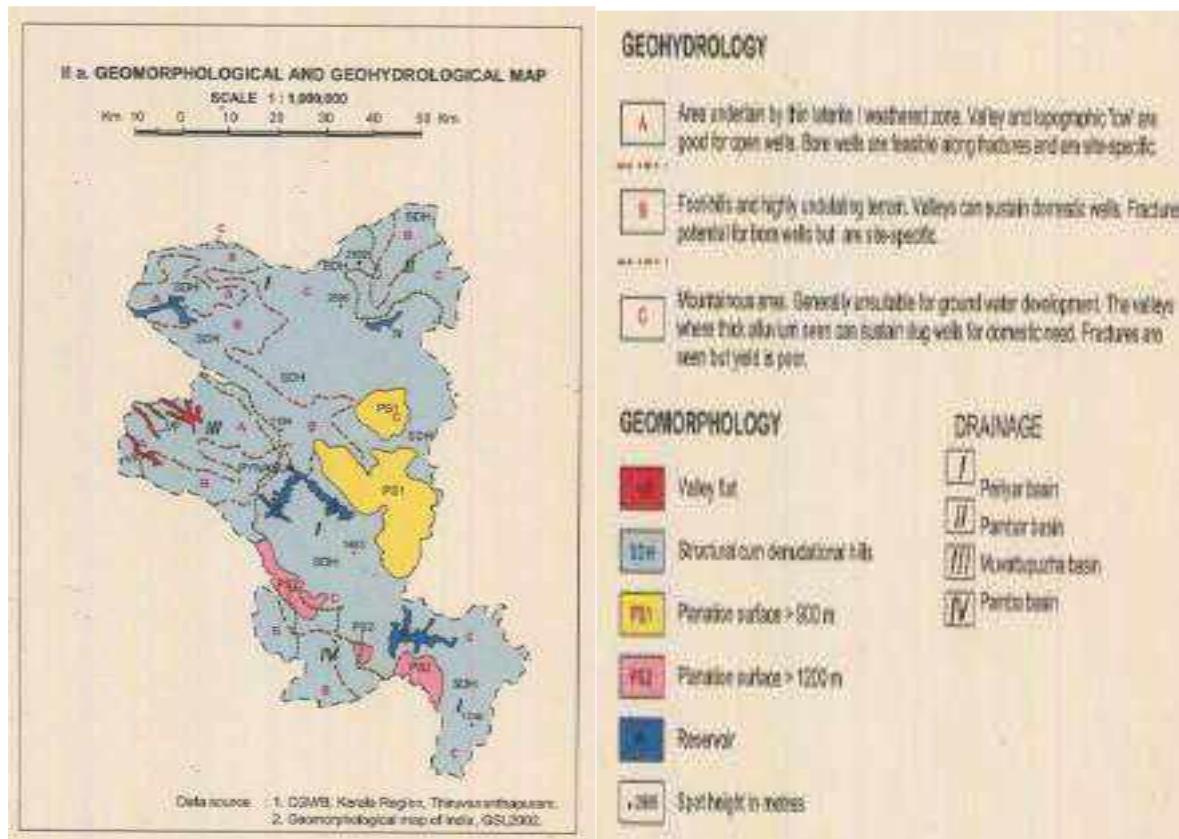


Fig.5.2. Regional Geomorphology of the Idukki District

Geologically, Kerala is occupied by Precambrian crystallines, acid to ultrabasic intrusives of Archaean to Proterozoic age, Tertiary (Mio-Pliocene) sedimentary rocks and Quaternary sediments of fluvial and marine origin. Both the crystallines and the Tertiary sediments have been extensively lateritised. Geologically the district can be divided into three major belts in a north-south direction (i) Peninsular Gneissic Complex in the north and (ii) Charnockite Group of rocks in the south and (iii) Migmatitic Complex in between.

The stratigraphic succession of the Kerala State is given below-

Quaternary (Q)	Pebble bed Kadappuram Formation (marine) Perniyar Formation (fluvial) Vivayam Formation (fluvio-marine) Guruvayur Formation (Palaeo-marine)
Mio-Pliocene (N 12) (Tertiary Tt)	Laterite Warkali Formation (Sandstone and clay with lignite intercalations) Quilon Formation (Fossiliferous limestone and calcareous marl).
Mesozoic (61-144 Ma.)	Gabbro / Dolerite dykes

P	Younger granites (550-390Ma)	Alkali granites, granite, Granophyres and other acid intrusives
R		
O	Charnockites(Younger) (550Ma)	Massive charnockite, incipient charnockite, Cordierite charnockite
T		
E	Ultrabasic/basics(Younger) (700-600Ma)	Fernthalta anorthosite, Kartikulam gabbro, Adakkathoda gabbro, Begur diorite
R		
O	Basic Intrusives (2100-1600Ma)	Agali-Anakkathi dykes
Z		
O	Migmatite-gneiss/older granitoid(PGC II) (Ptm)(2500-2200Ma)	Garnet-biotite - gneiss with associated migmatites, quartz-feldspathic gneiss, hornblende gneiss, hornblende-biotite gneiss, quartz-mica gneiss
I	Vengad (APre) Group	Quartz-mica schist and quartzite, conglomerate
C		
A	Charnockite(older) (Ac) 2600Ma	Mafic granulite, pyroxene granulite, Banded magnetite quartzite and gneissic charnockite
R		
C	Khondalite Group (Ak)	Quartzite, mafic granulite, calc-granulite garnet-biotite-sillimanite-cordierite gneiss, garnet-biotite gneiss, leptynite
H	Peninsular Gneissic Complex (PGC I) (Ap) (3000Ma)	Foliated granite, hornblende gneiss, pink granite gneiss, biotite gneiss
A	Layerd ultrabasic - basic Complex (3100-3000Ma)	Peridotite, dunite, pyroxenite, anorthosite
E		
A	Wynad Schist Complex (Aw)(3200Ma)	Talc-tremolite schist, fuchsite quartzite, amphibolite, calc granulite, quartz sericite schist, kyanite quartzite, garnet-sillimanite gneiss schist, magnetite quartzite, kyanite mica schist
N		

Unknown Base

The oldest rock of the area belongs to Peninsular Gneissic Complex represented by granite gneiss. The rocks are well foliated and show regional folding as well. Khondalite group is represented by calc- granulite and quartzite. These rocks are seen as linear bands, lenticular bodies or enclaves, mostly within the gneissic terrain. The charnockitic Group comprises of pyroxene granulite, magnetite quartzite and charnockite among which the charnockite is dominant and widespread. Pyroxene granulite and magnetite quartzite occur as linear bands of a few metre width and a few tens of metre in length within the gneissic terrain. They are aligned generally parallel to the trend of foliation. charnockite occurs as continuous rock unit covering the hilly region in the south and northwest. It is mostly massive but gneissic

varieties are also seen, with intermediate to acidic in composition. Central, northeast and southeast parts of the district are dominated by rocks of migmatitic complex comprising of biotite gneiss and hornblende-biotite gneiss (composite gneiss). While the south central part around Pynavu and Thodupuzha is occupied by biotite gneiss, the north eastern and south eastern parts are covered by hornblende biotite gneiss. The biotite gneiss has plenty of restites of older Khondalite and Charnockite Groups of rocks occurring as lensoidal and linear bodies, conformable with the trend of foliation. Granite emplacement is seen around Munnar, Devikolam and along the eastern boundary. Both pink and grey varieties of granite intrusive are present. The older rocks are traversed by pegmatites and quartz veins and basic intrusive (dolerite and gabbro) (**Fig.5.3**).

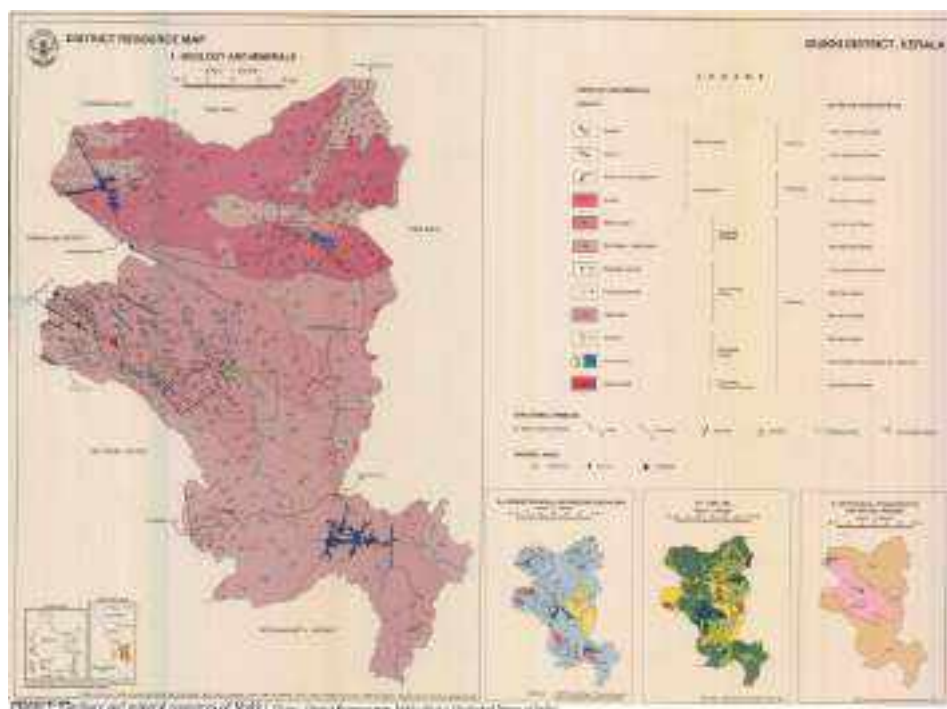


Fig5.3. District Resource Map of Idukki showing biotite gneiss in the proposed project area of Idukki extension scheme and existing Idukki & Kulamavu Reservoir

A series of NW-SE, NE-SW & NNW-SSE trending lineaments (shear, fault) are also present in the area as reflected on District Resource Map of GSI on 1:2,50,000 scale (**Plate-5.I**).

There are four major soil types encountered in the district. They are forest loams, lateritic soils, brown hydromorphic soils and alluvial soils. About 60 % of the district is

covered under forest loams which are the product of weathering of the rock under forest cover. They are characterized by a surface layer very rich in organic matter. They are generally acidic, high in nitrogen and poor in bases, due to heavy leaching. They are dark reddish brown to black with loamy to silty loam texture. In denuded areas leaching and deposition of humus in the lower layer of soil profile is common. The lateritic soils are derived from laterites and are encountered mainly in Elamdesam and Thodupuzha blocks of the district. They are well-drained and are low in plant nutrients and organic matter. The fertility of the soil is generally poor with low available nitrogen and phosphorous. Brown hydromorphic soils are confined to valley portions in undulating terrain. These soils are formed as a result of transportation and sedimentation of materials from adjoining hill slopes and are brownish black in colour. The surface texture varies from sandy loam to clay. Alluvial soils are seen as narrow strips along the banks of rivers. They are more common along the banks of Thodupuzha River.

5.3.1 Seismicity

Idukki Extension Scheme Hydroelectric Project is located within metamorphic terrain comprises of pyroxene granulite, magnetite quartzite and charnockite among which the charnockite is dominant and widespread. Pyroxene granulite and magnetite quartzite occur as linear bands of a few metre width and a few tens of metre in length within the gneissic terrain. They are aligned generally parallel to the trend of foliation. Charnockite occurs as continuous rock unit covering the hilly region in the south and northwest. It is mostly massive but gneissic varieties are also seen, with intermediate to acidic in composition. These are belongs from Archaean to Proterozoic age. A series of NW-SE, NE-SW & NNW-SSE trending lineaments (shear, fault) are also present in the area as reflected on District Resource Map of GSI on 1:2,50,000 scale (Plate-I).

The area falls under seismic zone-III(Fig.4)as per Seismic Zonation Map of India(IS: 1893-2002, Part-1).

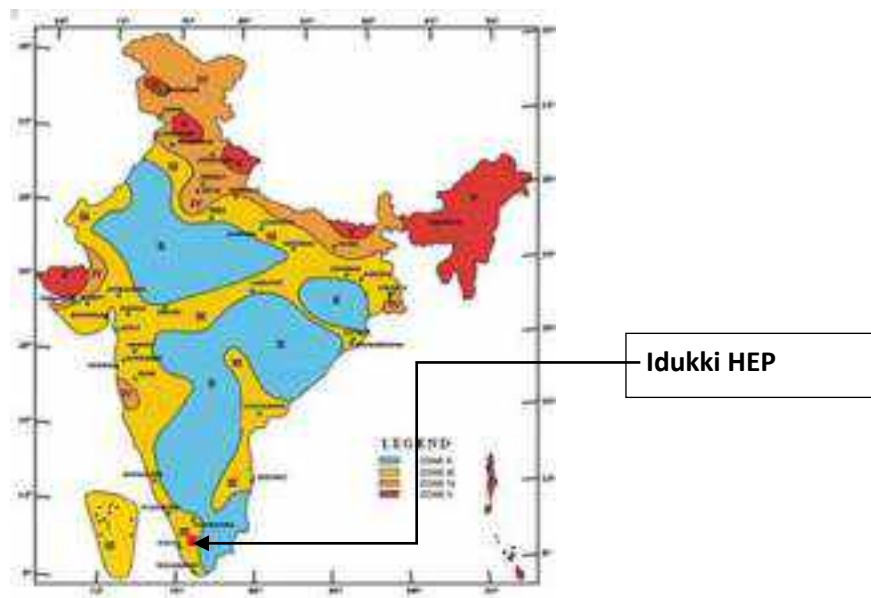


Fig.5.4. Seismic Zonation Map of India showing project area

Both deterministic and probabilistic approaches for evaluation of design ground motion for a project site require a comprehensive database on past earthquakes in the region of the project. It is proposed to consider the seismic design parameters of the existing Idukki Dam to be used. The seismo-tectonic map of the area (SEISAT-38) from Seismotectonic Atlas of India and its Environ, 2000, GSI is enclosed as **Fig 5.5.**

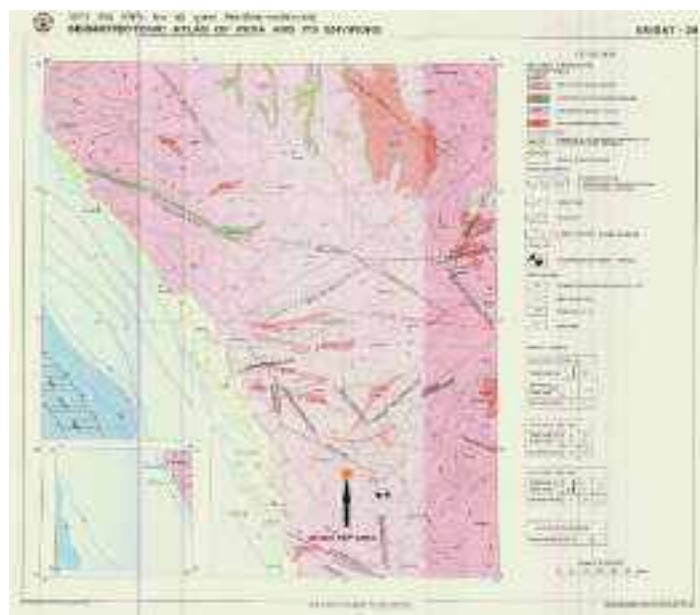


Fig.5: Seismotectonic map showing project area

5.3.2 Geomorphology and Geology of the Project Area

The project area lies in the southern region of the Idukki district of Kerala. Different types of landforms are found in the area like structural hills, denudational hills, shallow weathered pediplain, linear ridges & recent flood plain deposits.

Idukki district is represented by rocks of Archaean age. The main rock types encountered are charnockite, hornblende biotite gneiss and granite gneiss. Ground water occurs under water table condition in laterites and weathered mantle of crystalline rocks and under semi confined to confined conditions in the deeper fractured crystallines. Weathered and fractured crystallines form aquifers in the entire district. Laterites occur in the gentle slopes and valleys in Thodupuzha and western parts of Elamdesam blocks and as patches in Adimali, Nedumkandam and Kattapana blocks. They also form aquifers of low to moderate potentials in parts of the district. Alluvium, found in isolated discontinuous patches in the valleys and river banks do not constitute important aquifers in the district. The important hydro-geological units encountered in the district are laterites, weathered crystalline and fractured crystalline.

The slope forming material exposed along the road cuttings consists predominantly of crystalline rocks, and their highly weathered equivalents. The main rock types include biotite gneiss (granitic gneiss), hornblende biotite gneiss (composite gneiss), granite gneiss, charnockites and pyroxene granulite. These rocks are intruded by basic, acidic and alkaline intrusives. Pink granites are seen in the Munnar area. The general trend of foliation is NW-SE with deviations ranging from NNW-SSE to NNE-SSW. The foliation dip is steep to vertical (50° to 90°), low dips being rare. All these rocks are capped with varying thickness of weathered material. The thickness of the weathered material varies from 1 to 23 meter and is site specific. These weathered materials are less coherent and structurally anisotropic, which thus becomes one of the dominant lithology exposed in the area.

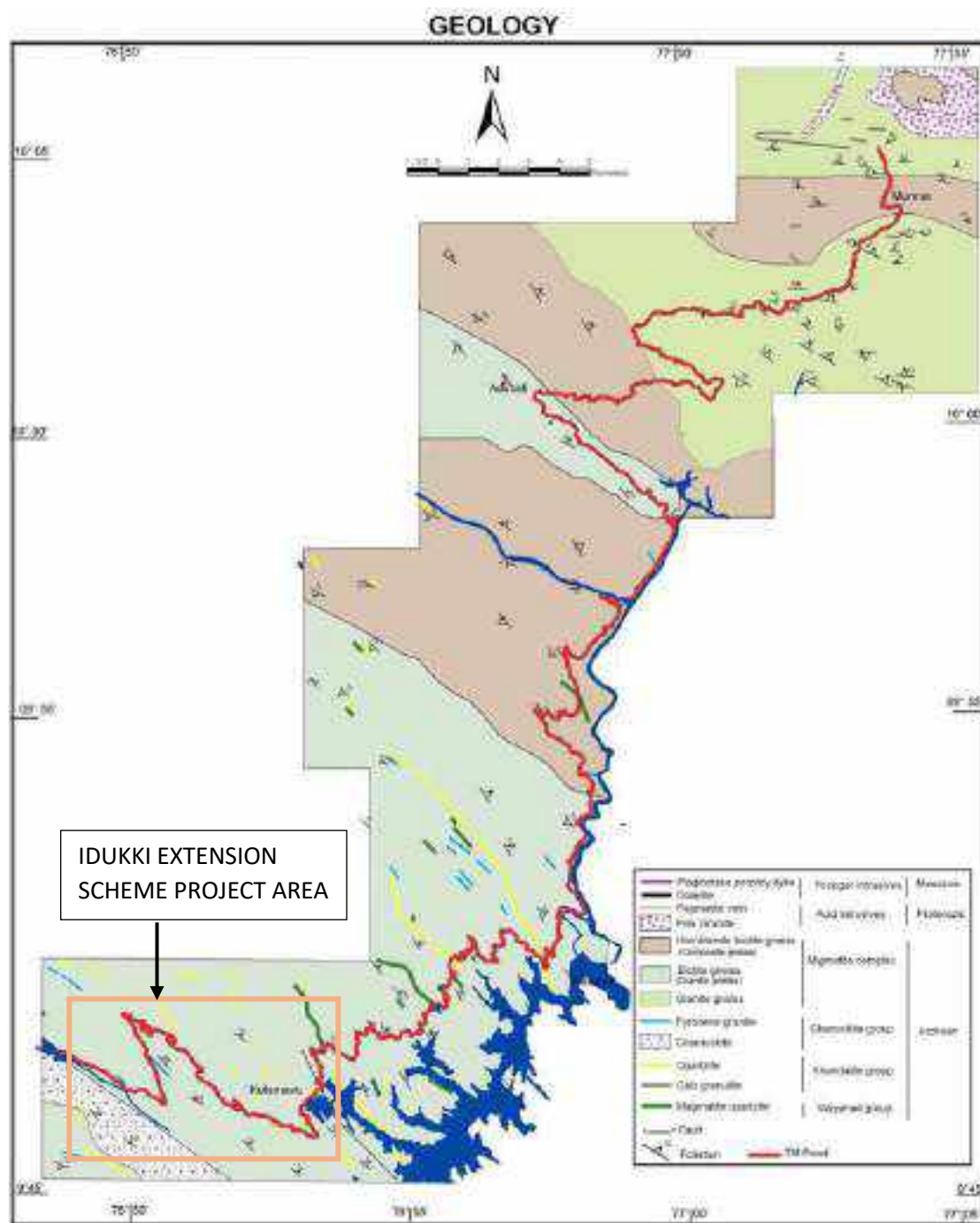


Fig 5.6: Geological Map of the project area (modified after GSI 1989; Source: P.ABRAHAM BIJU P and SHAJI E. et. al 2013)

The geological map reveals that majority of the area dominated by Granite gneiss and its variants and charnockite is present near Thodupuza i.e. at lower reaches (**Fig 5.6**).

Two options i.e. Alternative-1A, Alternative-1B and Alternative-2 have been studied on the basis of site visit and available sources (Geological map, District Resource Map etc) techno-economic feasibility. Alternative 1B was selected to go-ahead for the proposed scheme. Details of alternatives and criteria for selection of alternative has been discussed in detail in Chapter 7 of this FSR. Details wrt to geological point of view have been discussed below-

5.4 Geology of Civil Components

The proposed option is a conventional hydro-electric project similar to existing scheme. The component wise assessments are given below:

5.4.1 Intake

The proposed intake as per KESEB PFR, is located at the right bank of existing Kulamavu Reservoir at the upper reaches where elevation ranges from El.680.0m to El.750.0m (**Fig.5.7**). A conventional Trapezoidal type with anti-vortex louver intake is proposed to carry discharge capacity of 151 cumecs instead of Morning Glory type intake present at the existing project. The centre line of intake is fixed at EL 680.79 and the MDDL at EL 694.94. District Resource map (1:2,50,000 scale) & geological map (1:50,000 scale, **Fig.5.6**) study reveals that hard, competent granite gneiss is present. The location of the Intake has been optimized during site visit and new location has been marked at about 150m upstream of the existing dam, considering the presence of sporadic outcrops of gneissic rock at the right bank of the reservoir and plotted in the layout. An intake channel will be required from bell mouth to the MDDL of the reservoir, where excavation mainly in rock will be involved. The location of intake will be optimized after completion of survey works at the DPR stage.

The rockmass belonging to Class-II/III categories is anticipated to form the tunneling media, whereas Class-IV/V categories rockmass may be present at weak/shear zones.



Fig.5.7: View of Upper Kulamavu Reservoir near Intake area

Optimum layout requirements have been considered to suit the alignment of the Water Conductor in fixing the alignment of Power Intake. The intake will be connected to a head race tunnel of diameter 7.0m and length of about 1900.0m.

5.4.2 Intake Gate Shaft

The intake gate shaft location is proposed at 150 m d/s of the Intake location. However, the actual location of the same will be fixed after carrying out the topographical as well as geological investigation during DPR stage. Mainly slope wash material is present as overburden in the area. District Resource map (1:2,50,000 scale) & geological map (1:50,000 scale, **Fig.5.6**) study reveals that hard, competent granite gneiss is likely to be present. The rockmass is likely to be Class-II/III categories whereas Class-IV/V categories rockmass may be present at weak/shear zones. Actual support system will be assessed after carrying out geological mapping & sub-surface investigation during DPR stage.

5.4.3 Head Race Tunnel

One 1900.0 m long and 7.0m dia concrete lined Head Race Tunnel (HRT) has been proposed to carry a max discharge of 151 Cumec. At the proposed alignment chances of daylighting of HRT in the valley near the existing gate shaft was

anticipated. The maximum cover of HRT will be about 203m. Due to modification of intake and gate shaft, the alignment of the HRT has been reassessed so that adequate cover can be ensured, especially at the valley portion present at the initial stretch and same will be finalized after completion of Topographical Survey works at DPR stage.

District Resource map (1:2,50,000 scale) & geological map (1:50,000 scale, **Fig.5.6**) study reveals that hard, competent massive granite gneiss will form the tunneling media. The rockmass may likely belongs to Class-I/II/III categories whereas Class-IV/V categories rockmass may be present at weak/shear zones along the HRT. Installation of adequate and timely support in form of shotcrete, and rock bolts as primary support along with installation of steel ribs in very poor rockmass, if present at places and drainage of water away from the face by providing drainage holes prior to face advancement in water charged strata may be required. However, actual support system will be decided after geological investigations and data analysis at DPR stage. The detail surface geological mapping along the proposed HRT alignment & sub-surface geology through drill holes may also be required at certain reaches.

5.4.4 Surge Shaft

A restricted orifice type surge shaft is proposed for the project. The diameter of Surge shaft 10.0 m and of its orifice is 3.5 m. The exact location will be finalized after completion of topographical survey and geological mapping. Granite gneiss of Class-II/III categories is anticipated along the surge shaft except at weak/shear zones, if present, where rockmass may deteriorate to Class-IV/V.

5.4.5 Pressure Shaft

Two nos. of steel lined pressure shaft of 3.90 m dia. and 850.0 m long is also provided which will connect into four horizontal pressure tunnels at the bottom. The length of horizontal pressure tunnel will be about 55 m and 2.80m dia. In general, rock-bolts and shotcrete will be required as temporary support system.

Study of District Resource map (1:2, 50,000 scale) and geological map (1:50,000 scale, **Fig.5.6**) reveals that hard, competent granite gneiss will form the tunneling

media. The rockmass may belongs to Class-II/III categories whereas Class-IV/V categories rockmass may be present at weak/shear zones. Actual support system will be decided after geological investigations and analysis at DPR stage.

5.4.6 Powerhouse& Transformer Cavern

An underground Power House (UGPH) of size 146.0m (L) x 22m(W)x 44.5m (H) with a transformer cavern hall of 146m (L)x16m (W)x26.5m(H) have been proposed for this project which is about 550.0m north of the existing power house location. The Final alignment and location of the powerhouse will be reassessed after completion of topographical survey and geological mapping at site as there is chances of shifting the UGPH for a little distance to keep away from a valley and below the exposed rockmass. The power house will have four pelton turbines of 200 MW each. The design head for turbine mode as 654.57m has been assessed.

District Resource map (1:2,50,000 scale) & geological map (1:50,000 scale, **Fig.5.6**) study reveals that hard, competent massive granite gneiss will form the tunneling media. The rockmass may belongs to Class-I/II/III categories whereas Class-IV/V categories rockmass may be present at weak/shear zones, if encountered.

The general strike of gneissic rock is N42°W-S42°E with dip (50-70°) towards N48°E. The L-axis of powerhouse has been aligned along N3°E-S3°W. Therefore, the L-axis of powerhouse making an angle of 45° with the strike of the foliation. The alignment of powerhouse is found to be suitable considering the regional attitude of foliation. A tentative L-section has been prepared, where 309.0m cover is present at the centre of the powerhouse. Ingress of water along major discontinuities cannot be ruled out. Detailed surface and sub-surface geological investigations will be carried out at DPR stage for finalization of the orientation of powerhouse, realistic assessment of rockmass condition and to workout actual support system. An exploratory drift may also be required to know the rockmass condition inside the powerhouse.

5.4.7 Trail race Tunnel

Earlier for Alt-1A 6.92 m dia, 7.9 km long D shaped Tail Race Tunnel and 500m long Tail Race Channel had been proposed in the PFR, which prima facie seems to be

not feasible. Therefore, a TRT of shorter length (D-Shaped, 7.5 x 7.5m & 1465.0m) has been explored during the present assignment with new proposed surge shaft & powerhouse location and denoted as Alt-1B.

In addition, possibility of discharging the tail race water through natural drains near the Malankara Reservoir or discharge at the tail race channel of the existing Idukki Hydro-electric project has been explored. It also appears that Thoduphuza River in the upstream of Malankara Reservoir has capacity to discharge the tail water of the extension project also, as it is rating curve at various section (Refer Chapter 7) has capability to pass the required discharge.

Study of District Resource map (1:2,50,000 scale) & geological map (1:50,000 scale, **Fig.5.6**) reveals that hard, competent charnockite/ biotite gneiss may likely to form the tunnelling media. The rockmass belonging to Class-I/II/III categories is expected at the cavern, whereas Class-V/VI categories rockmass may be present at weak/shear zones, if encountered. Ingress of water along major discontinuities cannot be ruled out. The detail study of surface geological mapping and sub-surface explorations will be carried out during DPR stage to work out suitable rock support system depending upon the geological strata.

5.5 Construction Material

Coarse aggregate

Granite gneiss & its variants are the major rock type in the project area with some mafic intrusion at places. Fresh mafic rocks can be used as coarse aggregate of concrete as well as granite. However, determination of engineering properties and quantity assessment will be undertaken during DPR stage to know their suitability for wearing and non-wearing surfaces as well as availability insufficient quantities.

Fine aggregate

The sand deposit of Thodupuzha River may be utilized as fine aggregates. However, suitable quarry sites will be selected in DPR stage. The required tests will be done to know their suitability. In addition, the material from crushing of fresh rock (gneiss & mafic) may also be used as fine aggregate, if found suitable.

5.6 Conclusions and Recommendations

1. The proposed 800 MW Idukki Hydroelectric extension project is located in Idukki district, Kerala, India. The project area is bounded by Lat. N 9°45'to 9°50'and Long. E 76°30' to 77°10'. Idukki District is represented by rocks of Archaean age. Geologically the district can be divided into three major belts in a north-south direction (i) Peninsular Gneissic Complex in the north and (ii) Charnockite Group of rocks in the south and (iii) Migmatitic Complex in between. The oldest rock of the area belongs to Peninsular Gneissic Complex represented by granite gneiss. The main rock types are charnockite, hornblende biotite gneiss and granite gneiss.
2. The slope forming material exposed along the road cuttings consists predominantly of crystalline rocks, and their highly weathered equivalents. The main rock types include biotite gneiss (granitic gneiss), hornblende biotite gneiss (composite gneiss), granite gneiss, charnockites and pyroxene granulite. These rocks are intruded by basic, acidic and alkaline intrusives. Pink granites are seen in the Munnar area.
3. A PFR was prepared by KSESL keeping this Extension scheme (Alt-1A) parallel and close to the existing project, but doubting the combined discharge capacity of Thodupuzha River, a long TRT (about 7.9km) was proposed to discharge the tail water at the Malankara Reservoir created across Thodupuzha River at the downstream.
4. Various alternatives (Alt-1A, 1B & 2) have been considered and are being examined to evolve the most optimal scheme. Accordingly, two possible layouts are selected for further studies. Alternative-1A is as per the Layout proposed in Preliminary Report prepared by KSEB which is located northwards of the existing Idukki H. E. Project and involves approx. 7.9 km TRT Length. Considering 7.9 Km long TRT of Alternate-1A, it was found necessary to explore other possible alternatives. Accordingly, has shorter TRT (2.0 km length) for Alt-1B & Alt-2 were identified which is proposed southwards of the existing Idukki H.E. Project proposing a small downstream balancing reservoir to stagger the discharge from extension scheme to avoid flooding in Thodupuzha River thereby eliminating 7.9 km long TRT of Alt-1A.

5. The Alt-2 is worked out primarily as a pumped storage project as well as a conventional hydro-electric project similar to existing scheme. It was prima facie also felt that this balancing reservoir may act as Lower pond and a pumped storage scheme can also be thought off.
6. Alternate-1B: Competent granite gneiss may also be present at major portion of intake, surge shaft & HRT. At the powerhouse cavern granite gneiss will be present and same rock will form the tunneling media of TRT. Presence of charnockite at the later stretch of TRT cannot be ruled out. The rockmass is expected to be Class-I/III categories whereas Class-IV/V category rockmass may be present at weak/shear zones, if present. The general strike of granite gneiss is N42°W-S42°E with dip (50-70°) towards N48°E. The L-axis of powerhouse has been aligned along N3°E-S3°W. Therefore, the L-axis of powerhouse making an angle of 45° with the strike of the foliation. The alignment of powerhouse is found to be suitable considering the regional attitude of foliation.
7. Prima facie, on the basis of the preliminary geological studies, it can be concluded that no major geological surprise is envisaged. Geological setup is conducive for underground works. Overall geology of the project area is good and the project has merits for taking up for FSR / DPR stage investigations. Detailed investigations will be required during preparation of DPR.

8. Construction Material

- 8A. **Coarse aggregate:** Granite gneiss & its variants are the major rock type in the project area with some mafic intrusion at places. Fresh mafic rocks and granite can be used as coarse aggregate of concrete after determination of suitability and quantity assessment during DPR.
- 8B. **Fine aggregate:** The sand deposit of Thodupuzha River may be utilized as fine aggregates. The required tests will be done to know their suitability. In addition, the material from crushing of fresh rock (gneiss & mafic) may also be used as fine aggregate, if found suitable.

CHAPTER-6: PROJECT PLANNING & IC

CHAPTER – 6

6. POWER POTENTIAL & INSTALLED CAPACITY

6.1 Introduction

The proposed IDUKKI Extension Scheme H.E. Project aims to construct another underground power house preferably of similar range of installed capacity as existing scheme and then operating both power houses at peak hours to overcome the gap up to a certain extent between demand and availability of power during peak hours. Hence this is a storage type project but no dam or additional reservoir needs to be created for this project. The water available in the existing IDUKKI reservoir is proposed to be shared between two power houses through an efficient water management system.

The proposed project is located in the IDUKKI district of Kerala. The site is located at about 500m away from the existing underground power house at Moolamattom.

6.2 Objective of the Study

The demand of power in Kerala State is increasing at an average rate of about 8% per annum. Peak demand of Kerala has touched a figure 4131 MW in Year 2016-17. According to the 19th National Electricity Plan-2018, the anticipated peak demand in Kerala state will shoot up to 5263 MW in 2021-22 and 6603 MW in 2026-27. The demand will increase further in future and the demand supply gap widens. The installed capacity of Kerala State Electricity Board Ltd is 2232.44 MW. The deficit is being managed at present by power purchase from external sources. To reduce the peak deficit, it is essential to implement new projects which can cater power during peak hours and also to reduce the power purchase during peak hours at peak rates, which in turn will help to achieve financial stability of the power utility.

Accordingly, the Idukki Extension Scheme is envisaged as a hydroelectric peaking station by sharing the daily water drawl from the existing Idukki reservoir to reduce the power purchase during peak hours

6.3 Assessment of peaking hours for optimization of Potential of Idukki reservoir

The maximum demand in particular day in a particular month for the State of Kerala is available in the monthly progress report prepared by Southern regional load dispatch centre. The Data has been extracted and is presented at **Table 6.1**

Table 6.1: Maximum Demand Data

Date	Max Demand (MW)	Min Demand (MW)	Peak duration	Peak hours
07 Oct 2020	3491	2436	18.08 - 21.52	4 hours
26 Mar 2021	3936	2771	18.09- 22.00	4 hours and 9 min.
09 Aug 2021	3297	2660	18.09- 22.00	4 hours and 9 min.

It is observed from above that peak power of 4-4.15 hours may reduce the power purchase during peak hours at peak rates, which in turn will help to achieve financial stability of the power utility.

The power demand graphs of Kerala state on maximum demand day in particular month is presented at **Figure 6.1**

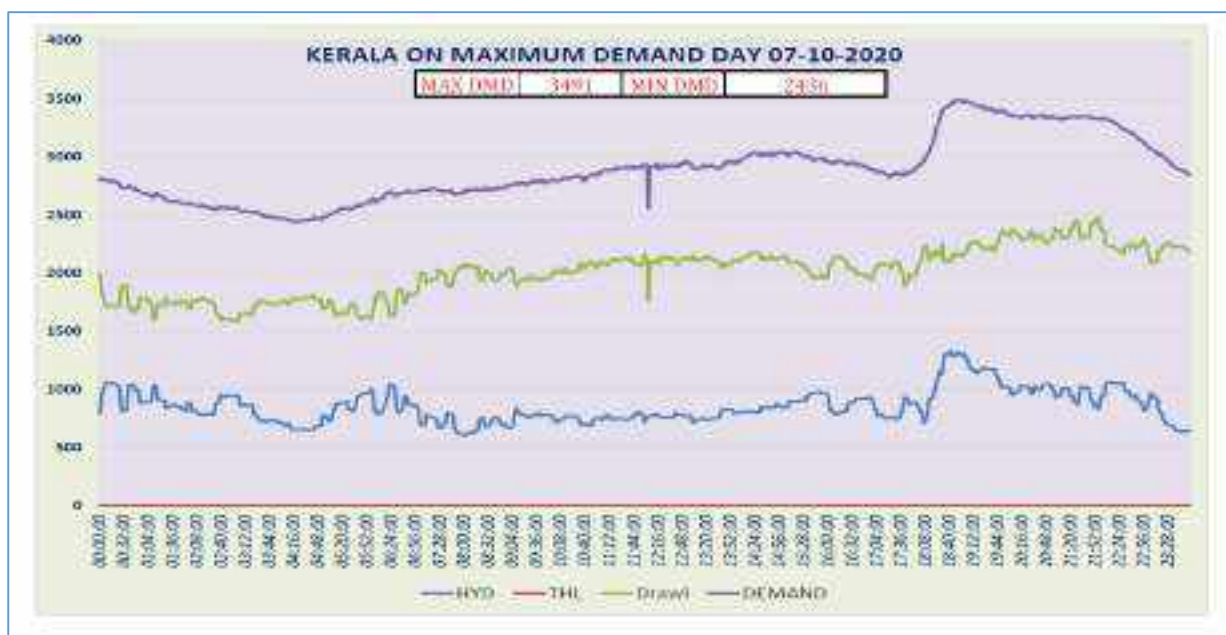


Fig 6.1: Power Kerala on Maximum Demand Day 07.10.2020

Peak starts at 18.08 and finished at 21.52 – Total 4 hours.

Peak starts at 18.09 and finished at 22.00 – Total 4 hours and 9 min.

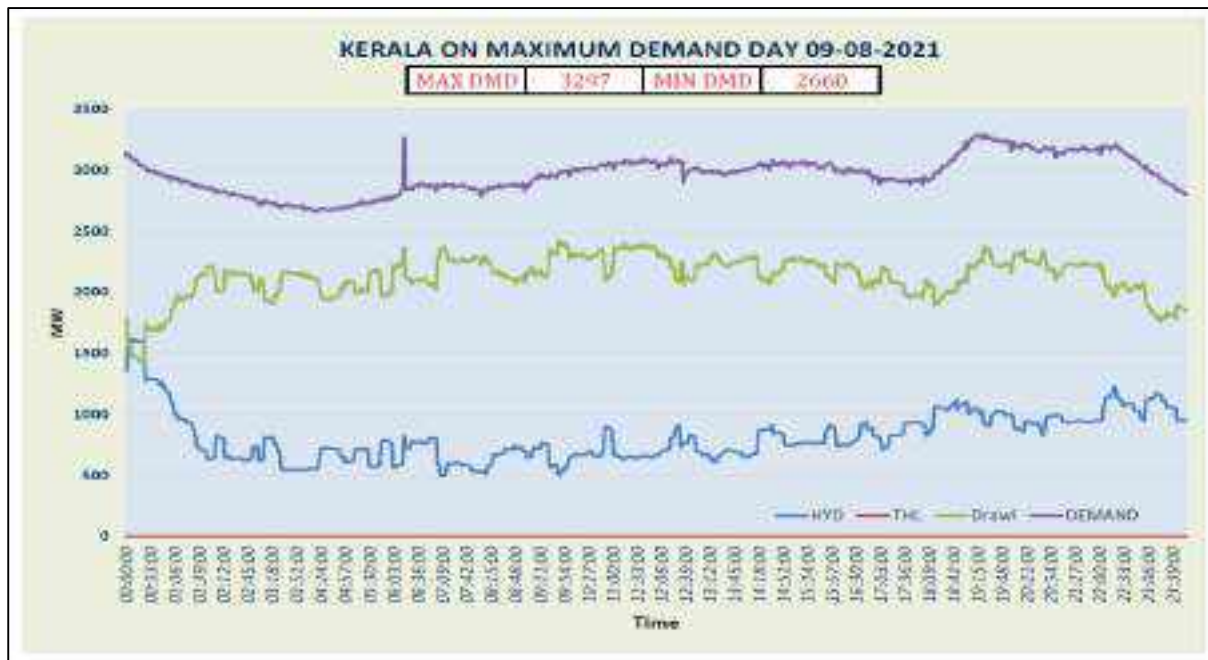


Fig 6.2: Power Kerala on Maximum Demand Day 09.08.2021

Peak starts at 18.09 and finished at 22.00 – Total 4 hours and 9 min.

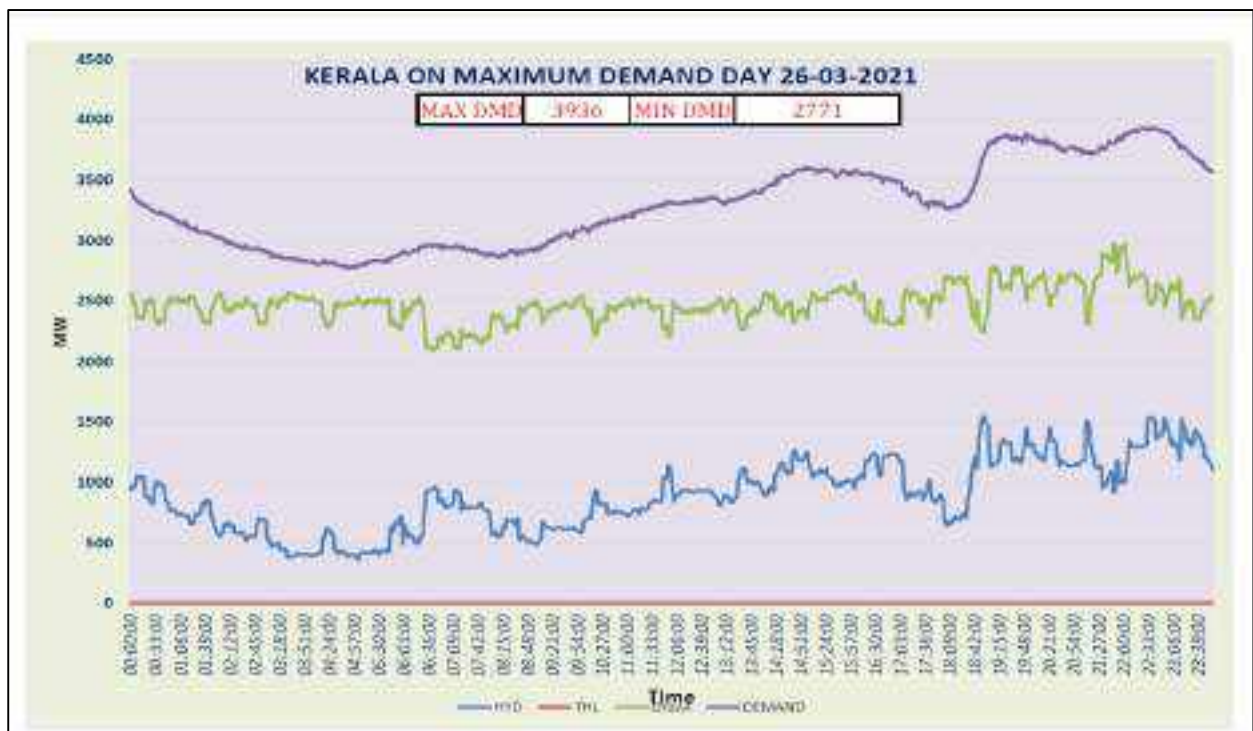


Fig 6.3: Power Kerala on Maximum Demand Day 26.03.2021

6.4 Reservoir Parameters

The operation simulation of the two reservoirs for pumped storage operation has been carried out considering the storage characteristics. The simulation has been carried out considering a shorter time interval of 10 minutes to take into account the level variations in the two reservoirs.

6.4.1 Full Reservoir Level

The Full reservoir level (FRL) of the proposed Idukki Extension Scheme has been kept at El. 732.43 m as per the existing IHEP.

6.4.2 Minimum Draw Down Level

The Minimum Draw Down level (MDDL) of the proposed Idukki Extension Scheme has been kept at El. 694.94 m as per the existing IHEP.

6.4.3 Tail Water Level

Maximum tail water level has been derived keeping maximum discharge and has been kept as El. 49. m based on the rating curve at TRC outfall near Triveni.

6.4.4 Reservoir Elevation-Area -Capacity Characteristic

Elevation- Area Capacity curve is presented in Chapter-4: Hydrological Studies at Annexure-4.1.

6.4.5 Water Conductor Losses.

The water conductor losses due to friction losses, bend losses etc. in the intake, head race tunnel, and penstock etc. has been taken as 10.5 m on the discharge through water conductor system.

6.4.6 Rated Head.

Considering the FRL at El. 732.43 m, MDDL at El. 694.94 m, and maximum TWL at El. 49.3 m, the Turbine Centre line of proposed Idukki Extension Scheme has been

fixed at El. 54.86. Accordingly, rated net head is determined as 654.57 m with a variation from 629.58 m to 677.07 m.

6.4.7 Evaporation Losses.

The monthly evaporation losses considered for the simulation studies has been taken from previous studies and is presented in Chapter-4: Hydrological Studies at Annexure-4.4.

6.5 Generating Units Efficiency

6.5.1 Turbine Efficiency

On the considerations of the head available for power generation the pelton turbines have been proposed. Uniform average efficiency of the turbines has been adopted as 93 % for all the alternatives.

6.5.2 Generator Efficiency

The efficiency of the generator has been adopted as 98.6 %.

6.5.3 Combined Efficiency

The combined efficiency of the Turbine- Generator set has been adopted as 91.70 %.

6.6 Power Potential Studies

The power potential studies have been carried out on carry over basis for the period of 1995-96 to 2019-2020 totaling to 25 years of 10 daily inflows also, considering the optimized FRL at EL. 732.43 m, MDDL at El. 694.94 m and maximum TWL at El. 49.3 m.

The studies have also taken into account for the evaporation losses and losses in the water conductor system.

Detailed reservoir operation simulation studies of the system are carried out to assess the power potential of the project.

The studies have been made on 90% dependability basis wherein the failure in the generation of firm power has been allowed for 2 years. The dependability has been determined as given below:

$$90\% \text{ dependable year} = (N+1) 0.9$$

Where N is the number of years for which inflow discharge series is available.

Here, N = 25

$$\text{Hence, } 90\% \text{ dependable year} = (25+1) \times 0.9 = 26 \times 0.9 = 23.4 = 23\text{th year,}$$

i.e. 2 failures are permissible.

The Firm Power is the minimum power produced in MW continuous on monthly basis in a 90% dependable year. The Firm Power and desirable load factor which in turn is dependent on power system requirement are the factors which determines the installed capacity of a peaking stations which provides peaking benefits throughout the year.

The study indicates that the plant would afford a firm power of 271.6 MW with allowing the maximum 2 failures.

The detailed reservoir operation simulation studies have initially been carried out with no restrictions on the installed capacity at Idduki Hydro Electric Project with firm power of 271.6 MW which reveals :

- The annual energy potential varies from a minimum of 2313.02 GWh to a maximum of 3669.67 GWh.
- The average annual energy unrestricted potential at Idukki reservoir is 2587.35 GWh

The year wise summary of the unrestricted potential for 25 years period from (1995-95 to -2019-20) is presented at **Annexure – 6.1**

Normally, Hydro generating station play an important role in the ease with which ramping requirement during peak hours can be met. Hydro generator are also expected to play a prominent role in providing balancing capacity as more and more renewable energy get integrated into the grid. Accordingly, study has been done for the restricted installed capacity varying from 1460 MW to 1640 MW and outcome of the studies are presented at **Table 6.2** are as under :

Table 6.2:

S. No.	Firm Power (MW)	IC (MW)	Peaking Hours	Average Annual Energy (GWh)	KWh/ KW	Incremental Average Annual Energy	Average annual Load Factor (%)
1	271.60	1460.00	4.46	2568.54	1759.27	-	20.08
2	271.60	1490.00	4.37	2568.84	1724.05	10.00	19.68
3	271.60	1520.00	4.29	2569.12	1690.21	9.33	19.29
4	271.60	1550.00	4.21	2569.41	1657.68	9.67	18.92
5	271.60	1580.00	4.13	2569.70	1626.39	9.68	18.57
6	271.60	1610.00	4.05	2569.99	1596.27	9.66	18.22
7	271.60	1640.00	3.97	2570.08	1567.12	3.00	17.89

It is seen from the above table that annual energy benefits are decreasing after 1580 MW, therefore, 1580 MW can be chosen as the optimum power potential at Idduki Reservoir.

Detailed reservoir simulation study for all the 25 years from Year 1995-96 – 2019-20 is presented at **Annexure - 6.2**

6.7 Conclusion

The power potential studies have been carried out for power potential with idduki reservoir and can be optimized upto 1580 MW based on the 25 years of hydrological data. The carryover reservoirs simulation studies carried out for FRL at El. 732.43 m, MDDL at El. 694.94 m and maximum TWL ot El. 49.3 m.

The studies indicate that the project would afford a firm power of 271.6 MW cont. on 90% dependable basis with an installed capacity of 1580 MW.

Further, as existing Idukki Hydroelectric project is operating at 780 MW with 6 nos. of unit of 130 MW each. Therefore Idduki Extension Scheme is proposed to have an Installed Capacity of 800 MW wherein 4 nos. units is recommended with unit size of 200 MW each with Tecno-economic consideration.

The scenario of Idduki reservoir having integrated operation of Idduki existing HEP and proposed Idduki Extension Scheme and both the projects in standalone operation is presented at **Table 6.3:**

Table 6.3:

Particulars	Total potential with Idduki reservoir	Idduki HEP (existing) – Standalone operation	Idduki HEP (extension) – Standalone operation
Installed Capacity (MW)	1580 (780 MW + 800 MW)	780 (6x780 MW)	800 (4x200 MW)
Firm Power (MW)	271.6	271.6	271.6
Average Annual Energy (GWh)	2569.70	2535.20	2537.44
Firm Energy (GWh)	2379.22	2379.22	2379.22
Secondary Energy (GWh)	190.48	155.98	158.22
Annual Load Factor (%)	18.57	37.10	36.20
Daily (min) Peaking hours in lean flow	Approx. 4.13	Approx. 8.35	Approx. 8.15

In view of the above, the following **Table 6.4** clearly depicts the share of Idduki existing HEP and proposed Idduki Extension Scheme in Integrated operation of Idduki HEP.

Table 6.4:

tem	Total potential with Idduki reservoir	Share in integrated operation	
		Idduki HEP (existing)	Idduki HEP (extension)
Installed Capacity (MW)	1580 (780 MW + 800 MW)	780 (6x780 MW)	800 (4x200 MW)
Firm Power (MW)	271.6	271.6	271.6
Average Annual Energy (GWh)	2569.70 (Peak Energy – 2379.22 Off Peak Energy – 190.48)	1268.42 (Peak Energy – 1174.39 Off Peak Energy – 94.03)	1301.27 (Peak Energy – 1204.83 Off Peak Energy – 96.45)
Daily (min) Peaking hours in lean flow	Approx. 4.13 hours		

Annexure - 6.1

IDUKKI EXTENSION SCHEME H.E. PROJECT
SUMMARY OF UNRESTRICTED POTENTIALS

S.no.	Year	Firm Power	Firm Energy	Sec. Energy	Total Energy
		MW	GWh	GWh	GWh
1	1995-96	267.53	2344.07	0.00	2344.07
2	1996-97	271.60	2379.22	0.00	2379.22
3	1997-98	271.60	2379.22	0.00	2379.22
4	1998-99	271.60	2379.22	293.81	2673.02
5	1999-20	271.60	2379.22	481.77	2860.99
6	2000-01	271.60	2379.22	248.25	2627.47
7	2001-02	271.60	2379.22	376.99	2756.20
8	2002-03	271.60	2379.22	0.00	2379.22
9	2003-04	271.60	2379.22	0.00	2379.22
10	2004-05	264.55	2313.02	0.00	2313.02
11	2005-06	266.97	2339.20	0.00	2339.20
12	2006-07	271.60	2379.22	0.00	2379.22
13	2007-08	271.60	2379.22	1084.12	3463.33
14	2008-09	271.60	2379.22	0.00	2379.22
15	2009-10	271.60	2379.22	0.00	2379.22
16	2010-11	271.60	2379.22	18.30	2397.52
17	2011-12	271.60	2379.22	725.20	3104.41
18	2012-13	271.60	2379.22	0.00	2379.22
19	2013-14	271.60	2379.22	334.80	2714.02
20	2014-15	271.60	2379.22	490.97	2870.19
21	2015-16	271.60	2379.22	0.00	2379.22
22	2016-17	271.60	2379.22	0.00	2379.22
23	2017-18	271.60	2379.22	0.00	2379.22
24	2018-19	271.60	2379.22	1290.45	3669.67
25	2019-20	271.60	2379.22	0.00	2379.22
Avg. Annual Energy (GWh)					2587.35

Annexure - 6.2

**IDUKKI EXTENSION SCHEME H. E. PROJECT, (4 X200 MW)
SUMMARY OF RESULTS OF POWER POTENTIAL STUDIES**

Firm Power (MW)	271.6
IC (MW)	1580.00
T.G.EFF.	91.70%
W.C.Losses (m)	10.5
Annual LF	18.57%
Load Factor	17.19%
Failure Years (nos)	2.00

S.no.	Year	Firm Power	Firm Energy	Sec. Energy	Total Energy
		(MW)	(GWh)	(GWh)	(GWh)
1	1995-96	267.53	2344.07	0.00	2344.07
2	1996-97	271.60	2379.22	0.00	2379.22
3	1997-98	271.60	2379.22	0.00	2379.22
4	1998-99	271.60	2379.22	293.81	2673.02
5	1999-20	271.60	2379.22	481.77	2860.99
6	2000-01	271.60	2379.22	248.25	2627.47
7	2001-02	271.60	2379.22	376.99	2756.20
8	2002-03	271.60	2379.22	0.00	2379.22
9	2003-04	271.60	2379.22	0.00	2379.22
10	2004-05	264.55	2313.02	0.00	2313.02
11	2005-06	266.97	2339.20	0.00	2339.20
12	2006-07	271.60	2379.22	0.00	2379.22
13	2007-08	271.60	2379.22	1084.12	3463.33
14	2008-09	271.60	2379.22	0.00	2379.22
15	2009-10	271.60	2379.22	0.00	2379.22
16	2010-11	271.60	2379.22	18.30	2397.52
17	2011-12	271.60	2379.22	725.20	3104.41
18	2012-13	271.60	2379.22	0.00	2379.22
19	2013-14	271.60	2379.22	334.80	2714.02
20	2014-15	271.60	2379.22	490.97	2870.19
21	2015-16	271.60	2379.22	0.00	2379.22
22	2016-17	271.60	2379.22	0.00	2379.22
23	2017-18	271.60	2379.22	0.00	2379.22
24	2018-19	271.60	2379.22	849.26	3228.48
25	2019-20	271.60	2379.22	0.00	2379.22
Avg. Annual Energy (GWh)					2569.70

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

=	91.70%
=	271.600
=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECs	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECs	MW	MW	MW	GWh	GWh	GWh
1995	JUN1	694.94	536.80	23.17	20.02	0.92	0.00	0.00	19.10	694.94	536.80	54.86	629.58	22.10	125.17	0.00	0.00	30.04	0.00	30.04
1995	JUN2	694.94	536.80	108.67	93.89	0.96	0.00	0.00	41.36	697.14	588.37	54.86	630.68	47.87	271.60	0.00	0.00	65.18	0.00	65.18
1995	JUN3	697.14	588.37	93.70	80.96	1.02	0.00	0.00	41.24	698.72	627.07	54.86	632.57	47.73	271.60	0.00	0.00	65.18	0.00	65.18
1995	JUL 1	698.72	627.07	145.60	125.80	1.37	0.00	0.00	41.09	701.78	710.41	54.86	634.89	47.56	271.60	0.00	0.00	65.18	0.00	65.18
1995	JUL2	701.78	710.41	203.17	175.54	1.54	0.00	0.00	40.85	706.26	843.56	54.86	638.66	47.28	271.60	0.00	0.00	65.18	0.00	65.18
1995	JUL3	706.26	843.56	114.14	108.48	1.69	0.00	0.00	44.71	708.12	905.64	54.86	641.83	47.04	271.60	0.00	0.00	71.70	0.00	71.70
1995	AUG1	708.12	905.64	110.46	95.44	1.36	0.00	0.00	40.54	709.69	959.19	54.86	643.54	46.92	271.60	0.00	0.00	65.18	0.00	65.18
1995	AUG2	709.69	959.19	67.67	58.47	1.39	0.00	0.00	40.47	710.16	975.79	54.86	644.57	46.84	271.60	0.00	0.00	65.18	0.00	65.18
1995	AUG3	710.16	975.79	180.48	171.53	1.46	0.00	0.00	44.38	713.63	1101.48	54.86	646.54	46.70	271.60	0.00	0.00	71.70	0.00	71.70
1995	SEP1	713.63	1101.48	401.35	346.77	1.71	0.00	0.00	40.01	720.97	1406.53	54.86	651.94	46.31	271.60	0.00	0.00	65.18	0.00	65.18
1995	SEP2	720.97	1406.53	87.93	75.97	1.88	0.00	0.00	39.77	721.73	1440.86	54.86	655.99	46.03	271.60	0.00	0.00	65.18	0.00	65.18
1995	SEP3	721.73	1440.86	53.36	46.10	1.90	0.00	0.00	39.74	721.83	1445.31	54.86	656.42	46.00	271.60	0.00	0.00	65.18	0.00	65.18
1995	OCT1	721.83	1445.31	49.09	42.41	1.84	0.00	0.00	39.74	721.84	1446.14	54.86	656.47	45.99	271.60	0.00	0.00	65.18	0.00	65.18
1995	OCT2	721.84	1446.14	38.39	33.17	1.84	0.00	0.00	39.74	721.66	1437.73	54.86	656.39	46.00	271.60	0.00	0.00	65.18	0.00	65.18
1995	OCT3	721.66	1437.73	33.00	31.36	1.83	0.00	0.00	43.73	721.35	1423.53	54.86	656.14	46.02	271.60	0.00	0.00	71.70	0.00	71.70
1995	NOV1	721.35	1423.53	54.42	47.02	1.88	0.00	0.00	39.76	721.46	1428.91	54.86	656.05	46.02	271.60	0.00	0.00	65.18	0.00	65.18
1995	NOV2	721.46	1428.91	35.28	30.48	1.88	0.00	0.00	39.77	721.22	1417.74	54.86	655.98	46.03	271.60	0.00	0.00	65.18	0.00	65.18
1995	NOV3	721.22	1417.74	23.01	19.88	1.86	0.00	0.00	39.79	720.74	1395.96	54.86	655.62	46.05	271.60	0.00	0.00	65.18	0.00	65.18
1995	DEC1	720.74	1395.96	14.33	12.38	2.30	0.00	0.00	39.82	720.08	1366.22	54.86	655.05	46.09	271.60	0.00	0.00	65.18	0.00	65.18
1995	DEC2	720.08	1366.22	9.65	8.34	2.26	0.00	0.00	39.87	719.34	1332.44	54.86	654.35	46.14	271.60	0.00	0.00	65.18	0.00	65.18
1995	DEC3	719.34	1332.44	15.70	14.92	2.22	0.00	0.00	43.90	718.64	1301.24	54.86	653.63	46.19	271.60	0.00	0.00	71.70	0.00	71.70
1996	JAN1	718.64	1301.24	12.58	10.87	2.04	0.00	0.00	39.96	717.87	1270.11	54.86	652.89	46.24	271.60	0.00	0.00	65.18	0.00	65.18
1996	JAN2	717.87	1270.11	11.04	9.54	2.00	0.00	0.00	40.00	717.06	1237.65	54.86	652.11	46.30	271.60	0.00	0.00	65.18	0.00	65.18
1996	JAN3	717.06	1237.65	4.59	4.36	1.96	0.00	0.00	44.07	716.03	1195.98	54.86	651.19	46.37	271.60	0.00	0.00	71.70	0.00	71.70
1996	FEB1	716.03	1195.98	8.21	7.09	2.46	0.00	0.00	40.12	715.13	1160.49	54.86	650.22	46.43	271.60	0.00	0.00	65.18	0.00	65.18
1996	FEB2	715.13	1160.49	9.43	8.15	2.41	0.00	0.00	40.17	714.26	1126.06	54.86	649.34	46.50	271.60	0.00	0.00	65.18	0.00	65.18
1996	FEB3	714.26	1126.06	9.36	6.47	2.36	0.00	0.00	32.18	713.54	1097.98	54.86	648.54	46.55	271.60	0.00	0.00	52.15	0.00	52.15
1996	MAR1	713.54	1097.98	6.45	5.57	1.87	0.00	0.00	40.27	712.61	1061.41	54.86	647.71	46.61	271.60	0.00	0.00	65.18	0.00	65.18
1996	MAR2	712.61	1061.41	8.50	7.34	1.83	0.00	0.00	40.33	711.61	1026.59	54.86	646.75	46.68	271.60	0.00	0.00	65.18	0.00	65.18
1996	MAR3	711.61	1026.59	9.05	8.60	1.79	0.00	0.00	44.44	710.54	988.96	54.86	645.72	46.76	271.60	0.00	0.00	71.70	0.00	71.70
1996	APR1	710.54	988.96	10.61	9.17	1.81	0.00	0.00	40.46	709.60	955.86	54.86	644.71	46.83	271.60	0.00	0.00	65.18	0.00	65.18
1996	APR2	709.60	955.86	22.64	19.56	1.77	0.00	0.00	40.51	708.93	933.14	54.86	643.90	46.89	271.60	0.00	0.00	65.18	0.00	65.18
1996	APR3	708.93	933.14	16.50	14.26	1.74	0.00	0.00	40.56	708.10	905.09	54.86	643.16	46.94	271.60	0.00	0.00	65.18	0.00	65.18
1996	MAY1	708.10	905.09	10.32	8.92	1.65	0.00	0.00	40.62	707.12	871.75	54.86	642.25	47.01	271.60	0.00	0.00	65.18	0.00	65.18
1996	MAY2	707.12	871.75	7.47	6.45	1.61	0.00	0.00	40.68	706.01	835.91	54.86	641.21	47.09	271.60	0.00	0.00	65.18	0.00	65.18
1996	MAY3	706.01	835.91	12.17	11.57	1.56	0.00	0.00	44.83	704.84	801.09	54.86	640.06	47.17	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1776.85	63.98	0.00	0.00	1448.58									2344.07	0.00	2344.07

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34

M.D.D.L 694.94 536.80

C/L 54.86

T.G.EFF. = 91.70%

Firm Power exep.(MW) = 271.600

Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
1996	JUN1	704.84	801.09	16.62	14.36	1.25	0.00	0.00	40.82	703.91	773.38	54.86	639.02	47.25	271.60	0.00	0.00	65.18	0.00	65.18
1996	JUN2	703.91	773.38	100.78	87.07	1.26	0.00	0.00	40.80	705.42	818.38	54.86	639.31	47.23	271.60	0.00	0.00	65.18	0.00	65.18
1996	JUN3	705.42	818.38	81.16	70.12	1.30	0.00	0.00	40.73	706.36	846.47	54.86	640.53	47.14	271.60	0.00	0.00	65.18	0.00	65.18
1996	JUL 1	706.36	846.47	24.86	21.48	1.64	0.00	0.00	40.72	705.66	825.60	54.86	640.65	47.13	271.60	0.00	0.00	65.18	0.00	65.18
1996	JUL2	705.66	825.60	122.88	106.17	1.67	0.00	0.00	40.68	707.64	889.42	54.86	641.29	47.08	271.60	0.00	0.00	65.18	0.00	65.18
1996	JUL3	707.64	889.42	357.87	340.12	1.87	0.00	0.00	44.40	715.71	1183.28	54.86	646.31	46.72	271.60	0.00	0.00	71.70	0.00	71.70
1996	AUG1	715.71	1183.28	93.43	80.72	1.61	0.00	0.00	40.08	716.68	1222.30	54.86	650.84	46.39	271.60	0.00	0.00	65.18	0.00	65.18
1996	AUG2	716.68	1222.30	164.83	142.41	1.67	0.00	0.00	39.98	719.13	1323.06	54.86	652.55	46.27	271.60	0.00	0.00	65.18	0.00	65.18
1996	AUG3	719.13	1323.06	94.16	89.49	1.74	0.00	0.00	43.86	720.10	1366.95	54.86	654.25	46.15	271.60	0.00	0.00	71.70	0.00	71.70
1996	SEP1	720.10	1366.95	75.45	65.19	1.84	0.00	0.00	39.83	720.62	1390.48	54.86	655.00	46.10	271.60	0.00	0.00	65.18	0.00	65.18
1996	SEP2	720.62	1390.48	68.26	58.98	1.86	0.00	0.00	39.80	721.00	1407.80	54.86	655.45	46.06	271.60	0.00	0.00	65.18	0.00	65.18
1996	SEP3	721.00	1407.80	119.38	103.14	1.90	0.00	0.00	39.75	722.34	1469.30	54.86	656.31	46.00	271.60	0.00	0.00	65.18	0.00	65.18
1996	OCT1	722.34	1469.30	85.63	73.98	1.88	0.00	0.00	39.69	723.04	1501.71	54.86	657.33	45.93	271.60	0.00	0.00	65.18	0.00	65.18
1996	OCT2	723.04	1501.71	122.85	106.14	1.93	0.00	0.00	39.62	724.42	1566.30	54.86	658.37	45.86	271.60	0.00	0.00	65.18	0.00	65.18
1996	OCT3	724.42	1566.30	56.26	53.47	1.96	0.00	0.00	43.53	724.59	1574.27	54.86	659.15	45.81	271.60	0.00	0.00	71.70	0.00	71.70
1996	NOV1	724.59	1574.27	35.58	30.74	2.03	0.00	0.00	39.58	724.36	1563.41	54.86	659.12	45.81	271.60	0.00	0.00	65.18	0.00	65.18
1996	NOV2	724.36	1563.41	23.54	20.34	2.01	0.00	0.00	39.60	723.90	1542.14	54.86	658.77	45.83	271.60	0.00	0.00	65.18	0.00	65.18
1996	NOV3	723.90	1542.14	24.41	21.09	1.99	0.00	0.00	39.63	723.46	1521.62	54.86	658.32	45.86	271.60	0.00	0.00	65.18	0.00	65.18
1996	DEC1	723.46	1521.62	16.27	14.06	2.46	0.00	0.00	39.66	722.86	1493.56	54.86	657.80	45.90	271.60	0.00	0.00	65.18	0.00	65.18
1996	DEC2	722.86	1493.56	19.09	16.49	2.42	0.00	0.00	39.69	722.31	1467.94	54.86	657.23	45.94	271.60	0.00	0.00	65.18	0.00	65.18
1996	DEC3	722.31	1467.94	11.93	11.34	2.39	0.00	0.00	43.70	721.56	1433.19	54.86	656.58	45.99	271.60	0.00	0.00	71.70	0.00	71.70
1997	JAN1	721.56	1433.19	14.69	12.69	2.19	0.00	0.00	39.77	720.91	1403.91	54.86	655.88	46.03	271.60	0.00	0.00	65.18	0.00	65.18
1997	JAN2	720.91	1403.91	12.31	10.64	2.16	0.00	0.00	39.81	720.22	1372.58	54.86	655.21	46.08	271.60	0.00	0.00	65.18	0.00	65.18
1997	JAN3	720.22	1372.58	8.16	7.76	2.12	0.00	0.00	43.85	719.38	1334.37	54.86	654.44	46.13	271.60	0.00	0.00	71.70	0.00	71.70
1997	FEB1	719.38	1334.37	8.44	7.29	2.66	0.00	0.00	39.91	718.59	1299.09	54.86	653.62	46.19	271.60	0.00	0.00	65.18	0.00	65.18
1997	FEB2	718.59	1299.09	14.09	12.17	2.61	0.00	0.00	39.96	717.83	1268.69	54.86	652.85	46.25	271.60	0.00	0.00	65.18	0.00	65.18
1997	FEB3	717.83	1268.69	11.08	7.66	2.57	0.00	0.00	32.00	717.16	1241.78	54.86	652.14	46.30	271.60	0.00	0.00	52.15	0.00	52.15
1997	MAR1	717.16	1241.78	8.67	7.49	2.04	0.00	0.00	40.05	716.31	1207.18	54.86	651.38	46.35	271.60	0.00	0.00	65.18	0.00	65.18
1997	MAR2	716.31	1207.18	12.30	10.63	2.00	0.00	0.00	40.10	715.52	1175.71	54.86	650.55	46.41	271.60	0.00	0.00	65.18	0.00	65.18
1997	MAR3	715.52	1175.71	16.74	15.91	1.96	0.00	0.00	44.16	714.75	1145.50	54.86	649.78	46.47	271.60	0.00	0.00	71.70	0.00	71.70
1997	APR1	714.75	1145.50	17.93	15.49	1.99	0.00	0.00	40.19	714.07	1118.80	54.86	649.05	46.52	271.60	0.00	0.00	65.18	0.00	65.18
1997	APR2	714.07	1118.80	13.85	11.97	1.96	0.00	0.00	40.24	713.30	1088.58	54.86	648.33	46.57	271.60	0.00	0.00	65.18	0.00	65.18
1997	APR3	713.30	1088.58	11.24	9.71	1.92	0.00	0.00	40.29	712.46	1056.08	54.86	647.52	46.63	271.60	0.00	0.00	65.18	0.00	65.18
1997	MAY1	712.46	1056.08	26.01	22.47	1.83	0.00	0.00	40.33	711.89	1036.39	54.86	646.81	46.68	271.60	0.00	0.00	65.18	0.00	65.18
1997	MAY2	711.89	1036.39	19.00	16.42	1.80	0.00	0.00	40.37	711.16	1010.63	54.86	646.17	46.73	271.60	0.00	0.00	65.18	0.00	65.18
1997	MAY3	711.16	1010.63	9.96	9.47	1.77	0.00	0.00	44.47	710.11	973.86	54.86	645.27	46.79	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1704.67	70.26	0.00	0.00	1461.63									2379.22	0.00	2379.22

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34
M.D.D.L 694.94 536.80
C/L 54.86

T.G.EFF. = 91.70%
Firm Power exep.(MW) = 271.600
Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
1997	JUN1	710.11	973.86	7.65	6.61	1.43	0.00	0.00	40.49	709.09	938.55	54.86	644.24	46.87	271.60	0.00	0.00	65.18	0.00	65.18
1997	JUN2	709.09	938.55	7.94	6.86	1.40	0.00	0.00	40.56	708.06	903.46	54.86	643.21	46.94	271.60	0.00	0.00	65.18	0.00	65.18
1997	JUN3	708.06	903.46	22.73	19.64	1.37	0.00	0.00	40.61	707.40	881.12	54.86	642.37	47.00	271.60	0.00	0.00	65.18	0.00	65.18
1997	JUL 1	707.40	881.12	95.05	82.12	1.72	0.00	0.00	40.59	708.57	920.92	54.86	642.62	46.98	271.60	0.00	0.00	65.18	0.00	65.18
1997	JUL2	708.57	920.92	142.94	123.50	1.79	0.00	0.00	40.48	710.92	1002.15	54.86	644.38	46.86	271.60	0.00	0.00	65.18	0.00	65.18
1997	JUL3	710.92	1002.15	217.42	206.64	1.93	0.00	0.00	44.30	715.19	1162.55	54.86	647.69	46.62	271.60	0.00	0.00	71.70	0.00	71.70
1997	AUG1	715.19	1162.55	157.60	136.17	1.62	0.00	0.00	40.07	717.54	1257.04	54.86	651.00	46.38	271.60	0.00	0.00	65.18	0.00	65.18
1997	AUG2	717.54	1257.04	72.80	62.90	1.67	0.00	0.00	39.98	718.07	1278.28	54.86	652.45	46.28	271.60	0.00	0.00	65.18	0.00	65.18
1997	AUG3	718.07	1278.28	133.73	127.10	1.72	0.00	0.00	43.90	719.94	1359.77	54.86	653.64	46.19	271.60	0.00	0.00	71.70	0.00	71.70
1997	SEP1	719.94	1359.77	66.83	57.74	1.83	0.00	0.00	39.84	720.29	1375.84	54.86	654.76	46.11	271.60	0.00	0.00	65.18	0.00	65.18
1997	SEP2	720.29	1375.84	61.61	53.23	1.84	0.00	0.00	39.82	720.55	1387.41	54.86	655.06	46.09	271.60	0.00	0.00	65.18	0.00	65.18
1997	SEP3	720.55	1387.41	69.11	59.71	1.85	0.00	0.00	39.80	720.95	1405.46	54.86	655.39	46.07	271.60	0.00	0.00	65.18	0.00	65.18
1997	OCT1	720.95	1405.46	45.05	38.92	1.80	0.00	0.00	39.79	720.89	1402.78	54.86	655.56	46.06	271.60	0.00	0.00	65.18	0.00	65.18
1997	OCT2	720.89	1402.78	36.50	31.54	1.80	0.00	0.00	39.80	720.67	1392.73	54.86	655.42	46.07	271.60	0.00	0.00	65.18	0.00	65.18
1997	OCT3	720.67	1392.73	57.33	54.49	1.80	0.00	0.00	43.78	720.86	1401.64	54.86	655.41	46.07	271.60	0.00	0.00	71.70	0.00	71.70
1997	NOV1	720.86	1401.64	116.97	101.06	1.89	0.00	0.00	39.76	722.16	1461.05	54.86	656.15	46.01	271.60	0.00	0.00	65.18	0.00	65.18
1997	NOV2	722.16	1461.05	140.89	121.73	1.96	0.00	0.00	39.67	723.88	1541.16	54.86	657.66	45.91	271.60	0.00	0.00	65.18	0.00	65.18
1997	NOV3	723.88	1541.16	69.34	59.91	2.01	0.00	0.00	39.60	724.28	1559.46	54.86	658.72	45.84	271.60	0.00	0.00	65.18	0.00	65.18
1997	DEC1	724.28	1559.46	55.83	48.24	2.53	0.00	0.00	39.59	724.41	1565.59	54.86	658.98	45.82	271.60	0.00	0.00	65.18	0.00	65.18
1997	DEC2	724.41	1565.59	40.20	34.73	2.52	0.00	0.00	39.59	724.25	1558.21	54.86	658.97	45.82	271.60	0.00	0.00	65.18	0.00	65.18
1997	DEC3	724.25	1558.21	27.09	25.75	2.51	0.00	0.00	43.57	723.81	1537.89	54.86	658.67	45.84	271.60	0.00	0.00	71.70	0.00	71.70
1998	JAN1	723.81	1537.89	13.15	11.36	2.32	0.00	0.00	39.64	723.16	1507.29	54.86	658.12	45.88	271.60	0.00	0.00	65.18	0.00	65.18
1998	JAN2	723.16	1507.29	12.01	10.38	2.28	0.00	0.00	39.68	722.48	1475.72	54.86	657.46	45.92	271.60	0.00	0.00	65.18	0.00	65.18
1998	JAN3	722.48	1475.72	9.38	8.91	2.24	0.00	0.00	43.69	721.68	1438.69	54.86	656.72	45.97	271.60	0.00	0.00	71.70	0.00	71.70
1998	FEB1	721.68	1438.69	4.38	3.78	2.82	0.00	0.00	39.77	720.82	1399.88	54.86	655.89	46.03	271.60	0.00	0.00	65.18	0.00	65.18
1998	FEB2	720.82	1399.88	10.91	9.43	2.76	0.00	0.00	39.82	720.09	1366.73	54.86	655.10	46.09	271.60	0.00	0.00	65.18	0.00	65.18
1998	FEB3	720.09	1366.73	11.27	7.79	2.72	0.00	0.00	31.89	719.50	1339.92	54.86	654.44	46.14	271.60	0.00	0.00	52.15	0.00	52.15
1998	MAR1	719.50	1339.92	8.61	7.44	2.15	0.00	0.00	39.90	718.74	1305.30	54.86	653.76	46.18	271.60	0.00	0.00	65.18	0.00	65.18
1998	MAR2	718.74	1305.30	5.22	4.51	2.11	0.00	0.00	39.95	717.81	1267.75	54.86	652.91	46.24	271.60	0.00	0.00	65.18	0.00	65.18
1998	MAR3	717.81	1267.75	4.87	4.63	2.06	0.00	0.00	44.02	716.78	1226.30	54.86	651.94	46.31	271.60	0.00	0.00	71.70	0.00	71.70
1998	APR1	716.78	1226.30	10.91	9.43	2.09	0.00	0.00	40.07	715.97	1193.57	54.86	651.01	46.38	271.60	0.00	0.00	65.18	0.00	65.18
1998	APR2	715.97	1193.57	12.63	10.91	2.05	0.00	0.00	40.12	715.18	1162.31	54.86	650.21	46.43	271.60	0.00	0.00	65.18	0.00	65.18
1998	APR3	715.18	1162.31	11.53	9.96	2.01	0.00	0.00	40.17	714.36	1130.09	54.86	649.41	46.49	271.60	0.00	0.00	65.18	0.00	65.18
1998	MAY1	714.36	1130.09	12.35	10.67	1.91	0.00	0.00	40.22	713.56	1098.63	54.86	648.60	46.55	271.60	0.00	0.00	65.18	0.00	65.18
1998	MAY2	713.56	1098.63	16.70	14.43	1.87	0.00	0.00	40.27	712.85	1070.92	54.86	647.84	46.60	271.60	0.00	0.00	65.18	0.00	65.18
1998	MAY3	712.85	1070.92	14.15	13.45	1.84	0.00	0.00	44.35	711.94	1038.18	54.86	647.04	46.66	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1595.67	72.20	0.00	0.00	1459.15									2379.22	0.00	2379.22

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34
M.D.D.L 694.94 536.80
C/L 54.86

T.G.EFF. = 91.70%
Firm Power exep.(MW) = 271.600
Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECs	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECs	MW	MW	MW	GWh	GWh	GWh
1998	JUN1	711.94	1038.18	11.56	9.99	1.49	0.00	0.00	40.37	711.03	1006.31	54.86	646.13	46.73	271.60	0.00	0.00	65.18	0.00	65.18
1998	JUN2	711.03	1006.31	27.37	23.65	1.47	0.00	0.00	40.42	710.51	988.07	54.86	645.41	46.78	271.60	0.00	0.00	65.18	0.00	65.18
1998	JUN3	710.51	988.07	186.13	160.82	1.51	0.00	0.00	40.33	713.77	1107.05	54.86	646.78	46.68	271.60	0.00	0.00	65.18	0.00	65.18
1998	JUL 1	713.77	1107.05	181.27	156.62	2.03	0.00	0.00	40.14	716.66	1221.49	54.86	649.86	46.46	271.60	0.00	0.00	65.18	0.00	65.18
1998	JUL2	716.66	1221.49	121.69	105.14	2.14	0.00	0.00	40.00	718.22	1284.49	54.86	652.08	46.30	271.60	0.00	0.00	65.18	0.00	65.18
1998	JUL3	718.22	1284.49	162.27	154.22	2.24	0.00	0.00	43.87	720.66	1392.59	54.86	654.08	46.16	271.60	0.00	0.00	71.70	0.00	71.70
1998	AUG1	720.66	1392.59	171.53	148.20	1.84	0.00	0.00	39.74	722.98	1499.21	54.86	656.46	45.99	271.60	0.00	0.00	65.18	0.00	65.18
1998	AUG2	722.98	1499.21	178.15	153.92	1.95	0.00	0.00	39.60	725.33	1611.59	54.86	658.79	45.83	271.60	0.00	0.00	65.18	0.00	65.18
1998	AUG3	725.33	1611.59	112.05	106.49	2.03	0.00	0.00	43.44	726.48	1672.60	54.86	660.54	45.71	271.60	0.00	0.00	71.70	0.00	71.70
1998	SEP1	726.48	1672.60	116.74	100.86	2.17	0.00	0.00	39.42	727.61	1731.87	54.86	661.68	45.63	271.60	0.00	0.00	65.18	0.00	65.18
1998	SEP2	727.61	1731.87	122.96	106.24	2.23	0.00	0.00	39.36	728.80	1796.53	54.86	662.84	45.55	271.60	0.00	0.00	65.18	0.00	65.18
1998	SEP3	728.80	1796.53	95.21	82.26	2.29	0.00	0.00	39.30	729.55	1837.20	54.86	663.82	45.48	271.60	0.00	0.00	65.18	0.00	65.18
1998	OCT1	729.55	1837.20	83.61	72.24	2.25	0.00	0.00	39.26	730.12	1867.94	54.86	664.48	45.44	271.60	0.00	0.00	65.18	0.00	65.18
1998	OCT2	730.12	1867.94	278.54	240.66	2.33	0.00	0.00	109.93	732.43	1996.34	54.86	665.92	127.24	271.60	490.59	0.00	65.18	117.74	182.92
1998	OCT3	732.43	1996.34	69.61	66.16	2.38	0.00	0.00	63.78	732.43	1996.34	54.86	667.07	67.11	271.60	131.08	0.00	71.70	34.61	106.31
1998	NOV1	732.43	1996.34	76.45	66.05	2.46	0.00	0.00	63.59	732.43	1996.34	54.86	667.07	73.60	271.60	170.03	0.00	65.18	40.81	105.99
1998	NOV2	732.43	1996.34	99.46	85.93	2.46	0.00	0.00	83.47	732.43	1996.34	54.86	667.07	96.61	271.60	308.11	0.00	65.18	73.95	139.13
1998	NOV3	732.43	1996.34	39.38	34.02	2.46	0.00	0.00	39.11	732.30	1988.79	54.86	667.01	45.27	271.60	0.00	0.00	65.18	0.00	65.18
1998	DEC1	732.30	1988.79	31.67	27.36	3.06	0.00	0.00	39.12	732.04	1973.97	54.86	666.81	45.28	271.60	0.00	0.00	65.18	0.00	65.18
1998	DEC2	732.04	1973.97	93.26	80.58	3.07	0.00	0.00	55.14	732.43	1996.34	54.86	666.87	63.82	271.60	111.27	0.00	65.18	26.71	91.89
1998	DEC3	732.43	1996.34	21.73	20.65	3.06	0.00	0.00	43.03	731.98	1970.89	54.86	666.85	45.28	271.60	0.00	0.00	71.70	0.00	71.70
1999	JAN1	731.98	1970.89	14.46	12.49	2.84	0.00	0.00	39.15	731.45	1941.40	54.86	666.36	45.31	271.60	0.00	0.00	65.18	0.00	65.18
1999	JAN2	731.45	1941.40	9.20	7.95	2.80	0.00	0.00	39.18	730.84	1907.36	54.86	665.79	45.35	271.60	0.00	0.00	65.18	0.00	65.18
1999	JAN3	730.84	1907.36	4.43	4.21	2.76	0.00	0.00	43.14	730.08	1865.67	54.86	665.10	45.40	271.60	0.00	0.00	71.70	0.00	71.70
1999	FEB1	730.08	1865.67	17.36	15.00	3.48	0.00	0.00	39.26	729.57	1837.93	54.86	664.46	45.44	271.60	0.00	0.00	65.18	0.00	65.18
1999	FEB2	729.57	1837.93	12.38	10.70	3.44	0.00	0.00	39.29	728.98	1805.90	54.86	663.91	45.48	271.60	0.00	0.00	65.18	0.00	65.18
1999	FEB3	728.98	1805.90	10.73	7.42	3.39	0.00	0.00	31.46	728.47	1778.47	54.86	663.36	45.51	271.60	0.00	0.00	52.15	0.00	52.15
1999	MAR1	728.47	1778.47	6.75	5.83	2.69	0.00	0.00	39.36	727.80	1742.24	54.86	662.78	45.55	271.60	0.00	0.00	65.18	0.00	65.18
1999	MAR2	727.80	1742.24	8.81	7.61	2.65	0.00	0.00	39.40	727.15	1707.81	54.86	662.12	45.60	271.60	0.00	0.00	65.18	0.00	65.18
1999	MAR3	727.15	1707.81	11.40	10.83	2.60	0.00	0.00	43.38	726.48	1672.65	54.86	661.46	45.65	271.60	0.00	0.00	71.70	0.00	71.70
1999	APR1	726.48	1672.65	16.22	14.01	2.65	0.00	0.00	39.47	725.95	1644.54	54.86	660.86	45.69	271.60	0.00	0.00	65.18	0.00	65.18
1999	APR2	725.95	1644.54	11.83	10.22	2.61	0.00	0.00	39.51	725.35	1612.64	54.86	660.29	45.73	271.60	0.00	0.00	65.18	0.00	65.18
1999	APR3	725.35	1612.64	15.84	13.69	2.57	0.00	0.00	39.54	724.81	1584.22	54.86	659.72	45.77	271.60	0.00	0.00	65.18	0.00	65.18
1999	MAY1	724.81	1584.22	17.48	15.10	2.45	0.00	0.00	39.58	724.23	1557.29	54.86	659.16	45.80	271.60	0.00	0.00	65.18	0.00	65.18
1999	MAY2	724.23	1557.29	17.81	15.39	2.42	0.00	0.00	39.61	723.66	1530.65	54.86	658.58	45.84	271.60	0.00	0.00	65.18	0.00	65.18
1999	MAY3	723.66	1530.65	116.93	111.13	2.44	0.00	0.00	43.54	725.03	1595.79	54.86	658.98	45.82	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					2263.64	88.73	0.00	0.00	1617.30									2379.22	293.81	2673.02

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34
M.D.D.L 694.94 536.80
C/L 54.86

T.G.EFF. = 91.70%
Firm Power exep.(MW) = 271.600
Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
1999	JUN1	725.03	1595.79	81.66	70.55	2.07	0.00	0.00	39.53	725.58	1624.74	54.86	659.94	45.75	271.60	0.00	0.00	65.18	0.00	65.18
1999	JUN2	725.58	1624.74	203.17	175.54	2.15	0.00	0.00	39.44	728.11	1758.69	54.86	661.48	45.64	271.60	0.00	0.00	65.18	0.00	65.18
1999	JUN3	728.11	1758.69	79.83	68.97	2.24	0.00	0.00	39.35	728.61	1786.08	54.86	663.00	45.54	271.60	0.00	0.00	65.18	0.00	65.18
1999	JUL 1	728.61	1786.08	57.75	49.90	2.82	0.00	0.00	39.33	728.75	1793.83	54.86	663.32	45.52	271.60	0.00	0.00	65.18	0.00	65.18
1999	JUL2	728.75	1793.83	125.34	108.29	2.87	0.00	0.00	39.29	729.97	1859.96	54.86	664.00	45.47	271.60	0.00	0.00	65.18	0.00	65.18
1999	JUL3	729.97	1859.96	220.32	209.39	3.00	0.00	0.00	70.01	732.43	1996.34	54.86	665.84	73.67	271.60	169.64	0.00	71.70	44.78	116.49
1999	AUG1	732.43	1996.34	179.66	155.23	2.38	0.00	0.00	152.85	732.43	1996.34	54.86	667.07	176.91	271.60	789.97	0.00	65.18	189.59	254.78
1999	AUG2	732.43	1996.34	72.08	62.28	2.38	0.00	0.00	59.90	732.43	1996.34	54.86	667.07	69.33	271.60	144.40	0.00	65.18	34.66	99.84
1999	AUG3	732.43	1996.34	50.73	48.21	2.38	0.00	0.00	45.83	732.43	1996.34	54.86	667.07	48.22	271.60	17.75	0.00	71.70	4.69	76.39
1999	SEP1	732.43	1996.34	49.31	42.60	2.46	0.00	0.00	40.14	732.43	1996.34	54.86	667.07	46.46	271.60	7.17	0.00	65.18	1.72	66.90
1999	SEP2	732.43	1996.34	25.22	21.79	2.45	0.00	0.00	39.12	732.08	1976.56	54.86	666.90	45.27	271.60	0.00	0.00	65.18	0.00	65.18
1999	SEP3	732.08	1976.56	31.10	26.87	2.44	0.00	0.00	39.13	731.82	1961.86	54.86	666.59	45.29	271.60	0.00	0.00	65.18	0.00	65.18
1999	OCT1	731.82	1961.86	66.44	57.40	2.36	0.00	0.00	39.13	732.10	1977.76	54.86	666.60	45.29	271.60	0.00	0.00	65.18	0.00	65.18
1999	OCT2	732.10	1977.76	118.89	102.72	2.37	0.00	0.00	81.77	732.43	1996.34	54.86	666.91	94.64	271.60	296.18	0.00	65.18	71.08	136.27
1999	OCT3	732.43	1996.34	133.14	126.54	2.38	0.00	0.00	124.16	732.43	1996.34	54.86	667.07	130.64	271.60	512.31	0.00	71.70	135.25	206.95
1999	NOV1	732.43	1996.34	46.63	40.29	2.46	0.00	0.00	39.11	732.41	1995.06	54.86	667.06	45.26	271.60	0.00	0.00	65.18	0.00	65.18
1999	NOV2	732.41	1995.06	23.58	20.37	2.45	0.00	0.00	39.12	732.03	1973.86	54.86	666.86	45.28	271.60	0.00	0.00	65.18	0.00	65.18
1999	NOV3	732.03	1973.86	34.41	29.73	2.44	0.00	0.00	39.14	731.82	1962.02	54.86	666.57	45.30	271.60	0.00	0.00	65.18	0.00	65.18
1999	DEC1	731.82	1962.02	17.84	15.41	3.02	0.00	0.00	39.16	731.34	1935.25	54.86	666.22	45.32	271.60	0.00	0.00	65.18	0.00	65.18
1999	DEC2	731.34	1935.25	12.12	10.47	2.99	0.00	0.00	39.19	730.77	1903.54	54.86	665.70	45.35	271.60	0.00	0.00	65.18	0.00	65.18
1999	DEC3	730.77	1903.54	9.55	9.08	2.95	0.00	0.00	43.15	730.09	1866.53	54.86	665.07	45.40	271.60	0.00	0.00	71.70	0.00	71.70
2000	JAN1	730.09	1866.53	12.12	10.47	2.72	0.00	0.00	39.26	729.51	1835.02	54.86	664.44	45.44	271.60	0.00	0.00	65.18	0.00	65.18
2000	JAN2	729.51	1835.02	11.18	9.66	2.68	0.00	0.00	39.30	728.92	1802.71	54.86	663.86	45.48	271.60	0.00	0.00	65.18	0.00	65.18
2000	JAN3	728.92	1802.71	7.14	6.79	2.63	0.00	0.00	43.27	728.20	1763.60	54.86	663.20	45.53	271.60	0.00	0.00	71.70	0.00	71.70
2000	FEB1	728.20	1763.60	12.52	10.82	3.32	0.00	0.00	39.37	727.60	1731.73	54.86	662.54	45.57	271.60	0.00	0.00	65.18	0.00	65.18
2000	FEB2	727.60	1731.73	8.28	7.15	3.27	0.00	0.00	39.41	726.93	1696.20	54.86	661.91	45.61	271.60	0.00	0.00	65.18	0.00	65.18
2000	FEB3	726.93	1696.20	26.10	18.04	3.23	0.00	0.00	31.55	726.61	1679.46	54.86	661.41	45.65	271.60	0.00	0.00	52.15	0.00	52.15
2000	MAR1	726.61	1679.46	15.84	13.69	2.57	0.00	0.00	39.47	726.08	1651.11	54.86	660.98	45.68	271.60	0.00	0.00	65.18	0.00	65.18
2000	MAR2	726.08	1651.11	11.94	10.32	2.53	0.00	0.00	39.50	725.47	1619.40	54.86	660.41	45.72	271.60	0.00	0.00	65.18	0.00	65.18
2000	MAR3	725.47	1619.40	9.25	8.79	2.49	0.00	0.00	43.49	724.76	1582.21	54.86	659.76	45.76	271.60	0.00	0.00	71.70	0.00	71.70
2000	APR1	724.76	1582.21	18.77	16.22	2.53	0.00	0.00	39.58	724.21	1556.31	54.86	659.13	45.81	271.60	0.00	0.00	65.18	0.00	65.18
2000	APR2	724.21	1556.31	12.94	11.18	2.50	0.00	0.00	39.61	723.54	1525.38	54.86	658.52	45.85	271.60	0.00	0.00	65.18	0.00	65.18
2000	APR3	723.54	1525.38	12.05	10.41	2.46	0.00	0.00	39.65	722.86	1493.68	54.86	657.84	45.90	271.60	0.00	0.00	65.18	0.00	65.18
2000	MAY1	722.86	1493.68	13.72	11.85	2.34	0.00	0.00	39.69	722.22	1463.49	54.86	657.18	45.94	271.60	0.00	0.00	65.18	0.00	65.18
2000	MAY2	722.22	1463.49	18.47	15.96	2.31	0.00	0.00	39.73	721.65	1437.41	54.86	656.57	45.99	271.60	0.00	0.00	65.18	0.00	65.18
2000	MAY3	721.65	1437.41	14.84	14.10	2.27	0.00	0.00	43.75	720.95	1405.49	54.86	655.94	46.03	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1627.08	92.93	0.00	0.00	1724.44									2379.22	481.77	2860.99

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34
M.D.D.L 694.94 536.80
C/L 54.86

T.G.EFF. = 91.70%
Firm Power exep.(MW) = 271.600
Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2000	JUN1	720.95	1405.49	106.01	91.59	1.89	0.00	0.00	39.76	722.04	1455.44	54.86	656.14	46.02	271.60	0.00	0.00	65.18	0.00	65.18
2000	JUN2	722.04	1455.44	90.95	78.58	1.93	0.00	0.00	39.70	722.84	1492.39	54.86	657.08	45.95	271.60	0.00	0.00	65.18	0.00	65.18
2000	JUN3	722.84	1492.39	88.00	76.03	1.97	0.00	0.00	39.65	723.57	1526.79	54.86	657.84	45.90	271.60	0.00	0.00	65.18	0.00	65.18
2000	JUL 1	723.57	1526.79	150.60	130.12	2.53	0.00	0.00	39.58	725.39	1614.80	54.86	659.12	45.81	271.60	0.00	0.00	65.18	0.00	65.18
2000	JUL2	725.39	1614.80	101.34	87.56	2.62	0.00	0.00	39.50	726.25	1660.24	54.86	660.46	45.71	271.60	0.00	0.00	65.18	0.00	65.18
2000	JUL3	726.25	1660.24	34.88	33.15	2.64	0.00	0.00	43.43	726.00	1647.32	54.86	660.77	45.69	271.60	0.00	0.00	71.70	0.00	71.70
2000	AUG1	726.00	1647.32	55.81	48.22	2.04	0.00	0.00	39.48	726.13	1654.02	54.86	660.71	45.70	271.60	0.00	0.00	65.18	0.00	65.18
2000	AUG2	726.13	1654.02	107.14	92.57	2.07	0.00	0.00	39.45	727.10	1705.07	54.86	661.25	45.66	271.60	0.00	0.00	65.18	0.00	65.18
2000	AUG3	727.10	1705.07	458.49	435.75	2.25	0.00	0.00	142.23	732.43	1996.34	54.86	664.41	149.66	271.60	622.85	0.00	71.70	164.43	236.14
2000	SEP1	732.43	1996.34	90.13	77.87	2.46	0.00	0.00	75.41	732.43	1996.34	54.86	667.07	87.28	271.60	252.13	0.00	65.18	60.51	125.69
2000	SEP2	732.43	1996.34	39.56	34.18	2.46	0.00	0.00	39.11	732.30	1988.95	54.86	667.01	45.27	271.60	0.00	0.00	65.18	0.00	65.18
2000	SEP3	732.30	1988.95	64.13	55.41	2.46	0.00	0.00	45.56	732.43	1996.34	54.86	667.01	52.73	271.60	44.81	0.00	65.18	10.76	75.94
2000	OCT1	732.43	1996.34	56.74	49.02	2.38	0.00	0.00	46.64	732.43	1996.34	54.86	667.07	53.98	271.60	52.31	0.00	65.18	12.55	77.74
2000	OCT2	732.43	1996.34	42.19	36.45	2.38	0.00	0.00	39.11	732.34	1991.30	54.86	667.03	45.26	271.60	0.00	0.00	65.18	0.00	65.18
2000	OCT3	732.34	1991.30	25.72	24.44	2.37	0.00	0.00	43.03	731.97	1970.34	54.86	666.80	45.28	271.60	0.00	0.00	71.70	0.00	71.70
2000	NOV1	731.97	1970.34	16.54	14.29	2.43	0.00	0.00	39.15	731.48	1943.05	54.86	666.37	45.31	271.60	0.00	0.00	65.18	0.00	65.18
2000	NOV2	731.48	1943.05	9.41	8.13	2.40	0.00	0.00	39.18	730.89	1909.60	54.86	665.83	45.35	271.60	0.00	0.00	65.18	0.00	65.18
2000	NOV3	730.89	1909.60	22.64	19.56	2.37	0.00	0.00	39.21	730.48	1887.58	54.86	665.32	45.38	271.60	0.00	0.00	65.18	0.00	65.18
2000	DEC1	730.48	1887.58	13.32	11.51	2.93	0.00	0.00	39.24	729.92	1856.92	54.86	664.84	45.41	271.60	0.00	0.00	65.18	0.00	65.18
2000	DEC2	729.92	1856.92	7.99	6.90	2.89	0.00	0.00	39.27	729.27	1821.66	54.86	664.23	45.45	271.60	0.00	0.00	65.18	0.00	65.18
2000	DEC3	729.27	1821.66	14.16	13.46	2.84	0.00	0.00	43.24	728.67	1789.04	54.86	663.61	45.50	271.60	0.00	0.00	71.70	0.00	71.70
2001	JAN1	728.67	1789.04	13.59	11.74	2.62	0.00	0.00	39.34	728.11	1758.81	54.86	663.03	45.54	271.60	0.00	0.00	65.18	0.00	65.18
2001	JAN2	728.11	1758.81	4.58	3.96	2.58	0.00	0.00	39.38	727.40	1720.81	54.86	662.39	45.58	271.60	0.00	0.00	65.18	0.00	65.18
2001	JAN3	727.40	1720.81	3.28	3.12	2.53	0.00	0.00	43.37	726.59	1678.04	54.86	661.63	45.63	271.60	0.00	0.00	71.70	0.00	71.70
2001	FEB1	726.59	1678.04	11.33	9.79	3.18	0.00	0.00	39.47	725.96	1645.17	54.86	660.91	45.68	271.60	0.00	0.00	65.18	0.00	65.18
2001	FEB2	725.96	1645.17	10.07	8.70	3.13	0.00	0.00	39.51	725.32	1611.23	54.86	660.28	45.73	271.60	0.00	0.00	65.18	0.00	65.18
2001	FEB3	725.32	1611.23	9.85	6.81	3.08	0.00	0.00	31.63	724.79	1583.32	54.86	659.69	45.77	271.60	0.00	0.00	52.15	0.00	52.15
2001	MAR1	724.79	1583.32	6.77	5.85	2.45	0.00	0.00	39.58	724.01	1547.15	54.86	659.04	45.81	271.60	0.00	0.00	65.18	0.00	65.18
2001	MAR2	724.01	1547.15	5.56	4.80	2.40	0.00	0.00	39.63	723.21	1509.91	54.86	658.25	45.87	271.60	0.00	0.00	65.18	0.00	65.18
2001	MAR3	723.21	1509.91	12.65	12.02	2.36	0.00	0.00	43.64	722.48	1475.93	54.86	657.49	45.92	271.60	0.00	0.00	71.70	0.00	71.70
2001	APR1	722.48	1475.93	11.39	9.84	2.40	0.00	0.00	39.72	721.79	1443.65	54.86	656.78	45.97	271.60	0.00	0.00	65.18	0.00	65.18
2001	APR2	721.79	1443.65	26.37	22.78	2.36	0.00	0.00	39.75	721.36	1424.32	54.86	656.22	46.01	271.60	0.00	0.00	65.18	0.00	65.18
2001	APR3	721.36	1424.32	17.07	14.75	2.34	0.00	0.00	39.78	720.76	1396.95	54.86	655.70	46.05	271.60	0.00	0.00	65.18	0.00	65.18
2001	MAY1	720.76	1396.95	10.23	8.84	2.22	0.00	0.00	39.82	720.03	1363.74	54.86	655.03	46.09	271.60	0.00	0.00	65.18	0.00	65.18
2001	MAY2	720.03	1363.74	16.19	13.99	2.19	0.00	0.00	39.87	719.41	1335.68	54.86	654.36	46.14	271.60	0.00	0.00	65.18	0.00	65.18
2001	MAY3	719.41	1335.68	20.49	19.47	2.15	0.00	0.00	43.89	718.82	1309.10	54.86	653.76	46.18	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1581.25	88.31	0.00	0.00	1589.33									2379.22	248.25	2627.47

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34
M.D.D.L 694.94 536.80
C/L 54.86

T.G.EFF. = 91.70%
Firm Power exep.(MW) = 271.600
Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2001	JUN1	718.82	1309.10	39.38	34.02	1.76	0.00	0.00	39.93	718.65	1301.43	54.86	653.37	46.21	271.60	0.00	0.00	65.18	0.00	65.18
2001	JUN2	718.65	1301.43	107.44	92.83	1.79	0.00	0.00	39.90	719.78	1352.58	54.86	653.85	46.18	271.60	0.00	0.00	65.18	0.00	65.18
2001	JUN3	719.78	1352.58	194.49	168.04	1.87	0.00	0.00	39.78	722.55	1478.97	54.86	655.80	46.04	271.60	0.00	0.00	65.18	0.00	65.18
2001	JUL 1	722.55	1478.97	374.54	323.60	2.59	0.00	0.00	39.53	728.14	1760.45	54.86	659.98	45.75	271.60	0.00	0.00	65.18	0.00	65.18
2001	JUL2	728.14	1760.45	167.34	144.58	2.85	0.00	0.00	39.30	730.03	1862.88	54.86	663.72	45.49	271.60	0.00	0.00	65.18	0.00	65.18
2001	JUL3	730.03	1862.88	63.71	60.55	2.93	0.00	0.00	43.16	730.29	1877.34	54.86	664.80	45.42	271.60	0.00	0.00	71.70	0.00	71.70
2001	AUG1	730.29	1877.34	127.12	109.83	2.31	0.00	0.00	39.20	731.53	1945.66	54.86	665.55	45.36	271.60	0.00	0.00	65.18	0.00	65.18
2001	AUG2	731.53	1945.66	70.32	60.76	2.35	0.00	0.00	39.15	731.87	1964.93	54.86	666.34	45.31	271.60	0.00	0.00	65.18	0.00	65.18
2001	AUG3	731.87	1964.93	116.01	110.26	2.37	0.00	0.00	76.48	732.43	1996.34	54.86	666.79	80.47	271.60	211.09	0.00	71.70	55.73	127.43
2001	SEP1	732.43	1996.34	43.16	37.29	2.46	0.00	0.00	39.11	732.36	1992.06	54.86	667.04	45.26	271.60	0.00	0.00	65.18	0.00	65.18
2001	SEP2	732.36	1992.06	30.19	26.08	2.45	0.00	0.00	39.12	732.08	1976.57	54.86	666.86	45.28	271.60	0.00	0.00	65.18	0.00	65.18
2001	SEP3	732.08	1976.57	55.43	47.89	2.45	0.00	0.00	39.12	732.19	1982.89	54.86	666.78	45.28	271.60	0.00	0.00	65.18	0.00	65.18
2001	OCT1	732.19	1982.89	100.89	87.17	2.38	0.00	0.00	71.34	732.43	1996.34	54.86	666.95	82.57	271.60	223.82	0.00	65.18	53.72	118.90
2001	OCT2	732.43	1996.34	68.56	59.24	2.38	0.00	0.00	56.86	732.43	1996.34	54.86	667.07	65.81	271.60	123.29	0.00	65.18	29.59	94.77
2001	OCT3	732.43	1996.34	104.98	99.77	2.38	0.00	0.00	97.39	732.43	1996.34	54.86	667.07	102.47	271.60	343.29	0.00	71.70	90.63	162.33
2001	NOV1	732.43	1996.34	110.79	95.72	2.46	0.00	0.00	93.26	732.43	1996.34	54.86	667.07	107.94	271.60	376.10	0.00	65.18	90.26	155.45
2001	NOV2	732.43	1996.34	87.73	75.80	2.46	0.00	0.00	73.34	732.43	1996.34	54.86	667.07	84.88	271.60	237.75	0.00	65.18	57.06	122.24
2001	NOV3	732.43	1996.34	40.90	35.34	2.46	0.00	0.00	39.11	732.32	1990.11	54.86	667.02	45.27	271.60	0.00	0.00	65.18	0.00	65.18
2001	DEC1	732.32	1990.11	23.51	20.31	3.06	0.00	0.00	39.12	731.93	1968.24	54.86	666.77	45.28	271.60	0.00	0.00	65.18	0.00	65.18
2001	DEC2	731.93	1968.24	15.10	13.05	3.03	0.00	0.00	39.15	731.41	1939.11	54.86	666.31	45.31	271.60	0.00	0.00	65.18	0.00	65.18
2001	DEC3	731.41	1939.11	14.47	13.75	3.00	0.00	0.00	43.10	730.83	1906.76	54.86	665.76	45.35	271.60	0.00	0.00	71.70	0.00	71.70
2002	JAN1	730.83	1906.76	14.02	12.11	2.77	0.00	0.00	39.22	730.28	1876.89	54.86	665.20	45.39	271.60	0.00	0.00	65.18	0.00	65.18
2002	JAN2	730.28	1876.89	11.13	9.62	2.73	0.00	0.00	39.25	729.69	1844.53	54.86	664.63	45.43	271.60	0.00	0.00	65.18	0.00	65.18
2002	JAN3	729.69	1844.53	7.89	7.50	2.68	0.00	0.00	43.22	728.98	1806.13	54.86	663.97	45.47	271.60	0.00	0.00	71.70	0.00	71.70
2002	FEB1	728.98	1806.13	9.94	8.59	3.39	0.00	0.00	39.33	728.35	1772.01	54.86	663.31	45.52	271.60	0.00	0.00	65.18	0.00	65.18
2002	FEB2	728.35	1772.01	12.77	11.03	3.33	0.00	0.00	39.36	727.77	1740.34	54.86	662.70	45.56	271.60	0.00	0.00	65.18	0.00	65.18
2002	FEB3	727.77	1740.34	8.45	5.84	3.29	0.00	0.00	31.52	727.22	1711.38	54.86	662.13	45.60	271.60	0.00	0.00	52.15	0.00	52.15
2002	MAR1	727.22	1711.38	10.61	9.17	2.61	0.00	0.00	39.43	726.59	1678.50	54.86	661.55	45.64	271.60	0.00	0.00	65.18	0.00	65.18
2002	MAR2	726.59	1678.50	11.02	9.52	2.57	0.00	0.00	39.47	725.98	1645.99	54.86	660.93	45.68	271.60	0.00	0.00	65.18	0.00	65.18
2002	MAR3	725.98	1645.99	14.73	14.00	2.53	0.00	0.00	43.46	725.37	1614.00	54.86	660.31	45.72	271.60	0.00	0.00	71.70	0.00	71.70
2002	APR1	725.37	1614.00	13.32	11.51	2.57	0.00	0.00	39.54	724.79	1583.40	54.86	659.72	45.77	271.60	0.00	0.00	65.18	0.00	65.18
2002	APR2	724.79	1583.40	10.91	9.43	2.53	0.00	0.00	39.58	724.09	1550.72	54.86	659.08	45.81	271.60	0.00	0.00	65.18	0.00	65.18
2002	APR3	724.09	1550.72	17.94	15.50	2.49	0.00	0.00	39.62	723.52	1524.11	54.86	658.44	45.85	271.60	0.00	0.00	65.18	0.00	65.18
2002	MAY1	723.52	1524.11	18.15	15.68	2.38	0.00	0.00	39.65	722.95	1497.75	54.86	657.87	45.89	271.60	0.00	0.00	65.18	0.00	65.18
2002	MAY2	722.95	1497.75	27.62	23.86	2.35	0.00	0.00	39.68	722.56	1479.58	54.86	657.40	45.93	271.60	0.00	0.00	65.18	0.00	65.18
2002	MAY3	722.56	1479.58	29.92	28.44	2.33	0.00	0.00	43.68	722.18	1462.01	54.86	657.01	45.95	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1907.68	92.33	0.00	0.00	1662.44									2379.22	376.99	2756.20

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2002	JUN1	722.18	1462.01	25.72	22.22	1.91	0.00	0.00	39.73	721.77	1442.59	54.86	656.62	45.98	271.60	0.00	0.00	65.18	0.00	65.18
2002	JUN2	721.77	1442.59	50.50	43.63	1.90	0.00	0.00	39.74	721.81	1444.58	54.86	656.43	46.00	271.60	0.00	0.00	65.18	0.00	65.18
2002	JUN3	721.81	1444.58	78.19	67.56	1.92	0.00	0.00	39.72	722.37	1470.50	54.86	656.73	45.97	271.60	0.00	0.00	65.18	0.00	65.18
2002	JUL 1	722.37	1470.50	64.12	55.40	2.42	0.00	0.00	39.70	722.65	1483.79	54.86	657.15	45.94	271.60	0.00	0.00	65.18	0.00	65.18
2002	JUL2	722.65	1483.79	87.33	75.45	2.45	0.00	0.00	39.67	723.37	1517.12	54.86	657.65	45.91	271.60	0.00	0.00	65.18	0.00	65.18
2002	JUL3	723.37	1517.12	70.16	66.68	2.48	0.00	0.00	43.59	723.81	1537.73	54.86	658.23	45.87	271.60	0.00	0.00	71.70	0.00	71.70
2002	AUG1	723.81	1537.73	135.03	116.67	1.97	0.00	0.00	39.57	725.35	1612.86	54.86	659.22	45.80	271.60	0.00	0.00	65.18	0.00	65.18
2002	AUG2	725.35	1612.86	198.31	171.34	2.07	0.00	0.00	39.45	727.81	1742.68	54.86	661.22	45.66	271.60	0.00	0.00	65.18	0.00	65.18
2002	AUG3	727.81	1742.68	72.71	69.10	2.15	0.00	0.00	43.30	728.25	1766.33	54.86	662.67	45.56	271.60	0.00	0.00	71.70	0.00	71.70
2002	SEP1	728.25	1766.33	35.20	30.41	2.23	0.00	0.00	39.36	728.04	1755.15	54.86	662.78	45.55	271.60	0.00	0.00	65.18	0.00	65.18
2002	SEP2	728.04	1755.15	26.93	23.27	2.21	0.00	0.00	39.38	727.70	1736.84	54.86	662.51	45.57	271.60	0.00	0.00	65.18	0.00	65.18
2002	SEP3	727.70	1736.84	17.28	14.93	2.19	0.00	0.00	39.40	727.19	1710.18	54.86	662.09	45.60	271.60	0.00	0.00	65.18	0.00	65.18
2002	OCT1	727.19	1710.18	35.27	30.47	2.10	0.00	0.00	39.42	726.99	1699.13	54.86	661.73	45.63	271.60	0.00	0.00	65.18	0.00	65.18
2002	OCT2	726.99	1699.13	69.84	60.34	2.10	0.00	0.00	39.42	727.34	1717.95	54.86	661.80	45.62	271.60	0.00	0.00	65.18	0.00	65.18
2002	OCT3	727.34	1717.95	44.28	42.08	2.11	0.00	0.00	43.35	727.28	1714.57	54.86	661.95	45.61	271.60	0.00	0.00	71.70	0.00	71.70
2002	NOV1	727.28	1714.57	38.82	33.54	2.17	0.00	0.00	39.41	727.13	1706.52	54.86	661.84	45.62	271.60	0.00	0.00	65.18	0.00	65.18
2002	NOV2	727.13	1706.52	29.93	25.86	2.16	0.00	0.00	39.43	726.83	1690.79	54.86	661.62	45.63	271.60	0.00	0.00	65.18	0.00	65.18
2002	NOV3	726.83	1690.79	19.04	16.45	2.14	0.00	0.00	39.45	726.35	1665.65	54.86	661.23	45.66	271.60	0.00	0.00	65.18	0.00	65.18
2002	DEC1	726.35	1665.65	14.13	12.21	2.64	0.00	0.00	39.48	725.78	1635.74	54.86	660.71	45.70	271.60	0.00	0.00	65.18	0.00	65.18
2002	DEC2	725.78	1635.74	10.05	8.68	2.60	0.00	0.00	39.52	725.15	1602.30	54.86	660.11	45.74	271.60	0.00	0.00	65.18	0.00	65.18
2002	DEC3	725.15	1602.30	5.52	5.25	2.55	0.00	0.00	43.52	724.32	1561.49	54.86	659.37	45.79	271.60	0.00	0.00	71.70	0.00	71.70
2003	JAN1	724.32	1561.49	6.57	5.68	2.34	0.00	0.00	39.61	723.54	1525.22	54.86	658.57	45.85	271.60	0.00	0.00	65.18	0.00	65.18
2003	JAN2	723.54	1525.22	3.80	3.28	2.30	0.00	0.00	39.66	722.71	1486.54	54.86	657.77	45.90	271.60	0.00	0.00	65.18	0.00	65.18
2003	JAN3	722.71	1486.54	3.32	3.16	2.25	0.00	0.00	43.68	721.79	1443.77	54.86	656.89	45.96	271.60	0.00	0.00	71.70	0.00	71.70
2003	FEB1	721.79	1443.77	2.63	2.27	2.82	0.00	0.00	39.77	720.90	1403.45	54.86	655.99	46.03	271.60	0.00	0.00	65.18	0.00	65.18
2003	FEB2	720.90	1403.45	6.69	5.78	2.76	0.00	0.00	39.82	720.09	1366.65	54.86	655.14	46.09	271.60	0.00	0.00	65.18	0.00	65.18
2003	FEB3	720.09	1366.65	7.41	5.12	2.72	0.00	0.00	31.89	719.44	1337.16	54.86	654.41	46.14	271.60	0.00	0.00	52.15	0.00	52.15
2003	MAR1	719.44	1337.16	10.06	8.69	2.15	0.00	0.00	39.91	718.70	1303.80	54.86	653.71	46.19	271.60	0.00	0.00	65.18	0.00	65.18
2003	MAR2	718.70	1303.80	16.33	14.11	2.12	0.00	0.00	39.95	718.01	1275.84	54.86	653.00	46.24	271.60	0.00	0.00	65.18	0.00	65.18
2003	MAR3	718.01	1275.84	7.75	7.37	2.08	0.00	0.00	44.00	717.05	1237.14	54.86	652.17	46.30	271.60	0.00	0.00	71.70	0.00	71.70
2003	APR1	717.05	1237.14	5.90	5.10	2.10	0.00	0.00	40.06	716.13	1200.08	54.86	651.23	46.36	271.60	0.00	0.00	65.18	0.00	65.18
2003	APR2	716.13	1200.08	6.68	5.77	2.05	0.00	0.00	40.11	715.22	1163.68	54.86	650.31	46.43	271.60	0.00	0.00	65.18	0.00	65.18
2003	APR3	715.22	1163.68	5.58	4.82	2.01	0.00	0.00	40.17	714.26	1126.32	54.86	649.38	46.49	271.60	0.00	0.00	65.18	0.00	65.18
2003	MAY1	714.26	1126.32	10.83	9.36	1.90	0.00	0.00	40.23	713.43	1093.55	54.86	648.49	46.56	271.60	0.00	0.00	65.18	0.00	65.18
2003	MAY2	713.43	1093.55	10.14	8.76	1.86	0.00	0.00	40.28	712.57	1060.17	54.86	647.64	46.62	271.60	0.00	0.00	65.18	0.00	65.18
2003	MAY3	712.57	1060.17	7.80	7.41	1.82	0.00	0.00	44.37	711.46	1021.38	54.86	646.66	46.69	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1088.22	79.74	0.00	0.00	1449.11									2379.22	0.00	2379.22

IT HYDROELECTRIC PROJECTS (STUDIES

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2003	JUN1	711.46	1021.38	7.88	6.81	1.47	0.00	0.00	40.41	710.46	986.31	54.86	645.61	46.77	271.60	0.00	0.00	65.18	0.00	65.18
2003	JUN2	710.46	986.31	12.65	10.93	1.44	0.00	0.00	40.47	709.58	955.33	54.86	644.66	46.83	271.60	0.00	0.00	65.18	0.00	65.18
2003	JUN3	709.58	955.33	71.01	61.35	1.44	0.00	0.00	40.48	710.13	974.77	54.86	644.50	46.85	271.60	0.00	0.00	65.18	0.00	65.18
2003	JUL 1	710.13	974.77	55.05	47.56	1.81	0.00	0.00	40.45	710.29	980.06	54.86	644.85	46.82	271.60	0.00	0.00	65.18	0.00	65.18
2003	JUL2	710.29	980.06	86.37	74.62	1.83	0.00	0.00	40.42	711.21	1012.43	54.86	645.39	46.78	271.60	0.00	0.00	65.18	0.00	65.18
2003	JUL3	711.21	1012.43	70.66	67.16	1.86	0.00	0.00	44.41	711.81	1033.31	54.86	646.15	46.73	271.60	0.00	0.00	71.70	0.00	71.70
2003	AUG1	711.81	1033.31	56.81	49.08	1.46	0.00	0.00	40.35	712.01	1040.59	54.86	646.55	46.70	271.60	0.00	0.00	65.18	0.00	65.18
2003	AUG2	712.01	1040.59	79.24	68.46	1.47	0.00	0.00	40.32	712.76	1067.26	54.86	647.03	46.66	271.60	0.00	0.00	65.18	0.00	65.18
2003	AUG3	712.76	1067.26	121.29	115.27	1.52	0.00	0.00	44.26	714.53	1136.75	54.86	648.28	46.57	271.60	0.00	0.00	71.70	0.00	71.70
2003	SEP1	714.53	1136.75	58.03	50.14	1.60	0.00	0.00	40.18	714.74	1145.11	54.86	649.28	46.50	271.60	0.00	0.00	65.18	0.00	65.18
2003	SEP2	714.74	1145.11	25.07	21.66	1.60	0.00	0.00	40.19	714.23	1124.99	54.86	649.13	46.51	271.60	0.00	0.00	65.18	0.00	65.18
2003	SEP3	714.23	1124.99	16.28	14.07	1.57	0.00	0.00	40.22	713.52	1097.26	54.86	648.52	46.56	271.60	0.00	0.00	65.18	0.00	65.18
2003	OCT1	713.52	1097.26	139.10	120.18	1.55	0.00	0.00	40.18	715.52	1175.70	54.86	649.16	46.51	271.60	0.00	0.00	65.18	0.00	65.18
2003	OCT2	715.52	1175.70	91.33	78.91	1.60	0.00	0.00	40.09	716.45	1212.92	54.86	650.62	46.41	271.60	0.00	0.00	65.18	0.00	65.18
2003	OCT3	716.45	1212.92	55.67	52.91	1.62	0.00	0.00	44.07	716.63	1220.14	54.86	651.18	46.37	271.60	0.00	0.00	71.70	0.00	71.70
2003	NOV1	716.63	1220.14	27.38	23.66	1.67	0.00	0.00	40.07	716.18	1202.06	54.86	651.04	46.38	271.60	0.00	0.00	65.18	0.00	65.18
2003	NOV2	716.18	1202.06	17.87	15.44	1.65	0.00	0.00	40.10	715.52	1175.75	54.86	650.49	46.42	271.60	0.00	0.00	65.18	0.00	65.18
2003	NOV3	715.52	1175.75	13.81	11.93	1.62	0.00	0.00	40.15	714.76	1145.91	54.86	649.78	46.47	271.60	0.00	0.00	65.18	0.00	65.18
2003	DEC1	714.76	1145.91	11.59	10.01	1.99	0.00	0.00	40.20	713.94	1113.73	54.86	648.99	46.52	271.60	0.00	0.00	65.18	0.00	65.18
2003	DEC2	713.94	1113.73	7.99	6.90	1.95	0.00	0.00	40.25	713.04	1078.43	54.86	648.13	46.58	271.60	0.00	0.00	65.18	0.00	65.18
2003	DEC3	713.04	1078.43	4.38	4.16	1.90	0.00	0.00	44.34	711.89	1036.35	54.86	647.11	46.66	271.60	0.00	0.00	71.70	0.00	71.70
2004	JAN1	711.89	1036.35	5.25	4.54	1.74	0.00	0.00	40.38	710.82	998.76	54.86	646.00	46.74	271.60	0.00	0.00	65.18	0.00	65.18
2004	JAN2	710.82	998.76	7.35	6.35	1.70	0.00	0.00	40.45	709.80	962.97	54.86	644.95	46.81	271.60	0.00	0.00	65.18	0.00	65.18
2004	JAN3	709.80	962.97	8.35	7.94	1.66	0.00	0.00	44.57	708.68	924.68	54.86	643.88	46.89	271.60	0.00	0.00	71.70	0.00	71.70
2004	FEB1	708.68	924.68	8.91	7.70	2.07	0.00	0.00	40.58	707.65	889.73	54.86	642.81	46.97	271.60	0.00	0.00	65.18	0.00	65.18
2004	FEB2	707.65	889.73	5.72	4.94	2.02	0.00	0.00	40.65	706.54	852.00	54.86	641.74	47.05	271.60	0.00	0.00	65.18	0.00	65.18
2004	FEB3	706.54	852.00	4.69	3.24	1.96	0.00	0.00	32.57	705.50	820.70	54.86	640.66	47.13	271.60	0.00	0.00	52.15	0.00	52.15
2004	MAR1	705.50	820.70	3.62	3.13	1.53	0.00	0.00	40.79	704.19	781.51	54.86	639.48	47.21	271.60	0.00	0.00	65.18	0.00	65.18
2004	MAR2	704.19	781.51	4.35	3.76	1.47	0.00	0.00	40.88	702.89	742.92	54.86	638.18	47.31	271.60	0.00	0.00	65.18	0.00	65.18
2004	MAR3	702.89	742.92	7.14	6.79	1.41	0.00	0.00	45.06	701.53	703.24	54.86	636.85	47.41	271.60	0.00	0.00	71.70	0.00	71.70
2004	APR1	701.53	703.24	6.79	5.87	1.40	0.00	0.00	41.05	700.24	666.66	54.86	635.52	47.51	271.60	0.00	0.00	65.18	0.00	65.18
2004	APR2	700.24	666.66	9.61	8.30	1.34	0.00	0.00	41.13	698.94	632.49	54.86	634.23	47.61	271.60	0.00	0.00	65.18	0.00	65.18
2004	APR3	698.94	632.49	7.20	6.22	1.29	0.00	0.00	41.22	697.47	596.20	54.86	632.84	47.71	271.60	0.00	0.00	65.18	0.00	65.18
2004	MAY1	697.47	596.20	25.43	21.97	1.20	0.00	0.00	41.30	696.60	575.67	54.86	631.67	47.80	271.60	0.00	0.00	65.18	0.00	65.18
2004	MAY2	696.60	575.67	37.55	32.44	1.17	0.00	0.00	41.34	696.17	565.59	54.86	631.02	47.85	271.60	0.00	0.00	65.18	0.00	65.18
2004	MAY3	696.17	565.59	52.18	49.59	1.17	0.00	0.00	45.48	696.29	568.53	54.86	630.87	47.86	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1083.99	57.79	0.00	0.00	1479.05									2379.22	0.00	2379.22

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2004	JUN1	696.29	568.53	71.09	61.42	0.98	0.00	0.00	41.32	697.11	587.65	54.86	631.34	47.82	271.60	0.00	0.00	65.18	0.00	65.18
2004	JUN2	697.11	587.65	244.16	210.95	1.10	0.00	0.00	41.09	703.35	756.41	54.86	634.86	47.56	271.60	0.00	0.00	65.18	0.00	65.18
2004	JUN3	703.35	756.41	72.29	62.46	1.22	0.00	0.00	40.87	704.03	776.78	54.86	638.33	47.30	271.60	0.00	0.00	65.18	0.00	65.18
2004	JUL 1	704.03	776.78	88.09	76.11	1.57	0.00	0.00	40.81	705.16	810.52	54.86	639.23	47.23	271.60	0.00	0.00	65.18	0.00	65.18
2004	JUL2	705.16	810.52	89.28	77.14	1.62	0.00	0.00	40.74	706.32	845.30	54.86	640.38	47.15	271.60	0.00	0.00	65.18	0.00	65.18
2004	JUL3	706.32	845.30	87.83	83.47	1.67	0.00	0.00	44.73	707.44	882.36	54.86	641.52	47.06	271.60	0.00	0.00	71.70	0.00	71.70
2004	AUG1	707.44	882.36	271.25	234.36	1.40	0.00	0.00	40.45	712.95	1074.86	54.86	644.83	46.82	271.60	0.00	0.00	65.18	0.00	65.18
2004	AUG2	712.95	1074.86	101.64	87.82	1.51	0.00	0.00	40.25	714.13	1120.93	54.86	648.18	46.58	271.60	0.00	0.00	65.18	0.00	65.18
2004	AUG3	714.13	1120.93	50.22	47.73	1.53	0.00	0.00	44.23	714.18	1122.89	54.86	648.79	46.54	271.60	0.00	0.00	71.70	0.00	71.70
2004	SEP1	714.18	1122.89	35.21	30.42	1.58	0.00	0.00	40.22	713.89	1111.52	54.86	648.67	46.55	271.60	0.00	0.00	65.18	0.00	65.18
2004	SEP2	713.89	1111.52	40.73	35.19	1.57	0.00	0.00	40.23	713.72	1104.91	54.86	648.44	46.56	271.60	0.00	0.00	65.18	0.00	65.18
2004	SEP3	713.72	1104.91	57.14	49.37	1.57	0.00	0.00	40.23	713.91	1112.48	54.86	648.45	46.56	271.60	0.00	0.00	65.18	0.00	65.18
2004	OCT1	713.91	1112.48	75.60	65.32	1.54	0.00	0.00	40.20	714.51	1136.06	54.86	648.85	46.53	271.60	0.00	0.00	65.18	0.00	65.18
2004	OCT2	714.51	1136.06	77.03	66.55	1.56	0.00	0.00	40.17	715.14	1160.88	54.86	649.47	46.49	271.60	0.00	0.00	65.18	0.00	65.18
2004	OCT3	715.14	1160.88	39.70	37.73	1.57	0.00	0.00	44.17	714.94	1152.88	54.86	649.68	46.47	271.60	0.00	0.00	71.70	0.00	71.70
2004	NOV1	714.94	1152.88	34.50	29.81	1.61	0.00	0.00	40.17	714.63	1140.91	54.86	649.43	46.49	271.60	0.00	0.00	65.18	0.00	65.18
2004	NOV2	714.63	1140.91	30.79	26.60	1.60	0.00	0.00	40.19	714.25	1125.72	54.86	649.08	46.52	271.60	0.00	0.00	65.18	0.00	65.18
2004	NOV3	714.25	1125.72	17.30	14.95	1.58	0.00	0.00	40.22	713.56	1098.87	54.86	648.55	46.55	271.60	0.00	0.00	65.18	0.00	65.18
2004	DEC1	713.56	1098.87	12.21	10.55	1.93	0.00	0.00	40.27	712.76	1067.22	54.86	647.80	46.61	271.60	0.00	0.00	65.18	0.00	65.18
2004	DEC2	712.76	1067.22	6.81	5.88	1.89	0.00	0.00	40.33	711.74	1030.88	54.86	646.89	46.67	271.60	0.00	0.00	65.18	0.00	65.18
2004	DEC3	711.74	1030.88	5.67	5.39	1.85	0.00	0.00	44.43	710.57	989.99	54.86	645.79	46.75	271.60	0.00	0.00	71.70	0.00	71.70
2005	JAN1	710.57	989.99	8.16	7.05	1.69	0.00	0.00	40.46	709.57	954.88	54.86	644.71	46.83	271.60	0.00	0.00	65.18	0.00	65.18
2005	JAN2	709.57	954.88	10.10	8.73	1.65	0.00	0.00	40.52	708.58	921.44	54.86	643.72	46.90	271.60	0.00	0.00	65.18	0.00	65.18
2005	JAN3	708.58	921.44	10.40	9.88	1.61	0.00	0.00	44.65	707.51	885.06	54.86	642.69	46.98	271.60	0.00	0.00	71.70	0.00	71.70
2005	FEB1	707.51	885.06	10.63	9.18	2.02	0.00	0.00	40.65	706.53	851.56	54.86	641.66	47.05	271.60	0.00	0.00	65.18	0.00	65.18
2005	FEB2	706.53	851.56	6.62	5.72	1.96	0.00	0.00	40.72	705.29	814.60	54.86	640.55	47.14	271.60	0.00	0.00	65.18	0.00	65.18
2005	FEB3	705.29	814.60	4.37	3.02	1.89	0.00	0.00	32.64	704.24	783.09	54.86	639.41	47.22	271.60	0.00	0.00	52.15	0.00	52.15
2005	MAR1	704.24	783.09	12.13	10.48	1.48	0.00	0.00	40.87	703.17	751.22	54.86	638.35	47.30	271.60	0.00	0.00	65.18	0.00	65.18
2005	MAR2	703.17	751.22	11.03	9.53	1.43	0.00	0.00	40.94	702.06	718.39	54.86	637.26	47.38	271.60	0.00	0.00	65.18	0.00	65.18
2005	MAR3	702.06	718.39	10.47	9.95	1.38	0.00	0.00	45.11	700.77	681.85	54.86	636.06	47.47	271.60	0.00	0.00	71.70	0.00	71.70
2005	APR1	700.77	681.85	12.45	10.76	1.37	0.00	0.00	41.09	699.63	650.15	54.86	634.84	47.56	271.60	0.00	0.00	65.18	0.00	65.18
2005	APR2	699.63	650.15	13.44	11.61	1.32	0.00	0.00	41.17	698.41	619.27	54.86	633.66	47.65	271.60	0.00	0.00	65.18	0.00	65.18
2005	APR3	698.41	619.27	14.18	12.25	1.27	0.00	0.00	41.25	697.17	589.00	54.86	632.43	47.74	271.60	0.00	0.00	65.18	0.00	65.18
2005	MAY1	697.17	589.00	19.66	16.99	1.18	0.00	0.00	41.32	696.08	563.48	54.86	631.26	47.83	271.60	0.00	0.00	65.18	0.00	65.18
2005	MAY2	696.08	563.48	12.43	10.74	1.14	0.00	0.00	36.28	694.94	536.80	54.86	630.15	41.99	238.01	0.00	0.00	57.12	0.00	57.12
2005	MAY3	694.94	536.80	10.25	9.74	1.12	0.00	0.00	8.62	694.94	536.80	54.86	629.58	9.07	51.38	0.00	0.00	13.56	0.00	13.56
TOTAL					1464.85	54.98	0.00	0.00	1441.60									2313.02	0.00	2313.02

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2005	JUN1	694.94	536.80	19.58	16.92	0.92	0.00	0.00	16.00	694.94	536.80	54.86	629.58	18.51	104.85	0.00	0.00	25.16	0.00	25.16
2005	JUN2	694.94	536.80	61.18	52.86	0.93	0.00	0.00	41.42	695.39	547.31	54.86	629.81	47.94	271.60	0.00	0.00	65.18	0.00	65.18
2005	JUN3	695.39	547.31	96.64	83.50	0.97	0.00	0.00	41.35	697.14	588.50	54.86	630.91	47.86	271.60	0.00	0.00	65.18	0.00	65.18
2005	JUL 1	697.14	588.50	139.44	120.48	1.31	0.00	0.00	41.19	700.23	666.48	54.86	633.33	47.67	271.60	0.00	0.00	65.18	0.00	65.18
2005	JUL2	700.23	666.48	139.44	120.48	1.43	0.00	0.00	41.00	702.95	744.53	54.86	636.23	47.46	271.60	0.00	0.00	65.18	0.00	65.18
2005	JUL3	702.95	744.53	409.25	388.95	1.73	0.00	0.00	44.64	713.26	1087.11	54.86	642.74	46.97	271.60	0.00	0.00	71.70	0.00	71.70
2005	AUG1	713.26	1087.11	338.08	292.10	1.62	0.00	0.00	40.07	719.45	1337.52	54.86	650.99	46.38	271.60	0.00	0.00	65.18	0.00	65.18
2005	AUG2	719.45	1337.52	76.81	66.36	1.75	0.00	0.00	39.87	720.00	1362.26	54.86	654.36	46.14	271.60	0.00	0.00	65.18	0.00	65.18
2005	AUG3	720.00	1362.26	47.37	45.02	1.76	0.00	0.00	43.83	719.98	1361.69	54.86	654.63	46.12	271.60	0.00	0.00	71.70	0.00	71.70
2005	SEP1	719.98	1361.69	263.85	227.97	1.91	0.00	0.00	39.73	724.03	1548.02	54.86	656.64	45.98	271.60	0.00	0.00	65.18	0.00	65.18
2005	SEP2	724.03	1548.02	187.53	162.03	2.06	0.00	0.00	39.53	726.40	1668.45	54.86	659.86	45.76	271.60	0.00	0.00	65.18	0.00	65.18
2005	SEP3	726.40	1668.45	59.99	51.83	2.14	0.00	0.00	39.46	726.60	1678.69	54.86	661.14	45.67	271.60	0.00	0.00	65.18	0.00	65.18
2005	OCT1	726.60	1678.69	38.96	33.66	2.07	0.00	0.00	39.46	726.45	1670.83	54.86	661.16	45.67	271.60	0.00	0.00	65.18	0.00	65.18
2005	OCT2	726.45	1670.83	49.11	42.43	2.06	0.00	0.00	39.46	726.47	1671.73	54.86	661.10	45.67	271.60	0.00	0.00	65.18	0.00	65.18
2005	OCT3	726.47	1671.73	52.39	49.79	2.07	0.00	0.00	43.40	726.55	1676.06	54.86	661.15	45.67	271.60	0.00	0.00	71.70	0.00	71.70
2005	NOV1	726.55	1676.06	45.02	38.90	2.14	0.00	0.00	39.46	726.50	1673.36	54.86	661.16	45.67	271.60	0.00	0.00	65.18	0.00	65.18
2005	NOV2	726.50	1673.36	68.32	59.03	2.14	0.00	0.00	39.45	726.83	1690.80	54.86	661.30	45.66	271.60	0.00	0.00	65.18	0.00	65.18
2005	NOV3	726.83	1690.80	42.65	36.85	2.15	0.00	0.00	39.44	726.74	1686.06	54.86	661.42	45.65	271.60	0.00	0.00	65.18	0.00	65.18
2005	DEC1	726.74	1686.06	31.42	27.15	2.68	0.00	0.00	39.45	726.45	1671.08	54.86	661.24	45.66	271.60	0.00	0.00	65.18	0.00	65.18
2005	DEC2	726.45	1671.08	29.11	25.15	2.65	0.00	0.00	39.47	726.13	1654.11	54.86	660.93	45.68	271.60	0.00	0.00	65.18	0.00	65.18
2005	DEC3	726.13	1654.11	14.72	13.99	2.62	0.00	0.00	43.45	725.52	1622.03	54.86	660.47	45.71	271.60	0.00	0.00	71.70	0.00	71.70
2006	JAN1	725.52	1622.03	9.95	8.60	2.41	0.00	0.00	39.53	724.89	1588.68	54.86	659.85	45.76	271.60	0.00	0.00	65.18	0.00	65.18
2006	JAN2	724.89	1588.68	9.63	8.32	2.37	0.00	0.00	39.57	724.18	1555.06	54.86	659.18	45.80	271.60	0.00	0.00	65.18	0.00	65.18
2006	JAN3	724.18	1555.06	3.57	3.39	2.33	0.00	0.00	43.59	723.27	1512.53	54.86	658.36	45.86	271.60	0.00	0.00	71.70	0.00	71.70
2006	FEB1	723.27	1512.53	10.02	8.66	2.93	0.00	0.00	39.67	722.54	1478.59	54.86	657.54	45.92	271.60	0.00	0.00	65.18	0.00	65.18
2006	FEB2	722.54	1478.59	9.97	8.61	2.88	0.00	0.00	39.72	721.81	1444.61	54.86	656.81	45.97	271.60	0.00	0.00	65.18	0.00	65.18
2006	FEB3	721.81	1444.61	6.44	4.45	2.83	0.00	0.00	31.81	721.15	1414.42	54.86	656.12	46.02	271.60	0.00	0.00	52.15	0.00	52.15
2006	MAR1	721.15	1414.42	6.38	5.51	2.24	0.00	0.00	39.80	720.34	1377.88	54.86	655.38	46.07	271.60	0.00	0.00	65.18	0.00	65.18
2006	MAR2	720.34	1377.88	14.35	12.40	2.20	0.00	0.00	39.85	719.69	1348.23	54.86	654.65	46.12	271.60	0.00	0.00	65.18	0.00	65.18
2006	MAR3	719.69	1348.23	16.21	15.41	2.17	0.00	0.00	43.88	719.01	1317.60	54.86	653.99	46.17	271.60	0.00	0.00	71.70	0.00	71.70
2006	APR1	719.01	1317.60	11.10	9.59	2.20	0.00	0.00	39.93	718.24	1285.06	54.86	653.26	46.22	271.60	0.00	0.00	65.18	0.00	65.18
2006	APR2	718.24	1285.06	23.21	20.05	2.17	0.00	0.00	39.97	717.69	1262.97	54.86	652.60	46.26	271.60	0.00	0.00	65.18	0.00	65.18
2006	APR3	717.69	1262.97	16.78	14.50	2.14	0.00	0.00	40.01	717.00	1235.32	54.86	651.99	46.31	271.60	0.00	0.00	65.18	0.00	65.18
2006	MAY1	717.00	1235.32	18.29	15.80	2.04	0.00	0.00	40.05	716.35	1209.03	54.86	651.32	46.36	271.60	0.00	0.00	65.18	0.00	65.18
2006	MAY2	716.35	1209.03	18.36	15.86	2.00	0.00	0.00	40.09	715.70	1182.80	54.86	650.67	46.40	271.60	0.00	0.00	65.18	0.00	65.18
2006	MAY3	715.70	1182.80	72.44	68.85	2.00	0.00	0.00	44.10	716.27	1205.54	54.86	650.62	46.41	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					2175.45	74.02	0.00	0.00	1432.69									2339.20	0.00	2339.20

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34
M.D.D.L 694.94 536.80
C/L 54.86

T.G.EFF. = 91.70%
Firm Power exep.(MW) = 271.600
Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2006	JUN1	716.27	1205.54	76.45	66.05	1.68	0.00	0.00	40.06	716.87	1229.85	54.86	651.21	46.36	271.60	0.00	0.00	65.18	0.00	65.18
2006	JUN2	716.87	1229.85	26.18	22.62	1.68	0.00	0.00	40.05	716.39	1210.74	54.86	651.27	46.36	271.60	0.00	0.00	65.18	0.00	65.18
2006	JUN3	716.39	1210.74	120.31	103.95	1.70	0.00	0.00	40.02	717.94	1272.97	54.86	651.81	46.32	271.60	0.00	0.00	65.18	0.00	65.18
2006	JUL 1	717.94	1272.97	126.69	109.46	2.20	0.00	0.00	39.93	719.51	1340.30	54.86	653.36	46.21	271.60	0.00	0.00	65.18	0.00	65.18
2006	JUL2	719.51	1340.30	207.15	178.98	2.33	0.00	0.00	39.79	722.51	1477.16	54.86	655.65	46.05	271.60	0.00	0.00	65.18	0.00	65.18
2006	JUL3	722.51	1477.16	98.11	93.24	2.45	0.00	0.00	43.63	723.52	1524.32	54.86	657.65	45.91	271.60	0.00	0.00	71.70	0.00	71.70
2006	AUG1	723.52	1524.32	46.91	40.53	1.92	0.00	0.00	39.64	723.50	1523.29	54.86	658.15	45.88	271.60	0.00	0.00	65.18	0.00	65.18
2006	AUG2	723.50	1523.29	178.74	154.43	1.97	0.00	0.00	39.57	725.79	1636.19	54.86	659.28	45.80	271.60	0.00	0.00	65.18	0.00	65.18
2006	AUG3	725.79	1636.19	67.56	64.21	2.04	0.00	0.00	43.44	726.15	1654.92	54.86	660.61	45.70	271.60	0.00	0.00	71.70	0.00	71.70
2006	SEP1	726.15	1654.92	38.76	33.49	2.11	0.00	0.00	39.48	725.99	1646.82	54.86	660.71	45.70	271.60	0.00	0.00	65.18	0.00	65.18
2006	SEP2	725.99	1646.82	92.72	80.11	2.13	0.00	0.00	39.47	726.72	1685.33	54.86	661.00	45.68	271.60	0.00	0.00	65.18	0.00	65.18
2006	SEP3	726.72	1685.33	96.82	83.65	2.17	0.00	0.00	39.42	727.52	1727.40	54.86	661.76	45.62	271.60	0.00	0.00	65.18	0.00	65.18
2006	OCT1	727.52	1727.40	71.53	61.80	2.13	0.00	0.00	39.38	727.90	1747.68	54.86	662.35	45.58	271.60	0.00	0.00	65.18	0.00	65.18
2006	OCT2	727.90	1747.68	102.97	88.97	2.17	0.00	0.00	39.35	728.78	1795.14	54.86	662.98	45.54	271.60	0.00	0.00	65.18	0.00	65.18
2006	OCT3	728.78	1795.14	55.59	52.83	2.19	0.00	0.00	43.25	728.91	1802.52	54.86	663.49	45.51	271.60	0.00	0.00	71.70	0.00	71.70
2006	NOV1	728.91	1802.52	81.40	70.33	2.29	0.00	0.00	39.30	729.44	1831.27	54.86	663.82	45.48	271.60	0.00	0.00	65.18	0.00	65.18
2006	NOV2	729.44	1831.27	76.06	65.72	2.31	0.00	0.00	39.27	729.89	1855.41	54.86	664.31	45.45	271.60	0.00	0.00	65.18	0.00	65.18
2006	NOV3	729.89	1855.41	88.08	76.10	2.35	0.00	0.00	39.24	730.52	1889.93	54.86	664.85	45.41	271.60	0.00	0.00	65.18	0.00	65.18
2006	DEC1	730.52	1889.93	16.76	14.48	2.94	0.00	0.00	39.23	730.01	1862.24	54.86	664.91	45.41	271.60	0.00	0.00	65.18	0.00	65.18
2006	DEC2	730.01	1862.24	12.78	11.04	2.90	0.00	0.00	39.27	729.44	1831.11	54.86	664.37	45.45	271.60	0.00	0.00	65.18	0.00	65.18
2006	DEC3	729.44	1831.11	2.70	2.57	2.85	0.00	0.00	43.24	728.64	1787.60	54.86	663.68	45.49	271.60	0.00	0.00	71.70	0.00	71.70
2007	JAN1	728.64	1787.60	11.98	10.35	2.62	0.00	0.00	39.35	728.06	1755.99	54.86	662.99	45.54	271.60	0.00	0.00	65.18	0.00	65.18
2007	JAN2	728.06	1755.99	9.03	7.80	2.58	0.00	0.00	39.38	727.42	1721.83	54.86	662.38	45.58	271.60	0.00	0.00	65.18	0.00	65.18
2007	JAN3	727.42	1721.83	5.58	5.30	2.53	0.00	0.00	43.37	726.65	1681.23	54.86	661.67	45.63	271.60	0.00	0.00	71.70	0.00	71.70
2007	FEB1	726.65	1681.23	7.58	6.55	3.19	0.00	0.00	39.47	725.96	1645.12	54.86	660.94	45.68	271.60	0.00	0.00	65.18	0.00	65.18
2007	FEB2	725.96	1645.12	3.50	3.02	3.13	0.00	0.00	39.51	725.21	1605.50	54.86	660.23	45.73	271.60	0.00	0.00	65.18	0.00	65.18
2007	FEB3	725.21	1605.50	6.66	4.60	3.07	0.00	0.00	31.64	724.62	1575.39	54.86	659.55	45.78	271.60	0.00	0.00	52.15	0.00	52.15
2007	MAR1	724.62	1575.39	10.60	9.16	2.44	0.00	0.00	39.59	723.91	1542.52	54.86	658.90	45.82	271.60	0.00	0.00	65.18	0.00	65.18
2007	MAR2	723.91	1542.52	10.39	8.98	2.40	0.00	0.00	39.63	723.20	1509.47	54.86	658.20	45.87	271.60	0.00	0.00	65.18	0.00	65.18
2007	MAR3	723.20	1509.47	10.05	9.55	2.36	0.00	0.00	43.65	722.42	1473.02	54.86	657.45	45.92	271.60	0.00	0.00	71.70	0.00	71.70
2007	APR1	722.42	1473.02	10.94	9.45	2.39	0.00	0.00	39.72	721.72	1440.35	54.86	656.71	45.98	271.60	0.00	0.00	65.18	0.00	65.18
2007	APR2	721.72	1440.35	16.81	14.52	2.36	0.00	0.00	39.76	721.11	1412.75	54.86	656.05	46.02	271.60	0.00	0.00	65.18	0.00	65.18
2007	APR3	721.11	1412.75	18.89	16.32	2.32	0.00	0.00	39.80	720.54	1386.95	54.86	655.46	46.06	271.60	0.00	0.00	65.18	0.00	65.18
2007	MAY1	720.54	1386.95	10.44	9.02	2.21	0.00	0.00	39.84	719.81	1353.92	54.86	654.82	46.11	271.60	0.00	0.00	65.18	0.00	65.18
2007	MAY2	719.81	1353.92	14.85	12.83	2.17	0.00	0.00	39.88	719.17	1324.70	54.86	654.13	46.16	271.60	0.00	0.00	65.18	0.00	65.18
2007	MAY3	719.17	1324.70	20.24	19.24	2.14	0.00	0.00	43.91	718.56	1297.89	54.86	653.50	46.20	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1621.25	84.40	0.00	0.00	1444.51									2379.22	0.00	2379.22

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2007	JUN1	718.56	1297.89	14.07	12.16	1.74	0.00	0.00	39.96	717.82	1268.35	54.86	652.83	46.25	271.60	0.00	0.00	65.18	0.00	65.18
2007	JUN2	717.82	1268.35	40.68	35.15	1.72	0.00	0.00	39.99	717.66	1261.79	54.86	652.38	46.28	271.60	0.00	0.00	65.18	0.00	65.18
2007	JUN3	717.66	1261.79	210.29	181.69	1.79	0.00	0.00	39.89	720.87	1401.79	54.86	653.90	46.17	271.60	0.00	0.00	65.18	0.00	65.18
2007	JUL 1	720.87	1401.79	321.64	277.90	2.47	0.00	0.00	39.65	725.82	1637.58	54.86	657.98	45.89	271.60	0.00	0.00	65.18	0.00	65.18
2007	JUL2	725.82	1637.58	317.42	274.25	2.77	0.00	0.00	39.37	730.15	1869.69	54.86	662.62	45.57	271.60	0.00	0.00	65.18	0.00	65.18
2007	JUL3	730.15	1869.69	138.14	131.29	2.98	0.00	0.00	43.11	731.69	1954.88	54.86	665.56	45.36	271.60	0.00	0.00	71.70	0.00	71.70
2007	AUG1	731.69	1954.88	176.83	152.78	2.36	0.00	0.00	108.96	732.43	1996.34	54.86	666.70	126.11	271.60	484.75	0.00	65.18	116.34	181.52
2007	AUG2	732.43	1996.34	130.57	112.81	2.38	0.00	0.00	110.43	732.43	1996.34	54.86	667.07	127.81	271.60	495.35	0.00	65.18	118.88	184.07
2007	AUG3	732.43	1996.34	77.11	73.29	2.38	0.00	0.00	70.91	732.43	1996.34	54.86	667.07	74.61	271.60	176.10	0.00	71.70	46.49	118.19
2007	SEP1	732.43	1996.34	92.95	80.31	2.46	0.00	0.00	77.85	732.43	1996.34	54.86	667.07	90.10	271.60	269.07	0.00	65.18	64.58	129.76
2007	SEP2	732.43	1996.34	158.02	136.53	2.46	0.00	0.00	134.07	732.43	1996.34	54.86	667.07	155.17	271.60	659.54	0.00	65.18	158.29	223.47
2007	SEP3	732.43	1996.34	211.69	182.90	2.46	0.00	0.00	180.44	732.43	1996.34	54.86	667.07	208.84	271.60	981.59	0.00	65.18	235.58	300.77
2007	OCT1	732.43	1996.34	67.99	58.74	2.38	0.00	0.00	56.36	732.43	1996.34	54.86	667.07	65.23	271.60	119.82	0.00	65.18	28.76	93.94
2007	OCT2	732.43	1996.34	82.03	70.87	2.38	0.00	0.00	68.49	732.43	1996.34	54.86	667.07	79.27	271.60	204.06	0.00	65.18	48.97	114.16
2007	OCT3	732.43	1996.34	157.93	150.10	2.38	0.00	0.00	147.72	732.43	1996.34	54.86	667.07	155.43	271.60	661.07	0.00	71.70	174.52	246.22
2007	NOV1	732.43	1996.34	105.91	91.51	2.46	0.00	0.00	89.05	732.43	1996.34	54.86	667.07	103.06	271.60	346.86	0.00	65.18	83.25	148.43
2007	NOV2	732.43	1996.34	53.98	46.64	2.46	0.00	0.00	44.18	732.43	1996.34	54.86	667.07	51.13	271.60	35.23	0.00	65.18	8.45	73.64
2007	NOV3	732.43	1996.34	28.98	25.04	2.45	0.00	0.00	39.11	732.14	1979.81	54.86	666.93	45.27	271.60	0.00	0.00	65.18	0.00	65.18
2007	DEC1	732.14	1979.81	15.73	13.59	3.04	0.00	0.00	39.14	731.63	1951.22	54.86	666.52	45.30	271.60	0.00	0.00	65.18	0.00	65.18
2007	DEC2	731.63	1951.22	20.07	17.34	3.01	0.00	0.00	39.17	731.19	1926.38	54.86	666.05	45.33	271.60	0.00	0.00	65.18	0.00	65.18
2007	DEC3	731.19	1926.38	19.13	18.18	2.98	0.00	0.00	43.11	730.68	1898.46	54.86	665.57	45.36	271.60	0.00	0.00	71.70	0.00	71.70
2008	JAN1	730.68	1898.46	8.60	7.43	2.75	0.00	0.00	39.23	730.04	1863.91	54.86	665.00	45.40	271.60	0.00	0.00	65.18	0.00	65.18
2008	JAN2	730.04	1863.91	8.26	7.14	2.71	0.00	0.00	39.27	729.40	1829.08	54.86	664.36	45.45	271.60	0.00	0.00	65.18	0.00	65.18
2008	JAN3	729.40	1829.08	13.04	12.39	2.67	0.00	0.00	43.23	728.79	1795.57	54.86	663.73	45.49	271.60	0.00	0.00	71.70	0.00	71.70
2008	FEB1	728.79	1795.57	14.07	12.16	3.37	0.00	0.00	39.34	728.22	1765.02	54.86	663.14	45.53	271.60	0.00	0.00	65.18	0.00	65.18
2008	FEB2	728.22	1765.02	12.82	11.08	3.32	0.00	0.00	39.37	727.63	1733.40	54.86	662.57	45.57	271.60	0.00	0.00	65.18	0.00	65.18
2008	FEB3	727.63	1733.40	8.19	5.66	3.27	0.00	0.00	31.52	727.08	1704.26	54.86	662.00	45.61	271.60	0.00	0.00	52.15	0.00	52.15
2008	MAR1	727.08	1704.26	12.73	11.00	2.60	0.00	0.00	39.44	726.49	1673.22	54.86	661.43	45.65	271.60	0.00	0.00	65.18	0.00	65.18
2008	MAR2	726.49	1673.22	16.90	14.60	2.57	0.00	0.00	39.47	725.97	1645.79	54.86	660.87	45.69	271.60	0.00	0.00	65.18	0.00	65.18
2008	MAR3	725.97	1645.79	20.64	19.62	2.53	0.00	0.00	43.45	725.47	1619.42	54.86	660.36	45.72	271.60	0.00	0.00	71.70	0.00	71.70
2008	APR1	725.47	1619.42	16.67	14.40	2.58	0.00	0.00	39.53	724.95	1591.71	54.86	659.85	45.76	271.60	0.00	0.00	65.18	0.00	65.18
2008	APR2	724.95	1591.71	15.49	13.38	2.54	0.00	0.00	39.57	724.35	1562.98	54.86	659.29	45.80	271.60	0.00	0.00	65.18	0.00	65.18
2008	APR3	724.35	1562.98	19.51	16.86	2.51	0.00	0.00	39.60	723.81	1537.73	54.86	658.72	45.84	271.60	0.00	0.00	65.18	0.00	65.18
2008	MAY1	723.81	1537.73	10.96	9.47	2.39	0.00	0.00	39.64	723.11	1505.16	54.86	658.10	45.88	271.60	0.00	0.00	65.18	0.00	65.18
2008	MAY2	723.11	1505.16	19.05	16.46	2.36	0.00	0.00	39.68	722.56	1479.59	54.86	657.48	45.92	271.60	0.00	0.00	65.18	0.00	65.18
2008	MAY3	722.56	1479.59	16.07	15.27	2.32	0.00	0.00	43.68	721.90	1448.85	54.86	656.87	45.96	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					2329.99	92.07	0.00	0.00	2086.96									2379.22	1084.12	3463.33

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34
M.D.D.L 694.94 536.80
C/L 54.86

T.G.EFF. = 91.70%
Firm Power exep.(MW) = 271.600
Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2008	JUN1	721.90	1448.85	17.51	15.13	1.89	0.00	0.00	39.75	721.32	1422.33	54.86	656.25	46.01	271.60	0.00	0.00	65.18	0.00	65.18
2008	JUN2	721.32	1422.33	35.20	30.41	1.87	0.00	0.00	39.78	721.07	1411.09	54.86	655.84	46.04	271.60	0.00	0.00	65.18	0.00	65.18
2008	JUN3	721.07	1411.09	74.28	64.18	1.88	0.00	0.00	39.77	721.57	1433.62	54.86	655.96	46.03	271.60	0.00	0.00	65.18	0.00	65.18
2008	JUL 1	721.57	1433.62	69.16	59.75	2.37	0.00	0.00	39.74	721.95	1451.26	54.86	656.40	46.00	271.60	0.00	0.00	65.18	0.00	65.18
2008	JUL2	721.95	1451.26	47.64	41.16	2.39	0.00	0.00	39.73	721.93	1450.30	54.86	656.58	45.98	271.60	0.00	0.00	65.18	0.00	65.18
2008	JUL3	721.93	1450.30	176.70	167.94	2.46	0.00	0.00	43.62	724.55	1572.16	54.86	657.88	45.89	271.60	0.00	0.00	71.70	0.00	71.70
2008	AUG1	724.55	1572.16	133.74	115.55	2.00	0.00	0.00	39.53	725.98	1646.18	54.86	659.90	45.75	271.60	0.00	0.00	65.18	0.00	65.18
2008	AUG2	725.98	1646.18	181.72	157.01	2.10	0.00	0.00	39.42	728.16	1761.67	54.86	661.71	45.63	271.60	0.00	0.00	65.18	0.00	65.18
2008	AUG3	728.16	1761.67	76.18	72.40	2.17	0.00	0.00	43.28	728.66	1788.63	54.86	663.05	45.54	271.60	0.00	0.00	71.70	0.00	71.70
2008	SEP1	728.66	1788.63	128.53	111.05	2.29	0.00	0.00	39.29	729.94	1858.09	54.86	663.94	45.48	271.60	0.00	0.00	65.18	0.00	65.18
2008	SEP2	729.94	1858.09	142.30	122.95	2.37	0.00	0.00	39.21	731.42	1939.46	54.86	665.32	45.38	271.60	0.00	0.00	65.18	0.00	65.18
2008	SEP3	731.42	1939.46	40.23	34.76	2.41	0.00	0.00	39.17	731.30	1932.64	54.86	666.00	45.33	271.60	0.00	0.00	65.18	0.00	65.18
2008	OCT1	731.30	1932.64	29.33	25.34	2.32	0.00	0.00	39.18	731.01	1916.48	54.86	665.79	45.35	271.60	0.00	0.00	65.18	0.00	65.18
2008	OCT2	731.01	1916.48	33.96	29.34	2.31	0.00	0.00	39.20	730.79	1904.32	54.86	665.54	45.37	271.60	0.00	0.00	65.18	0.00	65.18
2008	OCT3	730.79	1904.32	81.71	77.66	2.32	0.00	0.00	43.10	731.37	1936.56	54.86	665.72	45.35	271.60	0.00	0.00	71.70	0.00	71.70
2008	NOV1	731.37	1936.56	31.04	26.82	2.40	0.00	0.00	39.18	731.10	1921.80	54.86	665.88	45.34	271.60	0.00	0.00	65.18	0.00	65.18
2008	NOV2	731.10	1921.80	20.97	18.12	2.38	0.00	0.00	39.20	730.68	1898.34	54.86	665.53	45.37	271.60	0.00	0.00	65.18	0.00	65.18
2008	NOV3	730.68	1898.34	24.49	21.16	2.36	0.00	0.00	39.22	730.30	1877.92	54.86	665.13	45.39	271.60	0.00	0.00	65.18	0.00	65.18
2008	DEC1	730.30	1877.92	16.05	13.87	2.92	0.00	0.00	39.25	729.78	1849.62	54.86	664.68	45.42	271.60	0.00	0.00	65.18	0.00	65.18
2008	DEC2	729.78	1849.62	11.19	9.67	2.88	0.00	0.00	39.28	729.18	1817.13	54.86	664.12	45.46	271.60	0.00	0.00	65.18	0.00	65.18
2008	DEC3	729.18	1817.13	7.92	7.53	2.83	0.00	0.00	43.25	728.47	1778.58	54.86	663.47	45.51	271.60	0.00	0.00	71.70	0.00	71.70
2009	JAN1	728.47	1778.58	4.58	3.96	2.60	0.00	0.00	39.36	727.77	1740.58	54.86	662.76	45.56	271.60	0.00	0.00	65.18	0.00	65.18
2009	JAN2	727.77	1740.58	3.81	3.29	2.56	0.00	0.00	39.40	727.04	1701.91	54.86	662.04	45.61	271.60	0.00	0.00	65.18	0.00	65.18
2009	JAN3	727.04	1701.91	5.12	4.87	2.51	0.00	0.00	43.39	726.26	1660.88	54.86	661.29	45.66	271.60	0.00	0.00	71.70	0.00	71.70
2009	FEB1	726.26	1660.88	4.07	3.52	3.15	0.00	0.00	39.49	725.52	1621.75	54.86	660.53	45.71	271.60	0.00	0.00	65.18	0.00	65.18
2009	FEB2	725.52	1621.75	2.00	1.73	3.09	0.00	0.00	39.54	724.73	1580.86	54.86	659.77	45.76	271.60	0.00	0.00	65.18	0.00	65.18
2009	FEB3	724.73	1580.86	5.90	4.08	3.03	0.00	0.00	31.67	724.08	1550.24	54.86	659.05	45.81	271.60	0.00	0.00	52.15	0.00	52.15
2009	MAR1	724.08	1550.24	8.06	6.96	2.41	0.00	0.00	39.62	723.32	1515.16	54.86	658.34	45.86	271.60	0.00	0.00	65.18	0.00	65.18
2009	MAR2	723.32	1515.16	11.16	9.64	2.37	0.00	0.00	39.67	722.63	1482.77	54.86	657.62	45.91	271.60	0.00	0.00	65.18	0.00	65.18
2009	MAR3	722.63	1482.77	9.41	8.94	2.32	0.00	0.00	43.68	721.83	1445.70	54.86	656.87	45.96	271.60	0.00	0.00	71.70	0.00	71.70
2009	APR1	721.83	1445.70	8.69	7.51	2.36	0.00	0.00	39.76	721.07	1411.09	54.86	656.09	46.02	271.60	0.00	0.00	65.18	0.00	65.18
2009	APR2	721.07	1411.09	7.82	6.76	2.31	0.00	0.00	39.81	720.29	1375.73	54.86	655.32	46.07	271.60	0.00	0.00	65.18	0.00	65.18
2009	APR3	720.29	1375.73	7.86	6.79	2.27	0.00	0.00	39.85	719.51	1340.40	54.86	654.54	46.13	271.60	0.00	0.00	65.18	0.00	65.18
2009	MAY1	719.51	1340.40	10.21	8.82	2.16	0.00	0.00	39.90	718.78	1307.16	54.86	653.79	46.18	271.60	0.00	0.00	65.18	0.00	65.18
2009	MAY2	718.78	1307.16	12.26	10.59	2.12	0.00	0.00	39.95	718.01	1275.69	54.86	653.03	46.23	271.60	0.00	0.00	65.18	0.00	65.18
2009	MAY3	718.01	1275.69	18.31	17.40	2.08	0.00	0.00	43.99	717.29	1247.01	54.86	652.29	46.29	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1326.66	86.27	0.00	0.00	1442.22									2379.22	0.00	2379.22

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2009	JUN1	717.29	1247.01	38.55	33.31	1.70	0.00	0.00	40.02	717.09	1238.60	54.86	651.83	46.32	271.60	0.00	0.00	65.18	0.00	65.18
2009	JUN2	717.09	1238.60	23.00	19.87	1.69	0.00	0.00	40.04	716.54	1216.74	54.86	651.46	46.35	271.60	0.00	0.00	65.18	0.00	65.18
2009	JUN3	716.54	1216.74	38.23	33.03	1.67	0.00	0.00	40.07	716.33	1208.03	54.86	651.08	46.37	271.60	0.00	0.00	65.18	0.00	65.18
2009	JUL 1	716.33	1208.03	164.84	142.42	2.15	0.00	0.00	40.00	718.80	1308.31	54.86	652.21	46.29	271.60	0.00	0.00	65.18	0.00	65.18
2009	JUL2	718.80	1308.31	279.14	241.18	2.33	0.00	0.00	39.79	723.16	1507.37	54.86	655.62	46.05	271.60	0.00	0.00	65.18	0.00	65.18
2009	JUL3	723.16	1507.37	90.29	85.81	2.48	0.00	0.00	43.59	724.01	1547.10	54.86	658.22	45.87	271.60	0.00	0.00	71.70	0.00	71.70
2009	AUG1	724.01	1547.10	66.82	57.73	1.95	0.00	0.00	39.60	724.36	1563.29	54.86	658.82	45.83	271.60	0.00	0.00	65.18	0.00	65.18
2009	AUG2	724.36	1563.29	66.86	57.77	1.96	0.00	0.00	39.57	724.71	1579.52	54.86	659.17	45.80	271.60	0.00	0.00	65.18	0.00	65.18
2009	AUG3	724.71	1579.52	63.12	59.99	1.98	0.00	0.00	43.51	724.99	1594.02	54.86	659.49	45.78	271.60	0.00	0.00	71.70	0.00	71.70
2009	SEP1	724.99	1594.02	185.31	160.11	2.11	0.00	0.00	39.48	727.24	1712.54	54.86	660.76	45.69	271.60	0.00	0.00	65.18	0.00	65.18
2009	SEP2	727.24	1712.54	73.80	63.76	2.19	0.00	0.00	39.40	727.66	1734.71	54.86	662.09	45.60	271.60	0.00	0.00	65.18	0.00	65.18
2009	SEP3	727.66	1734.71	58.96	50.94	2.20	0.00	0.00	39.38	727.84	1744.06	54.86	662.39	45.58	271.60	0.00	0.00	65.18	0.00	65.18
2009	OCT1	727.84	1744.06	157.57	136.14	2.19	0.00	0.00	39.33	729.58	1838.69	54.86	663.35	45.52	271.60	0.00	0.00	65.18	0.00	65.18
2009	OCT2	729.58	1838.69	49.29	42.59	2.24	0.00	0.00	39.27	729.60	1839.77	54.86	664.23	45.46	271.60	0.00	0.00	65.18	0.00	65.18
2009	OCT3	729.60	1839.77	23.48	22.32	2.22	0.00	0.00	43.21	729.17	1816.65	54.86	664.03	45.47	271.60	0.00	0.00	71.70	0.00	71.70
2009	NOV1	729.17	1816.65	52.87	45.68	2.29	0.00	0.00	39.30	729.25	1820.75	54.86	663.85	45.48	271.60	0.00	0.00	65.18	0.00	65.18
2009	NOV2	729.25	1820.75	60.23	52.04	2.30	0.00	0.00	39.29	729.44	1831.21	54.86	663.99	45.47	271.60	0.00	0.00	65.18	0.00	65.18
2009	NOV3	729.44	1831.21	27.41	23.68	2.29	0.00	0.00	39.29	729.11	1813.30	54.86	663.92	45.48	271.60	0.00	0.00	65.18	0.00	65.18
2009	DEC1	729.11	1813.30	18.48	15.97	2.84	0.00	0.00	39.32	728.63	1787.12	54.86	663.51	45.50	271.60	0.00	0.00	65.18	0.00	65.18
2009	DEC2	728.63	1787.12	18.59	16.06	2.80	0.00	0.00	39.34	728.15	1761.04	54.86	663.03	45.54	271.60	0.00	0.00	65.18	0.00	65.18
2009	DEC3	728.15	1761.04	13.35	12.69	2.76	0.00	0.00	43.31	727.53	1727.65	54.86	662.48	45.58	271.60	0.00	0.00	71.70	0.00	71.70
2010	JAN1	727.53	1727.65	9.40	8.12	2.54	0.00	0.00	39.41	726.88	1693.81	54.86	661.85	45.62	271.60	0.00	0.00	65.18	0.00	65.18
2010	JAN2	726.88	1693.81	8.66	7.48	2.50	0.00	0.00	39.45	726.23	1659.34	54.86	661.20	45.66	271.60	0.00	0.00	65.18	0.00	65.18
2010	JAN3	726.23	1659.34	6.18	5.87	2.45	0.00	0.00	43.45	725.47	1619.31	54.86	660.49	45.71	271.60	0.00	0.00	71.70	0.00	71.70
2010	FEB1	725.47	1619.31	2.72	2.35	3.09	0.00	0.00	39.54	724.70	1579.03	54.86	659.72	45.77	271.60	0.00	0.00	65.18	0.00	65.18
2010	FEB2	724.70	1579.03	8.62	7.45	3.03	0.00	0.00	39.59	723.94	1543.87	54.86	658.96	45.82	271.60	0.00	0.00	65.18	0.00	65.18
2010	FEB3	723.94	1543.87	10.30	7.12	2.98	0.00	0.00	31.70	723.35	1516.30	54.86	658.28	45.87	271.60	0.00	0.00	52.15	0.00	52.15
2010	MAR1	723.35	1516.30	9.97	8.61	2.37	0.00	0.00	39.67	722.63	1482.88	54.86	657.63	45.91	271.60	0.00	0.00	65.18	0.00	65.18
2010	MAR2	722.63	1482.88	7.63	6.59	2.33	0.00	0.00	39.71	721.87	1447.43	54.86	656.89	45.96	271.60	0.00	0.00	65.18	0.00	65.18
2010	MAR3	721.87	1447.43	9.45	8.98	2.28	0.00	0.00	43.74	721.06	1410.39	54.86	656.10	46.02	271.60	0.00	0.00	71.70	0.00	71.70
2010	APR1	721.06	1410.39	10.38	8.97	2.31	0.00	0.00	39.81	720.33	1377.24	54.86	655.33	46.07	271.60	0.00	0.00	65.18	0.00	65.18
2010	APR2	720.33	1377.24	11.63	10.05	2.27	0.00	0.00	39.85	719.62	1345.17	54.86	654.61	46.12	271.60	0.00	0.00	65.18	0.00	65.18
2010	APR3	719.62	1345.17	12.38	10.70	2.23	0.00	0.00	39.89	718.92	1313.74	54.86	653.91	46.17	271.60	0.00	0.00	65.18	0.00	65.18
2010	MAY1	718.92	1313.74	16.92	14.62	2.13	0.00	0.00	39.93	718.27	1286.30	54.86	653.24	46.22	271.60	0.00	0.00	65.18	0.00	65.18
2010	MAY2	718.27	1286.30	16.78	14.50	2.09	0.00	0.00	39.98	717.59	1258.73	54.86	652.57	46.27	271.60	0.00	0.00	65.18	0.00	65.18
2010	MAY3	717.59	1258.73	18.34	17.43	2.06	0.00	0.00	44.02	716.87	1230.08	54.86	651.87	46.32	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1511.93	83.01	0.00	0.00	1445.85									2379.22	0.00	2379.22

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2010	JUN1	716.87	1230.08	28.63	24.74	1.68	0.00	0.00	40.05	716.45	1213.08	54.86	651.30	46.36	271.60	0.00	0.00	65.18	0.00	65.18
2010	JUN2	716.45	1213.08	143.94	124.36	1.71	0.00	0.00	40.00	718.50	1295.73	54.86	652.12	46.30	271.60	0.00	0.00	65.18	0.00	65.18
2010	JUN3	718.50	1295.73	89.72	77.52	1.77	0.00	0.00	39.91	719.32	1331.56	54.86	653.55	46.20	271.60	0.00	0.00	65.18	0.00	65.18
2010	JUL 1	719.32	1331.56	103.81	89.69	2.27	0.00	0.00	39.86	720.37	1379.13	54.86	654.48	46.13	271.60	0.00	0.00	65.18	0.00	65.18
2010	JUL2	720.37	1379.13	118.55	102.43	2.33	0.00	0.00	39.79	721.70	1439.44	54.86	655.67	46.05	271.60	0.00	0.00	65.18	0.00	65.18
2010	JUL3	721.70	1439.44	170.62	162.16	2.44	0.00	0.00	43.64	724.19	1555.52	54.86	657.58	45.91	271.60	0.00	0.00	71.70	0.00	71.70
2010	AUG1	724.19	1555.52	87.99	76.02	1.96	0.00	0.00	39.57	724.92	1590.00	54.86	659.19	45.80	271.60	0.00	0.00	65.18	0.00	65.18
2010	AUG2	724.92	1590.00	114.80	99.19	2.01	0.00	0.00	39.52	726.01	1647.66	54.86	660.10	45.74	271.60	0.00	0.00	65.18	0.00	65.18
2010	AUG3	726.01	1647.66	150.51	143.04	2.09	0.00	0.00	43.37	727.86	1745.24	54.86	661.57	45.64	271.60	0.00	0.00	71.70	0.00	71.70
2010	SEP1	727.86	1745.24	93.19	80.52	2.23	0.00	0.00	39.35	728.58	1784.17	54.86	662.86	45.55	271.60	0.00	0.00	65.18	0.00	65.18
2010	SEP2	728.58	1784.17	83.61	72.24	2.27	0.00	0.00	39.32	729.14	1814.83	54.86	663.50	45.51	271.60	0.00	0.00	65.18	0.00	65.18
2010	SEP3	729.14	1814.83	84.42	72.94	2.30	0.00	0.00	39.28	729.72	1846.18	54.86	664.07	45.47	271.60	0.00	0.00	65.18	0.00	65.18
2010	OCT1	729.72	1846.18	132.36	114.36	2.28	0.00	0.00	39.23	731.06	1919.04	54.86	665.03	45.40	271.60	0.00	0.00	65.18	0.00	65.18
2010	OCT2	731.06	1919.04	81.37	70.30	2.33	0.00	0.00	39.17	731.57	1947.84	54.86	665.95	45.34	271.60	0.00	0.00	65.18	0.00	65.18
2010	OCT3	731.57	1947.84	64.94	61.72	2.35	0.00	0.00	43.06	731.86	1964.15	54.86	666.35	45.31	271.60	0.00	0.00	71.70	0.00	71.70
2010	NOV1	731.86	1964.15	49.91	43.12	2.43	0.00	0.00	39.14	731.89	1965.69	54.86	666.51	45.30	271.60	0.00	0.00	65.18	0.00	65.18
2010	NOV2	731.89	1965.69	56.70	48.99	2.44	0.00	0.00	39.13	732.02	1973.11	54.86	666.59	45.29	271.60	0.00	0.00	65.18	0.00	65.18
2010	NOV3	732.02	1973.11	87.71	75.78	2.45	0.00	0.00	50.10	732.43	1996.34	54.86	666.87	45.29	271.60	76.27	0.00	65.18	18.30	83.49
2010	DEC1	732.43	1996.34	47.30	40.87	3.08	0.00	0.00	39.11	732.41	1995.02	54.86	667.06	45.26	271.60	0.00	0.00	65.18	0.00	65.18
2010	DEC2	732.41	1995.02	22.60	19.53	3.06	0.00	0.00	39.12	732.01	1972.37	54.86	666.85	45.28	271.60	0.00	0.00	65.18	0.00	65.18
2010	DEC3	732.01	1972.37	16.39	15.58	3.03	0.00	0.00	43.06	731.46	1941.86	54.86	666.37	45.31	271.60	0.00	0.00	71.70	0.00	71.70
2011	JAN1	731.46	1941.86	21.42	18.51	2.81	0.00	0.00	39.18	731.04	1918.38	54.86	665.89	45.34	271.60	0.00	0.00	65.18	0.00	65.18
2011	JAN2	731.04	1918.38	11.52	9.95	2.78	0.00	0.00	39.20	730.46	1886.35	54.86	665.39	45.38	271.60	0.00	0.00	65.18	0.00	65.18
2011	JAN3	730.46	1886.35	3.76	3.57	2.73	0.00	0.00	43.17	729.68	1844.02	54.86	664.71	45.42	271.60	0.00	0.00	71.70	0.00	71.70
2011	FEB1	729.68	1844.02	9.48	8.19	3.44	0.00	0.00	39.29	729.04	1809.47	54.86	664.00	45.47	271.60	0.00	0.00	65.18	0.00	65.18
2011	FEB2	729.04	1809.47	11.26	9.73	3.39	0.00	0.00	39.32	728.43	1776.49	54.86	663.38	45.51	271.60	0.00	0.00	65.18	0.00	65.18
2011	FEB3	728.43	1776.49	23.00	15.90	3.35	0.00	0.00	31.48	728.09	1757.56	54.86	662.90	45.55	271.60	0.00	0.00	52.15	0.00	52.15
2011	MAR1	728.09	1757.56	9.54	8.24	2.67	0.00	0.00	39.38	727.45	1723.75	54.86	662.41	45.58	271.60	0.00	0.00	65.18	0.00	65.18
2011	MAR2	727.45	1723.75	6.47	5.59	2.62	0.00	0.00	39.42	726.76	1687.29	54.86	661.75	45.63	271.60	0.00	0.00	65.18	0.00	65.18
2011	MAR3	726.76	1687.29	18.36	17.45	2.58	0.00	0.00	43.40	726.22	1658.76	54.86	661.13	45.67	271.60	0.00	0.00	71.70	0.00	71.70
2011	APR1	726.22	1658.76	14.18	12.25	2.63	0.00	0.00	39.49	725.65	1628.89	54.86	660.58	45.71	271.60	0.00	0.00	65.18	0.00	65.18
2011	APR2	725.65	1628.89	17.18	14.84	2.59	0.00	0.00	39.52	725.14	1601.61	54.86	660.04	45.74	271.60	0.00	0.00	65.18	0.00	65.18
2011	APR3	725.14	1601.61	40.32	34.84	2.57	0.00	0.00	39.54	725.00	1594.34	54.86	659.71	45.77	271.60	0.00	0.00	65.18	0.00	65.18
2011	MAY1	725.00	1594.34	22.25	19.22	2.47	0.00	0.00	39.56	724.53	1571.53	54.86	659.41	45.79	271.60	0.00	0.00	65.18	0.00	65.18
2011	MAY2	724.53	1571.53	16.47	14.23	2.44	0.00	0.00	39.59	723.94	1543.73	54.86	658.88	45.82	271.60	0.00	0.00	65.18	0.00	65.18
2011	MAY3	723.94	1543.73	17.63	16.76	2.40	0.00	0.00	43.59	723.31	1514.50	54.86	658.26	45.87	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1824.37	90.01	0.00	0.00	1449.94									2379.22	18.30	2397.52

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34
M.D.D.L 694.94 536.80
C/L 54.86

T.G.EFF. = 91.70%
Firm Power exep.(MW) = 271.600
Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2011	JUN1	723.31	1514.50	160.73	138.87	2.02	0.00	0.00	39.59	725.33	1611.76	54.86	658.96	45.82	271.60	0.00	0.00	65.18	0.00	65.18
2011	JUN2	725.33	1611.76	149.66	129.31	2.12	0.00	0.00	39.48	726.99	1699.48	54.86	660.80	45.69	271.60	0.00	0.00	65.18	0.00	65.18
2011	JUN3	726.99	1699.48	87.07	75.23	2.18	0.00	0.00	39.41	727.63	1733.12	54.86	661.95	45.61	271.60	0.00	0.00	65.18	0.00	65.18
2011	JUL 1	727.63	1733.12	68.00	58.75	2.76	0.00	0.00	39.38	727.94	1749.73	54.86	662.43	45.58	271.60	0.00	0.00	65.18	0.00	65.18
2011	JUL2	727.94	1749.73	157.87	136.40	2.83	0.00	0.00	39.32	729.68	1843.98	54.86	663.45	45.51	271.60	0.00	0.00	65.18	0.00	65.18
2011	JUL3	729.68	1843.98	157.92	150.09	2.96	0.00	0.00	43.13	731.57	1947.98	54.86	665.26	45.38	271.60	0.00	0.00	71.70	0.00	71.70
2011	AUG1	731.57	1947.98	186.33	160.99	2.36	0.00	0.00	110.27	732.43	1996.34	54.86	666.64	127.62	271.60	493.73	0.00	65.18	118.50	183.68
2011	AUG2	732.43	1996.34	132.88	114.81	2.38	0.00	0.00	112.43	732.43	1996.34	54.86	667.07	130.12	271.60	509.24	0.00	65.18	122.22	187.40
2011	AUG3	732.43	1996.34	145.97	138.73	2.38	0.00	0.00	136.35	732.43	1996.34	54.86	667.07	143.46	271.60	589.28	0.00	71.70	155.57	227.27
2011	SEP1	732.43	1996.34	175.06	151.25	2.46	0.00	0.00	148.79	732.43	1996.34	54.86	667.07	172.21	271.60	761.77	0.00	65.18	182.83	248.01
2011	SEP2	732.43	1996.34	111.10	95.99	2.46	0.00	0.00	93.53	732.43	1996.34	54.86	667.07	108.25	271.60	377.98	0.00	65.18	90.71	155.90
2011	SEP3	732.43	1996.34	49.24	42.54	2.46	0.00	0.00	40.08	732.43	1996.34	54.86	667.07	46.39	271.60	6.75	0.00	65.18	1.62	66.80
2011	OCT1	732.43	1996.34	24.49	21.16	2.37	0.00	0.00	39.12	732.07	1976.01	54.86	666.89	45.27	271.60	0.00	0.00	65.18	0.00	65.18
2011	OCT2	732.07	1976.01	55.25	47.74	2.37	0.00	0.00	39.12	732.18	1982.26	54.86	666.77	45.28	271.60	0.00	0.00	65.18	0.00	65.18
2011	OCT3	732.18	1982.26	67.07	63.74	2.38	0.00	0.00	47.28	732.43	1996.34	54.86	666.95	49.75	271.60	26.87	0.00	71.70	7.09	78.80
2011	NOV1	732.43	1996.34	80.51	69.56	2.46	0.00	0.00	67.10	732.43	1996.34	54.86	667.07	77.66	271.60	194.41	0.00	65.18	46.66	111.84
2011	NOV2	732.43	1996.34	38.01	32.84	2.46	0.00	0.00	39.11	732.28	1987.61	54.86	667.00	45.27	271.60	0.00	0.00	65.18	0.00	65.18
2011	NOV3	732.28	1987.61	31.31	27.05	2.45	0.00	0.00	39.12	732.02	1973.09	54.86	666.79	45.28	271.60	0.00	0.00	65.18	0.00	65.18
2011	DEC1	732.02	1973.09	28.66	24.76	3.04	0.00	0.00	39.14	731.71	1955.67	54.86	666.50	45.30	271.60	0.00	0.00	65.18	0.00	65.18
2011	DEC2	731.71	1955.67	15.94	13.77	3.02	0.00	0.00	39.16	731.20	1927.26	54.86	666.10	45.33	271.60	0.00	0.00	65.18	0.00	65.18
2011	DEC3	731.20	1927.26	14.47	13.75	2.98	0.00	0.00	43.11	730.62	1894.91	54.86	665.55	45.37	271.60	0.00	0.00	71.70	0.00	71.70
2012	JAN1	730.62	1894.91	13.91	12.02	2.75	0.00	0.00	39.23	730.06	1864.95	54.86	664.98	45.40	271.60	0.00	0.00	65.18	0.00	65.18
2012	JAN2	730.06	1864.95	11.16	9.64	2.71	0.00	0.00	39.26	729.47	1832.62	54.86	664.41	45.44	271.60	0.00	0.00	65.18	0.00	65.18
2012	JAN3	729.47	1832.62	7.21	6.85	2.67	0.00	0.00	43.23	728.75	1793.57	54.86	663.75	45.49	271.60	0.00	0.00	71.70	0.00	71.70
2012	FEB1	728.75	1793.57	7.85	6.78	3.36	0.00	0.00	39.34	728.09	1757.64	54.86	663.06	45.54	271.60	0.00	0.00	65.18	0.00	65.18
2012	FEB2	728.09	1757.64	9.86	8.52	3.31	0.00	0.00	39.38	727.45	1723.47	54.86	662.41	45.58	271.60	0.00	0.00	65.18	0.00	65.18
2012	FEB3	727.45	1723.47	8.12	5.61	3.26	0.00	0.00	31.53	726.89	1694.29	54.86	661.81	45.62	271.60	0.00	0.00	52.15	0.00	52.15
2012	MAR1	726.89	1694.29	10.79	9.32	2.59	0.00	0.00	39.45	726.27	1661.57	54.86	661.22	45.66	271.60	0.00	0.00	65.18	0.00	65.18
2012	MAR2	726.27	1661.57	9.84	8.50	2.55	0.00	0.00	39.49	725.64	1628.03	54.86	660.60	45.71	271.60	0.00	0.00	65.18	0.00	65.18
2012	MAR3	725.64	1628.03	14.43	13.71	2.50	0.00	0.00	43.48	725.03	1595.76	54.86	659.97	45.75	271.60	0.00	0.00	71.70	0.00	71.70
2012	APR1	725.03	1595.76	13.18	11.39	2.55	0.00	0.00	39.56	724.39	1565.04	54.86	659.35	45.79	271.60	0.00	0.00	65.18	0.00	65.18
2012	APR2	724.39	1565.04	9.75	8.42	2.51	0.00	0.00	39.60	723.67	1531.35	54.86	658.67	45.84	271.60	0.00	0.00	65.18	0.00	65.18
2012	APR3	723.67	1531.35	15.89	13.73	2.47	0.00	0.00	39.64	723.06	1502.96	54.86	658.01	45.88	271.60	0.00	0.00	65.18	0.00	65.18
2012	MAY1	723.06	1502.96	12.77	11.03	2.35	0.00	0.00	39.68	722.40	1471.96	54.86	657.37	45.93	271.60	0.00	0.00	65.18	0.00	65.18
2012	MAY2	722.40	1471.96	11.10	9.59	2.31	0.00	0.00	39.72	721.70	1439.51	54.86	656.69	45.98	271.60	0.00	0.00	65.18	0.00	65.18
2012	MAY3	721.70	1439.51	10.86	10.32	2.27	0.00	0.00	43.75	720.91	1403.81	54.86	655.95	46.03	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1852.76	93.07	0.00	0.00	1870.38									2379.22	725.20	3104.41

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2012	JUN1	720.91	1403.81	14.38	12.42	1.85	0.00	0.00	39.81	720.27	1374.57	54.86	655.23	46.08	271.60	0.00	0.00	65.18	0.00	65.18
2012	JUN2	720.27	1374.57	46.76	40.40	1.83	0.00	0.00	39.83	720.24	1373.30	54.86	654.89	46.10	271.60	0.00	0.00	65.18	0.00	65.18
2012	JUN3	720.24	1373.30	58.02	50.13	1.84	0.00	0.00	39.83	720.43	1381.77	54.86	654.97	46.10	271.60	0.00	0.00	65.18	0.00	65.18
2012	JUL 1	720.43	1381.77	90.15	77.89	2.32	0.00	0.00	39.80	721.21	1417.54	54.86	655.46	46.06	271.60	0.00	0.00	65.18	0.00	65.18
2012	JUL2	721.21	1417.54	64.00	55.30	2.35	0.00	0.00	39.77	721.50	1430.72	54.86	656.00	46.03	271.60	0.00	0.00	65.18	0.00	65.18
2012	JUL3	721.50	1430.72	70.95	67.43	2.37	0.00	0.00	43.72	721.97	1452.06	54.86	656.38	46.00	271.60	0.00	0.00	71.70	0.00	71.70
2012	AUG1	721.97	1452.06	42.89	37.06	1.85	0.00	0.00	39.73	721.87	1447.54	54.86	656.56	45.99	271.60	0.00	0.00	65.18	0.00	65.18
2012	AUG2	721.87	1447.54	96.70	83.55	1.86	0.00	0.00	39.71	722.77	1489.52	54.86	656.96	45.96	271.60	0.00	0.00	65.18	0.00	65.18
2012	AUG3	722.77	1489.52	71.62	68.07	1.90	0.00	0.00	43.63	723.26	1512.06	54.86	657.66	45.91	271.60	0.00	0.00	71.70	0.00	71.70
2012	SEP1	723.26	1512.06	122.95	106.23	2.00	0.00	0.00	39.61	724.64	1576.68	54.86	658.59	45.84	271.60	0.00	0.00	65.18	0.00	65.18
2012	SEP2	724.64	1576.68	60.06	51.89	2.04	0.00	0.00	39.56	724.86	1586.97	54.86	659.39	45.79	271.60	0.00	0.00	65.18	0.00	65.18
2012	SEP3	724.86	1586.97	32.49	28.07	2.04	0.00	0.00	39.56	724.58	1573.44	54.86	659.36	45.79	271.60	0.00	0.00	65.18	0.00	65.18
2012	OCT1	724.58	1573.44	21.92	18.94	1.95	0.00	0.00	39.59	724.09	1550.84	54.86	658.97	45.82	271.60	0.00	0.00	65.18	0.00	65.18
2012	OCT2	724.09	1550.84	46.13	39.86	1.94	0.00	0.00	39.60	724.05	1549.15	54.86	658.71	45.84	271.60	0.00	0.00	65.18	0.00	65.18
2012	OCT3	724.05	1549.15	33.26	31.61	1.94	0.00	0.00	43.57	723.76	1535.26	54.86	658.54	45.85	271.60	0.00	0.00	71.70	0.00	71.70
2012	NOV1	723.76	1535.26	27.37	23.65	1.98	0.00	0.00	39.63	723.37	1517.29	54.86	658.20	45.87	271.60	0.00	0.00	65.18	0.00	65.18
2012	NOV2	723.37	1517.29	16.76	14.48	1.96	0.00	0.00	39.66	722.79	1490.15	54.86	657.72	45.91	271.60	0.00	0.00	65.18	0.00	65.18
2012	NOV3	722.79	1490.15	15.03	12.99	1.93	0.00	0.00	39.70	722.17	1461.50	54.86	657.12	45.95	271.60	0.00	0.00	65.18	0.00	65.18
2012	DEC1	722.17	1461.50	9.04	7.81	2.38	0.00	0.00	39.74	721.43	1427.20	54.86	656.44	45.99	271.60	0.00	0.00	65.18	0.00	65.18
2012	DEC2	721.43	1427.20	5.91	5.11	2.33	0.00	0.00	39.79	720.61	1390.19	54.86	655.66	46.05	271.60	0.00	0.00	65.18	0.00	65.18
2012	DEC3	720.61	1390.19	5.40	5.13	2.28	0.00	0.00	43.82	719.71	1349.21	54.86	654.80	46.11	271.60	0.00	0.00	71.70	0.00	71.70
2013	JAN1	719.71	1349.21	5.94	5.13	2.09	0.00	0.00	39.89	718.89	1312.36	54.86	653.94	46.17	271.60	0.00	0.00	65.18	0.00	65.18
2013	JAN2	718.89	1312.36	1.83	1.58	2.05	0.00	0.00	39.95	717.91	1271.95	54.86	653.04	46.23	271.60	0.00	0.00	65.18	0.00	65.18
2013	JAN3	717.91	1271.95	2.47	2.35	2.00	0.00	0.00	44.01	716.83	1228.29	54.86	652.01	46.31	271.60	0.00	0.00	71.70	0.00	71.70
2013	FEB1	716.83	1228.29	3.02	2.61	2.50	0.00	0.00	40.07	715.84	1188.32	54.86	650.97	46.38	271.60	0.00	0.00	65.18	0.00	65.18
2013	FEB2	715.84	1188.32	2.38	2.06	2.44	0.00	0.00	40.14	714.81	1147.80	54.86	649.96	46.45	271.60	0.00	0.00	65.18	0.00	65.18
2013	FEB3	714.81	1147.80	1.97	1.36	2.39	0.00	0.00	32.15	713.96	1114.61	54.86	649.03	46.52	271.60	0.00	0.00	52.15	0.00	52.15
2013	MAR1	713.96	1114.61	5.14	4.44	1.89	0.00	0.00	40.25	713.00	1076.92	54.86	648.12	46.58	271.60	0.00	0.00	65.18	0.00	65.18
2013	MAR2	713.00	1076.92	7.34	6.34	1.84	0.00	0.00	40.31	712.03	1041.11	54.86	647.16	46.65	271.60	0.00	0.00	65.18	0.00	65.18
2013	MAR3	712.03	1041.11	9.35	8.89	1.80	0.00	0.00	44.41	710.96	1003.78	54.86	646.14	46.73	271.60	0.00	0.00	71.70	0.00	71.70
2013	APR1	710.96	1003.78	7.89	6.82	1.82	0.00	0.00	40.44	709.95	968.34	54.86	645.10	46.80	271.60	0.00	0.00	65.18	0.00	65.18
2013	APR2	709.95	968.34	6.66	5.75	1.78	0.00	0.00	40.50	708.89	931.81	54.86	644.06	46.88	271.60	0.00	0.00	65.18	0.00	65.18
2013	APR3	708.89	931.81	8.46	7.31	1.74	0.00	0.00	40.57	707.86	896.81	54.86	643.02	46.95	271.60	0.00	0.00	65.18	0.00	65.18
2013	MAY1	707.86	896.81	5.60	4.84	1.64	0.00	0.00	40.64	706.76	859.38	54.86	641.95	47.03	271.60	0.00	0.00	65.18	0.00	65.18
2013	MAY2	706.76	859.38	4.21	3.64	1.59	0.00	0.00	40.71	705.50	820.72	54.86	640.77	47.12	271.60	0.00	0.00	65.18	0.00	65.18
2013	MAY3	705.50	820.72	4.91	4.67	1.53	0.00	0.00	44.88	704.10	778.98	54.86	639.44	47.22	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					905.81	72.06	0.00	0.00	1458.58									2379.22	0.00	2379.22

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34
M.D.D.L 694.94 536.80
C/L 54.86

T.G.EFF. = 91.70%
Firm Power exep.(MW) = 271.600
Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2013	JUN1	704.10	778.98	36.78	31.78	1.23	0.00	0.00	40.85	703.76	768.68	54.86	638.57	47.28	271.60	0.00	0.00	65.18	0.00	65.18
2013	JUN2	703.76	768.68	168.66	145.72	1.29	0.00	0.00	40.75	707.14	872.36	54.86	640.09	47.17	271.60	0.00	0.00	65.18	0.00	65.18
2013	JUN3	707.14	872.36	283.43	244.88	1.44	0.00	0.00	40.46	712.96	1075.33	54.86	644.69	46.83	271.60	0.00	0.00	65.18	0.00	65.18
2013	JUL 1	712.96	1075.33	211.98	183.15	2.01	0.00	0.00	40.17	716.53	1216.30	54.86	649.39	46.49	271.60	0.00	0.00	65.18	0.00	65.18
2013	JUL2	716.53	1216.30	235.36	203.35	2.19	0.00	0.00	39.94	720.33	1377.52	54.86	653.07	46.23	271.60	0.00	0.00	65.18	0.00	65.18
2013	JUL3	720.33	1377.52	256.92	244.18	2.42	0.00	0.00	43.67	724.62	1575.61	54.86	657.12	45.95	271.60	0.00	0.00	71.70	0.00	71.70
2013	AUG1	724.62	1575.61	376.47	325.27	2.11	0.00	0.00	39.41	729.96	1859.36	54.86	661.93	45.61	271.60	0.00	0.00	65.18	0.00	65.18
2013	AUG2	729.96	1859.36	125.08	108.07	2.29	0.00	0.00	39.22	731.18	1925.93	54.86	665.21	45.39	271.60	0.00	0.00	65.18	0.00	65.18
2013	AUG3	731.18	1925.93	73.88	70.22	2.33	0.00	0.00	43.08	731.62	1950.73	54.86	666.04	45.33	271.60	0.00	0.00	71.70	0.00	71.70
2013	SEP1	731.62	1950.73	88.21	76.21	2.44	0.00	0.00	39.14	732.24	1985.37	54.86	666.57	45.30	271.60	0.00	0.00	65.18	0.00	65.18
2013	SEP2	732.24	1985.37	173.37	149.79	2.46	0.00	0.00	136.37	732.43	1996.34	54.86	666.98	157.83	271.60	675.36	0.00	65.18	162.09	227.27
2013	SEP3	732.43	1996.34	118.53	102.41	2.46	0.00	0.00	99.95	732.43	1996.34	54.86	667.07	115.68	271.60	422.56	0.00	65.18	101.42	166.60
2013	OCT1	732.43	1996.34	51.10	44.15	2.38	0.00	0.00	41.77	732.43	1996.34	54.86	667.07	48.34	271.60	18.48	0.00	65.18	4.44	69.62
2013	OCT2	732.43	1996.34	66.38	57.35	2.38	0.00	0.00	54.97	732.43	1996.34	54.86	667.07	63.62	271.60	110.16	0.00	65.18	26.44	91.62
2013	OCT3	732.43	1996.34	73.28	69.65	2.38	0.00	0.00	67.27	732.43	1996.34	54.86	667.07	70.78	271.60	153.12	0.00	71.70	40.42	112.13
2013	NOV1	732.43	1996.34	32.69	28.24	2.46	0.00	0.00	39.11	732.20	1983.01	54.86	666.96	45.27	271.60	0.00	0.00	65.18	0.00	65.18
2013	NOV2	732.20	1983.01	34.79	30.06	2.45	0.00	0.00	39.13	731.99	1971.50	54.86	666.73	45.28	271.60	0.00	0.00	65.18	0.00	65.18
2013	NOV3	731.99	1971.50	38.89	33.60	2.44	0.00	0.00	39.14	731.85	1963.53	54.86	666.56	45.30	271.60	0.00	0.00	65.18	0.00	65.18
2013	DEC1	731.85	1963.53	20.14	17.40	3.03	0.00	0.00	39.15	731.41	1938.75	54.86	666.27	45.32	271.60	0.00	0.00	65.18	0.00	65.18
2013	DEC2	731.41	1938.75	13.99	12.09	3.00	0.00	0.00	39.18	730.87	1908.66	54.86	665.78	45.35	271.60	0.00	0.00	65.18	0.00	65.18
2013	DEC3	730.87	1908.66	6.74	6.41	2.95	0.00	0.00	43.14	730.14	1868.97	54.86	665.14	45.39	271.60	0.00	0.00	71.70	0.00	71.70
2014	JAN1	730.14	1868.97	5.41	4.67	2.71	0.00	0.00	39.26	729.45	1831.67	54.86	664.43	45.44	271.60	0.00	0.00	65.18	0.00	65.18
2014	JAN2	729.45	1831.67	14.28	12.34	2.67	0.00	0.00	39.30	728.91	1802.04	54.86	663.82	45.48	271.60	0.00	0.00	65.18	0.00	65.18
2014	JAN3	728.91	1802.04	7.03	6.68	2.63	0.00	0.00	43.27	728.18	1762.82	54.86	663.18	45.53	271.60	0.00	0.00	71.70	0.00	71.70
2014	FEB1	728.18	1762.82	6.25	5.40	3.31	0.00	0.00	39.38	727.49	1725.53	54.86	662.47	45.58	271.60	0.00	0.00	65.18	0.00	65.18
2014	FEB2	727.49	1725.53	4.63	4.00	3.25	0.00	0.00	39.42	726.75	1686.85	54.86	661.76	45.62	271.60	0.00	0.00	65.18	0.00	65.18
2014	FEB3	726.75	1686.85	5.79	4.00	3.20	0.00	0.00	31.57	726.17	1656.09	54.86	661.10	45.67	271.60	0.00	0.00	52.15	0.00	52.15
2014	MAR1	726.17	1656.09	13.80	11.92	2.54	0.00	0.00	39.49	725.60	1625.97	54.86	660.52	45.71	271.60	0.00	0.00	65.18	0.00	65.18
2014	MAR2	725.60	1625.97	6.57	5.68	2.50	0.00	0.00	39.53	724.91	1589.62	54.86	659.89	45.75	271.60	0.00	0.00	65.18	0.00	65.18
2014	MAR3	724.91	1589.62	9.09	8.64	2.45	0.00	0.00	43.53	724.12	1552.27	54.86	659.16	45.81	271.60	0.00	0.00	71.70	0.00	71.70
2014	APR1	724.12	1552.27	9.33	8.06	2.49	0.00	0.00	39.62	723.39	1518.22	54.86	658.40	45.86	271.60	0.00	0.00	65.18	0.00	65.18
2014	APR2	723.39	1518.22	6.05	5.23	2.45	0.00	0.00	39.67	722.60	1481.34	54.86	657.63	45.91	271.60	0.00	0.00	65.18	0.00	65.18
2014	APR3	722.60	1481.34	16.12	13.93	2.41	0.00	0.00	39.71	721.99	1453.15	54.86	656.94	45.96	271.60	0.00	0.00	65.18	0.00	65.18
2014	MAY1	721.99	1453.15	28.61	24.72	2.30	0.00	0.00	39.74	721.62	1435.83	54.86	656.45	45.99	271.60	0.00	0.00	65.18	0.00	65.18
2014	MAY2	721.62	1435.83	19.93	17.22	2.28	0.00	0.00	39.77	721.07	1411.01	54.86	655.98	46.03	271.60	0.00	0.00	65.18	0.00	65.18
2014	MAY3	721.07	1411.01	18.79	17.86	2.24	0.00	0.00	43.78	720.45	1382.84	54.86	655.40	46.07	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					2334.33	87.57	0.00	0.00	1642.90									2379.22	334.80	2714.02

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

Level(M) Storage
(MCUM)
F.R.L 732.43 1996.34
M.D.D.L 694.94 536.80
C/L 54.86

T.G.EFF. = 91.70%
Firm Power exep.(MW) = 271.600
Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2014	JUN1	720.45	1382.84	29.39	25.39	1.83	0.00	0.00	39.83	720.09	1366.57	54.86	654.91	46.10	271.60	0.00	0.00	65.18	0.00	65.18
2014	JUN2	720.09	1366.57	54.11	46.75	1.83	0.00	0.00	39.84	720.20	1371.65	54.86	654.79	46.11	271.60	0.00	0.00	65.18	0.00	65.18
2014	JUN3	720.20	1371.65	101.45	87.65	1.85	0.00	0.00	39.81	721.22	1417.64	54.86	655.35	46.07	271.60	0.00	0.00	65.18	0.00	65.18
2014	JUL 1	721.22	1417.64	52.92	45.72	2.35	0.00	0.00	39.77	721.30	1421.25	54.86	655.90	46.03	271.60	0.00	0.00	65.18	0.00	65.18
2014	JUL2	721.30	1421.25	227.84	196.85	2.44	0.00	0.00	39.67	724.63	1575.98	54.86	657.60	45.91	271.60	0.00	0.00	65.18	0.00	65.18
2014	JUL3	724.63	1575.98	159.04	151.15	2.61	0.00	0.00	43.46	726.64	1681.06	54.86	660.28	45.73	271.60	0.00	0.00	71.70	0.00	71.70
2014	AUG1	726.64	1681.06	302.53	261.39	2.18	0.00	0.00	39.33	730.73	1900.94	54.86	663.32	45.52	271.60	0.00	0.00	65.18	0.00	65.18
2014	AUG2	730.73	1900.94	103.39	89.33	2.32	0.00	0.00	39.18	731.59	1948.77	54.86	665.80	45.35	271.60	0.00	0.00	65.18	0.00	65.18
2014	AUG3	731.59	1948.77	131.31	124.80	2.36	0.00	0.00	74.87	732.43	1996.34	54.86	666.65	78.78	271.60	200.82	0.00	71.70	53.02	124.72
2014	SEP1	732.43	1996.34	187.96	162.40	2.46	0.00	0.00	159.94	732.43	1996.34	54.86	667.07	185.11	271.60	839.21	0.00	65.18	201.41	266.59
2014	SEP2	732.43	1996.34	67.45	58.28	2.46	0.00	0.00	55.82	732.43	1996.34	54.86	667.07	64.60	271.60	116.07	0.00	65.18	27.86	93.04
2014	SEP3	732.43	1996.34	54.63	47.20	2.46	0.00	0.00	44.74	732.43	1996.34	54.86	667.07	51.78	271.60	39.12	0.00	65.18	9.39	74.57
2014	OCT1	732.43	1996.34	52.05	44.97	2.38	0.00	0.00	42.59	732.43	1996.34	54.86	667.07	49.29	271.60	24.18	0.00	65.18	5.80	70.99
2014	OCT2	732.43	1996.34	57.09	49.33	2.38	0.00	0.00	46.95	732.43	1996.34	54.86	667.07	54.34	271.60	54.46	0.00	65.18	13.07	78.25
2014	OCT3	732.43	1996.34	110.17	104.71	2.38	0.00	0.00	102.33	732.43	1996.34	54.86	667.07	107.67	271.60	374.48	0.00	71.70	98.86	170.57
2014	NOV1	732.43	1996.34	104.75	90.50	2.46	0.00	0.00	88.04	732.43	1996.34	54.86	667.07	101.90	271.60	339.85	0.00	65.18	81.56	146.75
2014	NOV2	732.43	1996.34	47.36	40.92	2.46	0.00	0.00	39.11	732.42	1995.69	54.86	667.07	45.26	271.60	0.00	0.00	65.18	0.00	65.18
2014	NOV3	732.42	1995.69	26.34	22.76	2.45	0.00	0.00	39.12	732.09	1976.88	54.86	666.90	45.27	271.60	0.00	0.00	65.18	0.00	65.18
2014	DEC1	732.09	1976.88	17.30	14.95	3.04	0.00	0.00	39.14	731.60	1949.65	54.86	666.48	45.30	271.60	0.00	0.00	65.18	0.00	65.18
2014	DEC2	731.60	1949.65	16.37	14.14	3.01	0.00	0.00	39.17	731.10	1921.61	54.86	665.99	45.33	271.60	0.00	0.00	65.18	0.00	65.18
2014	DEC3	731.10	1921.61	11.99	11.40	2.97	0.00	0.00	43.12	730.47	1886.91	54.86	665.42	45.37	271.60	0.00	0.00	71.70	0.00	71.70
2015	JAN1	730.47	1886.91	10.22	8.83	2.74	0.00	0.00	39.24	729.86	1853.77	54.86	664.80	45.42	271.60	0.00	0.00	65.18	0.00	65.18
2015	JAN2	729.86	1853.77	8.98	7.76	2.70	0.00	0.00	39.28	729.23	1819.55	54.86	664.18	45.46	271.60	0.00	0.00	65.18	0.00	65.18
2015	JAN3	729.23	1819.55	6.99	6.64	2.65	0.00	0.00	43.25	728.50	1780.29	54.86	663.51	45.50	271.60	0.00	0.00	71.70	0.00	71.70
2015	FEB1	728.50	1780.29	4.84	4.18	3.34	0.00	0.00	39.36	727.79	1741.77	54.86	662.79	45.55	271.60	0.00	0.00	65.18	0.00	65.18
2015	FEB2	727.79	1741.77	7.41	6.40	3.28	0.00	0.00	39.40	727.11	1705.49	54.86	662.09	45.60	271.60	0.00	0.00	65.18	0.00	65.18
2015	FEB3	727.11	1705.49	3.52	2.43	3.23	0.00	0.00	31.55	726.49	1673.14	54.86	661.44	45.65	271.60	0.00	0.00	52.15	0.00	52.15
2015	MAR1	726.49	1673.14	12.43	10.74	2.56	0.00	0.00	39.47	725.90	1641.84	54.86	660.84	45.69	271.60	0.00	0.00	65.18	0.00	65.18
2015	MAR2	725.90	1641.84	4.04	3.49	2.52	0.00	0.00	39.51	725.17	1603.30	54.86	660.17	45.73	271.60	0.00	0.00	65.18	0.00	65.18
2015	MAR3	725.17	1603.30	11.32	10.76	2.47	0.00	0.00	43.51	724.46	1568.08	54.86	659.45	45.78	271.60	0.00	0.00	71.70	0.00	71.70
2015	APR1	724.46	1568.08	10.60	9.16	2.51	0.00	0.00	39.60	723.75	1535.13	54.86	658.75	45.83	271.60	0.00	0.00	65.18	0.00	65.18
2015	APR2	723.75	1535.13	34.27	29.61	2.48	0.00	0.00	39.63	723.48	1522.62	54.86	658.26	45.87	271.60	0.00	0.00	65.18	0.00	65.18
2015	APR3	723.48	1522.62	45.90	39.66	2.47	0.00	0.00	39.64	723.43	1520.17	54.86	658.10	45.88	271.60	0.00	0.00	65.18	0.00	65.18
2015	MAY1	723.43	1520.17	27.95	24.15	2.38	0.00	0.00	39.65	723.05	1502.29	54.86	657.88	45.89	271.60	0.00	0.00	65.18	0.00	65.18
2015	MAY2	723.05	1502.29	31.59	27.29	2.36	0.00	0.00	39.67	722.73	1487.54	54.86	657.53	45.92	271.60	0.00	0.00	65.18	0.00	65.18
2015	MAY3	722.73	1487.54	25.09	23.85	2.34	0.00	0.00	43.67	722.26	1465.39	54.86	657.13	45.95	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1905.54	90.76	0.00	0.00	1732.24									2379.22	490.97	2870.19

HYDROELECTRIC PROJECTS (ST

IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE

Level(M) Storage
(MCUM)

F.R.L 732.43 1996.34

M.D.D.L 694.94 536.80

C/L 54.86

T.G.EFF. = 91.70%

Firm Power exep.(MW) = 271.600

Installed Capacity (MW) = 1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2015	JUN1	722.26	1465.39	16.25	14.04	1.91	0.00	0.00	39.73	721.66	1437.79	54.86	656.60	45.98	271.60	0.00	0.00	65.18	0.00	65.18
2015	JUN2	721.66	1437.79	35.19	30.40	1.89	0.00	0.00	39.76	721.41	1426.54	54.86	656.18	46.01	271.60	0.00	0.00	65.18	0.00	65.18
2015	JUN3	721.41	1426.54	241.30	208.48	1.97	0.00	0.00	39.65	724.98	1593.40	54.86	657.84	45.90	271.60	0.00	0.00	65.18	0.00	65.18
2015	JUL 1	724.98	1593.40	77.01	66.54	2.58	0.00	0.00	39.53	725.44	1617.83	54.86	659.85	45.76	271.60	0.00	0.00	65.18	0.00	65.18
2015	JUL2	725.44	1617.83	91.52	79.07	2.62	0.00	0.00	39.50	726.14	1654.78	54.86	660.43	45.72	271.60	0.00	0.00	65.18	0.00	65.18
2015	JUL3	726.14	1654.78	149.53	142.11	2.71	0.00	0.00	43.37	727.96	1750.81	54.86	661.69	45.63	271.60	0.00	0.00	71.70	0.00	71.70
2015	AUG1	727.96	1750.81	56.61	48.91	2.15	0.00	0.00	39.37	728.10	1758.21	54.86	662.67	45.56	271.60	0.00	0.00	65.18	0.00	65.18
2015	AUG2	728.10	1758.21	109.69	94.77	2.18	0.00	0.00	39.33	729.08	1811.47	54.86	663.23	45.52	271.60	0.00	0.00	65.18	0.00	65.18
2015	AUG3	729.08	1811.47	43.49	41.33	2.20	0.00	0.00	43.24	729.00	1807.36	54.86	663.68	45.49	271.60	0.00	0.00	71.70	0.00	71.70
2015	SEP1	729.00	1807.36	47.31	40.88	2.28	0.00	0.00	39.31	728.99	1806.65	54.86	663.64	45.50	271.60	0.00	0.00	65.18	0.00	65.18
2015	SEP2	728.99	1806.65	47.63	41.15	2.28	0.00	0.00	39.31	728.98	1806.22	54.86	663.63	45.50	271.60	0.00	0.00	65.18	0.00	65.18
2015	SEP3	728.98	1806.22	58.87	50.86	2.28	0.00	0.00	39.30	729.15	1815.49	54.86	663.71	45.49	271.60	0.00	0.00	65.18	0.00	65.18
2015	OCT1	729.15	1815.49	89.68	77.48	2.23	0.00	0.00	39.28	729.82	1851.47	54.86	664.12	45.46	271.60	0.00	0.00	65.18	0.00	65.18
2015	OCT2	729.82	1851.47	65.09	56.24	2.26	0.00	0.00	39.25	730.09	1866.20	54.86	664.59	45.43	271.60	0.00	0.00	65.18	0.00	65.18
2015	OCT3	730.09	1866.20	28.42	27.01	2.25	0.00	0.00	43.18	729.75	1847.78	54.86	664.56	45.43	271.60	0.00	0.00	71.70	0.00	71.70
2015	NOV1	729.75	1847.78	43.82	37.86	2.32	0.00	0.00	39.27	729.68	1844.05	54.86	664.35	45.45	271.60	0.00	0.00	65.18	0.00	65.18
2015	NOV2	729.68	1844.05	51.00	44.06	2.32	0.00	0.00	39.27	729.72	1846.53	54.86	664.34	45.45	271.60	0.00	0.00	65.18	0.00	65.18
2015	NOV3	729.72	1846.53	46.37	40.06	2.32	0.00	0.00	39.27	729.70	1845.01	54.86	664.35	45.45	271.60	0.00	0.00	65.18	0.00	65.18
2015	DEC1	729.70	1845.01	51.75	44.71	2.90	0.00	0.00	39.27	729.74	1847.56	54.86	664.36	45.45	271.60	0.00	0.00	65.18	0.00	65.18
2015	DEC2	729.74	1847.56	33.78	29.19	2.89	0.00	0.00	39.27	729.50	1834.58	54.86	664.26	45.45	271.60	0.00	0.00	65.18	0.00	65.18
2015	DEC3	729.50	1834.58	19.19	18.24	2.86	0.00	0.00	43.22	728.99	1806.74	54.86	663.89	45.48	271.60	0.00	0.00	71.70	0.00	71.70
2016	JAN1	728.99	1806.74	10.00	8.64	2.64	0.00	0.00	39.33	728.38	1773.41	54.86	663.33	45.52	271.60	0.00	0.00	65.18	0.00	65.18
2016	JAN2	728.38	1773.41	8.47	7.32	2.60	0.00	0.00	39.36	727.74	1738.77	54.86	662.70	45.56	271.60	0.00	0.00	65.18	0.00	65.18
2016	JAN3	727.74	1738.77	7.29	6.93	2.55	0.00	0.00	43.35	727.00	1699.80	54.86	662.01	45.61	271.60	0.00	0.00	71.70	0.00	71.70
2016	FEB1	727.00	1699.80	9.57	8.27	3.22	0.00	0.00	39.45	726.35	1665.41	54.86	661.31	45.66	271.60	0.00	0.00	65.18	0.00	65.18
2016	FEB2	726.35	1665.41	7.69	6.64	3.16	0.00	0.00	39.49	725.66	1629.40	54.86	660.64	45.70	271.60	0.00	0.00	65.18	0.00	65.18
2016	FEB3	725.66	1629.40	8.74	6.04	3.11	0.00	0.00	31.62	725.12	1600.71	54.86	660.03	45.74	271.60	0.00	0.00	52.15	0.00	52.15
2016	MAR1	725.12	1600.71	7.33	6.33	2.47	0.00	0.00	39.56	724.39	1565.01	54.86	659.40	45.79	271.60	0.00	0.00	65.18	0.00	65.18
2016	MAR2	724.39	1565.01	6.16	5.32	2.42	0.00	0.00	39.61	723.61	1528.30	54.86	658.64	45.84	271.60	0.00	0.00	65.18	0.00	65.18
2016	MAR3	723.61	1528.30	10.71	10.18	2.38	0.00	0.00	43.62	722.84	1492.48	54.86	657.86	45.90	271.60	0.00	0.00	71.70	0.00	71.70
2016	APR1	722.84	1492.48	12.93	11.17	2.42	0.00	0.00	39.70	722.17	1461.54	54.86	657.15	45.95	271.60	0.00	0.00	65.18	0.00	65.18
2016	APR2	722.17	1461.54	9.55	8.25	2.38	0.00	0.00	39.74	721.44	1427.67	54.86	656.45	45.99	271.60	0.00	0.00	65.18	0.00	65.18
2016	APR3	721.44	1427.67	6.72	5.81	2.33	0.00	0.00	39.79	720.64	1391.36	54.86	655.68	46.05	271.60	0.00	0.00	65.18	0.00	65.18
2016	MAY1	720.64	1391.36	8.19	7.08	2.22	0.00	0.00	39.83	719.87	1356.39	54.86	654.89	46.10	271.60	0.00	0.00	65.18	0.00	65.18
2016	MAY2	719.87	1356.39	15.94	13.77	2.18	0.00	0.00	39.88	719.24	1328.11	54.86	654.19	46.15	271.60	0.00	0.00	65.18	0.00	65.18
2016	MAY3	719.24	1328.11	12.82	12.18	2.14	0.00	0.00	43.91	718.47	1294.24	54.86	653.49	46.20	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1357.32	87.59	0.00	0.00	1440.88									2379.22	0.00	2379.22

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2016	JUN1	718.47	1294.24	32.80	28.34	1.75	0.00	0.00	39.95	718.14	1280.88	54.86	652.94	46.24	271.60	0.00	0.00	65.18	0.00	65.18
2016	JUN2	718.14	1280.88	56.93	49.19	1.74	0.00	0.00	39.96	718.32	1288.37	54.86	652.87	46.25	271.60	0.00	0.00	65.18	0.00	65.18
2016	JUN3	718.32	1288.37	73.56	63.56	1.76	0.00	0.00	39.93	718.85	1310.24	54.86	653.22	46.22	271.60	0.00	0.00	65.18	0.00	65.18
2016	JUL 1	718.85	1310.24	94.26	81.44	2.24	0.00	0.00	39.89	719.71	1349.55	54.86	653.92	46.17	271.60	0.00	0.00	65.18	0.00	65.18
2016	JUL2	719.71	1349.55	142.25	122.90	2.31	0.00	0.00	39.81	721.50	1430.33	54.86	655.24	46.08	271.60	0.00	0.00	65.18	0.00	65.18
2016	JUL3	721.50	1430.33	78.45	74.56	2.38	0.00	0.00	43.71	722.11	1458.80	54.86	656.45	45.99	271.60	0.00	0.00	71.70	0.00	71.70
2016	AUG1	722.11	1458.80	58.73	50.74	1.86	0.00	0.00	39.71	722.31	1467.97	54.86	656.85	45.97	271.60	0.00	0.00	65.18	0.00	65.18
2016	AUG2	722.31	1467.97	69.66	60.19	1.87	0.00	0.00	39.70	722.71	1486.59	54.86	657.15	45.94	271.60	0.00	0.00	65.18	0.00	65.18
2016	AUG3	722.71	1486.59	51.39	48.84	1.88	0.00	0.00	43.65	722.78	1489.89	54.86	657.39	45.93	271.60	0.00	0.00	71.70	0.00	71.70
2016	SEP1	722.78	1489.89	35.65	30.80	1.94	0.00	0.00	39.69	722.55	1479.07	54.86	657.31	45.93	271.60	0.00	0.00	65.18	0.00	65.18
2016	SEP2	722.55	1479.07	27.36	23.64	1.93	0.00	0.00	39.71	722.16	1461.07	54.86	657.00	45.96	271.60	0.00	0.00	65.18	0.00	65.18
2016	SEP3	722.16	1461.07	34.20	29.55	1.91	0.00	0.00	39.73	721.90	1448.98	54.86	656.67	45.98	271.60	0.00	0.00	65.18	0.00	65.18
2016	OCT1	721.90	1448.98	21.02	18.16	1.83	0.00	0.00	39.75	721.39	1425.56	54.86	656.29	46.01	271.60	0.00	0.00	65.18	0.00	65.18
2016	OCT2	721.39	1425.56	27.51	23.77	1.81	0.00	0.00	39.78	721.00	1407.74	54.86	655.83	46.04	271.60	0.00	0.00	65.18	0.00	65.18
2016	OCT3	721.00	1407.74	19.43	18.47	1.79	0.00	0.00	43.79	720.40	1380.63	54.86	655.34	46.07	271.60	0.00	0.00	71.70	0.00	71.70
2016	NOV1	720.40	1380.63	18.13	15.66	1.83	0.00	0.00	39.84	719.83	1354.63	54.86	654.75	46.11	271.60	0.00	0.00	65.18	0.00	65.18
2016	NOV2	719.83	1354.63	7.65	6.61	1.80	0.00	0.00	39.88	719.05	1319.56	54.86	654.08	46.16	271.60	0.00	0.00	65.18	0.00	65.18
2016	NOV3	719.05	1319.56	6.28	5.43	1.76	0.00	0.00	39.93	718.20	1283.30	54.86	653.26	46.22	271.60	0.00	0.00	65.18	0.00	65.18
2016	DEC1	718.20	1283.30	4.10	3.54	2.15	0.00	0.00	39.99	717.24	1244.69	54.86	652.36	46.28	271.60	0.00	0.00	65.18	0.00	65.18
2016	DEC2	717.24	1244.69	2.99	2.58	2.11	0.00	0.00	40.05	716.26	1205.12	54.86	651.39	46.35	271.60	0.00	0.00	65.18	0.00	65.18
2016	DEC3	716.26	1205.12	5.96	5.66	2.06	0.00	0.00	44.12	715.24	1164.60	54.86	650.39	46.42	271.60	0.00	0.00	71.70	0.00	71.70
2017	JAN1	715.24	1164.60	3.98	3.44	1.88	0.00	0.00	40.17	714.25	1125.99	54.86	649.39	46.49	271.60	0.00	0.00	65.18	0.00	65.18
2017	JAN2	714.25	1125.99	2.99	2.58	1.84	0.00	0.00	40.23	713.25	1086.50	54.86	648.39	46.57	271.60	0.00	0.00	65.18	0.00	65.18
2017	JAN3	713.25	1086.50	4.23	4.02	1.79	0.00	0.00	44.33	712.12	1044.41	54.86	647.33	46.64	271.60	0.00	0.00	71.70	0.00	71.70
2017	FEB1	712.12	1044.41	4.33	3.74	2.24	0.00	0.00	40.37	711.01	1005.54	54.86	646.21	46.72	271.60	0.00	0.00	65.18	0.00	65.18
2017	FEB2	711.01	1005.54	3.18	2.75	2.19	0.00	0.00	40.44	709.88	965.66	54.86	645.08	46.80	271.60	0.00	0.00	65.18	0.00	65.18
2017	FEB3	709.88	965.66	7.26	5.02	2.14	0.00	0.00	32.40	709.02	936.14	54.86	644.09	46.88	271.60	0.00	0.00	52.15	0.00	52.15
2017	MAR1	709.02	936.14	10.81	9.34	1.69	0.00	0.00	40.56	708.05	903.24	54.86	643.17	46.94	271.60	0.00	0.00	65.18	0.00	65.18
2017	MAR2	708.05	903.24	10.09	8.72	1.65	0.00	0.00	40.62	707.06	869.69	54.86	642.20	47.01	271.60	0.00	0.00	65.18	0.00	65.18
2017	MAR3	707.06	869.69	9.01	8.56	1.60	0.00	0.00	44.76	705.87	831.89	54.86	641.11	47.09	271.60	0.00	0.00	71.70	0.00	71.70
2017	APR1	705.87	831.89	7.12	6.15	1.60	0.00	0.00	40.77	704.66	795.67	54.86	639.91	47.18	271.60	0.00	0.00	65.18	0.00	65.18
2017	APR2	704.66	795.67	12.53	10.83	1.55	0.00	0.00	40.84	703.60	764.11	54.86	638.77	47.27	271.60	0.00	0.00	65.18	0.00	65.18
2017	APR3	703.60	764.11	9.77	8.44	1.50	0.00	0.00	40.91	702.47	730.15	54.86	637.68	47.35	271.60	0.00	0.00	65.18	0.00	65.18
2017	MAY1	702.47	730.15	9.04	7.81	1.40	0.00	0.00	40.98	701.26	695.58	54.86	636.50	47.44	271.60	0.00	0.00	65.18	0.00	65.18
2017	MAY2	701.26	695.58	15.15	13.09	1.35	0.00	0.00	41.06	700.22	666.26	54.86	635.38	47.52	271.60	0.00	0.00	65.18	0.00	65.18
2017	MAY3	700.22	666.26	6.84	6.50	1.30	0.00	0.00	45.25	698.69	626.21	54.86	634.10	47.62	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					864.62	66.40	0.00	0.00	1466.25									2379.22	0.00	2379.22

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2017	JUN1	698.69	626.21	16.54	14.29	1.03	0.00	0.00	41.23	697.55	598.25	54.86	632.76	47.72	271.60	0.00	0.00	65.18	0.00	65.18
2017	JUN2	697.55	598.25	27.52	23.78	1.00	0.00	0.00	41.29	696.77	579.74	54.86	631.80	47.79	271.60	0.00	0.00	65.18	0.00	65.18
2017	JUN3	696.77	579.74	140.14	121.08	1.04	0.00	0.00	41.21	699.95	658.58	54.86	633.00	47.70	271.60	0.00	0.00	65.18	0.00	65.18
2017	JUL 1	699.95	658.58	63.09	54.51	1.37	0.00	0.00	41.09	700.38	670.62	54.86	634.80	47.56	271.60	0.00	0.00	65.18	0.00	65.18
2017	JUL2	700.38	670.62	41.88	36.18	1.37	0.00	0.00	41.09	700.15	664.34	54.86	634.90	47.55	271.60	0.00	0.00	65.18	0.00	65.18
2017	JUL3	700.15	664.34	55.61	52.85	1.37	0.00	0.00	45.20	700.38	670.62	54.86	634.90	47.55	271.60	0.00	0.00	71.70	0.00	71.70
2017	AUG1	700.38	670.62	120.24	103.89	1.10	0.00	0.00	41.01	702.54	732.40	54.86	636.10	47.47	271.60	0.00	0.00	65.18	0.00	65.18
2017	AUG2	702.54	732.40	73.70	63.68	1.15	0.00	0.00	40.92	703.27	754.01	54.86	637.54	47.36	271.60	0.00	0.00	65.18	0.00	65.18
2017	AUG3	703.27	754.01	155.11	147.42	1.23	0.00	0.00	44.86	706.64	855.33	54.86	639.59	47.21	271.60	0.00	0.00	71.70	0.00	71.70
2017	SEP1	706.64	855.33	129.78	112.13	1.37	0.00	0.00	40.61	708.70	925.48	54.86	642.31	47.01	271.60	0.00	0.00	65.18	0.00	65.18
2017	SEP2	708.70	925.48	183.70	158.72	1.46	0.00	0.00	40.44	712.06	1042.31	54.86	645.02	46.81	271.60	0.00	0.00	65.18	0.00	65.18
2017	SEP3	712.06	1042.31	104.34	90.15	1.53	0.00	0.00	40.30	713.35	1090.63	54.86	647.35	46.64	271.60	0.00	0.00	65.18	0.00	65.18
2017	OCT1	713.35	1090.63	60.56	52.32	1.51	0.00	0.00	40.25	713.62	1101.19	54.86	648.13	46.58	271.60	0.00	0.00	65.18	0.00	65.18
2017	OCT2	713.62	1101.19	70.64	61.03	1.52	0.00	0.00	40.23	714.11	1120.47	54.86	648.51	46.56	271.60	0.00	0.00	65.18	0.00	65.18
2017	OCT3	714.11	1120.47	56.02	53.24	1.54	0.00	0.00	44.22	714.30	1127.95	54.86	648.85	46.53	271.60	0.00	0.00	71.70	0.00	71.70
2017	NOV1	714.30	1127.95	57.95	50.07	1.60	0.00	0.00	40.19	714.52	1136.23	54.86	649.05	46.52	271.60	0.00	0.00	65.18	0.00	65.18
2017	NOV2	714.52	1136.23	30.22	26.11	1.59	0.00	0.00	40.20	714.12	1120.55	54.86	648.96	46.52	271.60	0.00	0.00	65.18	0.00	65.18
2017	NOV3	714.12	1120.55	16.82	14.53	1.57	0.00	0.00	40.23	713.42	1093.28	54.86	648.41	46.56	271.60	0.00	0.00	65.18	0.00	65.18
2017	DEC1	713.42	1093.28	32.30	27.91	1.94	0.00	0.00	40.26	713.06	1078.99	54.86	647.88	46.60	271.60	0.00	0.00	65.18	0.00	65.18
2017	DEC2	713.06	1078.99	21.04	18.18	1.91	0.00	0.00	40.30	712.42	1054.96	54.86	647.38	46.64	271.60	0.00	0.00	65.18	0.00	65.18
2017	DEC3	712.42	1054.96	10.20	9.69	1.88	0.00	0.00	44.38	711.38	1018.39	54.86	646.54	46.70	271.60	0.00	0.00	71.70	0.00	71.70
2018	JAN1	711.38	1018.39	8.58	7.41	1.72	0.00	0.00	40.41	710.39	983.66	54.86	645.52	46.77	271.60	0.00	0.00	65.18	0.00	65.18
2018	JAN2	710.39	983.66	6.70	5.79	1.68	0.00	0.00	40.48	709.34	947.30	54.86	644.51	46.85	271.60	0.00	0.00	65.18	0.00	65.18
2018	JAN3	709.34	947.30	6.41	6.09	1.64	0.00	0.00	44.60	708.16	907.15	54.86	643.39	46.93	271.60	0.00	0.00	71.70	0.00	71.70
2018	FEB1	708.16	907.15	7.07	6.11	2.05	0.00	0.00	40.62	707.09	870.59	54.86	642.27	47.01	271.60	0.00	0.00	65.18	0.00	65.18
2018	FEB2	707.09	870.59	4.48	3.87	1.99	0.00	0.00	40.69	705.87	831.79	54.86	641.12	47.09	271.60	0.00	0.00	65.18	0.00	65.18
2018	FEB3	705.87	831.79	6.79	4.69	1.93	0.00	0.00	32.61	704.87	801.94	54.86	640.01	47.18	271.60	0.00	0.00	52.15	0.00	52.15
2018	MAR1	704.87	801.94	11.52	9.95	1.51	0.00	0.00	40.83	703.79	769.56	54.86	638.97	47.25	271.60	0.00	0.00	65.18	0.00	65.18
2018	MAR2	703.79	769.56	10.13	8.75	1.46	0.00	0.00	40.90	702.66	735.95	54.86	637.86	47.33	271.60	0.00	0.00	65.18	0.00	65.18
2018	MAR3	702.66	735.95	8.31	7.90	1.40	0.00	0.00	45.07	701.32	697.38	54.86	636.63	47.43	271.60	0.00	0.00	71.70	0.00	71.70
2018	APR1	701.32	697.38	7.29	6.30	1.39	0.00	0.00	41.06	700.04	661.23	54.86	635.32	47.52	271.60	0.00	0.00	65.18	0.00	65.18
2018	APR2	700.04	661.23	12.43	10.74	1.34	0.00	0.00	41.14	698.82	629.49	54.86	634.07	47.62	271.60	0.00	0.00	65.18	0.00	65.18
2018	APR3	698.82	629.49	14.31	12.36	1.29	0.00	0.00	41.22	697.60	599.34	54.86	632.85	47.71	271.60	0.00	0.00	65.18	0.00	65.18
2018	MAY1	697.60	599.34	14.56	12.58	1.20	0.00	0.00	41.30	696.33	569.42	54.86	631.61	47.80	271.60	0.00	0.00	65.18	0.00	65.18
2018	MAY2	696.33	569.42	25.35	21.90	1.16	0.00	0.00	41.37	695.45	548.79	54.86	630.53	47.88	271.60	0.00	0.00	65.18	0.00	65.18
2018	MAY3	695.45	548.79	37.27	35.42	1.13	0.00	0.00	45.56	694.97	537.53	54.86	629.85	47.94	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1451.62	52.95	0.00	0.00	1487.36									2379.22	0.00	2379.22

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2018	JUN1	694.97	537.53	59.70	51.58	0.93	0.00	0.00	41.42	695.37	546.75	54.86	629.81	47.94	271.60	0.00	0.00	65.18	0.00	65.18
2018	JUN2	695.37	546.75	260.71	225.25	1.05	0.00	0.00	41.18	702.45	729.78	54.86	633.55	47.66	271.60	0.00	0.00	65.18	0.00	65.18
2018	JUN3	702.45	729.78	126.41	109.22	1.22	0.00	0.00	40.87	704.70	796.90	54.86	638.22	47.31	271.60	0.00	0.00	65.18	0.00	65.18
2018	JUL 1	704.70	796.90	104.35	90.16	1.61	0.00	0.00	40.75	706.30	844.70	54.86	640.14	47.17	271.60	0.00	0.00	65.18	0.00	65.18
2018	JUL2	706.30	844.70	463.76	400.69	1.85	0.00	0.00	40.39	716.21	1203.15	54.86	645.89	46.75	271.60	0.00	0.00	65.18	0.00	65.18
2018	JUL3	716.21	1203.15	324.83	308.72	2.23	0.00	0.00	43.88	722.26	1465.75	54.86	653.87	46.18	271.60	0.00	0.00	71.70	0.00	71.70
2018	AUG1	722.26	1465.75	227.88	196.89	1.93	0.00	0.00	39.61	725.51	1621.09	54.86	658.52	45.85	271.60	0.00	0.00	65.18	0.00	65.18
2018	AUG2	725.51	1621.09	1009.48	872.19	2.20	0.00	0.00	228.68	732.43	1996.34	54.86	663.61	264.68	271.60	1308.40	1838.30	65.18	314.02	379.20
2018	AUG3	732.43	1996.34	245.94	233.74	2.38	0.00	0.00	231.36	732.43	1996.34	54.86	667.07	243.43	271.60	1189.16	0.00	71.70	313.94	385.64
2018	SEP1	732.43	1996.34	91.54	79.09	2.46	0.00	0.00	76.63	732.43	1996.34	54.86	667.07	88.69	271.60	260.60	0.00	65.18	62.54	127.73
2018	SEP2	732.43	1996.34	35.89	31.01	2.46	0.00	0.00	39.11	732.25	1985.78	54.86	666.98	45.27	271.60	0.00	0.00	65.18	0.00	65.18
2018	SEP3	732.25	1985.78	64.22	55.49	2.46	0.00	0.00	42.47	732.43	1996.34	54.86	666.98	49.16	271.60	23.35	0.00	65.18	5.60	70.79
2018	OCT1	732.43	1996.34	81.24	70.19	2.38	0.00	0.00	67.81	732.43	1996.34	54.86	667.07	78.48	271.60	199.34	0.00	65.18	47.84	113.03
2018	OCT2	732.43	1996.34	89.18	77.05	2.38	0.00	0.00	74.67	732.43	1996.34	54.86	667.07	86.42	271.60	246.98	0.00	65.18	59.28	124.46
2018	OCT3	732.43	1996.34	76.83	73.02	2.38	0.00	0.00	70.64	732.43	1996.34	54.86	667.07	74.32	271.60	174.40	0.00	71.70	46.04	117.74
2018	NOV1	732.43	1996.34	34.98	30.22	2.46	0.00	0.00	39.11	732.23	1984.99	54.86	666.97	45.27	271.60	0.00	0.00	65.18	0.00	65.18
2018	NOV2	732.23	1984.99	39.54	34.16	2.45	0.00	0.00	39.12	732.10	1977.58	54.86	666.81	45.28	271.60	0.00	0.00	65.18	0.00	65.18
2018	NOV3	732.10	1977.58	28.03	24.22	2.44	0.00	0.00	39.13	731.79	1960.23	54.86	666.58	45.29	271.60	0.00	0.00	65.18	0.00	65.18
2018	DEC1	731.79	1960.23	16.68	14.41	3.02	0.00	0.00	39.16	731.29	1932.46	54.86	666.18	45.32	271.60	0.00	0.00	65.18	0.00	65.18
2018	DEC2	731.29	1932.46	10.72	9.26	2.99	0.00	0.00	39.19	730.70	1899.54	54.86	665.64	45.36	271.60	0.00	0.00	65.18	0.00	65.18
2018	DEC3	730.70	1899.54	5.10	4.85	2.94	0.00	0.00	43.15	729.94	1858.30	54.86	664.96	45.41	271.60	0.00	0.00	71.70	0.00	71.70
2019	JAN1	729.94	1858.30	6.80	5.87	2.70	0.00	0.00	39.27	729.28	1822.20	54.86	664.25	45.45	271.60	0.00	0.00	65.18	0.00	65.18
2019	JAN2	729.28	1822.20	7.99	6.90	2.66	0.00	0.00	39.31	728.63	1787.13	54.86	663.59	45.50	271.60	0.00	0.00	65.18	0.00	65.18
2019	JAN3	728.63	1787.13	7.10	6.75	2.61	0.00	0.00	43.29	727.91	1747.97	54.86	662.91	45.55	271.60	0.00	0.00	71.70	0.00	71.70
2019	FEB1	727.91	1747.97	7.77	6.71	3.29	0.00	0.00	39.39	727.23	1712.00	54.86	662.21	45.59	271.60	0.00	0.00	65.18	0.00	65.18
2019	FEB2	727.23	1712.00	7.58	6.55	3.23	0.00	0.00	39.43	726.54	1675.89	54.86	661.53	45.64	271.60	0.00	0.00	65.18	0.00	65.18
2019	FEB3	726.54	1675.89	4.58	3.16	3.18	0.00	0.00	31.58	725.95	1644.29	54.86	660.89	45.69	271.60	0.00	0.00	52.15	0.00	52.15
2019	MAR1	725.95	1644.29	4.61	3.98	2.52	0.00	0.00	39.51	725.22	1606.24	54.86	660.23	45.73	271.60	0.00	0.00	65.18	0.00	65.18
2019	MAR2	725.22	1606.24	10.48	9.05	2.48	0.00	0.00	39.55	724.57	1573.26	54.86	659.54	45.78	271.60	0.00	0.00	65.18	0.00	65.18
2019	MAR3	724.57	1573.26	10.19	9.68	2.43	0.00	0.00	43.56	723.79	1536.95	54.86	658.82	45.83	271.60	0.00	0.00	71.70	0.00	71.70
2019	APR1	723.79	1536.95	7.97	6.89	2.47	0.00	0.00	39.64	723.04	1501.72	54.86	658.05	45.88	271.60	0.00	0.00	65.18	0.00	65.18
2019	APR2	723.04	1501.72	7.05	6.09	2.43	0.00	0.00	39.69	722.26	1465.70	54.86	657.29	45.94	271.60	0.00	0.00	65.18	0.00	65.18
2019	APR3	722.26	1465.70	16.86	14.57	2.39	0.00	0.00	39.73	721.67	1438.15	54.86	656.61	45.98	271.60	0.00	0.00	65.18	0.00	65.18
2019	MAY1	721.67	1438.15	13.71	11.84	2.28	0.00	0.00	39.77	721.00	1407.95	54.86	655.98	46.03	271.60	0.00	0.00	65.18	0.00	65.18
2019	MAY2	721.00	1407.95	11.34	9.79	2.24	0.00	0.00	39.81	720.29	1375.70	54.86	655.29	46.08	271.60	0.00	0.00	65.18	0.00	65.18
2019	MAY3	720.29	1375.70	15.18	14.43	2.20	0.00	0.00	43.84	719.59	1344.09	54.86	654.58	46.12	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					3113.68	85.35	0.00	0.00	1955.70									2379.22	849.26	3228.48

**IDUKKI HYDROELECTRIC PROJECTS
RESERVOIR OPERATION TABLE**

	Level(M)	Storage (MCUM)
F.R.L	732.43	1996.34
M.D.D.L	694.94	536.80
C/L	54.86	

T.G.EFF.	=	91.70%
Firm Power exep.(MW)	=	271.600
Installed Capacity (MW)	=	1580.00

YEAR	MONTH	INITIAL LEVEL	INITIAL STORAGE	INFLOW	INFLOW	EVAPORAT ION	IRRIGATION RELEASES	ENVIRONMENTAL RELEASES	WITHDRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	MCUM	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
2019	JUN1	719.59	1344.09	14.55	12.57	1.79	0.00	0.00	39.89	718.95	1314.98	54.86	653.91	46.17	271.60	0.00	0.00	65.18	0.00	65.18
2019	JUN2	718.95	1314.98	20.21	17.46	1.76	0.00	0.00	39.93	718.38	1290.75	54.86	653.31	46.22	271.60	0.00	0.00	65.18	0.00	65.18
2019	JUN3	718.38	1290.75	28.88	24.96	1.74	0.00	0.00	39.96	717.96	1274.01	54.86	652.81	46.25	271.60	0.00	0.00	65.18	0.00	65.18
2019	JUL 1	717.96	1274.01	31.11	26.88	2.16	0.00	0.00	39.98	717.59	1258.74	54.86	652.42	46.28	271.60	0.00	0.00	65.18	0.00	65.18
2019	JUL2	717.59	1258.74	55.28	47.76	2.15	0.00	0.00	39.99	717.73	1264.36	54.86	652.30	46.29	271.60	0.00	0.00	65.18	0.00	65.18
2019	JUL3	717.73	1264.36	103.82	98.67	2.19	0.00	0.00	43.94	718.99	1316.90	54.86	653.00	46.24	271.60	0.00	0.00	71.70	0.00	71.70
2019	AUG1	718.99	1316.90	281.91	243.57	1.81	0.00	0.00	39.78	723.40	1518.88	54.86	655.84	46.04	271.60	0.00	0.00	65.18	0.00	65.18
2019	AUG2	723.40	1518.88	250.38	216.33	1.99	0.00	0.00	39.54	726.88	1693.68	54.86	659.78	45.76	271.60	0.00	0.00	65.18	0.00	65.18
2019	AUG3	726.88	1693.68	116.27	110.50	2.12	0.00	0.00	43.34	728.11	1758.73	54.86	662.13	45.60	271.60	0.00	0.00	71.70	0.00	71.70
2019	SEP1	728.11	1758.73	196.16	169.49	2.29	0.00	0.00	39.29	730.46	1886.63	54.86	663.92	45.48	271.60	0.00	0.00	65.18	0.00	65.18
2019	SEP2	730.46	1886.63	85.95	74.26	2.38	0.00	0.00	39.20	731.06	1919.31	54.86	665.40	45.38	271.60	0.00	0.00	65.18	0.00	65.18
2019	SEP3	731.06	1919.31	58.59	50.63	2.40	0.00	0.00	39.18	731.22	1928.36	54.86	665.78	45.35	271.60	0.00	0.00	65.18	0.00	65.18
2019	OCT1	731.22	1928.36	41.01	35.43	2.32	0.00	0.00	39.18	731.11	1922.29	54.86	665.81	45.35	271.60	0.00	0.00	65.18	0.00	65.18
2019	OCT2	731.11	1922.29	37.46	32.37	2.31	0.00	0.00	39.19	730.95	1913.15	54.86	665.67	45.36	271.60	0.00	0.00	65.18	0.00	65.18
2019	OCT3	730.95	1913.15	81.51	77.47	2.32	0.00	0.00	43.09	731.52	1945.20	54.86	665.88	45.34	271.60	0.00	0.00	71.70	0.00	71.70
2019	NOV1	731.52	1945.20	59.71	51.59	2.42	0.00	0.00	39.15	731.70	1955.22	54.86	666.25	45.32	271.60	0.00	0.00	65.18	0.00	65.18
2019	NOV2	731.70	1955.22	31.01	26.79	2.42	0.00	0.00	39.16	731.44	1940.44	54.86	666.21	45.32	271.60	0.00	0.00	65.18	0.00	65.18
2019	NOV3	731.44	1940.44	14.87	12.85	2.40	0.00	0.00	39.18	730.92	1911.71	54.86	665.82	45.35	271.60	0.00	0.00	65.18	0.00	65.18
2019	DEC1	730.92	1911.71	13.23	11.43	2.96	0.00	0.00	39.21	730.36	1880.96	54.86	665.28	45.38	271.60	0.00	0.00	65.18	0.00	65.18
2019	DEC2	730.36	1880.96	7.49	6.47	2.92	0.00	0.00	39.25	729.70	1845.27	54.86	664.67	45.42	271.60	0.00	0.00	65.18	0.00	65.18
2019	DEC3	729.70	1845.27	6.96	6.61	2.87	0.00	0.00	43.22	728.97	1805.80	54.86	663.98	45.47	271.60	0.00	0.00	71.70	0.00	71.70
2020	JAN1	728.97	1805.80	6.35	5.48	2.64	0.00	0.00	39.33	728.30	1769.31	54.86	663.28	45.52	271.60	0.00	0.00	65.18	0.00	65.18
2020	JAN2	728.30	1769.31	5.67	4.90	2.59	0.00	0.00	39.37	727.61	1732.25	54.86	662.60	45.57	271.60	0.00	0.00	65.18	0.00	65.18
2020	JAN3	727.61	1732.25	5.41	5.14	2.54	0.00	0.00	43.35	726.84	1691.49	54.86	661.87	45.62	271.60	0.00	0.00	71.70	0.00	71.70
2020	FEB1	726.84	1691.49	5.66	4.89	3.20	0.00	0.00	39.46	726.12	1653.73	54.86	661.12	45.67	271.60	0.00	0.00	65.18	0.00	65.18
2020	FEB2	726.12	1653.73	3.74	3.23	3.14	0.00	0.00	39.50	725.38	1614.31	54.86	660.39	45.72	271.60	0.00	0.00	65.18	0.00	65.18
2020	FEB3	725.38	1614.31	3.35	2.31	3.08	0.00	0.00	31.63	724.76	1581.91	54.86	659.71	45.77	271.60	0.00	0.00	52.15	0.00	52.15
2020	MAR1	724.76	1581.91	5.20	4.49	2.44	0.00	0.00	39.59	723.95	1544.37	54.86	658.99	45.82	271.60	0.00	0.00	65.18	0.00	65.18
2020	MAR2	723.95	1544.37	4.17	3.61	2.40	0.00	0.00	39.63	723.13	1505.95	54.86	658.18	45.87	271.60	0.00	0.00	65.18	0.00	65.18
2020	MAR3	723.13	1505.95	4.17	3.96	2.35	0.00	0.00	43.65	722.22	1463.90	54.86	657.32	45.93	271.60	0.00	0.00	71.70	0.00	71.70
2020	APR1	722.22	1463.90	9.50	8.21	2.38	0.00	0.00	39.74	721.49	1429.99	54.86	656.50	45.99	271.60	0.00	0.00	65.18	0.00	65.18
2020	APR2	721.49	1429.99	8.50	7.35	2.34	0.00	0.00	39.78	720.72	1395.22	54.86	655.75	46.04	271.60	0.00	0.00	65.18	0.00	65.18
2020	APR3	720.72	1395.22	11.67	10.08	2.30	0.00	0.00	39.83	720.02	1363.18	54.86	655.01	46.09	271.60	0.00	0.00	65.18	0.00	65.18
2020	MAY1	720.02	1363.18	8.03	6.94	2.18	0.00	0.00	39.87	719.24	1328.07	54.86	654.27	46.15	271.60	0.00	0.00	65.18	0.00	65.18
2020	MAY2	719.24	1328.07	12.54	10.83	2.14	0.00	0.00	39.92	718.53	1296.84	54.86	653.53	46.20	271.60	0.00	0.00	65.18	0.00	65.18
2020	MAY3	718.53	1296.84	12.60	11.97	2.10	0.00	0.00	43.96	717.69	1262.75	54.86	652.75	46.25	271.60	0.00	0.00	71.70	0.00	71.70
TOTAL					1447.49	85.56	0.00	0.00	1443.27									2379.22	0.00	2379.22

CHAPTER-7:

DESIGN OF CIVIL STRUCTURES

CHAPTER – 7

7. DESIGN OF CIVIL STRUCTURES

7.1 The Existing Idukki H.E. Project

The IDUKKI Hydroelectric Project is the biggest Hydroelectric Project in Kerala. It comprises of three dams at Idukki, Cheruthony and Kulamavu and related systems. The IDUKKI dam is the first arch dam in India. The project is on Periyar River Basin in Kerala. The Installed capacity of this project is 780 MW. The powerhouse has six generators of 130 MW capacity each. The project was completed in three stages in Year 1976, 1987 and 1991. FRL of this project is as El. 732.43m and provide a live storage between FRL & MDDL is 1459.50 MCM. The Schematic profile of the existing Idukki H.E. Project is shown at **Figure 7.1**.

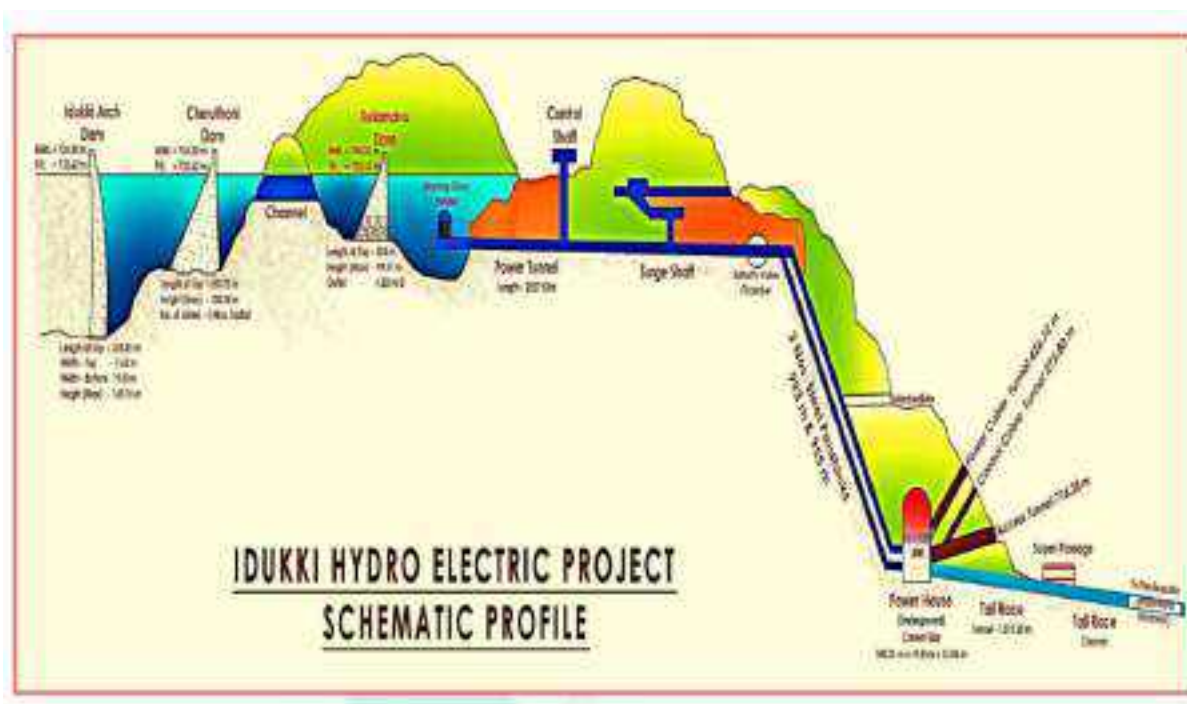


Fig-7.1: Schematic Profile of Existing Idukki Hydro Electric Project

The power house of the existing project is located at Moolamattom and consist of six no. Vertical Pelton turbines generating units each of 130 MW capacity in underground cavern. After power generation, water from the power station is

released to the Thodupuzha River through an underground tunnel, 1220 meters in length. This tail race water is used for irrigation purpose with the help of Irrigation dam at Malankara and access water after irrigation used for power generation in the Malankara Small Hydro Electric Station of 10.5 MW. Malankara Reservoir has also gross storage of 37 MCM available at FRL El. 42 m.

220 KV underground switchyard is located outside the power house with seven 220 KV feeders. The firm annual generation capacity is 2398 MU.

7.2 The Proposed Idukki Extension Scheme

The proposed IDUKKI Extension Scheme aims to construct another underground power house preferably of similar range of installed capacity as existing scheme and then operating both power houses at peak hours to overcome the gap up to a certain extent between demand and availability of power during peak hours. Hence this is a storage type project but no dam or additional reservoir needs to be created for this project. The water available in the existing IDUKKI reservoir is proposed to be shared between two power houses through an efficient water management system.

The Project is located in the vicinity of the existing scheme at Moolamattom in Idukki District of Kerala. The Scheme aims to construct additional power generating scheme of installed capacity 800 MW (4 x 200MW).

7.3 Present Proposal

Existing Idukki Hydro Electric Project of installed capacity of 780MW at present withdraws water from intake near Kulamavu Dam from Idukki Reservoir and after generation, discharges to the triveni junction in Thodupuzha River at Moolamattom through tail race channel.

The present scheme envisages construction of intake near Kulamavu Dam in exiting Idukki Reservoir in the vicinity of existing intake. The FRL and MDDL is fixed at El. 732.43 m and El. 694.94 m respectively. The Idukki Extension Scheme is proposed to generate 800 MW of power by utilising net rated head of 654.57 m.

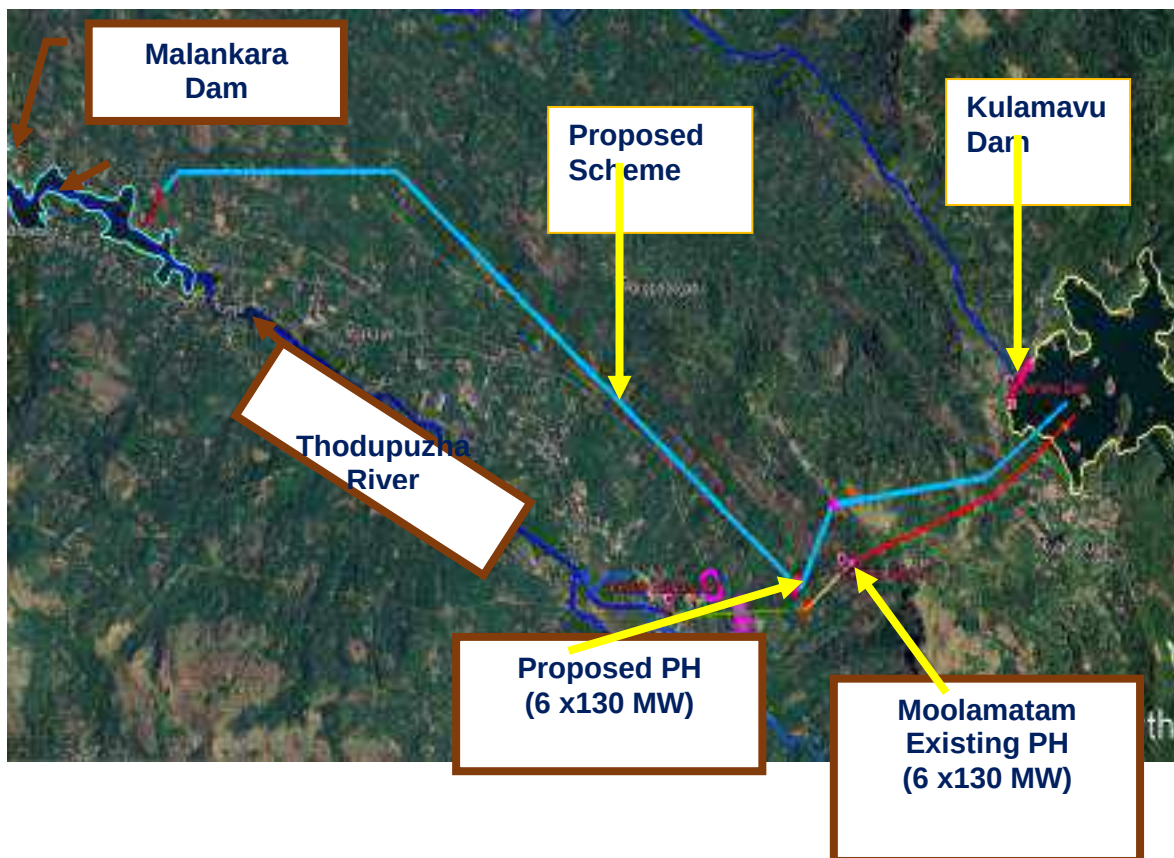
The water from Idukki reservoir will be diverted through power house and TRT/TRC to Thodupuzha River near Triveni junction which leads to Malankara Reservoir.

7.4 Alternative Layout Studies

As a part of the assignment following alternatives for the extension scheme has been worked out.

Alternate -1A

Alternative -1A is as per the Layout Proposed in Preliminary Report prepared by KSEBL which is located Northwards of the Existing Idukki H. E. Project and involves approx. 8 km TRT Length discharging water in to Malankara Reservoir. The reason behind such a long TRT was the preliminary finding in PFR that the Thodupuzha river may not be able to accommodate the combined discharge of existing Idukki HEP and proposed extension scheme simultaneously and may result in flooding. The General layout Plan of Alternate -1A is shown in **Figure 7.2**



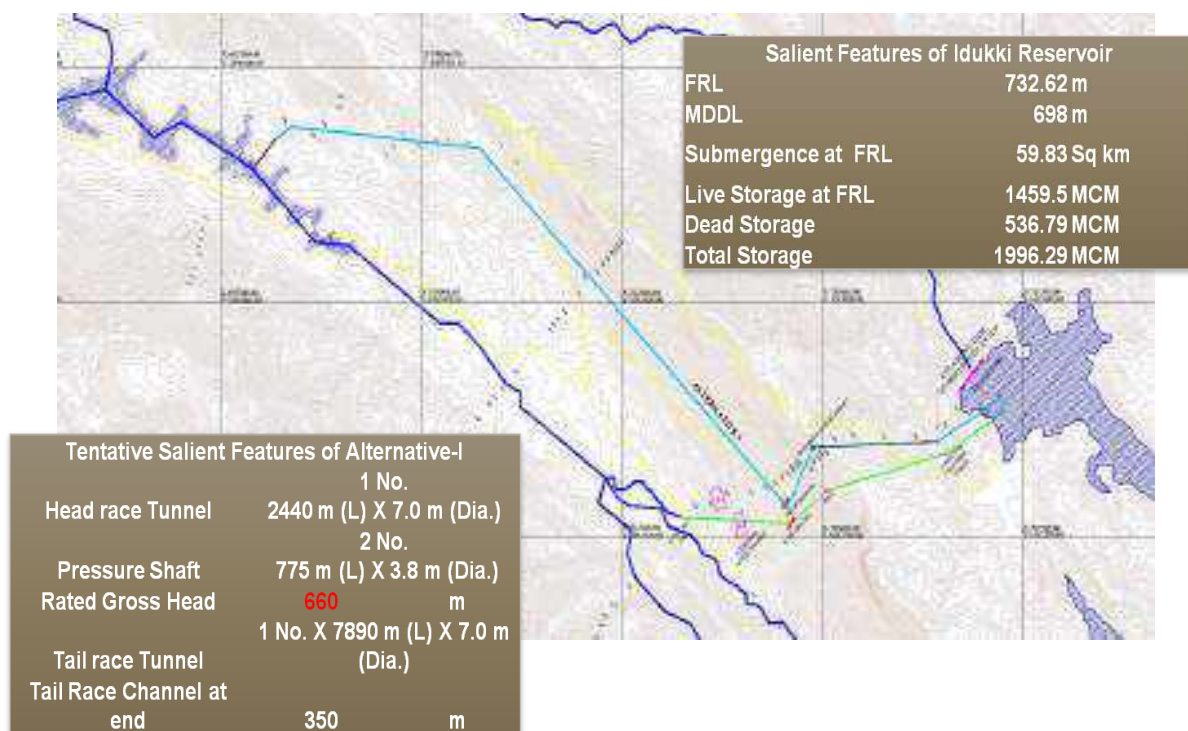


Fig-7.2: General Layout Plan of Idukki Extension Hydro Electric Project (Alternative-1A)

Alternate -1B

Alternative -1B is the optimized version of Alternative-1A. which avoids the 8 km TRT and discharge the Tail water in to Thodupuzha River through 1465m long TRT and 730m Long TRC.. The General layout Plan of Alternate -1B is shown in **Figure 7.3**



Fig-7.3: General Layout Plan of Idukki Extension Scheme H.E. Project (Alternative-1B)

Alternate -2

In view of discharging capacity of Thodupuza river, and on review, considering the long TRT of 8 Km from Techno-economic considerations, it was found necessary to explore other possible alternatives by WAPCOS. Accordingly Alternative-2 was identified based on the preliminary studies which is proposed Southwards of the Existing Idukki H.E. Project proposing a small downstream balancing reservoir to stagger the discharge from extension scheme to avoid flooding in Thodupuza river thereby eliminating 8 km long TRT. The General layout Plan of Alternate -2 is shown in **Figure 7.4**

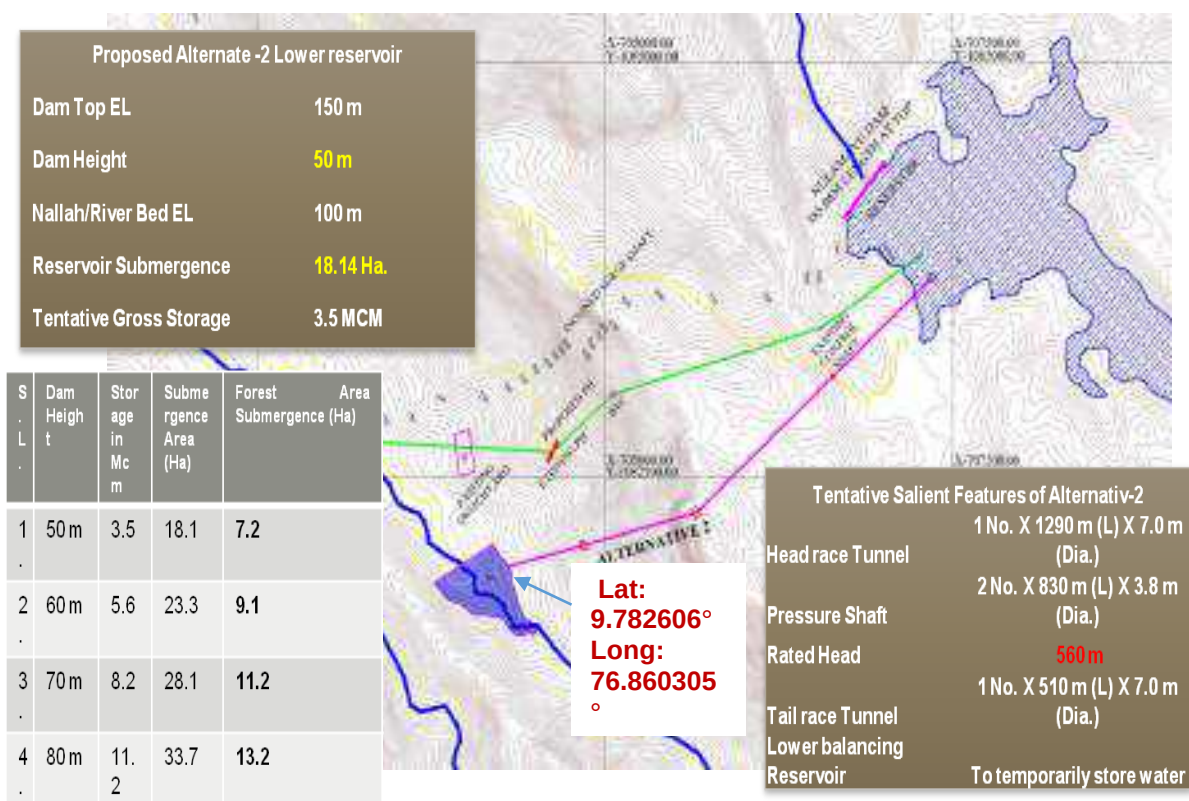


Fig-7.4: General Layout Plan of Idukki Extension Scheme H.E. Project (Alternative-2)

7.5 Determination of Discharge Carrying capacity of Thodupuzha River

Since the primary reason for not discharging Extension Scheme flow in to Thodupuza river together with the discharge of existing tail water of Idukki Hydroelectric project (163m³/sec), as it was suggested that combined discharge of both schemes may cause flooding issues in the narrow sections of river during

monsoon. When both power houses start functioning as peak load stations, there will be considerable diurnal fluctuation in river to the order of 3 to 4 meters in the downstream until the water reaches to Malankara reservoir. The sudden variation in water level due to combined discharge of 315m³/sec during evening may cause accidental drowning of man and animals. Hence the Discharge Carrying capacity of the Thodupuzha River needs to be ascertained. Moreover, considering the natural inflow of the river along with two power houses releases the overall discharge will be higher.

Considering the rainfall data for last 25 Years of the project area, the maximum river discharge in the river is coming out to be 303 cumec. Combining it with simultaneous Power house discharges, a total of 618 cumec discharge is the worst possible scenario when both the power house will be peaking.

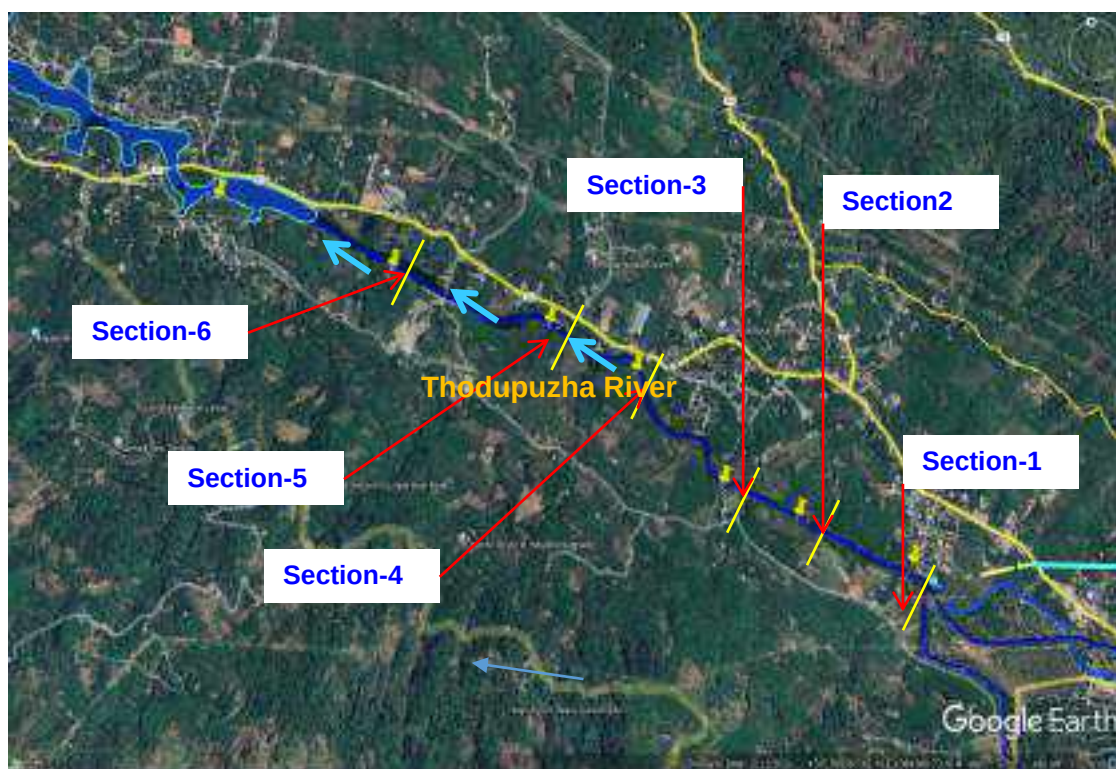


Fig-7.5: Details of Section at Thodupuzha River

Calculation of Determining the Maximum flood discharge of 618 cumec is stated as under.

I. Existing Idukki H.E.Project Power House Discharge : 163 Cumec

- II. Proposed Idukki Extension H.E. Project discharge = 151 Cumec (10 % Overload)
- III. Natural Flood Discharge of Thodupuzha River taking maximum Rainfall =

Max Rainfall	295	mm
Date	16.08.2018	
CA	183.8	sq km'
Run off	26.19	MCM
Flood Discharge	303.13	cumec

Total Flood Discharge (I+II+III) = (303.13+151 +163) = 617.13 Cumec

Accordingly 7 nos. of cross sections have been developed on the Thodupuzha River to prepare the rating curve to ascertain the discharging capacity of the river stretch. The Details of section along with Water Level at 618 cumec flood is shown at **Table 7.1.**

Table-7.1

Rating Curve No. / River Section No.	Section Distance from Triveni	Maximum Flood Discharge	Corresponding Water Level in m
Section -1	130 m	617.13	49.27
Section -2	770 m	617.13	46.91
Section -3	1210 m	617.13	46.77
Section -4	2010 m	617.13	45.72
Section -5	2575 m	617.13	45.51
Section -6	3520 m	617.13	44.84
Section -7	4575 m	617.13	43.55

The rating curve of river section at various stretch is given in **Figure 7.6 to Figure 7.12.**

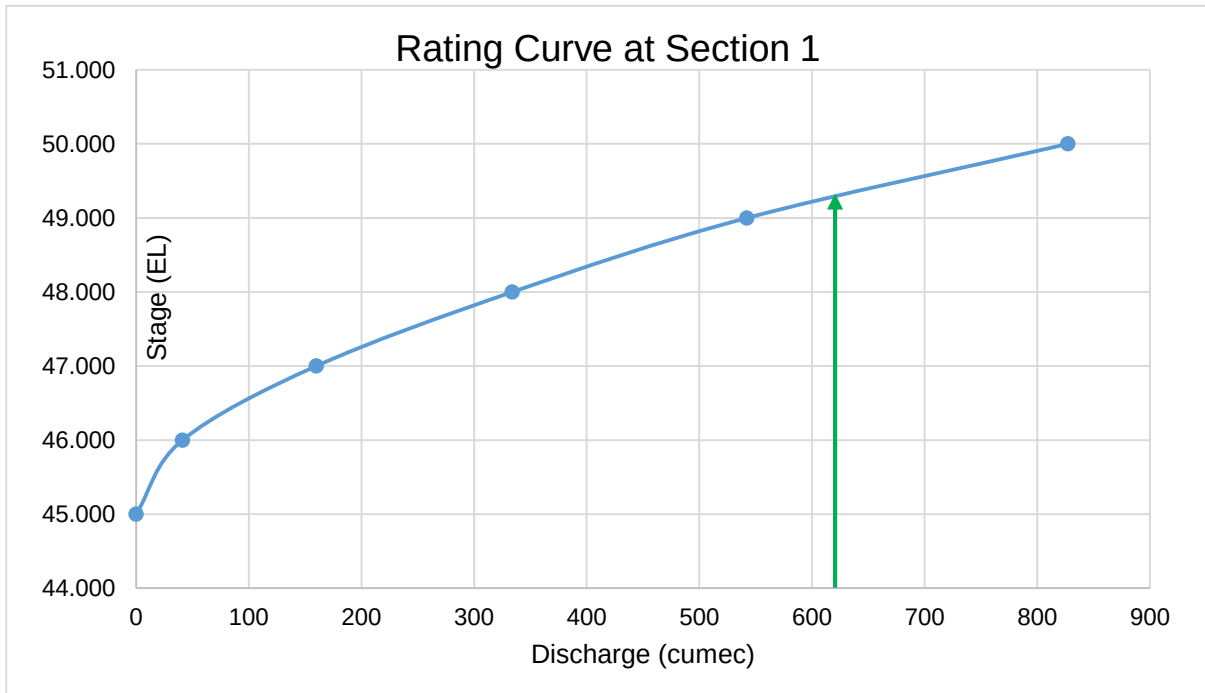


Fig-7.6: Details of Section-1 at Thodupuzha River

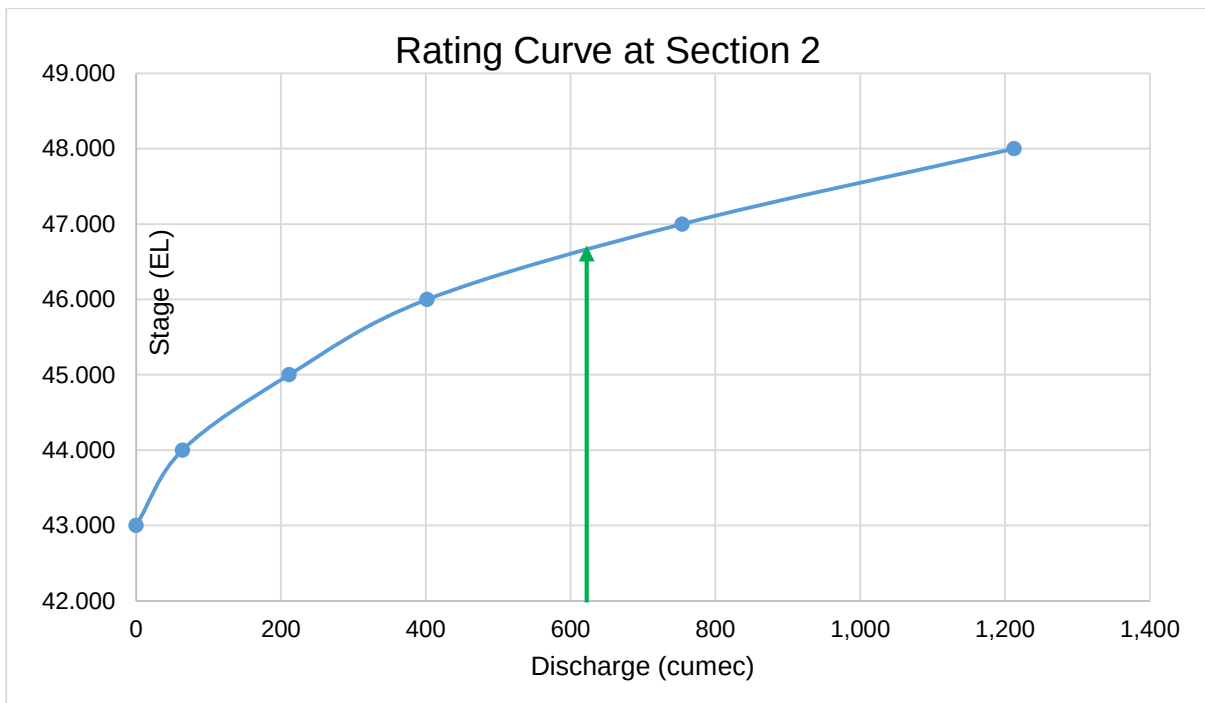


Fig-7.7: Details of Section-2 at Thodupuzha River

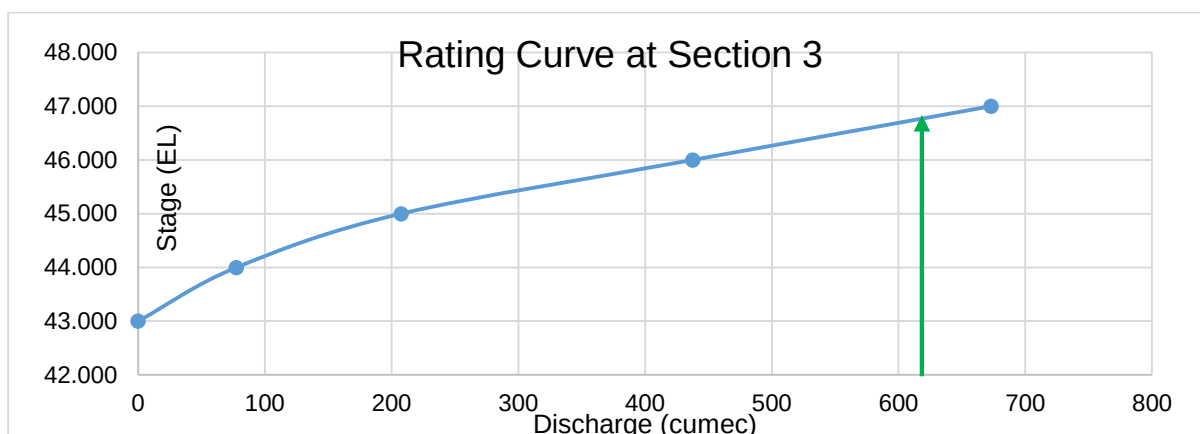


Fig-7.8: Details of Section-3 at Thodupuzha River

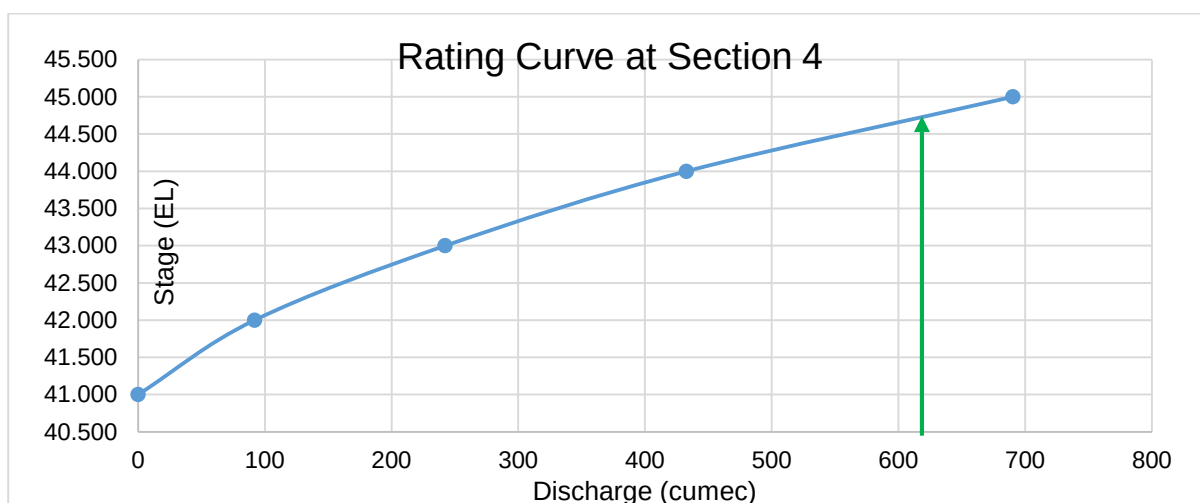


Fig-7.9: Details of Section-4 at Thodupuzha River

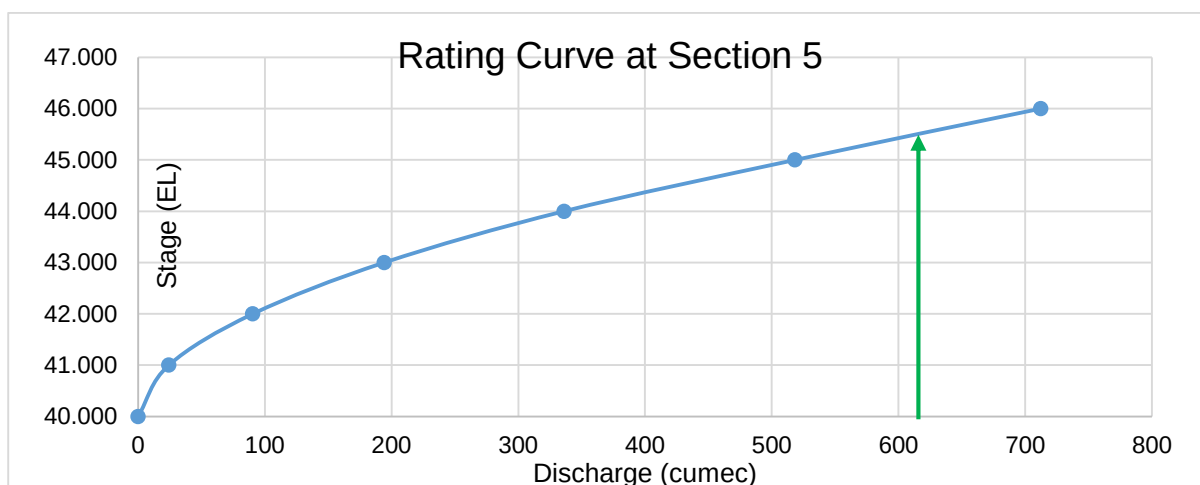


Fig-7.10: Details of Section-5 at Thodupuzha River

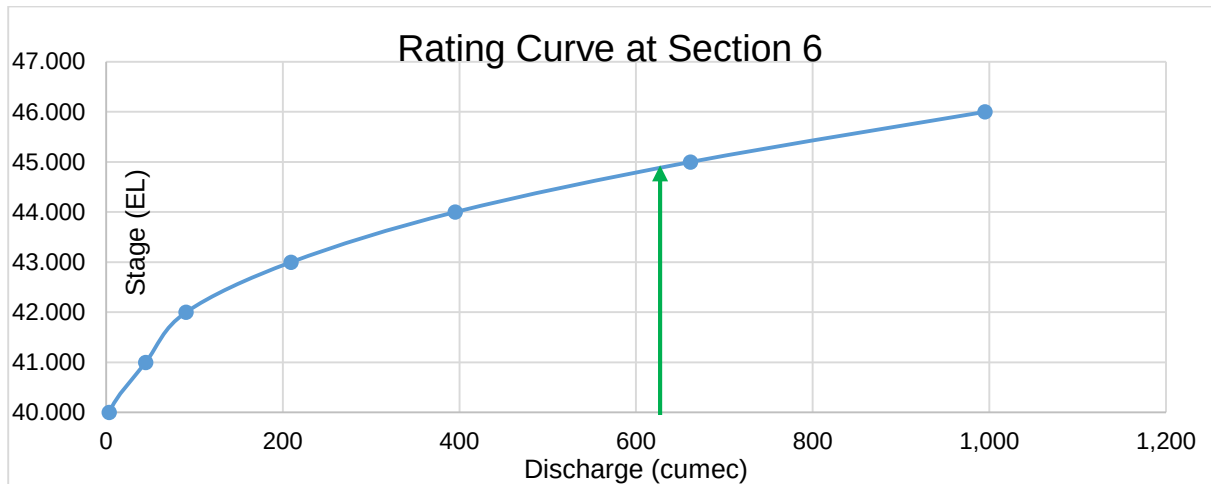


Fig-7.11: Details of Section-11 at Thodupuzha River

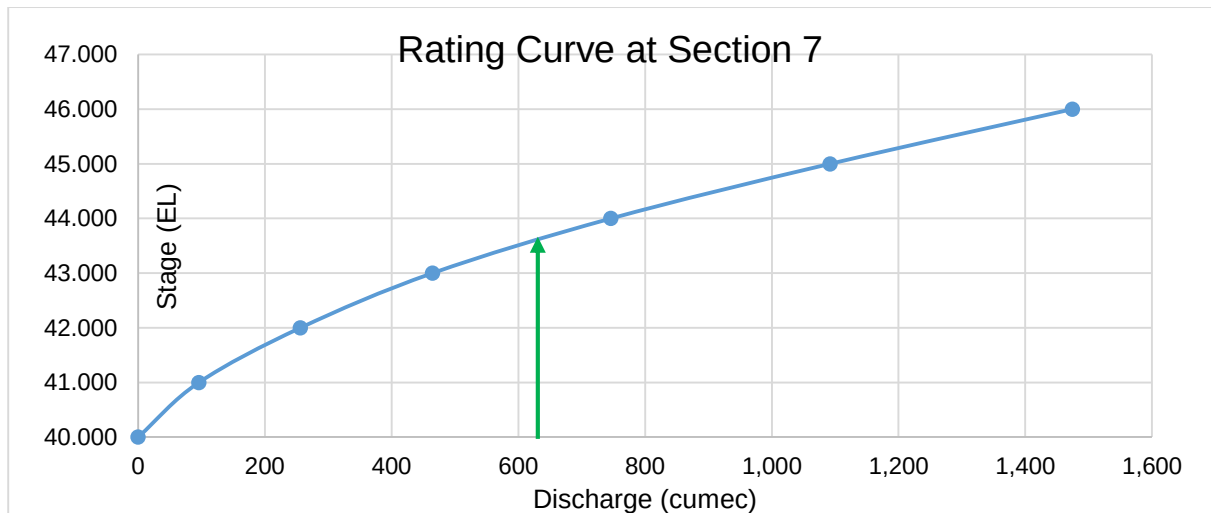


Fig-7.12: Details of Section-12 at Thodupuzha River

Prima facie, rating curve at various section along the river indicates that river is capable of discharging the required capacity during simultaneous operation of power houses without submerging any major populated area. Although, Hydrographic Survey of complete river stretch will yield better results and same will be done at DPR stage. At some section, if required, a embankment of 1-2 m can be constructed for safety.

7.6 Comparison and Selection of Best Alternative

Following is the Broad Comparison of all the Alternatives.

Table: 7.2

Particulars	Alternative: 1A	Alternative: 1B	Alternative: 2
Design Head (m)	648	654	570
Installed Capacity (MW)	780	800	800
HRT (Length and Dia.)	2440 m (L) , 7.0 m (Dia.)	1900 m (L) , 7.0 m (Dia.)	2440 m (L) , 7.0 m (Dia.)
Inclined Pressure shaft (No. , Length, Dia.)	2 No. , 775 m (L) , 3.8 m (Dia.)	2 No. , 850 m (L) , 3.8 m (Dia.)	2 No. , 830 m (L) , 3.8 m (Dia.)
TRT (Length, Dia.)	7890 m (L) , 7.0 m (Dia.)	1465 m (L) , 7.5 m (Dia.)	510 m (L) , 7.0 m (Dia.) TRT
TRC (Length, Bed Widht, Depth)	350 m (L) , 10.0 m (B) , 4.0 m (H)	730 m (L) , 10.0 m (B) , 4.0 m (H)	-----
Requirement of New Reservoir	No	No	Yes

In the view of the above finding, a modified layout i.e Alternative-1B is finally proposed in the present study. The General Layout Map Showing all the alternatives are presented at **Annexure-7.1** and for **Alternative -1B** is presented at **Annexure - 7.2**.

7.7 Idukki Reservoir

The Idukki reservoir is formed in Periyar River basin by constructing three dams viz. Idukki Arch Dam, Cheruthoni & Kulamavu and two diversion dams/weirs across Kallar and Erattayar streams. At 167.68 metres, Idukki Arch dam is one of the highest arch dams in Asia and third tallest arch dam. The three dams have created an artificial lake that is 60 km² in area.

A total of 6 Units of 130 MW is currently operational utilising water of Idukki Reservoir. 3 Unit of Operational Hydro-Electric Scheme was commissioned in 1976 and other 3 units were in 1986.

Brief particulars of Idukki Reservoir are shown in Table 7.2:

Table: 7.3

S. No.	Particulars	Details
1.	FRL	EL 732.43 m
2.	MDDL	EL 694.94 m
3.	Gross Storage	1996.34 MCM
4.	Live Storage	1459.54 MCM
5.	Area under submergence	59.57 Sq km.
6.	Catchment Area	675.89 Sq km.

The layout map of the project and reservoirs under the project are shown in **Figure 7.13** and **Figure 7.14**.

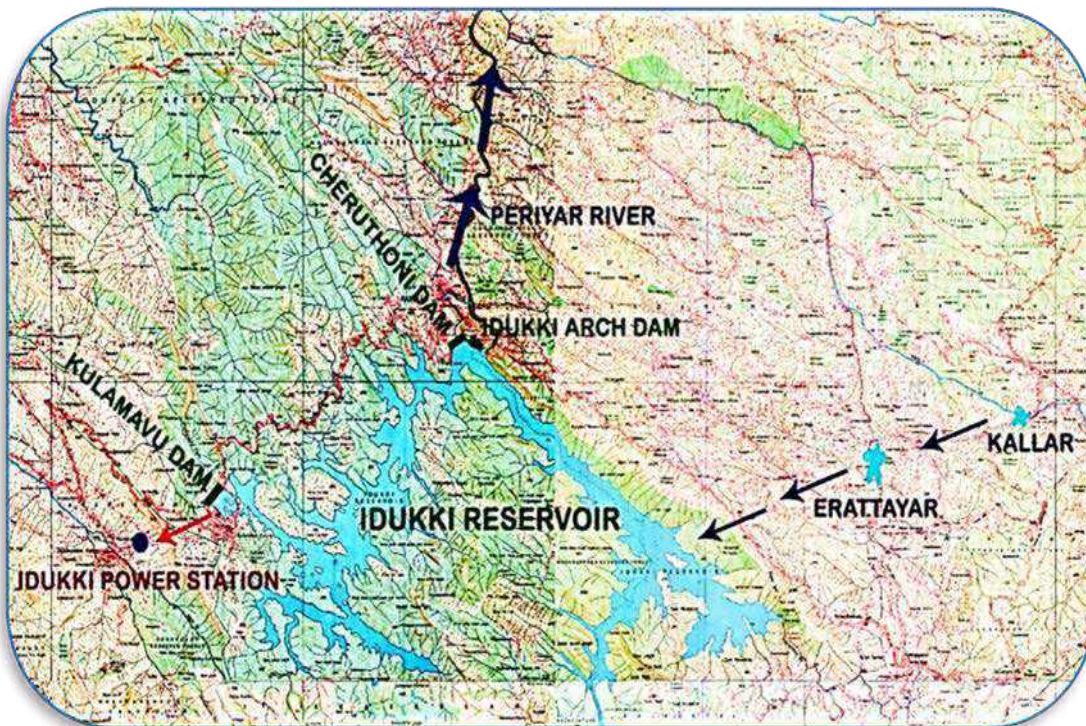


Fig-7.13: General Layout Map of Idukki Reservoir



Fig-7.14: Details of Projects under Idukki Reservoir

7.8 Design of Civil Components

7.8.1 Intake Structure

Intake structure has been proposed from the left bank of Kulamavu Dam between Kulamavu Dam and existing intake. The location of the Intake has been marked at about 150m upstream of the existing Kulamavu dam, considering the presence of sporadic outcrops of gneissic rock at the left bank of the dam. As per the operating levels of existing Idukki Reservoir, FRL and MDDL has been taken as EL. 732.43 m and EL. 694.94 m respectively. Existing hydro-electric scheme is provided with tower type (Morning-glory) intake with its top slab permanently submerged in reservoir water. Since, planning similar type of intake in the vicinity of existing will not only hamper the existing Hydro-electric operation during construction period but also affects the hydraulics of the existing intake. Hence, a trapezoidal type intake with anti-vortex louver has been proposed for the Idukki Extension Scheme.

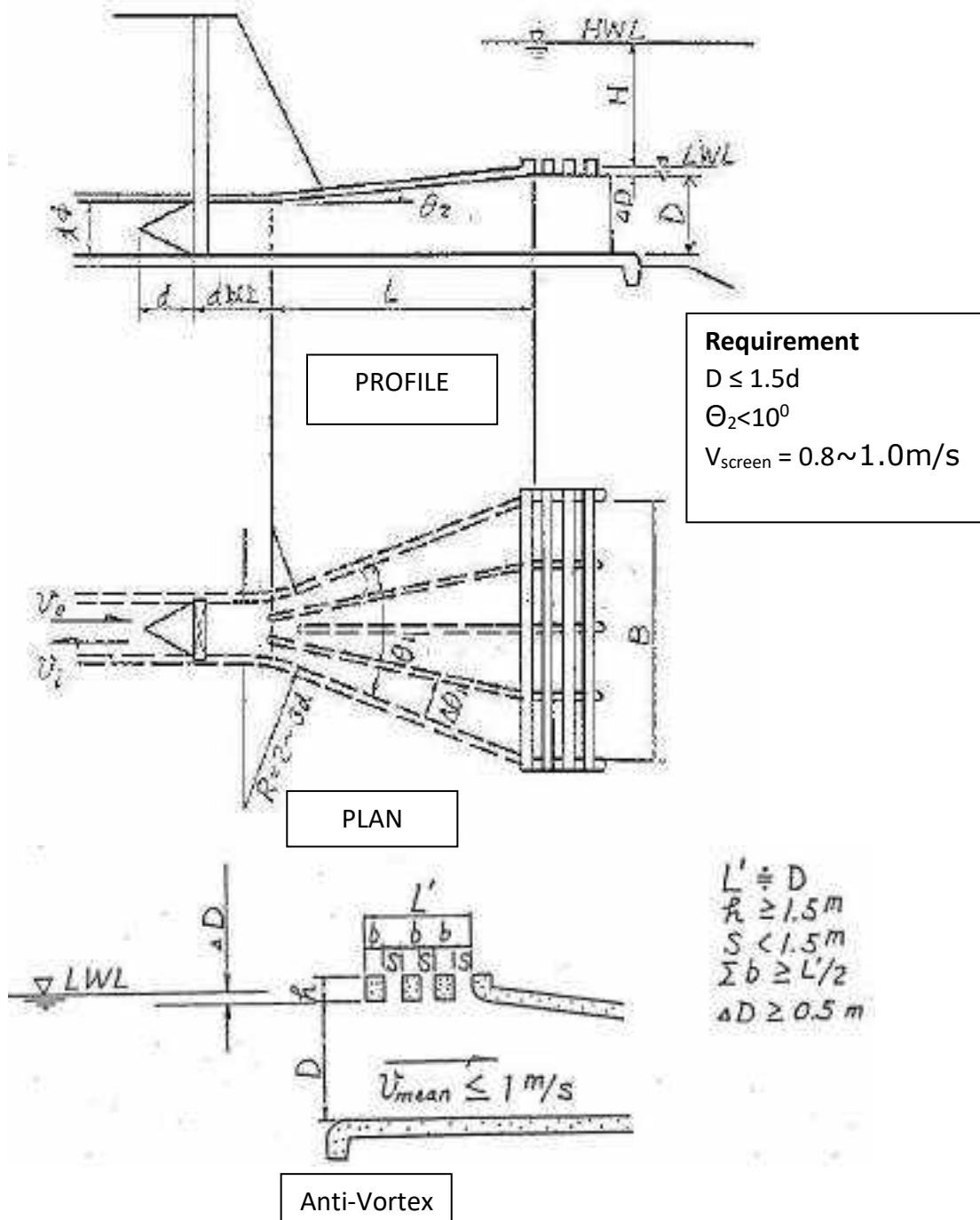


Figure 7.15 Guideline on Hydraulic Design for Inlet Structure

Generally, the Layout of the intake structure is dependent on the topography and site geology. Trash racks are provided at the front of intake, in order to prevent any debris entering into the system. Total width of intake structure is governed by width of trash rack to be provided satisfying the velocity criteria. The intake structure is designed so as to produce an adequate acceleration of water from reservoir into the

water conductor system. This is ascertained by means of smooth entrance curves at the intake, having elliptical bell mouth shape; and also by placing the intake invert so as to provide an adequate submergence depth.

The function of intake structure is to allow the smooth entry of water from the reservoir into the water conductor system. Water is flowing at very low velocities in the reservoir, whereas in the water conductor system flow velocity is of the order of 3-6 m/s. Intake structures are designed, so as to ascertain the smooth entry of water, with transition from lower velocity to higher velocity, without turbulence and air entrainment into the water conveyance system. The various design criteria taken into consideration to design an optimum size of intake. The exact location and orientation of the intake will be finalised at DPR Stage.

Trash racks are provided at the entrance of intake in order to prevent the entry of debris into the water conductor system so as to protect the turbines from objectionably large debris. **Here, as per IS 11388:1995**, the flow velocity through trash racks shall be limited to 0.75m/s for manual cleaning of racks and 1.5m/s for mechanical cleaning of racks. This velocity is included of the allowance for partial clogging of racks. The layout plan and section for Intake is provided at **Annexure 7.4 and 7.5** respectively.

7.8.2 Intake Gate Shaft

As for Intake gates, they are furnished at appropriate location downstream from the beginning of the waterway tunnel to prevent water from inflowing into the waterway in the case of internal inspection under the condition that water inside the waterways is drained out. Intake gates are furnished in the vertical shaft. The location is selected in light of reduction of amount in shaft excavation as well as nearby the existing Gate shaft to utilise existing infrastructure. The Location of Intake Gate Shaft for Idukki Extension Scheme has been proposed just 150 m downstream of the proposed intake, however the same will be finalized after completion of field survey works during DPR stage.

7.8.3 Water Conductor System (WCS)

As Alignment and profile of the waterway is also one of major elements to be optimized in the selection of optimum general layout, because it governs other layouts of structures such as switchyard, access tunnel etc. and comprises of major portion of Civil component cost of hydroelectric project.

Following aspects are considered while finalizing the alignment of the waterway from the intake to the tailrace outlet;

- Shortest possible Length of waterway.
- Bends are to be avoided as far as possible.
- Intake and HRT are aligned in such a way that it has favorable flow characteristics.
- The rock cover for water conductor system is at least twice its diameter at any section.

The Longitudinal section along the alignment of the waterway from the intake to the tailrace outlet is presented in **Annexure-7.3**.

Determination of Head Loss in WCS

Head losses in water conductor system is calculated as per IS 4880 (Part 3): 1976 and IS 2961: 1965 (Part 1 & 2). A summary of head losses in various components are listed in **Table 7.4** below.

Table 7.4: Head losses in various components

S.No	Summary of head loss		
	Component		Head Loss (m)
1	head loss due to Tash rack	=	0.131
2	Head loss through- HRT power Intake	=	0.010
3	Transition loss at HRT entry-power intake (rectangular to Circular)	=	0.351

4	Head loss due to Emergency gate at HRT Intake	=	0.096
5	Head loss due to friction in Head Race Tunnel (HRT)	=	3.501
6	Transition loss due to contraction at Pr.Shaft Entry	=	0.256
7	Friction loss in Inclined Pressure Shaft	=	3.775
8	Head loss due to bends in Pressure shaft	=	0.551
9	Head Loss in PS due to bifurcation- wye piece	=	0.096
10	Friction loss in Horizontal Pressure shaft after bifurcation	=	0.349
	Grand total of all losses	=	9.12
	Taking 15% Extra for other minor losses not considered here at FSR Level	Say (m)	10.5

Head Race Tunnel (HRT) cum Pressure Shaft

The rated discharge for proposed scheme is 137 Cumec and considering 10% overload it comes out to be 151 Cumec. To carry a discharge of 151 cumec, off taking from intake, one number of modified horse shoe shaped tunnel of Dia. 7.0 m is proposed. The cover of HRT varies between minimum of 32 m and maximum of 203m. The length of HRT is 1900 m and it culminates into Surge Shaft. The Alignment of the HRT is reassessed so that the adequate cover can be ensured, especially at the valley portion present at the initial stretch after the gate shaft. The velocity of flow in the tunnel is taken as 3.92 m/s.

Typical support system for HRT is provided at **Annexure- 7.6** and the detailed support system will be provided after completion of field works and geological investigations during DPR stage.

7.8.4 Surge tank

A surge tank serves two main functions in a hydropower system:

- To absorb the pressure rise occurring during the load rejection condition.
- To immediate fulfil the requirement of supply of water to the system during the load acceptance condition.

The need of surge tank is preliminary determined using following criteria:

- a) According to a thumb rule, surge tank is usually necessary for following condition.

$$\frac{L}{H} > 5$$

Where,

L – Length of water conductor (HRT/TRT) (m)

H – Net head (m)

- b) Another criterion pertains to the acceleration time of the hydraulic system. The acceleration time of a hydraulic system is given by the equation.

$$Ta = \frac{LXV}{gXH}$$

Where,

L – Length of water conductor (HRT/TRT) (m)

V – Velocity of flow in water conductor (m/s)

H – Net head (m)

g – Acceleration due to gravity (m/s²)

If the acceleration of a hydraulic system is less than 2 seconds, no surge tank is required in the hydraulic system. For acceleration time between 2 and 5 seconds. Surge tank may be provided for a stable operation of the system. For acceleration time greater than 5 sec, a surge tank is almost always required.

In the present scenario, the necessity of the surge tank is assessed using the empirical formulae given above.

HRT Branch

It is inferred that acceleration of a hydraulic system is approximately 2 sec for the proposed scheme, hence a surge tank is proposed for Idukki Extension hydraulic system. The same may be further confirmed once the turbine parameters obtained from the manufacturer and after transient analysis at the time of DPR Stage.

TRT Branch

In case of TRT, the acceleration of a hydraulic system is less than 2 sec for the proposed scheme, so no surge tank is required in the hydraulic system.

In order to satisfy the functional requirement, generally two types of surge shaft; either a simple surge shaft or a restricted orifice surge shaft can be provided, which is largely governed by the topographic condition at the site location. More over providing an orifice type of surge shaft, as compared to a simple surge shaft, helps in faster dampening of the mass oscillations occurring in the surge shaft during the transient conditions. Hence the option of a restricted orifice surge shaft is adopted in the upstream water conductor system of the project, and further analysis is carried out for a restricted orifice surge shaft.

Hydraulic Design of Surge Tank is proposed as outlined in IS 7396 (Part I): 1985 according to Thoma Criteria. However, the area for orifice opening is governed by Calme & Gaden Equation.

7.8.5 Pressure Shaft (Steel Lined)

Off taking from surge shaft, two inclined pressure shaft is proposed with a diameter of 3.90 m. Pressure shafts are inclined at 50° from horizontal. Two pressure shafts are proposed to account for flexibility during operation in case of maintenance required in any of the machines. Inclined pressure shaft drops approximately 600 m in elevation. At El. 54.86, inclined pressure shaft bend at 50° and is aligned horizontal. Each inclined pressure shaft again bifurcates into 2 pressure shaft of dia. 2.80 m. A total of 4 Nos. of 2.80 m diameter pressure shaft caters to 4 turbines.

Due to high head, Pressure shaft shall be designed to withstand internal pressure which is resulted due to hydrostatic head and this internal hydrostatic pressure acts both in normal, intermittent and emergency condition. Steel lining is proposed for the pressure shaft and thickness for steel plates of pressure shaft is calculated as per IS 11639 (Part 2): 1995. At Feasibility Study Report level, steel plates considered are of standard thickness available and are of ASTM 537 class 2 and ASTM 517 Grade F. .

7.8.6 Underground Power House Cavern and Underground Transformer Cavern

An underground Power House (UGPH) of size 146m (L) x 22m (W) x 44.5m (H) and a transformer cavern hall of 146m (L) x 16m (W) x 26.5m (H) have been proposed

for this project. The power house will have four Pelton type vertical axis shaft units of 200 MW each. The net rated head for generation is 654.57 m.

The Transformer cavern accommodates 4 sets of unit transformers at El. 66.36m. The roof arch of this cavity would be of circular arch shape with 5.0m rise of crown from the spring level for roof and walls for draining the seepage water adjoining the cavern.

The X-section of power house and transformer cavern is presented at **Annexure-8.1**.

7.8.7 Machine Cavern

The Machine hall cavern would be 146m in length, 22m in width and overall height of the power house cavity from the lowest excavation of the turbine pit would be 44.5m. The entrance to the Machine hall cavern shall be through Main Access Tunnel (MAT) of D-Shaped having size 8m x 8m. The auxiliary rooms shall be located at different floors provided on the services bay side of the machine hall cavern.

The penstock for each generating unit would enter the power house horizontally and will make a casing around generating unit to feed 6 Jets. The center line of the horizontal penstocks entering the power house cavity would be El. 54.86 m in line with jets of the turbines.

7.8.8 Tail Race Tunnel (Concrete Lined) and Tail Race Channel

After mobilising Pelton Buckets, water drops down to pit below turbine barrel. A Tail Race Tunnel is proposed to take this water further downstream to Thodupuzha River. Proposed Tail Race Tunnel is of D-Shape with finished base width of 7.5 m and total height of 7.50 m of which water level at full rated capacity will be maintained at 6.0 m. A section for tail race tunnel is shown in Fig 7.16.

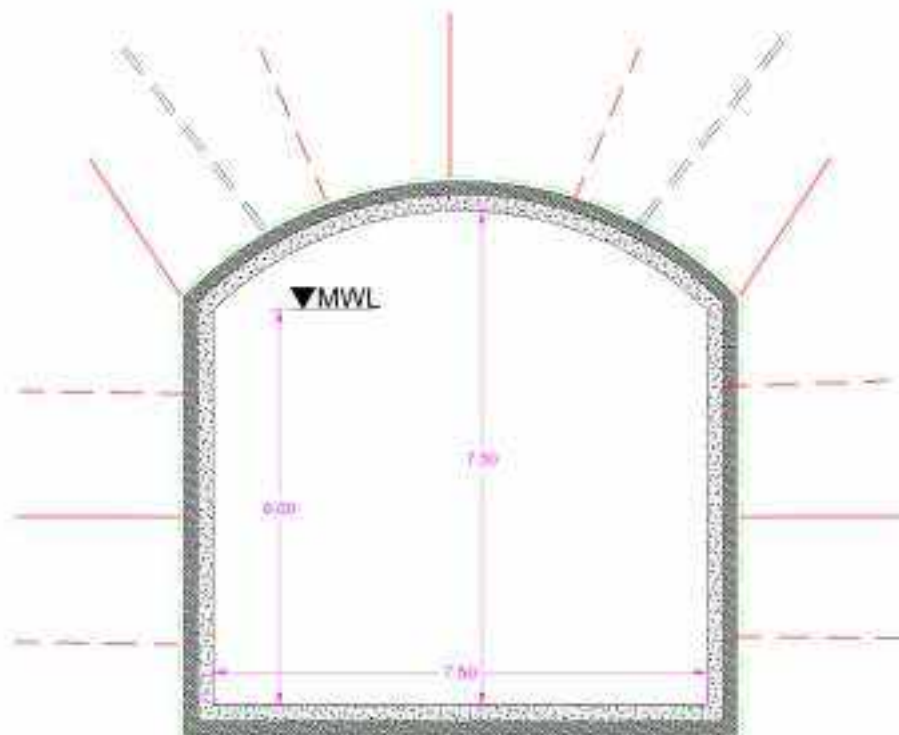


Fig 7.16 : Typical Cross Section for TRT

Tail race tunnel is designed for gravity flow and required slope is calculated using Manning's Equation to make is sufficient to carry the rated discharge of all four units. The total length of TRT is 1465 m and cover for TRT varies between 326 and 22 m. TRT will be provided with suitable rock support system depending upon the geological strata. Actual support system will be decided after geological investigations and analysis at DPR stage. Due to insufficient cover at the downstream end of the tunnel, 10m wide and 4m Height and 730 m long Tail Race Channel is also proposed off taking from TRT exit. The dimension of tail race channel is tabulated below:

Table 7.5

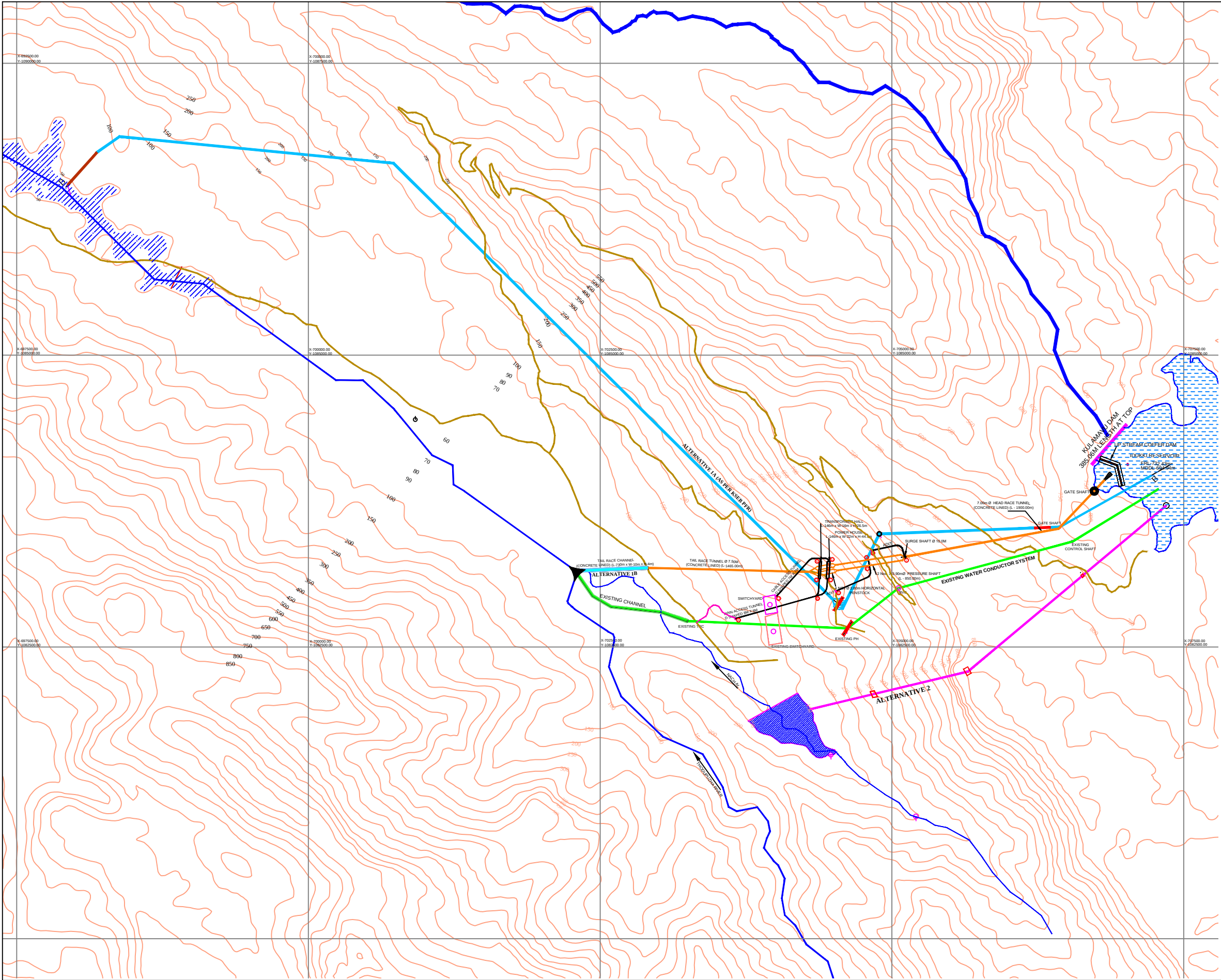
Bed Width	10.0
Side Slope	1 H : 8 V
Longitudinal Slope	1: 1000
Depth at full discharge	4.0 m
Length	730 m

The Typical cross section for TRT and TRC is presented at **Annexure-7.7**. The Cross section of Thodupuzha River at Triveni Sangam is presented at **Annexure 7.8**.

The Hydraulic Design of HRT, Surge Shaft, Steel Liner Thickness, TRT and calculation of Head Loss is presented at **Annexure- 7.9**.

Annexure - 7.1

ANNEXURE - 7.1



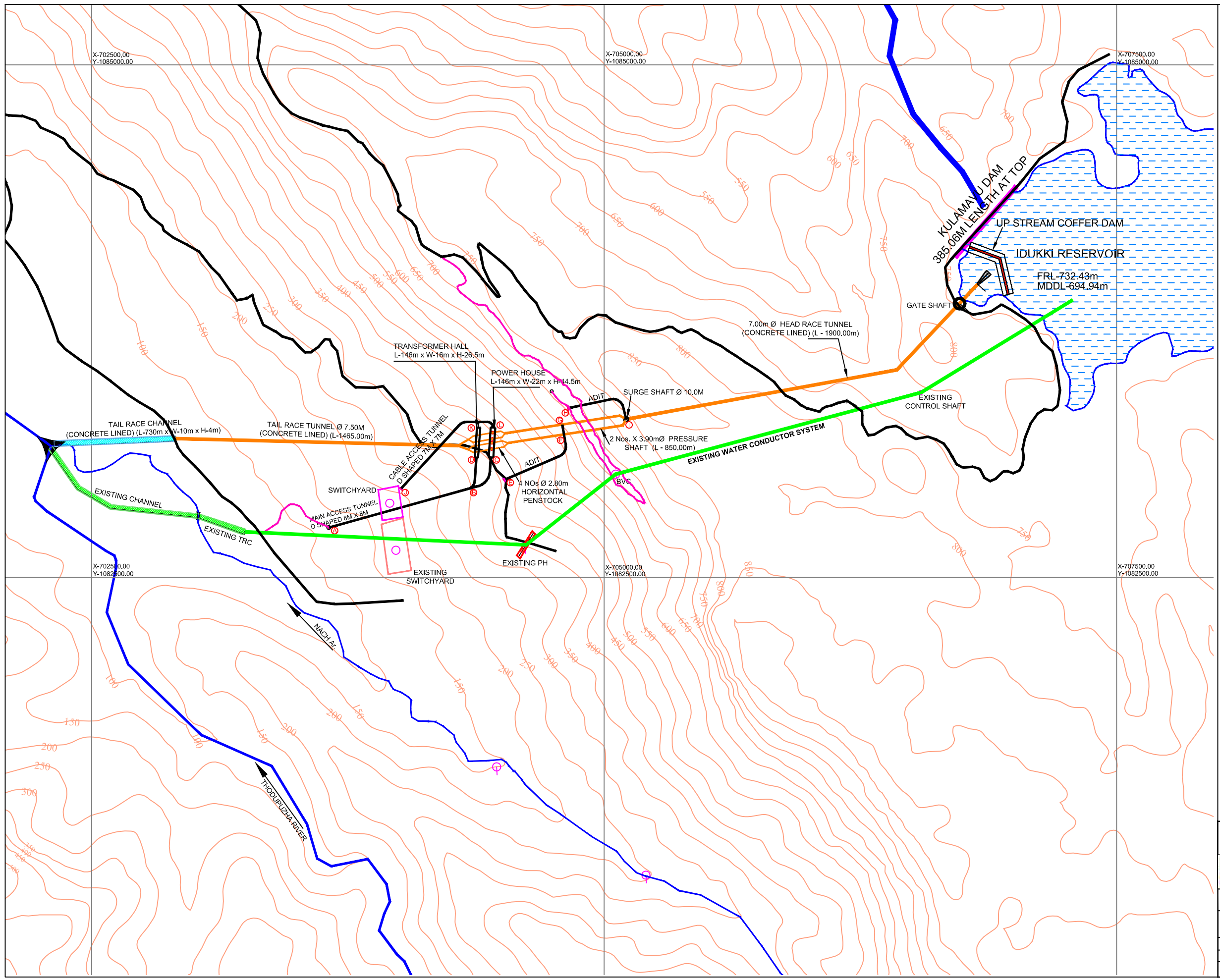
LEGEND:-

- RESERVOIR AREA
- RIVER
- HEAD RACE TUNNEL
- TAIL RACE TUNNEL
- EXISTING WCS
- EXISTING ROAD
- PROPOSED ROAD
- TAIL RACE CHANNEL
- EXISTING CHANNEL

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CONSULTANTS WAPCOS LIMITED (A GOVERNMENT OF INDIA UNDERTAKING) MINISTRY OF JAL SHAKTI		
IDUKKI EXTENSION SCHEME		
ALTERNATE LAYOUT PLAN		
DEGN.	CHKD.	SUBM.
DRAWN.	REV. NO.	APPRD.
DATE: SEP. 2021	DRG. NO. WAPID&RE/IDUKKI/PPR/1	

Annexure - 7.2

ANNEXURE - 7.2

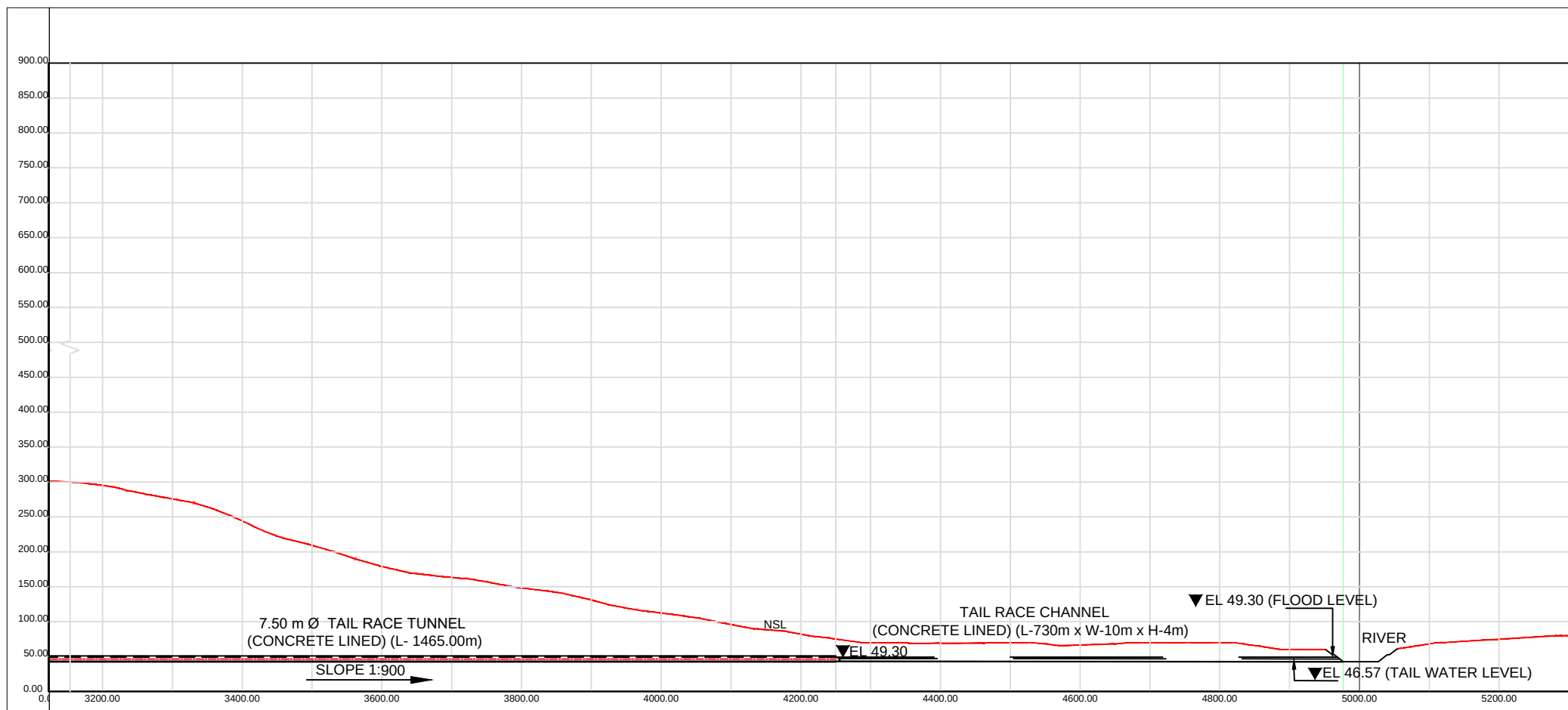
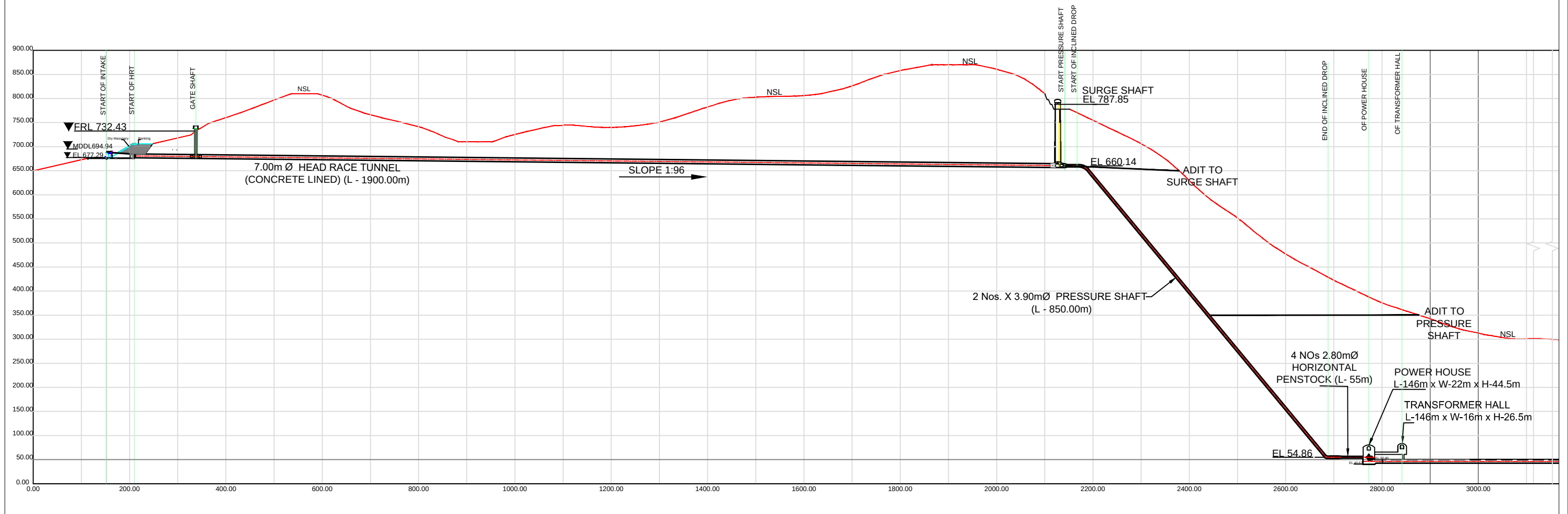


LEGEND:-

RESERVOIR AREA	
RIVER	
HEAD RACE TUNNEL	
TAIL RACE TUNNEL	
EXISTING WCS	
EXISTING ROAD	
PROPOSED ROAD	
TAIL RACE CHANNEL	
EXISTING CHANNEL	

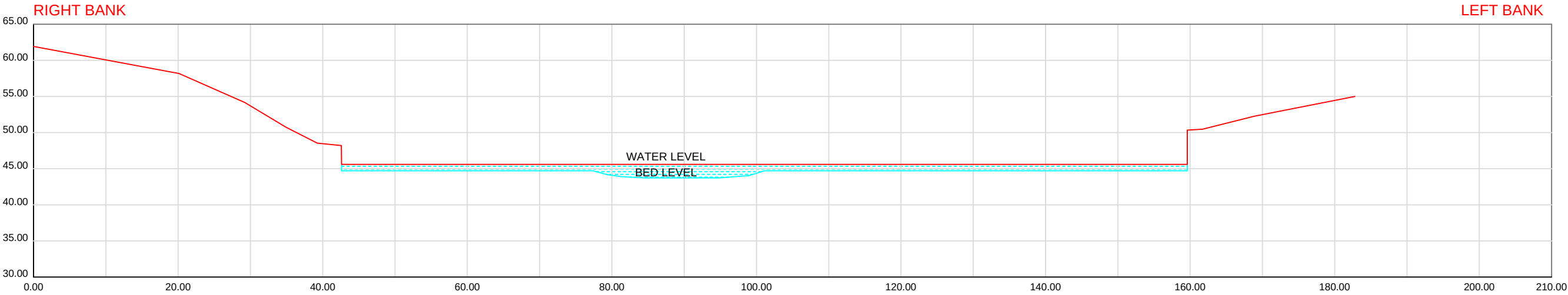
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IDUKKI EXTENSION SCHEME		
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DATE: SEP. 2021	DRG. NO. WAPID&RE/IDUKKI/PR/2	

Annexure - 7.3

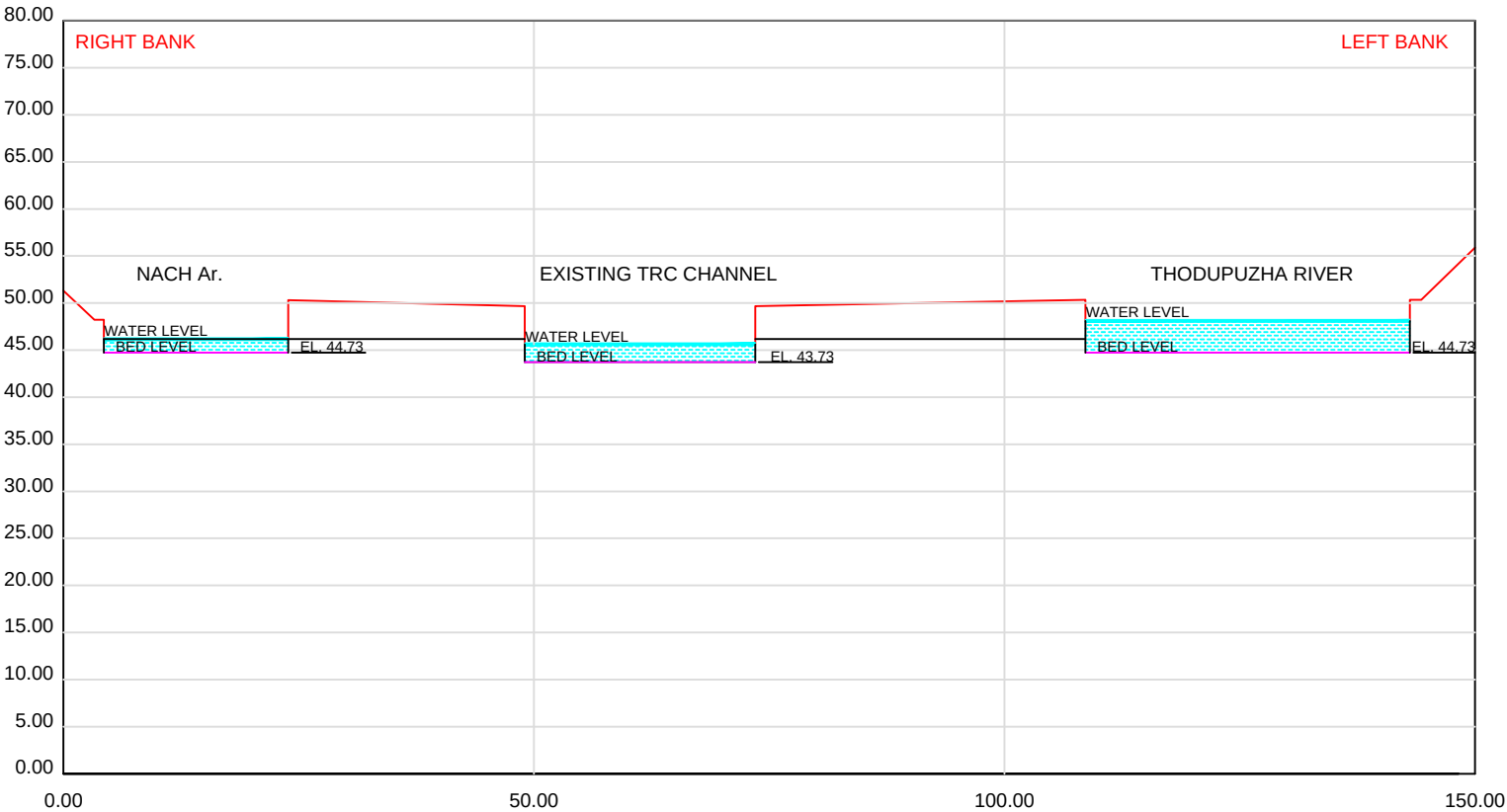


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DRAWN.	REV. NO.	APPRD.
DATE: SEP, 2021	DRG. NO. WAP/D&RE/IDUKKI/PR/3	

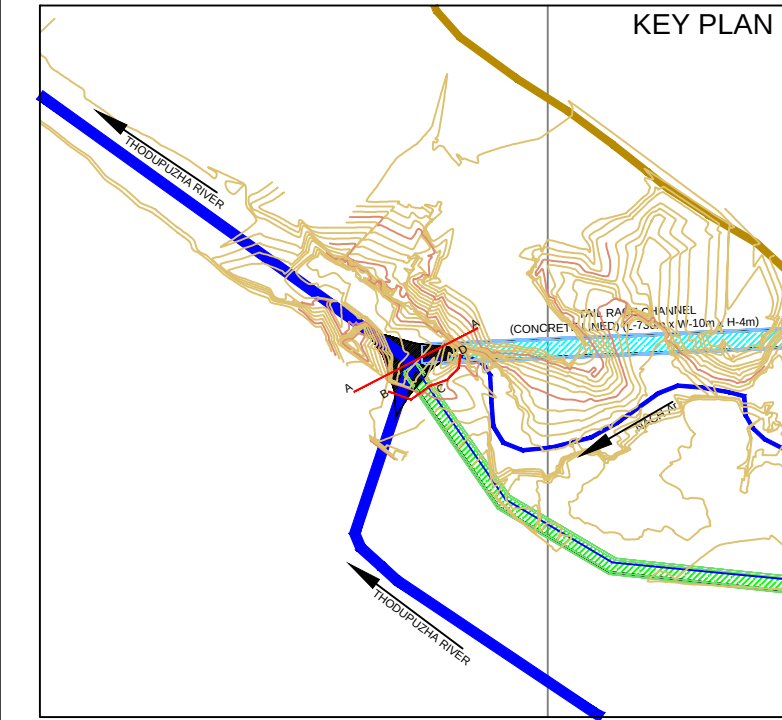
Annexure - 7.8



RIVER CROSS SECTION AT TRIVENI (A-A)



CROSS SECTION TRIVENI (B-C-D)



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MINISTRY OF JAL SHAKTI

IDUKKI EXTENSION SCHEME

CROSS SECTION AT TRIVENI SANGAM

DEGN.	CHKD.	SUBM.
DRAWN.	REV. NO.	APPRD.
DATE: SEP. 2021	DRG. NO. WAP/D&RE/IDUKKI/PFR/8	

Annexure - 7.9

Annexure- 7.9 (A)

IDUKKI EXTENSION SCHEME				
(REF : CBIP Publication no. 265)				
PRELIMINARY COMPUTATIONS FOR GENERATION CAPACITY				
RESERVOIR				
	FRL	=	732.43	m
	MDDL	=	694.94	m
gross storage capacity		=	1996.34	MCM
live storage capacity		=	1459.54	MCM
Water Spread area at full reservoir level		=	59.57	Sq.Km
Hrt design discharge		=	137.3	cumec
assumed head loss of WCS		=	10.5	m
		=		
Turbine CL		=	54.86	m
Average Gross head		=	665.07	m
Average Net Head		=	654.57	m
		=		
§ Gen capacity (MW) = $9.81 \cdot Q \cdot H \cdot \eta_t \cdot \eta_g \cdot 1/1000$				
efficiency of the generator ' η_g '		=	0.98	Assumed
efficiency of the turbine ' η_t '		=	0.93	Assumed
Combined efficiency of generation ' η '			0.91	
Generation capacity		=	800.0	MW
No. of Units provided			4	
each unit Gen. cap		=	200	MW
Say		=	200	MW

			Annexure- 7.9 (B)	
A	(REF : CBIP Publication no. 265)	Idukki Ext. Scheme		
		Unit Size	=	200 MW
		No. of Units	=	4 Nos.
	RATED DISCHARGE			
		losses in WCS	=	10.5 m
		average gross head	=	665.07 m
		average net head	=	654.57 m
	Rated discharge (in Generation)			
		$P=9.81*Q*H*\eta_g*\eta_t$		
		Generation efficiency (assumed)	=	0.91
		for generation of power 'P'	=	800
B	Preliminary estimation of size of tunnels / Pressure Shaft			
		$V=Q/A$		
	HRT	No. of HRT Proposed	=	1 Nos.
		Discharge 'Q' through each HRT (with 10% overload)	=	152 cumec
		dia .of HRT proposed	=	7.00 m
		area	=	38.465 m ²
	permitted vel.= <4m/sec (incl. 10% overloading)	velocity	=	3.95 m/sec
				OK
	Inclined steel liner PS	No of Pressure Shaft	=	2 Nos.
		Discharge 'Q' witheach (with 10% overload)	=	76 cumec
		dia .of PS proposed	=	3.90 m
		area	=	11.94 m ²
	permitted vel.= <6.5 m/sec (incl. 10% overloading)	velocity	=	6.37 m/sec
				OK
	Penstock after bye furcation			
		Discharge 'Q' each (with 10% overload)	=	38.00 cumec
		area of UNIT PS reqd.	=	5.97 m ²
		dia of unit PS	=	2.80 m
		velocity adopting from PS before bifurcation	=	6.37 m/sec
				OK

Annexure- 7.9 (C)

PROJECT

Idukki Ext. Project Feasibility Study Report

NAME OF WORK

Idukki Reservoir - Hydraulic Design of INTAKE

HYDRAULIC DESIGN OF INTAKE

Straight Type Intake Structure

Design Data

i Design Discharge (for HRT), Q	=	152.00 m ³ /sec (Including 10% overload)
ii Nos. of Intake structure	=	1
iii Discharge(per Intake str.) , q	=	152.00 m ³ /sec
iv Min.draw down level , (MDDL)	=	694.94 m
v Full reservoir level , FRL	=	732.43 m
vi HRT diameter (Circular)	=	7.00 m

A Opening Area required

Area required

$$\text{Area, } A = \frac{\text{Penstock Area}}{C_c \cos \phi}$$

As per the CI
5.1.3 IS

Area of HRT	=	38.465 m ²
Coefficient of Contrction, C _c	=	0.6
Angle of inclination of HRT	=	0 deg
opening area at Intake, A	=	64.11 m ²

As per the CI
5.1.3 IS

Conduit before transition

Shape	=	Rectangular
Height	=	10 m
Width	=	14 m

Assume

B Check for Intake center line

i) As per CI 5.2.2 Is 9761:1995

5.2.2 To prevent vortices, the centre line of intake should be so located as to ensure submergence requirements given in Fig. 18 which has been developed by an evaluation of minimum design submergence at prototypes operating satisfactorily.

For large size intakes at power plants:

$$\left(F_r = \frac{v}{\sqrt{gD}} \leq 1/3 \right)$$

especially at pumped storage system, a submergence depth,

$h = 1$ to 1.5 times the intake height or diameter is recommended.

For medium and small size installations ($F_r > 1/3$), especially at pump sumps, submergence requirements may be calculated using the formula:

$$\frac{h}{D} = 0.5 + 2 F_r$$

Froude No of flow at Intake, Fr	=	$V/\sqrt{gD}$	
Area of Flow (rectangular section)	=	140 m ²	
Velocity of flow through Rect.section	=	1.09 m/s	
Entry Froude No. Fr	=	0.110	
	≤	1/3	Considered Large Intake

The Intake shall be Considered Large Intake (As per CI 5.2.2, IS 9761:1995)

Ratio h/d	=	2.0 Fr +0.5	
	=	0.719	
Submergence, h	=	7.19 m	
Invert Elevation required	=	682.75 m	
Invert Elevation provided	=	677.3 m	Ok

ii) As per USBR guidelines

Intake center line depth from MDDL	=	0.8he	
	=	12.656 m	
Invert Elevation required	=	677.29 m	
Invert Elevation provided	=	677.29 m	Ok

iii) As per Gordon Formula

Ratio S/d	=	2.3 Fr +0.5	
	=	0.752	
Submergence, S	=	7.521 m	
Invert Elevation required	=	682.42 m	
Invert Elevation provided	=	677.29 m	Ok

iv) As per Amphlett Equation

Ratio S/d	=	3.3 Fr - 0.5	
	=	-0.138	
Submergence, S	=	-1.383 m	
Invert Elevation required	=	691.33 m	
Invert Elevation provided	=	677.29 m	Ok

Minimum invert elevation = 677.29

Now, as per above all it is recommended to fix the invert level of intake at El. 677.29 m

Annexure- 7.9 (D)

PROJECT

Idukki Extension Scheme

Feasibility Study Report

NAME OF WORK

Intake- Trash Rack System

HYDRAULIC DESIGN OF TRASH RACK

Straight Type Intake Structure

Design Data

i	Design Discharge (for HRT), Q	=	152 m ³ /sec	(Including 10% overload)
ii	Nos. of Intake structure	=	1	
iii	Discharge(per Intake str.) , q	=	152.00 m ³ /sec	
iv	Min.draw down level , (MDDL)	=	694.94 m	
v	Full reservoir level , FRL	=	732.43 m	
vi	HRT diameter (Circular)	=	7 m	
vii	Bottom of Trash Rack	=	677.29 m	(at Invert Level)
viii	Top of trash rack	=	694.94 m	
ix	Intake sill level	=		
	U/s of transition	=	677.29 m	

Design of Trash Rack

a Trash rack with mechanical Cleaning

Angle of Inclination	=	70 deg, (with horz)
Permissible Velocity	=	1.5 m/s (CI 5.3.6, IS 9761:1995)

5.3.6 The normal velocity of flow through the rack structure is indicated below:

For units with hand raking,

$$V = 0.75 \text{ m/s}$$

For units with mechanical raking

$$V = 1.5 \text{ m/s}$$

Available Flow depth through trash rack	=	17.65 m
Effective flow depth	=	15.18 m
Area Required	=	Discharge/velocity
	=	101.33 m ²
Width of Trash rack required	=	6.67 m
Providing 2.0 bays of 7.0 m width		
Width Provided	=	14 m
Gross area of flow	=	212.56 m ²

Flow Velocity through Trash Rack

Area of Trash rack excluding steel flats	=	75% of the Gross area
Clear area	=	159.419 m ²
Velocity	=	0.953 m/s < 1.0 m/sec

Ok

Area of flow through Trash rack (excluding 25% cloggingg clogging)	=	75% of the clear area
Clear area after clogging	=	119.564 m ²
Velocity	=	1.271 m/s < 1.5 m/sec

Ok (CI 5.3.6, IS 9761:1995)

TITLE:

PRELIMINARY WATER CONDUCTOR SYSTEM - HEAD LOSS CALCULATION

Head loss for the Generation mode are estimated as below for the water conductor system

Project Parameters:

Reservoir FRL		m	=	732.43
Reservoir MDDL		m	=	694.94
Max. Tail Water Level at TRC Exit		m	=	49.26
Turbine Center Line		m	=	54.86
Design Discharge (taking 10% overload condition)		cumec	=	152.0
Installed capacity in MW		MW	=	800
No of units			=	4
Gross Head		m	=	665.07
Design Head	Gross head - losses	m	=	654.57

Major Component Parameters

HRT Intake				
Height of intake entrance		m	=	10.00
Width of intake entrance		m	=	14.00
Head Race Tunnel Concrete Lined (circular)				
No. of HRT				1
Diameter		m	=	7.00
Length of HRT including intake transition		m	=	1950
Manning's 'n'			=	0.013
Absolute roughness 'e'	Concrete	mm	=	1.65
Pressure shaft Tunnel Steel Lined (circular)				
Diameter		m	=	3.90
Length of pressure shaft before bifurcation		m	=	850
Manning's 'n'			=	0.010
Absolute roughness 'e'	Steel	mm	=	0.0675
No. of Pressure Shaft				2
Penstock Steel Lined (Circular)				
Diameter of unit pressure shaft		m	=	2.80
Length of unit pressure shaft		m	=	60
Manning's 'n'			=	0.010
Acc. Due to gravity		m / s ²	=	9.81
No. of Penstock from one Pressure shaft				2

COMPONENT WISE HEAD LOSS ESTIMATION

1	Head loss due to trash racks of HRT Power Intake				
	<i>the trash rack is provided before the intake entrance to restrict the entry of debris</i>				
	Velocity through Trash Rack - Select Type of cleaning	Mechanical Raking	m/s	=	1.5
	Minimum Head loss				
	Net area to Gross area ratio, R			=	0.75
	Loss coefficient			=	$1.45-0.45*0.75-0.75^2$
				=	0.55
	Head loss			=	$0.55*1.5^2/19.62$
	Maximum Head loss				
	<i>Considering 50% clogging</i>				
	Net area to Gross area ratio, R			=	$0.75*0.50$
				=	0.375
	Loss coefficient			=	$1.45-0.45*0.375-0.375^2$
				=	1.14
	Head loss			=	$1.14*1.5^2/19.62$
	head loss due to Tash rack		m	=	0.131

2	Head loss through- HRT power Intake				
	The water has to pass through entrance of Intake.-2 nos Intake				
	The size of the openings	10.000	Height	x	14.00
	Discharge through each Intake	(= 152 /1)	m ³ /s	=	152.00
	Area of entrance	10*14	m ²	=	
			m ²	=	140.00
	Velocity of flow			=	152/140
			m/s	=	1.09
	Head loss through each Intake			=	$K_e*V^2/2g$
	Corresponding to Square Intake Entrance	(Ref Tab IS 4880 (P-3)-1976)	K_e	=	0.16
	Head loss			=	$0.16*(1.1^2)/(2*9.81)$
	head loss one Intake entrance		m	=	0.01
	Total head loss - entrance for one power intake - HRT		m	=	0.01

3	Transition loss at HRT entry-power intake (rectangular to Circular)									
A transition from Rectangular Shape Intake to circular HRT is provided.										
Design discharge through transition Discharge				m ³ /s	=		152.00			
Length of transition				m	=		11			
Width before transition				m	=		14			
Depth before transition				m	=		10			
Depth /Dia. after transition				m	=		7			
Total Area before transition				m ²	=		140			
Velocity before transition					=		152 / 140			
				V1	m/s	=	1.09			
Area after transition					=		3.142 x 7 ²			
					m ²	=	38.71			
Velocity after transition				V2		=	152 / 38.71			
					m/s	=	3.9			
										
Transition angle										
					$\alpha/2$	=	17.65			
					k_{t1}	=	$3.5 \cdot \text{TAN}((17.65 \cdot 3.14/180))^1.2 / 2$			
			(Reference: cl.2.4, IS2951(p-ii) -1965		K_{t1}	=	0.865			
Loss due toTransition						=	$K_{t1} \cdot (V_1 - V_2)^2 / 2g$			
head loss due to transition				m	=		0.356			

4.1	Head loss due to Emergency gate at HRT Intake				
Number of gates				=	1
Height of the gate			m	=	7.00
Width of gate			m	=	7.00
Discharge through the gate			m ³ /s	=	152
Loss co-efficient			K _g	=	0.1
Area of entrance				=	7 x 7
			m ²	=	49
Velocity through the gate slot				=	152/49
			m/s	=	3.1
Head loss				=	K _g V ² /2g
				=	0.1 x (3.1 ²) / (2*9.81)
			m	=	0.049
Total Head loss due to emergency gates slots			m	=	0.049

4.2	Head loss due to Service Gate at HRT Intake					
	Water is conveyed into the system through gates					
	Number of gate				=	1
	Height of gate			m	=	7.00
	Width of gate			m	=	7.00
	Discharge through the gate			m ³ /s	=	152.00
	Loss co-efficient			K _g	=	0.1
	Area of gate entrance				=	7 x 7
				m ²	=	49
	Velocity through gate slot				=	152 / 49
				m/s	=	3.1
	Head loss				=	K _g V ² /2g
					=	0.1 x (3.1 ²)/2*9.81
				m	=	0.049
Total Head loss due to service gates slots			m	=	0.049	

5	Head loss due to friction in Head Race Tunnel (HRT)								
A Head Race Tunnel of circular Shape with 7 m diameter and 1950m length, is provided after the intake									
Design Discharge					m ³ /s	=		152.00	
Length of HRT					m	=		1950	
Diameter of tunnel					m	=		7	
Area of cross section of tunnel				A	m ²	=		38.47	
Dyn. Viscosity value at 25 °C					Pa.S	=		0.00089	
Density of water					kg/m ³	=		997	
Velocity					m/s	=		3.95	
Reynolds number (Re)						=		3.099E+07	
Relative Roughness e/D						=		2.357E-04	
Friction factor (from Moodys Diagram)				f		=		0.017	
Head loss in HRT					Hf	m		3.769	

6	Transition loss due to contraction at Pr.Shaft Entry				
	Design discharge through transition		m ³ /s	=	152.00
	Length of transition (Considering 10 m transition of each side of Surge Shaft)		m	=	40.00
	Diameter before transition		m	=	7.00
	Diameter after transition		m	=	3.90
	Area before transition		m ²	=	38.47
	Velocity before transition			=	3.952
		V1	m/s	=	3.95
	Area after transition		m ²	=	11.940
	Velocity after transition	V2	m/s	=	12.730
	Transition angle				
			/2	=	2.22
				=	3.5 * TAN((2.22*3.14/180))^1.22
		K _{t1}		=	0.066
	Loss due to CONTRACTION AT SS - PS ENTRY			=	K _{t1} *(V ₁ -V ₂) ² /2g
	Head loss due to contraction		m	=	0.259
7	Friction loss in Pressure Shaft				
	Design Discharge one PS		m ³ /s	=	76.00
	Diameter of Pressure shaft		m	=	3.90
	Length of the Pressure shaft		m	=	850
	Area of Pressure shaft		m ²	=	11.94
	Dyn. Viscosity value at 25 °C		Pa.S	=	0.00089
	Density of water		kg/m ³	=	997
	Velocity		m/s	=	6.37
	Reynolds number (Re)			=	2.781E+07
	Relative Roughness e/D			=	1.731E-05
	Friction factor (from Moodys Diagram)	f		=	0.0085
	Head loss due to Pressure Shaft	H _f	m	=	3.826
8	Head loss due to bends in Pressure shaft				
	Design Discharge		m ³ /s	=	76.00
	Diameter		m	=	3.9
	Area		m ²	=	11.94
	Velocity			=	76/11.94
			m/s	=	6.37
	First 50 degree Bend in PS				
	Deflection angle		degree	=	50
	Radius of curve		m	=	15
	Considering R/D ratio			=	3.85
	Loss coefficient			=	0.10
	Head loss due to bend		m	=	K _b *V ² /2g
			m	=	0.207
	Second 50 Degree Bend in PS				
	Deflection angle		degree	=	50
	Radius of curve		m	=	15
	Considering R/D ratio			=	3.85
	Loss coefficient			=	0.10
	Head loss due to bend			=	K _b *V ² /2g
			m	=	0.2068
	Total head loss due to 2. bends in PS		m	=	0.4136
	Hor. Bend no 1 in Penstock after Wye-Piece near Power House				
	Deflection angle		degree	=	45
	Radius of curve		m	=	8.40
	Considering R/D ratio			=	3.00
	Loss coefficient			=	0.08
	Head loss due to Hor. bend			=	K _b *V ² /2g
			m	=	0.1457
	TOTAL HEAD LOSS DUE TO BENDS		m	=	0.5594
9	Head Loss in PS due to bifurcation- wye piece				
	<i>each PS bifurcates into 3 nos.</i>				
	Design Discharge		m ³ /s	=	38.00
	Diameter		m	=	2.80
	Area		m ²	=	6.15
	Velocity		m/s	=	6.17
	Loss coefficient			=	0.05
	Head loss due to bifurcation			=	k*V ² /2g
	Head loss due to bifurcation		m	=	0.097

10	Friction loss in Penstock after bifucation				
	Design Discharge one PS			m ³ /s	= 38.00
	Diameter of Penstock			m	= 2.80
	Length of the Penstock			m	= 60
	Area of Penstock			m ²	= 6.15
	Dyn. Viscosity value at 25 °C			Pa.S	= 0.00089
	Density of water			kg/m ³	= 997
	Velocity			m/s	= 6.17
	Reynolds number (Re)				= 1.937E+07
	Relative Roughness e/D				= 2.411E-05
	Friction factor (from Moodys Diagram)		f		= 0.0085
	Head loss in Penstock		Hf	m	0.354

S.No	Summary of head loss			
	Component		Head Loss (m)	
1	head loss due to Tash rack	=	0.131	
2	Head loss through- HRT power Intake	=	0.010	
3	Transition loss at HRT entry-power intake (rectangular to Circular)	=	0.356	
4	Head loss due to Emergency gate at HRT Intake	=	0.098	
5	Head loss due to friction in Head Race Tunnel (HRT)	=	3.769	
6	Transition loss due to contraction at Pr.Shaft Entry	=	0.259	
7	Friction loss in Pressure Shaft	=	3.826	
8	Head loss due to bends in Pressure shaft	=	0.559	
9	Head Loss in PS due to bifurcation- wye piece	=	0.097	
10	Friction loss in Penstock after bifucation	=	0.354	
	Grand total of calculated losses	=	9.46	
	Taking 10% Extra for other minor losses not considered here at FSR Level	Say (m)	10.5	

Annexure- 7.9 (F)

Design of Surge Tank

Turbine	Pelton	
FRL	732.43 m	
CL of Turbine	54.86 m	
HRT Length	1930 m	
HRT Diameter	7.00 m	Circular Section
Design Discharge	151 cumec	Considering for 10% overload condition
Penstock Length	830 m	
Penstock Dia.	3.90 m	
MDDL	694.94 m	

Restricted Orifice Surge Shaft

Velocity in HRT $V_1 = Q_d / A_t$

No. of HRT	1
$A_t =$	38.465 sq.m
$P_t =$	21.980 m
$V_1 =$	3.926 m/s

Head Loss in HRT $h_f = V^2 N^2 L / R^{4/3}$

$h_f \text{ min} =$	2.031 m	$N =$	0.012
$h_f \text{ avg} =$	2.384 m	$N =$	0.013
$h_f \text{ max} =$	2.765 m	$N =$	0.014

Velocity in Penstock $V_2 = Q_d / A_p$

No. Tunnel/PS	2
$A_p =$	11.940 sq.m
$P_p =$	12.246 m
$V_2 =$	6.324 m/s

Head Loss in Penstock $h_f = f L V^2 / 2g D$ Steel Lined

$h_f \text{ min} =$	3.774 m	$f =$	0.0087
$h_f \text{ avg} =$	3.948 m	$f =$	0.0091
$h_f \text{ max} =$	4.121 m	$f =$	0.0095

Net Max. Head acting on Turbine

$$H_0 = H_G - h_{f@HRT} - h_{f@Penstock} = 671.237 \text{ m}$$

Coefficient of Hydraulic Losses $\beta = V_1^2 / h_f$

$\beta \text{ min.} =$	0.132
$\beta \text{ avg.} =$	0.155
$\beta \text{ max.} =$	0.179

Thoma Area

$$A_{th} = 42.774 \text{ sq.m}$$

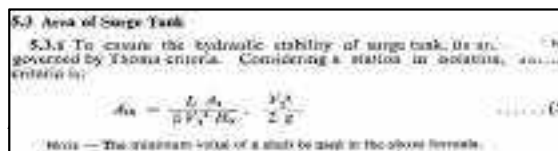
Diameter of Surge Shaft $A_s = \text{FOS} * A_{th}$

$A_s =$	68.438 sq.m	FOS =	1.6
$D_s =$	10 m	$A_s =$	78.50 sq.m

Diameter of Orifice

$$Z_* = V_1 \sqrt{(L A_t / g A_s)} = 38.547$$

$$h_{or \text{ min.}} = (Z_* / \sqrt{2}) + (h_f / 4) = 27.853 \quad h_{or \text{ avg.}} = 28.449$$



$$h_{or \text{ max.}} = (Z_s/\sqrt{2}) + (h_f^{3/4}) = 29.045$$

$$A_0 = \sqrt{(Q_0^2 / C_d^2 h_{or} 2g)} = 9.131 \text{ sq.m} \quad C_d = 0.7 \text{ bt } 0.6\text{--}0.9$$

$$D_0 = 3.5 \text{ m} \quad A_0 = 9.62 \text{ sq.m}$$

$$\text{Coefficient of Resistance for Orifice} \quad \eta = h_{or} / (V_1 - V_2)^2$$

$$h_{or} = 3873.919$$

$$\eta = 251.330 \quad \text{Assume, } V_2 = 0 \text{ m/s}$$

Height of Upsurge

$$\beta / (\beta + \eta) = 0.00 \quad (\beta + \eta) V^2 / Z_s = 100.56$$

$$Z_{\text{max}} / Z_s = 0.67 \quad \text{IS:7396 (Part 1)-1985, P-14, Fig-4.}$$

$$Z_{\text{max}} = 26 \text{ m}$$

Depth of Downsurge

$$Q = 37.754 \text{ cumec} \quad \% \text{ Discharge for one unit start-t} = 25.00\%$$

$$V_1 = 0.982 \text{ m/s}$$

$$h_f = 0.173 \text{ m}$$

$$Z_{\text{max}} = 29 \text{ m}$$

Top Level of Surge Tank

$$\text{FRL} = 732.43 \text{ m}$$

$$\text{min. Head Loss} = 5.805 \text{ m}$$

$$\text{Ht. of Upsurge} = 26 \text{ m}$$

$$\text{max. Upsurge Level} = 752.62 \text{ m}$$

$$\text{Top Level of Surge Tank} = 755.00 \text{ m} \quad \text{IS:7396 (Part 1)-1985, P-17, C-6.1}$$

Bottom Level of Surge Tank

$$\text{MDDL} = 694.94 \text{ m}$$

$$\text{max. Head Loss} = 0.173 \text{ m}$$

$$\text{Depth of Downsurge} = 29 \text{ m}$$

$$\text{max. Downsurge Level} = 665.767 \text{ m}$$

$$\text{Bottom Level of Surge Tank} = 663.000 \text{ m} \quad \text{IS:7396 (Part 1)-1985, P-17, C-6.1}$$

Annexure- 7.9 (G)			
Preliminary estimation of PS liner thickness			
Using BIS method			
Minimum Handling thickness of Pressure Shaft			
Dia. of Steel liner	=	3.90	m
Radius of liner	=	1.95	m
Thickness	=	0.011	m
	$Thk = \frac{R + 0.25}{200}$		
Add Corrosion Allowance of 1.5mm	=	12.5	mm
PROVIDE MIN. THICKNESS for HRT PS	=	13	mm
Minimum Handling thickness of Unit Penstock			
Dia. of Steel liner Unit Penstock	=	2.80	m
Radius of liner	=	1.400	m
Thickness	=	0.00825	m
	$Thk = \frac{R + 0.25}{200}$		
Add Corrosion Allowance of 1.5mm	=	9.750	mm
PROVIDE MIN. THICKNESS for Unit PS	=	10	mm
Upper Reservoir FRL	=	732.4	m
Upper Reservoir MDDL	=	694.9	m
C/L of Turbine	=	54.9	m
Invert of start of Steel liner Pressure shaft	=	658.3	m
Internal Dia of Pressure Shaft	=	3.90	m
Unit Pressure Shaft dia.	=	2.80	m
Materials proposed for steel liner			
ASTM 537, Class 2			
YS	415	Mpa	
UTS	550	Mpa	
Allowable Hoop stress			
=minimum of 1/3 of UTS and 0.6 of YP	183.33	Mpa	
(upto mid of inclined Pressure shaft)	1869.5	Kg/cm2	
ASTM 517, Grade F			
YS	690	Mpa	
UTS	795	Mpa	
Allowable Hoop stress			
=minimum of 1/3 of UTS and 0.6 of YP	265	Mpa	
From mid of inclined pressure shaft to Power House	2702.2	Kg/cm2	

***PS >Economic Diameter analysis of PS shall be detailed in DPR.**

- > Rock participation shall be considered in the design of liner based on the rock mass quality
- > Design for external pressure shall be carried out at the detailed design stage in DPR
- > This design is for preliminary cost estimate
- > This design is for internal pressure considering 10% water hammer

Preliminary estimation of PS liner thickness For Internal Pressure

Thickness of liner against internal pressure

$$Thk, t = \frac{PD}{2 \times 0.9 \times \sigma}$$

Allowable stresses in steel σ in kg/cm²

Internal Diameter of Steel liner D in cm

Net Pressure head without rock participation in Kg/cm²

Thickness of Steel liner t in cm

Min Thickness as per BIS in 3.9 m dia. 13 mm

Min Thickness as per BIS in 2.8 m dia. 10 mm

Reach EL in m upto which THK provided		Water Head	Net Pressure head considering 20% water hammer	Allowable stress in steel	Diameter of liner	Thickness Thk	Add 1.5mm Allowance for Corrosion allowance	Adopted THK	Length
From EL	To EL	m	Kg/cm ²	Kg/cm ²	m	mm	mm	mm	m
Start of Transition from SS	Upto 50 Degree bend	74.13	6.2269	1869.45	3.90	7.22	8.72	13	38.45
657.55	650.00	82.43	6.9241	1869.45	3.90	8.02	9.52	13	10
650.00	550.00	182.43	15.3241	1869.45	3.90	17.76	19.26	20	130.54
550	450.00	282.43	23.7241	1869.45	3.90	27.50	29.00	28	130.54
450	350.00	382.43	32.1241	1869.45	3.90	37.23	38.73	38	130.54
350	250.00	482.43	40.5241	1869.45	3.90	46.97	48.47	48	130.54
250	200.00	532.43	44.7241	2702.21	3.90	35.86	37.36	38	65.27
200	150.00	582.43	48.9241	2702.21	3.90	39.23	40.73	40	65.27
150	100.00	632.43	53.1241	2702.21	3.90	42.60	44.10	44	65.27
100	54.86	677.57	56.9159	2702.21	3.90	45.64	47.14	48	58.93
Lower PS bend	Penstock Bifurcation	677.57	56.9159	2702.21	3.90	45.64	47.14	48	24.84
Penstock Bifurcation	Power House	677.57	56.9159	2702.21	2.80	32.76	34.26	34	62

*The steel liner shall also be checked for external pressure at the detailed design stage in DPR.

**Actual Rock participation shall be considered at the DPR stage based on the rock mass properties and use of stiffeners for reducing the liner thickness. However, at FSR level 30% rock participation has been assumed.

***The Wye piece bifurcation design shall be carried out at the detailed design stage in DPR. (weight added in gross weight)

Preliminary estimation of PS liner Weight											Annexure- 7.9 (I)	
Sr.No.	Reach		Type of Liner	Inner dia. of penstock	Radius	Length	Liner thickness	Radius to C/L of liner	Perimeter	Volume	weight of steel	Weight of unit
	in meter			in meter	in meter	in meter	in m	in meter	in meter	m3	Kg/m3	Kg
1	Start of Transition from SS	Upto 50 Degree bend	ASTM 537 Cl. 2	3.90	1.95	38.45	0.013	1.9565	12.3	6.1	7850	48235.75
2	657.55	650	ASTM 537 Cl. 2	3.90	1.95	9.85583	0.013	1.9565	12.3	1.6	7850	12364.19
3	650	550	ASTM 537 Cl. 2	3.90	1.95	130.541	0.020	1.96	12.3	32.2	7850	252395.51
4	550	450	ASTM 537 Cl. 2	3.90	1.95	130.541	0.028	1.964	12.3	45.1	7850	354074.84
5	450	350	ASTM 537 Cl. 2	3.90	1.95	130.541	0.038	1.969	12.4	61.4	7850	481753.49
6	350	250	ASTM 537 Cl. 2	3.90	1.95	130.541	0.048	1.974	12.4	77.7	7850	610076.01
7	250	200	ASTM 517 Gr. F	3.90	1.95	65.2704	0.038	1.969	12.4	30.7	7850	240876.75
8	200	150	ASTM 517 Gr. F	3.90	1.95	65.2704	0.040	1.97	12.4	32.3	7850	253683.24
9	150	100	ASTM 517 Gr. F	3.90	1.95	65.2704	0.044	1.972	12.4	35.6	7850	279334.87
10	100	54.86	ASTM 517 Gr. F	3.90	1.95	58.9261	0.048	1.974	12.4	35.1	7850	275388.31
11	Lower PS bend	Penstock Bifurcation	ASTM 517 Gr. F	3.90	1.95	24.84	0.048	1.974	12.4	14.8	7850	116088.58
12	Penstock Bifurcation	Power House	ASTM 517 Gr. F	2.80	1.4	62	0.034	1.417	8.9	18.8	7850	147329.59
	Total length of one Inclined Pressure Shaft					850		Total Wt of one PS for			ASTM 537 Cl. 2	1758899.80
	Total length of one Unit Penstock					62		Total Wt of one PS for			ASTM 517 Gr. F	1165371.75
								Total Wt of one Unit Penstock			ASTM 517 Gr. F	147329.59

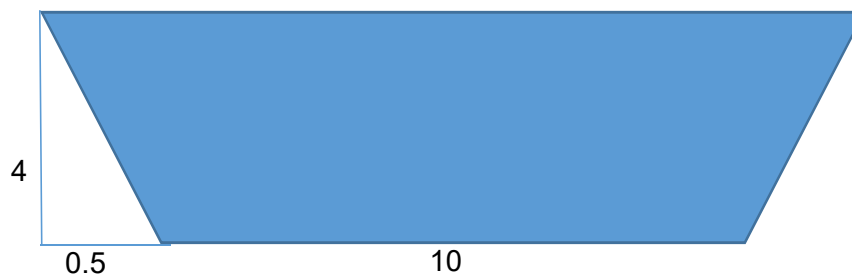
		ASTM 537 Cl. 2	ASTM 517 Gr. F
Total wt of 2 Nos. HRT/PS in Tonns	=	3517.8	2330.7
Total wt of 4 Nos. Unit PS in Tonns	=	0.0	589.3
Gross Wt	=	3517.8	2920.1
Y piece and other accessories		0.0	100.0
Say (in Tonnes)		3518	3030

**Tail Race Channel
Trapezoidal Lined Channel**

Slope	n	Base Width	Side slope	Depth (m)
0.001	0.015	10	0.125	4
IS 10430 Table 1				

Side Length	4.031	m
P	18.062	m
A	42.000	sq m
R	2.325	m
Velocity	3.700	m/s
Q	155.409	cumec
Length	730	m

Finished Dimension



CHAPTER-8:

DESIGN OF E&M EQUIPMENT'S

CHAPTER – 8

8. DESIGN OF ELECTRO-MECHANICAL EQUIPMENTS

8.1 General

The proposed Idukki Extension Scheme of 800 MW is envisaged to have 4 vertical pelton turbines driven generating units of rating 200 MW with 10% continuous overload capacity and operating under a rated head of 654.57 m in an underground power house. There will be two caverns i.e., Main Power House cavern and Transformer cavern. Main inlet valves, turbines, generators and auxiliary equipment would be housed in the Main Power House cavern. The Generator Step up Transformers, shunt reactor, TRT gates and GIS would be accommodated in the Transformer cavern. The 245 kV Gas Insulated Switchgear (GIS) would be installed in the Transformer cavern on the floor above the Generator Step up Transformers. Isolated phase bus ducts connecting the generator transformer with the generator will be routed through the interconnecting tunnels between the two caverns. LAVTs, UATs, Excitation transformers and dynamic braking panels will also be housed in the interconnecting tunnel enclosed six circuits of 220 kV transmission lines shall take-off from the pothead yard to evacuate power to the proposed 220 kV Substations at nearest pooling station mentioned in power evacuation arrangement. The connection between equipment located at pothead yard and respective GIS bays located in the transformer cavern would be made through 220 kV XLPE cables as indicated in the Single Line Diagram enclosed. The layout of equipment is indicated in the relevant layout drawings. The Powerhouse X- section and L- section is presented at **Annexure- 8.1 and Annexure 8.2** respectively. The Single Line Diagram is enclosed at **Annexure -8.3**.

8.1.1 Layout Plan of Electro-Mechanical Equipment

The machine hall at EL 66.36 m shall be 146.0 m in length (including service bay of length 42.0 m) and 22.0 m in width. The dimensions of power house from deepest foundation to top of roof shall be 146 (L) x 22 (W) x 44.5 (H) m.

Auxiliary bays of 10 m width have been proposed at service bay end & auxiliary block of 15 m at far end of the power house to accommodate electrical and mechanical auxiliaries such as Mechanical workshop, DC power equipment, control room, ventilation system, etc. Also, drainage, dewatering and flood protection sumps at either end of the power house shall be provided due to long length of the power house cavern.

Generators shall be connected to the Transformers located on the Transformer deck on upstream side of the machine hall by Insulated Phase Bus Ducts of 24 kV rating. The dimensions of Transformer Hall shall be 146 (L) x 16 (W) x 26.5(H) m.

The access to Power House shall be from Main Access Tunnel at Machine Hall floor at EL. 66.36 m Unit -1 side.

The dewatering, drainage sumps shall be provided on unit-4 side of MIV hall at EL. 51.36 m.

Suitable ventilation and air conditioning ducts, as required, shall be installed at different locations on various floors of machine hall & Auxiliary Bay.

Two nos. of 250/40/10 Ton EOT Crane shall be installed in the machine hall for erection & maintenance of equipment in the power house.

8.2 Electro-Mechanical Equipment

8.2.1 Turbine

The turbine will be vertical Pelton wheel with rated speed of 375 rpm. The rated output of each turbine would be about 203.04 MW to match with rated generator rating of 200 MW. The centre line of the turbine would be at EL 54.86 i.e., 4.5 m above the maximum tail water level at EL 50.36 m. The turbine would be designed to withstand runaway speed for 15 minutes without causing any damage.

The runner will be of integrally casted, made of stainless-steel Cr-Ni 13-4 equivalent material or better composition available at the time of supply. Provision will be made to remove the runner from the bottom side for repair/ replacement as and when needed.

Distributor will be designed to withstand, without any support from the concrete, the maximum internal pressure. This internal design pressure results from the maximum static head at the distributor centerline, including pressure rise due to water hammer.

The turbine main shaft will be of forged and properly heat treated. The turbine main shaft will operate safely in combination with the generator shaft at any speed up to the maximum runaway speed without detrimental vibration or objectionable distortion.

Nozzles will be of the straight-flow type with internal hydraulic servomotors. The nozzle assembly will be removable and the design will incorporate lugs or other means for raising and lowering the assemblies. The nozzles will have a self-closing tendency due to penstock pressure and spring action in the event of failure of the governor oil pressure, or breakage of any connecting mechanism. Such automatic closing will be at a controlled rate, which will not result in a pressure rise greater than 15% (fifteen percent) of maximum static head.

The turbines shall be designed for 10% continuous overload capacity which may be utilized during any of the following conditions:

- i) Shutdown of any one or more number of units
- ii) High discharge conditions during monsoon

8.2.2 Basic Hydraulic System

i)	Reservoir levels	
	a) Full Reservoir Level (FRL)	El. 732.43 m
	b) Minimum Draw Down Level (MDDL)	El. 694.94 m
ii)	Water Conductor Losses	10.5 m

iii)	Distributor Centre Line	54.86 m
iv)	Operating Range	
	a) Maximum Net head	667.07 m
	b) Minimum Net head	629.58 m
	c) Net Rated head	654.57 m
v)	Turbine Basic Data	
	a) Rated Output at rated head	203.04 MW
	b) Overload Capacity (continuous)	10 %
	c) Specific Speed	50.89 rpm
	d) Rated Speed	375 rpm
	e) Turbine Rated Discharge	34.48 cumecs
	f) No. of jets	6

8.2.3 Governor

Governor for turbine regulations shall be of the Electronic cum digital electro-hydraulic type, having the provisions for adjustment of the basic parameters. It will have PID functions. The capacity of the governor shall not be less than the capacity of servomotors for operation of guide vanes. For pressurizing OPU, Nitrogen Bottles are proposed to be used. Operational mechanism of Guide vanes shall be oil hydraulic with two single acting servomotors mounted in the turbine Pit on the upstream of turbine runner. The runner servomotor shall be housed in the runner boss. The Hydraulic oil for runner servomotor is fed from the oil supply device at the end of the generator shaft. Normal pressure for operation of Oil system shall be as per standard practice of the manufacturer. Cooling water for generators shall be used for governor oil cooler.

8.3 Generator

The Generators will be synchronous and of the Horizontal shaft type. Each of the four Generators shall have the following characteristics:

Rated Output

200 MW

Continuous overload capacity	10%
Power Factor	0.85 lagging
Frequency	50 Hz
Phases	3
Speed	375 rpm
Generation Voltage	18 kV $\pm$ 5 %
Range of frequency	(-) 5 % to (+) 3 %
Run-away speed	To match with turbine run-away speed
Stator winding connection	Star(Y)
Generator earthing	Star Point earthed through grounding transformer

8.4 Excitation System and AVR

Static Excitation system and AVR shall have microprocessor-based controls. The excitation equipment shall comprise of rectifier, power transformers, thyristors, field breaker with discharge resistor, field flashing circuit, automatic digital voltage regulator and protection and control devices along with accessories to make it a complete system.

The excitation system shall be capable of continuously supplying the maximum excitation power required to produce 110% of rated output, at rated generator voltage, rated power factor and upto 47.5 Hz frequency etc.

Three phase powers for excitation shall be obtained through a three phase, self cooled, indoor, metal enclosed, cast resin excitation transformers connected to segregated phase bus ducts.

The excitation system shall be complete with digital voltage regulator complete with feature for manual and automatic voltage regulation, excitation controls and indications.

8.5 Insulated Phase Bus Duct (IPBD) and Associated Equipment

The IPBDs shall serve as interconnection link between Generator and its associated Generator Transformers. The tapplings for Earthing Switches, SAVT Cubicles, Excitation Transformers, Unit Auxiliary Transformers and Station Auxiliary Transformers etc. shall also be taken from the IPBDs. The above equipment as well as excitation panels, 0.415 kV unit auxiliary boards, 0.415 kV station auxiliary boards, 11 kV station board and all above cubicles shall be installed in the auxiliary bay.

The IPBDs assemblies shall be mechanically designed so as to withstand all static & dynamic forces due to continuous 10% overload current and short circuit currents without injury or permanent deformation of any part of the support structures of IPBDs. Suitably design support structure shall require to be provided by the supplier for this purpose.

The bus conductors shall be of high conductivity aluminum alloy conforming to relevant standards. Provision shall be made in Insulated Phase Bus Duct for 4 units for shorting with shorting links which shall be used for drying out of the equipment before commissioning or for carrying out the short circuit test on the equipment.

Provisions shall be made for removable links in the main run of the bus ducts, at each tap-off connections i.e., for SAVT cubicle, Excitation Transformer, Station Auxiliary Transformers (SATs) etc.

The SAVT cubicles shall comprise of Surge Arresters and Voltage Transformers. SAVT cubicle shall be provided with Surge Arrester for DVR protection (including surge protection through SA & capacitors), metering and synchronizing and monitoring purposes.

The Current Transformers shall be of cast resin, ring type and mounted within the IPBD enclosures.

8.6 Generator Transformers

Weight of single-phase transformers of rating 87 MVA shall be within transportation limit upto the project site. The Generator Transformers shall be connected on LV side to the generating units through Insulated Phase Bus Ducts and on the HV side to the switchyard through 220 kV GIBs. The Generator Transformers shall be located in Transformer deck at EL 66.36 m. The single-phase Generator Transformers shall be oil immersed and shall be provided with ODWF/OFWF cooling. The transformers shall be suitable for outdoor installation. The rating and other parameters shall be as given below:

Type	Single Phase, core or shell type
Rated output on all tapings	87 MVA
Voltage	H.V. Side 220 kV; LV Side 18 kV
Rated frequency	50 Hz - 5% to + 3 %
Type of cooling	ODWF/OFWF
Cooling medium	Mineral oil
Tapping	Off-Load Type ($\pm 5\%$ in steps of 2.5%)
Earthing	HV neutral solidly earthed
Installation	Outdoor on rails

One spare single-phase transformer may also be installed at the Transformer deck. For the purpose of collecting the spurt-out insulating oil from Generator Transformers due to internal troubles, oil soaking pits will be provided beneath each of the generator transformers (including spares) to combined waste oil tank. The generator transformers shall be isolated from each other by fire resistant walls.

8.7 Neutral Grounding Resistor

Neutral Grounding Resistor (NGR) system and Neutral Grounding Transformer (NGT) system are available for the neutral point grounding of the generator.

Neutral Grounding Resistor (NGR) system would be suitable from the view point of cost and varying resistance characteristics with frequency during starting operation by back-to-back system. Hence, Neutral Grounding Resistor (NGR) system shall be used for grounding the neutral point of the generator windings.

The Neutral Grounding Device shall consist of:

- Neutral Grounding Resistor (NGR)
- Current Transformer

8.8 220 kV GIS and outdoor Pothead Yard

220 kV GIS shall be housed in the building at the transformer deck area. Double bus bar arrangement is proposed for this project after giving due consideration to its reliability, stability, easy maintenance and accessibility. The GIS has total 11 bays comprises of 04 Nos. generator transformer bays, one bus coupler bay, and 6 Nos. outgoing feeder bays. Provision shall be made for various control & protection equipment including PLCC equipment.

8.9 Control and Protection System

Automatic, sequential and step by step shall be possible from Unit Control Boards (UCB), automatic control of the units and complete station control will be done at main control room. The protection system for the following is envisaged:

- i) Generators
- ii) Generator Transformers
- iii) Station Auxiliary Transformers
- iv) Excitation Transformers
- v) 220 kV GIS
- vi) 220 kV Pothead Yard etc.

The centralized control and monitoring of protection system shall be located in the Power House control room and it shall be integrated with the Computerized Control System (CCS) through a gateway computer.

8.10 Computerized Control System (CCS)

All four units shall be designed to operate entirely independent of each other. Centralized control system shall be adopted by allocating computing power and automatic functions to computers on unit control level, along with overall computer control of units from central control room. Manual as well as automatic control of unit will be carried out by processing the necessary control signals from turbine, generator, generator transformer, switchgears and various auxiliaries.

Usually, the units shall be controlled from main control station in the control room. Manual step-by-step control at the local control boards shall be used in limited cases, for instance, during pre-commissioning tests or during emergency.

8.11 Mechanical Auxiliaries

8.11.1 EOT Crane

The heaviest equipment/assembly required to be lifted in the power house by the EOT crane shall be the assembled rotor. The assembled rotor weight for the 200 MW generating unit is expected to be of the order of 380 tonnes. Two crane of 250/40/10 tonnes main and auxiliary hook is proposed to be provided for handling the assembled rotor along the full length of the power house. The crane capacity will, however, be subject to review during preparation of bidding document/detailed design stage.

8.11.2 Oil Pressure System

The governor shall have provision of Nitrogen Bottles for pressuring individual OPU for the four units and shall have requisite valves and other piping system with necessary instrumentation and protection system and control panels etc.

8.11.3 Low Pressure Compress Air System

Low pressure compressed air system for generator brakes, common station services etc. shall consist of two compressors, two air receivers, complete air distribution system valves, and other piping system with necessary instrumentation and protection system and control panels etc.

8.11.4 Dewatering and Drainage System

Dewatering system shall be provided in the power house for dewatering of penstock and draft tube upto draft tube gate. The scheme shall comprise of submersible pump sets installed in the dewatering sumps. Water to be drained out shall be first drained into the dewatering sump and from where it shall be pumped out of the power house.

The automatically operating station drainage system shall drain all the water discharges, effluents/drainages, leakages from equipment and surrounding area of the power house etc. from power house to tail race beyond draft tube gate. All such water shall be arranged to be led into the drainage sump. The scheme shall comprise of submersible drainage pumps installed over the sump along with requisite piping, control panels etc.

8.11.5 Cooling Water System

Cooling water system for generating units, Generator transformer shall comprise of closed water circuit system, exchanging heat in the heat exchange to the circulating raw cooling water being pumped from draft tube/tail race and back. The water in the closed circuit shall be clean potable type being replenished from an overhead tank, which shall also be used for fire-fighting, air-conditioning, ventilation and drinking water system.

The raw cooling water shall also have the provision for supplying water, which after treatment and purification, shall meet the requirements for replenishment of closed-circuit cooling water, drinking water, air conditioning, ventilation etc.

8.11.6 Air Conditioning and Ventilation System

Various floors of the machine hall and auxiliary bay shall be provided with ventilation and packaged air conditioning system as required to maintain control room, conference room and other work areas at the required level of temperature, humidity and comfort.

8.11.7 Oil Handling System

Oil handling system for transformer oil and lubricating oil for generating units will be provided with suitable piping, valves, tanks, purifiers etc. 2 sets of portable centrifuging oil handling / purification units each comprising oil heaters, filters, tank etc. shall be provided in the power house at suitable locations for the treatment of governor & bearing oils. A portable dehydration plant comprising of oil heaters, filters, storage tank etc. of adequate capacity shall be provided for treatment of transformer oil.

8.11.8 Fire Fighting System

The fire protection system in the power house, shall be planned to timely detect the occurrence & quick extinguishing of fire break-outs, and prevent spread of fire so as to minimize the extent of damage. The complete fire-extinguishing system shall be broadly divided into the following categories:

a. Automatic Emulsifier System

Automatic Emulsifier System shall be provided for fire protection of four nos. three phase Generator Transformers located on the Transformer deck.

b. Fire – Extinguishing System from Hydrants

The system shall consist of pipelines laid in various floors of machine hall, auxiliary bay etc. along with hydrant valves with quick coupling end connectors etc. Water in the hydrant pipes/valves shall be under pressure, suitable for hand operation hydrant valve with pressure varying between 3.5 to 5.0 kg/cm².

c. Chemical Portable Extinguishers

Hand portable CO₂ Extinguishers, wheeled portable CO₂ Extinguisher units, Dry Chemical hand portable and wheeled portable fire extinguishers, Hand portable foam type Chemical Extinguishers, wheeled portable foam type Chemical Extinguishers etc. shall be provided for protection of areas such as oil storage/ treatment room, HT/LT and DC switchgear rooms etc. Suitable numbers of safety kits, respiratory system, automatic personnel distress alarm etc. shall also provide.

8.11.9 Potable Water and Sanitary System

The system, for supplying secondary cooling water, would also be used to supply the plant's potable and sanitary water needs including water required for air cooling system. The water would be filtered and chemically treated as per requirement. Sanitary/Sewage water would be treated in a septic tank before discharging the same into the river. The system shall comprise of pumps, pressure filters, chemical treatment units, storage, distribution piping etc. The details would be finalized during preparation of Bidding document/ detailed system design.

8.11.10 Lifts

1 no. electrically operated lift shall be provided specifically in the auxiliary bay building for use of power house personnel and for lifting of small size equipment/ material. Each lift shall be designed for approximately a load of 8 persons.

8.11.11 Mechanical Workshop

A workshop equipped with drilling, milling & lathe machines with other required machine tools, etc., would be provided to carry out normal repairs of the equipment in the power house itself.

8.12 Electrical Auxiliaries

8.12.1 LT/HT AC Station Supply

The station auxiliary supply is proposed to be met from the power generated by its own generating equipment as a primary LT power supply source.

The station auxiliary supply as an external source of auxiliary power supply is proposed to be arranged by tapping 11 kV lines passing near by the power house / pothead yard area. The 11 kV feeders are connected to the 11 kV switchgear (SAB-1) proposed to be located in the Pothead yard area through 11 kV XLPE cables.

2 nos. each of 2000 kVA, 11 kV DG sets are also proposed for auxiliary power supply during emergency when both above sources of auxiliary power supply are failed. These DG sets are proposed to be located in the pothead yard area and shall feed power generated at 11 kV to the SAB-1 located at Pothead yard. Finally, this DG power will be transferred to the power house through inter connection of both 11 kV switchgears.

Two nos. 11 kV feeders from SAB-1 shall be connected to SAB-2 located at Machine Hall area at EL 66.36 M to feed the station auxiliary supply.

2 x 8 MVA, 18 / 11 kV dry type station auxiliary transformers each connected to the bus ducts of generating units 1 & 8 are also proposed to supply the station auxiliary power through SAB-2 to be installed at Machine Hall area at EL 66.36 M through 11 kV XLPE cables.

SAB-2 is sectionalized into two parts and each section is capable to feed whole load of the power house.

The unit auxiliaries shall be fed through 800 kVA, 18 / 0.433 kV, dry type transformer connected on HV side to the 18 kV isolated phase bus-duct of each generator through tap off bus-duct and on LV side to the unit auxiliary board (UAB) through PVC insulated aluminum cables / LV bus-duct. UABs shall also be connected to

SSB-1 at Machine Hall Floor at EL 66.36 M through 415 V PVC insulated aluminum cables.

2 dry type transformers each of 3000 kVA, 11 / 0.433 kV capacity with LV side directly connected to SSB-1 by 415 V LT bus duct and HV side connected to the SAB-2 through 11 kV XLPE cables, are proposed to meet the load of unit auxiliaries during emergency.

2 dry type transformers each of 1000 kVA, 11 / 0.433 kV capacity with LV side directly connected to SSB-2 located at Turbine Floor at EL 57.36 M by 415 V LT bus duct and HV side connected to the SAB-2 through 11 kV XLPE cables, are proposed to meet the load of turbine floor & MIV floor.

2 dry type transformers each of 1000 kVA, 11 / 0.433 kV capacity with LV side directly connected to SSB-3 located at Generator floor at EL 61.86 M by 415 V LT bus duct and HV side connected to the SAB-2 through 11 kV XLPE cables, are proposed to meet the load of Generator Floor.

2 dry type transformers each of 1000 kVA, 11 / 0.433 kV capacity with LV side directly connected to SSB-4 located at Machine Hall floor at EL 66.36 M by 415 V LT bus duct and HV side connected to the SAB-2 located through 11 kV XLPE cables, are proposed to meet the load of Machine Hall Floor.

2 dry type transformers each of 1000 kVA, 11 / 0.433 kV capacity with LV side directly connected to SSB-5 located at GIS Floor by 415 V LT bus duct and HV side connected to the SAB-2 through 11 kV XLPE cables, are proposed to meet the load of Transformer & GIS Floor.

2 dry type transformers each of 2000 kVA, 11 / 0.433 kV capacity with LV side directly connected to SSB-6 located at Pothead yard area by 415 V LT bus duct and HV side connected to the SAB-1 through 11 kV XLPE cables, are proposed to meet the LT power requirement near pothead yard area, MAT portal & CCVT Portal.

8.12.2 DC Supply System

A 220 V DC system, with two sets of battery banks of Lead Acid cells suitable rating will provide power for unit control and protection equipment, field flashing, emergency lighting of the power house, emergency lube oil pumps for generator / turbine bearings etc. Each battery bank will be provided with 2 battery chargers, equipped with float and boost charging facilities, with all necessary control and protective devices. A DC main distribution board, alongwith required nos. of sub-distribution boards at various locations (including sub-DCDBs at Switchyard and Barrage), will be provided for feeding various DC loads. One set of 48 V DC battery of suitable rating along with charger and D.C. distribution board required for PLCC, SCADA, internal communication etc. will also be provided.

8.12.3 Power, Control & Instrumentation Cables

11 kV XLPE cables shall be used for connection from/ to the 11 kV switchboards installed at different load centers.

1.1 kV Grade PVC insulated Aluminum Power Cables shall be used for supplying power to various auxiliaries, while for control cables 1.1 kV Grade PVC insulated copper cables will be employed. The Instrumentation Cables including Fiber Optic Cables used will be immune to electromagnetic interference. The number of pairs/cores required will be as per the requirement of the system. All cables will be FRLS type.

All the accessories like Cable glands, Ferrules, Cable Trays with cable racks & supporting systems, Conduits etc., of adequate sizes as required, for the installation of cables will be included.

8.12.4 Illumination System

Illumination system shall be provided for power house, barrage area, switchyard etc. as well as for access roads to various locations of the project areas. The illumination of the various areas of the project will be provided by high pressure sodium, mercury vapour and fluorescent tube luminaries to suit the specific requirement for different

locations. LED type fixtures/ incandescent lamps shall be provided at different locations/floors of power house complex to meet DC emergency lighting requirement.

8.12.5 PLCC Equipment

PLCC system shall provide efficient source and reliable information links to meet the communication need of protection, voice and data including SCADA system. It shall provide for distance protection and direct tripping for remote end breakers, signal transmission & speech communication between power house and Kalimpong substation and data communication to remote places through various frequency channels etc.

8.12.6 Communication & Surveillance System

A suitable communication and surveillance system shall be installed in the power house complex to facilitate the communication and desired security in the power house area, switchyard and barrage areas. Communication system shall comprise of the public address system and EPBAX equipment. The surveillance system would comprise of access control system and CCTV system equipment.

8.12.7 Electrical Equipment & Testing Laboratory

A test laboratory will be provided to carryout normal testing of the power house equipments. The laboratory will be equipped with custom made CTs, HV test set, oil testing set, meggers, relay testing set, oil filtration kit, ground fault locator & safety tool kits etc.

8.12.8 Lightning and Grounding Protection system

Lightning protection system shall also be provided. It shall be designed to cover powerhouse building, switchyard and barrage areas. It shall comprise of vertical air terminators, down conductors, test links, surge counters (for counting the number of lightning strikes) and earth connections.

The grounding mat of MS flat, or combination of MS flat and rods having suitable cross-sectional area would be provided in power house complex comprising machine hall & auxiliary floors; Transformer deck; switchyard; Tail Race etc. Grounding electrodes of suitable size as required shall be buried and connected to grounding mats. Suitable number of grounding risers would be provided in the power house/auxiliary bay floors including transformer deck and switchyard for earthing of various electrical equipments. Separate provision would be made for earthing various electronic equipments in the power house. All non-current carrying equipments shall be grounded by using at least 2 earthing conductors of adequate sizes which shall finally be connected to the grounding grid. The grounding system would be designed to keep the touch & step potential within acceptable safe limits.

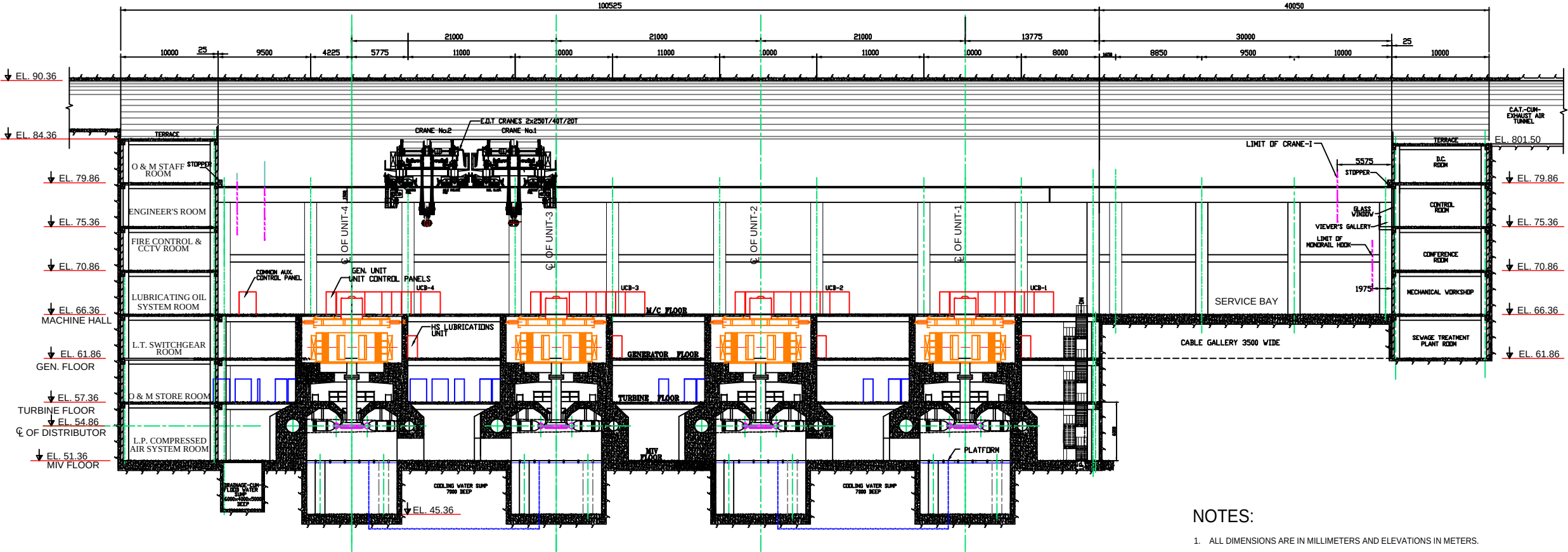
8.12.9 Diesel Generating Sets

Provision of 2 Nos. 11 kV, 3 Phase, 50Hz Diesel Generating Sets located at the Transformer deck is made. Each D.G. set would be of 1000 KVA capacity capable of continuously delivering rated output under site conditions at 0.9 lagging power factor for supplying A.C. electrical power when 11 kV external power supply is not available and also in case of emergency A.C. Supply to start the generating station during black out. The D.G. sets shall be delivering the power at 11 KV station Auxiliary boards installed in auxiliary bay.

One number electrically operated lifts shall be in the control block for easy movement. The lift shall be designed for approximately a load of 10 persons.

Annexure 8.1

Annexure 8.2



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS.

POWER HOUSE LONGITUDINAL SECTION L-L

 KERALA STATE ELECTRICITY BOARD LIMITED		
 CONSULTANTS WAPCOS LIMITED (A GOVERNMENT OF INDIA UNDERTAKING) MINISTRY OF JAL SHAKTI		
IDUKKI EXTENSION SCHEME		
L - SECTION OF POWER HOUSE		
DEGN.	CHKD.	SUBM.
DRAWN.	REV. NO.	APPRD.
DATE: SEP. 2021	DRG. NO. WAP/D&RE/IDUKKI/PFR/E&M/2	

Annexure 8.3

CHAPTER-9:

CONSTRUCTION PLANNING & SCHEDULE

CHAPTER – 9

9. CONSTRUCTION PROGRAMME AND SCHEDULE

9.1 General

Construction of proposed Idukki Extension Scheme H.E. Project including erection of the four generating units is planned to be completed in a period of Five years including Pre-construction works of 1 year for creation of infrastructure facilities viz. additional Investigations, improvement of Road network and colonies.

Two shift working is considered economical for surface works. For underground works which do not follow normal pattern of shift working because of cyclic operations, three shifts working with minimum 15 hrs. or upto completion of cycle operations/day has been considered. Opting 25 working days in a month, shift wise scheduled working hours annually are adopted as follows

Single Shift Work = $25 \times 10 \times 6$ hrs.	= 1500 hrs	} for Surface Works
Two Shift Work = $25 \times 10 \times 11$ hrs	= 2750 hrs	
Three Shift Work = $25 \times 10 \times 15$ hrs	= 3750 hrs	
Three Shift Works = $25 \times 10 \times 18$ hrs		= 4500 hrs for Underground.

9.2 Main Components of the Project

9.2.1 Main Structure/ Components

The construction schedule has been detailed for major items of the following main structures/ components.

i. Civil Works

- Coffer dam at intake
- Power intake
- Surge Shaft
- MAT and construction Adits
- Headrace tunnel

- f) Pressure Shaft
- g) Draft Tube and Tailrace tunnel.
- h) Tail Race Channel
- i) Switch yard and Cable Tunnel
- j) Underground powerhouse and transformer cavern.

ii. Electrical Works

- a) E.O.T. cranes
- b) Supply and erection of T.G./ 4 nos. 200 MW each
- c) 220 kv G.I.S. and bays equipment
- d) Main power transformers
- e) Other auxiliary electro-mechanical equipment

iii. Hydraulic equipment

- a) Intake gates
- b) Draft Tube gates

9.2.2 Target Schedule

The total construction period is scheduled as follows.

Pre-construction and Infrastructure	: 1 year
Construction Period (Main Works)	: 4 years
Total construction period	: 5 years

The Programme is also exhibited in the form of a bar chart and is enclosed as **Annexure 9.1.**

9.3 Infrastructure Facilities

The Idukki Extension Scheme H.E. Project is located in the Idukki district of Kerala. The site is located at about 500m away from the existing underground power house at Moolamattom. The project area lies between 9° 49' 42" N, 76° 48' 12" E and 9° 47' 23" N, 76° 53' 16" E. The Tail race tunnel and channel will be constructed to discharge the tail water from Power house into Thodupuzha River.

NH-49 Madurai-Kochi (280 km.) passes through the District starting from Kundannur and terminating at Bodim, thus covering 167.6 km. in the District. The Cochin-Munnar road, Kottayam-Kumily road, Thodupuzha- Idukki road and Kumily-Munnar road are the major roads in the District. Access to the site is through Thodupuzha – Muttam – Moolamatom.

The roads in Idukki are part of Ghat roads. The major roads connect the city of Kochi to Tamil Nadu. The KK road (Kumili - Kottayam), the PT road (Puliyannamala - Thodupuzha State Highway-33) are some of the other busy roads.

Construction of infrastructure works will be taken up in first years. Construction power may be obtained from the existing grid, but a new sub-station needs to be developed. Construction/ improvement of project road and upgrading of existing road will be taken up immediately. The construction of office and residential buildings will be started in first year and be completed by second year. Construction of Project road shall be taken up first priority to complete within a year due to short length.

Following provision is being kept for construction of offices and residential building at various sites:

- Permanent Office Buildings
- Temporary Office Buildings
- Temporary Site Offices
- Permanent Residential Buildings
- Temporary Residential Buildings

The existing colony of Idukki HEP can be utilized as project colony of the proposed Idukki extension project with some repair works. Temporary dormitory shall be constructed for the accommodation for the staff engaged during construction period. The construction of temporary labour colony within the existing colony of Idukki HEP will be taken up from first year and completed all within second year.

9.4 Coffor Dam at intake

Construction of bunds for the coffer dam at intake is proposed to be started in the 1st month of 2nd year and completed within the month itself. The Dewatering & treatment of foundation work will be completed in 2nd month of 2nd year. The placement of Earth fill work will be started in 2nd month of 2nd year and will be completed in 4th month of 2nd year. The placement of stone pitching will be completed in 4th month of 2nd year.

9.5 Power Intake

Open Excavation for Intake will start from 5th month of 2nd year as an independent activity. However, Concreting of Intake structure can only take place after completion of concrete Lining in 1st Phase of HRT from 9th month of 3rd year. The concreting of Intake may spread over twelve months from 9th month of 3rd year to 8th month of 4th year respectively.

9.6 Headrace, Surge Shaft & Pressure shaft

Excavation of HRT from intake face will be taken up in the 8th month of second year after completing the open excavation of intake. The same will be completed in the 8th month of third year. The backfilling, grouting will be taken up simultaneously and completed in the 7th month of 4th year.

The excavation of Surge shaft will be taken up simultaneously in the 6th month of second year after completing the adit 1 excavation. The concreting work will start in 3rd month of 3rd year and completed in the 3rd month of 4th year.

The excavation of inclined/horizontal pressure shaft will be taken up simultaneously in the 8th month of second year after completing the adit 2 excavation. The steel liners will be erected from 9th month of third year and completed in the 4th month of fifth year.

9.7 Tailrace Tunnel

Open Excavation of tailrace tunnel will start from 4th month of year 2 which will be completed in 3rd month of 3rd year. The concrete lining will start from 8th month of 2nd year and completed in 5th month of 3rd year. The backfilling, grouting will be taken up simultaneously and completed in the 9th month of 3rd year.

9.8 Tailrace Channel

Open Excavation of tailrace channel will start from 7th month of year 2 which will be completed in 6th month of 3rd year. The concrete lining will be taken up simultaneously in 11th month of 2nd year and completed in 8th month of 3rd year.

9.9 Underground Powerhouse/ Transformer Caverns

Main Access tunnel to power house will be done by 11th month of second year and the construction of cable tunnel will be completed by 1st month of 3rd year and then the excavation of the power house cavern will be taken up in the 1st month of the third year and will be completed by 2nd month of year 5. The concreting will be taken up in the 11th month of the third year and will take 19 months for completion.

9.10 Electro-Mechanical Works

Action for procurement of EOT cranes is proposed to be initiated in the 1st year itself. The entire process of inviting the tender, placing orders, manufacture, supply, erection and testing is planned to be carried out in the period of July of the 1st year to end of the 3rd year.

Pre-manufactured activities such as preparation of specifications, inviting and evaluation of tender etc. can be completed within the 1st year so that the supply orders are placed by the end of the 1st year. The model tests and approval to the supplier's drawings will require nine more months. Installation period for each turbine and generator has been considered as twenty nine months.

Annexure - 9

CHAPTER-10: ENVIRONMENTAL ASPECT

CHAPTER – 10

10. ENVIRONMENTAL ASPECT

10.1 General

The commissioning of any hydro power project leads to significant impacts on environmental resources of the project area and its surroundings. However, by proper planning at the inception stage and incorporating appropriate migratory measures in the planning, design, construction and operation phases, adverse impacts can be minimized to a large extent, whereas beneficial impacts can be maximized. The Chapter covers the impacts likely to accrue as a result during construction and operation phases of the proposed Idukki Extension H.E. Project project located in Idukki district, of Kerala. A broad framework of Environmental Management Plan for amelioration of adverse impacts on account of various phases of implementation of Idukki Extension H.E.P along with the outline of the Environmental Monitoring Programme too has also been covered as a part of the present Chapter.

10.2 Study Area

The Study Area considered for the Environmental Assessment study shall comprise of the following:

- Area to be acquired for various project appurtenances
- Reforestation aspect of the forest area

10.3 Environmental Baseline Status

The assessment of pre-project environmental status is essential to determine the environmental parameters which could be significantly affected due to the proposed Idukki Extension H.E. Project project. The baseline status has been assessed mainly based on review of secondary data and site visits. The existing project related documents too have been reviewed to assess the baseline environmental status.

10.3.1 Climate

The climate of Idukki district varies considerably from the rest of the State due to its peculiar topography. The highland region is having a comparatively cold climate. In the places above an elevation of 2400m, the temperature at times falls down to freezing point in the winter. Occurrence of mist is usual in the highland regions lying over an elevation of 1300m above mean sea level. The western part of the district comprising midland area experiences moderate climate, temperature varying between 21⁰ to 27⁰ degree with minimum variation. The eastern parts of the district located in the highland have a comparatively cold climate with temperature varying between -1⁰C to 15⁰ C in November/January and 5⁰ C to 15⁰ C during March/ April.

Idukki district also receives rainfall under the influence of south-west monsoon (Edavapathi) during the period from June to September and the north-east monsoons (Thulavarsham) during the months of October and November, the former is more prominent. The eastern and the north-eastern regions of the district get very low rainfall in contrast to the other areas. Marayoor, Kanthalloor, Vattavada and Thalayar regions come under this group. Marayoor and Kanthalloor are virtually rain-shadow areas, lying in the eastern side of the Western Ghats.

10.3.2 River System

The Periyar River is 244 km in length and the longest river of Kerala and drains an area of 5,398 sq km. The basin lies between latitude 9⁰ 15'N to 10⁰ 20'N and Longitude 76⁰ 10'E to 77⁰ 30'E. It rises at the forest land Sivagiri peak 80 km south of Devikulam at an elevation of 2,438m above msl and traverses the steep mountainous terrain before it is joined by the Mullaiyar, 16 km downstream. The river then turns west and continues to flow in the direction for about 16 km in a sandy bed. After a winding course of about 13 km, the river reaches Vandiperiyar and passes through a second narrow gorge below which the Perumthura joins it. Further down, it is joined by six tributaries of which the important tributary Edmala joins the Periyar. Passing Malayattur and thereafter taking a meandering course, the river reaches Alwaye where it divides itself into two branches. The upper branch joins the Chalakudi River at Punthenvelikara and then expands into a broad sheet of

water at Munambham. The other branch taking a southerly course is broken up into a number of small channels, which fall into the Vembanad Lake as Varapuzha. During this journey, Periyar passes through Periyar Tiger Reserve. The river drains Idukki, Ernakulam and Thrissur districts of Kerala and Coimbatore districts in Tamilnadu. About 1500 sq. km is covered by forests.

Mullaperiyar dam is constructed at the confluence of Periyar and Mullayar River to form the Periyar Thappady Lake and reserve. From this lake, some water is diverted to Tamil Nadu via a tunnel. The diverted water after hydropower generation is let into Vougai River (tributary). The Periyar River flows down for a stretch of 35 km and after existing from Periyar Tiger reserve reaches Idukki reservoir formed by the Idukki, Cheruthoni and Kulamavu dams. Idukki dam is the longest hydro-electric project in the state and is located on Periyar River with an installed capacity of (6 x 130 MW) 780 MW through an underground power house at Moolamattom. The tail water is diverted into Thodupuzha tributary of Muvathupuzha River. There exists a number of hydro-power projects in the basin along with Periyar Valley irrigation Project in Ernakulum district besides supplying water for drinking and industrial uses.

10.4 Prediction of impacts

Prediction is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur because of the implementation of the project. Based on the project details and the baseline environmental status, potential impacts as a result of the construction and operation of the proposed project have been identified.

10.4.1 Impacts on environment

10.4.1.1 Construction phase

i) Sewage from labour camps

The project construction is likely to last for a period of 5 years. The peak labour strength likely to be employed during project construction phase is about 1500 workers and 500 technical staff. The employment opportunities in the area are limited. Thus, during the project construction phase, some of the locals may get

employment. It has been observed during construction phase of many of the projects; the major works are contracted out, who bring their own skilled labour. However, it is only in the unskilled category, that locals get employment.

The construction phase, also leads to mushrooming of various allied activities to meet the demands of the immigrant labour population in the project area. Based on experience of similar projects and above referred assumptions, the increase in the population as a result of migration of labour population during construction phase is expected to be of the order of 8,000.

The domestic water requirement has been estimated as 70 lpcd. Thus, total water requirements work out to 0.56 mld. It is assumed that about 80% of the water supplied will be generated as sewage. Thus, total quantum of sewage generated is expected to be of the order of 0.45 mld. The BOD load contributed by domestic sources will be about c 4450 kg/day. It is recommended to commission units for treatment of sewage generated from labour camps. In the proposed project, sewage is proposed to be treated, prior to disposal.

ii) Effluent from Fabrication Units and Workshops

The fabrication units and workshops which shall be functional during construction phase will generate effluents with high suspended solids and oil and grease level. It is proposed to treat the effluent from fabrication units and workshops in a oil and grease separate unit prior to disposal.

10.4.1.2 Operation phase

No major impacts on water environment are expected during construction phase.

10.4.2 Impacts on environment

10.4.2.1 Construction Phase

In a water resources project, air pollution occurs mainly during project construction phase. The major sources of air pollution during construction phase are:

- Pollution due to fuel combustion in various equipment

- Fugitive emissions from various sources.
- Blasting Operations
- Pollution due to increased vehicular movement
- Dust emission from muck disposal

i) Pollution due to fuel combustion in various equipment

The operation of various construction equipment requires combustion of fuel. Normally, diesel is used in such equipment. The major pollutant which gets emitted as a result of combustion of diesel is SO₂. The SPM emissions are minimal due to low ash content in diesel. The short-term increase in SO₂, even assuming that all the equipment are operating at a common point, is quite low, i.e. of the order of less than 1µg/m³. Hence, no major impact is anticipated on this account on ambient air quality.

ii) Fugitive Emissions from Various Sources

During construction phase, there will be increased vehicular movement. Lot of construction material like sand, fine aggregate are stored at various sites, during the project construction phase. Normally, due to blowing of winds, especially when the environment is dry, some of the stored material can get entrained in the atmosphere. However, such impacts are visible only in and around the storage sites. The impacts on this account are generally, insignificant in nature.

iii) Blasting Operations

Blasting will result in vibration, which shall propagate through the rocks to various degrees and may cause loosening of rocks/boulders. The overall impact due to blasting operations will be restricted well below the surface and no major impacts are envisaged at the ground level.

During tunneling operations, dust will be generated during blasting. ID blowers will be provided with dust handling system to capture and generated dust. The dust will settle on vegetation, in the predominant down wind direction. Appropriate control

measures have been recommended to minimize the adverse impacts on this account.

iv) **Pollution due to increased vehicular movement**

During construction phase, there will be increased vehicular movement for transportation of various construction materials to the project site. Similarly, these will be increased traffic movement on account of disposal of muck or construction waste at the dumping site. The maximum increase in vehicle is expected to 50 vehicles per hour. Large quantity of dust is likely to be entrained due to the movement of trucks and other heavy vehicles. Similarly, marginal increase in Hydrocarbons, SO₂ and NO_x levels are anticipated for a short duration. Modelling studies for hydrocarbon emissions were conducted and the results are given in **Table-10.1**.

TABLE-10.1

Increase in hydrocarbon concentration due to vehicular movement

Distance (m)	Increase in HC concentration ($\mu\text{g}/\text{m}^3$)
10	5
20	2.50
30	1.67
40	1.25
50	1.00
60	0.83
70	0.71
80	0.63
90	0.56
100	0.50

The increase in vehicular density is not expected to significant. In addition, these ground level emissions do not travel for long distances. Thus, no major adverse impacts are anticipated on this account.

v) Dust emission from muck disposal

The loading and unloading of muck is one of the source of dust generation. Since, muck will be mainly in form of small rock pieces, stone, etc., with very little dust particles. Significant amount of dust is not expected to be generated on this account. Thus, adverse impacts due to dust generation during muck disposal are not expected.

10.4.2.2 Operation Phase

In a water resources project, no major impact on air pollution is expected during project operation phase.

10.4.3 Impacts on Noise Environment**10.4.3.1 Construction phase**

In a water resource projects, the impacts on ambient noise levels are expected only during the project construction phase, due to earth moving machinery, etc. Likewise, noise due to quarrying, blasting, vehicular movement will have some adverse impacts on the ambient noise levels in the area.

i) Impacts due to operation of construction equipment

The noise level due to operation of various construction equipment is given in **Table-10.2**.

TABLE-10.2**Noise level due to operation of various construction equipment**

Equipment	Noise level dB(A)
Earth moving	
Compactors	70-72
Loaders and Excavator	72-82
Dumper	72-92
Tractors	76-92
Scrappers, graders	82-92

Equipment	Noise level dB(A)
Pavers	86-88
Truck	84-94
Material handling	
Concrete mixers	75-85
Movable cranes	82-84
Stationary	
Pumps	68-70
Generators	72-82
Compressors	75-85

Under the worst-case scenario, considered for prediction of noise levels during construction phase, it has been assumed that all these equipment generate noise from a common point. The increase in noise levels due to operation of various construction equipment is given in **Table-10.3**.

TABLE-10.3

Increase in noise levels due to operation of various construction equipment

Distance (m)	Ambient noise levels dB(A)	Increase in noise level due to construction activities dB(A)	Increased noise level due to construction activities dB(A)	Increase in ambient noise level due to construction activities dB(A)
100	36	45	45	34
200	36	39	39	29
500	36	31	31	25
1000	36	25	25	25
1500	36	21	21	24
2000	36	19	19	24

Distance (m)	Ambient noise levels dB(A)	Increase in noise level due to construction activities dB(A)	Increased noise level due to construction activities dB(A)	Increase in ambient noise level due to construction activities dB(A)
2500	36	17	17	24
3000	36	15	15	24

It would be worthwhile to mention here that in absence of the data on actual location of various construction equipment, all the equipment have been assumed to operate at a common point. This assumption leads to over-estimation of the increase in noise levels. Also, it is a known fact that there is a reduction in noise level as the sound wave passes through a barrier. The transmission loss values for common construction materials are given in **Table-10.4**.

TABLE-10.4

Transmission loss for common construction materials

Material	Thickness of construction material (inches)	Decrease in noise level dB(A)
Light concrete	4	38
	6	39
Dense concrete	4	40
Concrete block	4	32
	6	36
Brick	4	33
Granite	4	40

Thus, the walls of various houses will attenuate at least 30 dB(A) of noise. In addition there are attenuation due to the following factors.

- Air absorption
- Rain

- Atmospheric inhomogeneties.
- Vegetal cover

Thus, no increase in noise levels is anticipated as a result of various activities, during the project construction phase. The noise generated due to blasting is not likely to have any effect on habitations. However, blasting can have adverse impact on wildlife, especially along the alignment of the tunnel portion. It would be worthwhile to mention that no major wildlife is observed in and around the project site. Hence, no significant impact is expected on this account.

Impacts on labour

The effect of high noise levels on the operating personnel, has to be considered as this may be particularly harmful. It is known that continuous exposures to high noise levels above 90 dB(A) affects the hearing acuity of the workers/operators and hence, should be avoided. To prevent these effects, it has been recommended by Occupational Safety and Health Administration (OSHA) that the exposure period of affected persons be limited as per the maximum exposure period specified in **Table-10.5**.

Table-10.5

Maximum Exposure Periods specified by OSHA

Maximum equivalent continuous Noise level dB(A)	Unprotected exposure period per day for 8 hrs/day and 5 days/week
90	8
95	4
100	2
105	1
110	1/2
115	1/4
120	No exposure permitted at or above this level

10.4.3.2 Operation phase

In a water resources project, no major impact on noise environment is expected during project operation phase.

10.4.4 Impacts on Land Environment

10.4.4.1 Construction phase

The major impacts anticipated on land environment during construction are as follows:

- Operation of construction equipment
- Muck disposal
- Acquisition of land

i) Operation of construction equipment

During construction phase, various types of equipment will be brought to the site. These include crushers, batching plant, drillers, earthmovers, rock bolters, etc. The siting of this construction equipment would require significant amount of space. Similarly, space will be required for storing of various other construction equipment. Efforts must be made for proper siting of these facilities. Various criteria for selection of these sites would be:

- Proximity to the site of use
- Sensitivity of forests in the nearby areas
- Proximity from habitations
- Proximity to drinking water source(s)

Efforts must be made to site the contractor's working space in such a way that the adverse impacts on environment are minimal, i.e. to locate the construction equipment, so that impacts on human and faunal population is minimal.

ii) Muck disposal

Muck generation and disposal could lead to various adverse impacts. The muck needs to be disposed at designated sites. This could lead to following impacts:

- loss of land
- problems regarding stability of spoil dumps
- access to spoil dump areas

A part of the muck can be used for the following purposes:

- Use of suitable rock from the excavation as aggregate in the mixing of concrete.

- Use of muck for maintenance of roads.
- Use of muck in coffer dam.
- Use as backfill material in quarry and borrow pits.

The balance muck shall be disposed at designated sites. Muck, if not securely transported and dumped at pre-designated sites, can have serious environmental impacts, such as:

- Muck, if not disposed properly, can be washed away into the main river which can cause negative impacts on the aquatic ecosystem of the river.
- Muck disposal can lead to impacts on various aspects of environment. Normally, the land is cleared before muck disposal. During clearing operations, trees are cut, and undergrowth perishes as a result of muck disposal.
- In many of the sites, muck is stacked without adequate stabilisation measures. In such a scenario, the muck moves along with runoff and creates landslide like situations. Many a times, boulders/large stone pieces enter the river/water body, affecting the benthic fauna, fisheries and other components of aquatic biota.
- Normally muck disposal is done at low lying areas, which get filled up due to stacking of muck. This can sometimes affect the natural drainage pattern of the area leading to accumulation of water or partial flooding of some area which can provide ideal breeding habitat for mosquitoes.

iii) Acquisition of land

The total land to be acquired for the project is 127 ha. The About 111 ha of forest land and balance (16 ha) land to be acquired is private land. Based on the ownership status of land to be acquired for the project, appropriate compensatory measures shall be implemented.

10.4.4.2 Operation Phase

In the proposed project, no major impact is expected on land environment during project operation phase.

10.4.5 Impacts on Terrestrial Flora

10.4.5.1 Construction Phase

i) Increased human interferences

The direct impact of construction activity of any water resource project is generally limited in the vicinity of the construction sites only. As mentioned earlier, a large population (8,000) including technical staff, workers and other group of people are likely to congregate in the area during the project construction phase. It can be assumed that the technical staff will be of higher economic status and will live in a more urbanized habitat, and will not use wood as fuel, if adequate alternate sources of fuel are provided. However, workers and other population groups residing in the area may use fuel wood, if no alternate fuel is provided for whom alternate fuel could be provided. There will be an increase in population by about 8,000 of which about 6,400 are likely to use fuel wood. On an average, the fuel wood requirements will be of the order of 2,700 m³. The wood generated by cutting tree is about 2 to 3 m³. Thus, every year fuel wood equivalent to about 1500 trees will be cut, which means every year on an average about 2-2.5 ha of forest area will be cleared for meeting fuel wood requirements, if no alternate sources of fuel are provided. Hence to minimize impacts, community kitchens have been recommended. These community kitchens shall use LPG or diesel as fuel.

ii) Impacts due to Vehicular movement and blasting

Dust is expected to be generated during blasting, vehicle movement for transportation of construction material or construction waste. The dust particles shall settle on the foliage of trees and plants, thereby reduction in amount of sunlight falling on tree foliage. This will reduce the photosynthetic activity. Based on experience in similar settings, the impact is expected to be localized upto a maximum of 50 to 100 m from the source. In addition, the area experiences rainfall for almost 8 to 9 months in a year. Thus, minimal deposition of dust is expected on flora. Thus, no significant impact is expected on this account.

iii) Acquisition of forest land

During project construction phase, land will be required for location of construction equipment, storage of construction material, muck disposal, widening of existing roads and construction of new project roads. The total land requirement for the project is 127 ha, of which about 111 ha is forest land.

10.4.5.2 Operation Phase

In the proposed project, no major impact is expected on terrestrial flora during project operation phase.

10.4.6 Impact on Terrestrial fauna

10.4.6.1 Construction Phase

i) Disturbance to wildlife

Based on the field studies and interaction with locals, it was confirmed that no major wildlife is reported in the project area. The project area and its surroundings are not reported to serve as habitat for wildlife nor do they lie on any known migratory route. Thus, no impacts are anticipated on this account.

During construction phase, large number of machinery and construction workers shall be mobilized, which may create disturbance to wildlife population in the vicinity of project area. The operation of various equipment will generate significant noise, especially during blasting which will have adverse impact on fauna of the area. The noise may scare the fauna and force them to migrate to other areas. Likewise siting of construction plants, workshops, stores, labour camps etc. could also lead to adverse impact on fauna of the area. During construction phase, accessibility to area will lead to influx of workers and the people associated with the allied activities from outside will also increase. Increase in human interference could have an impact on terrestrial ecosystem. The other major impact could be the blasting to be carried out during construction phase. This impact needs to be mitigated by adopting controlled blasting and strict surveillance regime and the same is proposed to be used in the project. This will reduce the noise level and vibrations due to blasting to a great extent.

Likewise, siting of construction equipment, godowns, stores, labour camps, etc. may generally disturb the fauna in the area. However, no large-scale fauna is observed in the area. Thus, impacts on this account are not expected to be significant. However, few stray animals sometimes venture in and around the project site. Thus, to minimize any harm due to poaching activities from immigrant labour population, strict anti-poaching surveillance measures need to be implemented, especially during project construction phase. The same have been suggested as a part of the Environmental Management Plan (EMP).

10.4.6.2 Operation Phase

i) Increased accessibility

During the project operation phase, the accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem. The increased accessibility to the area can lead to increased human interferences in the form of illegal logging, lopping of trees, collection of non-timber forest produce, etc. Since significant wildlife population is not found in the region, adverse impacts of such interferences are likely to be marginal.

10.4.7 Impacts on Socio-Economic Environment

10.4.7.1 Construction Phase

A water resources project is likely to entail both positive as well as negative impacts on the socio-cultural fabric of the area. During construction and operation phases, a lot of allied activities will mushroom in the project area.

i) Impacts due to influx of labour force

During the construction phase a large labour force, including skilled, semi-skilled and un-skilled labour force of the order of about 2000 persons, is expected to immigrate into the project area. It is felt that most of the labour force would come from other parts of the country. However, some of the locals would also be employed to work in the project. The labour force would stay near to the project construction sites.

The project will also lead to certain negative impacts. The most important negative impact would be during the construction phase. The labour force that would work in the construction site would settle around the site. They would temporarily reside there. This may lead to filth, in terms of domestic wastewater, human waste, etc. Besides, other deleterious impacts are likely to emerge due to inter-mixing of the local communities with the labour force. Differences in social, cultural and economic conditions among the locals and labour force could also lead to friction between the migrant labour population and the total population.

ii) Economic impacts of the project

Apart from direct employment, the opportunities for indirect employment will also be generated which would provide great impetus to the economy of the local area. Various types of business like shops, food-stall, tea stalls, etc. besides a variety of suppliers, traders, transporters will concentrate here and benefit immensely as demand will increase significantly for almost all types of goods and services. The business community as a whole will be benefited. The locals will avail these opportunities arising from the project and increase their income levels. With the increase in the income levels, there will be an improvement in the infrastructure facilities in the area.

iii) Impacts due to land acquisition

Another most important deleterious impact during construction phase will be that, pertaining to land acquisition. About 127 ha of land proposed to be acquired for the proposed project. Based on present level of investigations, about 16 ha of private land is to be acquired.

As a part of EIA study, the quantum of private land to be acquired shall be finalized. Subsequently, the number of families likely to lose land or homestead or both needs to be identified. A detailed Resettlement and Rehabilitation Plan will be formulated, as per the guidelines of the “The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act 2013”.

10.4.7.2 Operation Phase

Apart from direct employment, the opportunities for indirect employment will also be generated which would provide great impetus to the economy of the local area. Various types of business like shops, food-stall, tea stalls, etc. The impact is expected to be positive, though at a level lower than that observed during project construction phase.

10.5 Environmental Management Plan

Based on the environmental baseline conditions and project inputs, the adverse impacts will be identified and a set of measures will be suggested as a part of Environmental Management Plan (EMP) for their amelioration. An outline of various measures suggested as a part of Environmental Management Plan is briefly described in the following sections.

10.5.1 Facilities in labour camps

It is recommended that project authorities can compulsorily ask the contractor to make semi-permanent structures for their workers. These structures could be tin sheds. These sheds can have internal compartments allotted to each worker family. The sheds will have electricity and ventilation system, water supply and community latrines.

The water for meeting domestic requirements may be collected from the rivers or streams flowing upstream of the labour camps.

One community toilet can be provided per 20 persons. The sewage from the community latrines can be treated in a sewage treatment plant before disposal.

10.5.2 Solid waste management from labour camps

For solid waste collection, suitable number of masonry storage vats, each of 2 m³ capacity should be constructed at appropriate locations in various labour camps. These vats should be emptied at regular intervals and should be disposed at identified landfill sites. Suitable solid waste collection and disposal arrangement shall

be provided. A suitable landfill site should be identified and designed to contain municipal waste from various Project Township, labour colonies, etc.

10.5.3 Provision of free fuel

During the construction period of the project, there would be around 600 labour and technical staff would be involved in the project construction work. Many families may prefer cooking on their own instead of using community kitchen. In the absence of fuel for cooking, they would resort to tree cutting and using wood as fuel. To avoid such a situation, the project authority should make LPG and/ or kerosene available to these migrant workers. The supply of LPG and kerosene can be ensured on regular basis. A local depot can be established through LPG/ kerosene suppliers for supply of the same.

10.5.4 Muck Disposal

A part of the muck generated, is proposed to be utilised for construction works after crushing it into the coarse and fine aggregates. The balance quantum of muck would have to be disposed. The muck shall be disposed in low-lying areas (preferably over non-forest land). The sites shall then be stabilized by implementing bioengineering treatment measures.

The overall idea is to enhance/maintain aesthetic view in the surrounding area of the project in post-construction period and avoid contamination of any land or water resource due to muck disposal.

Suitable retaining walls shall be constructed to develop terraces so as to support the muck on vertical slope and for optimum space utilization. Loose muck would be compacted layer wise. The muck disposal area will be developed in a series of terraces of boulder crate wall and masonry wall to protect the area/muck from flood water during monsoons. In-between the terraces, catch water drain will be provided. The terraces of the muck disposal area will be ultimately covered with fertile soil and suitable plants will be planted adopting suitable bio-technological measures. Various activities proposed as a part of the management plan are given as below:

- Land acquisition for muck dumping sites
- Civil works (construction of retaining walls, boulder crate walls etc.)

- Dumping of muck
- Levelling of the area, terracing and implementation of various engineering control measures e.g., boulder, crate wall, masonry wall, catchwater drain.
- Spreading of soil
- Application of fertilizers to facilitate vegetation growth over disposal sites.

For stabilization of muck dumping areas following measures of engineering and biological measures have been proposed.

Engineering Measures

- Wire crate wall
- Boulder crate wall
- Retaining wall
- Catch water Drain
-

Biological Measures

- Plantation of suitable tree species and soil binding species
- Plantation of ornamental plants
- Barbed wire fencing

10.5.5 Compensation for Acquisition of Forest Land

As per the present level of investigations, about 111 ha of forest land is to be acquired. The quantum of land to be acquired shall be finalized as part of the EIA Study. Based on the ownership status of land to be acquired, it is proposed to afforest twice the forest area being acquired for the project. The species for afforestation shall be selected in consultation with local forest department.

10.5.6 Wildlife Conservation

It is recommended to commission check posts along major sites, i.e. power house site, labour camps, construction material storage site, etc. during project construction phase. Each check post will have 4 guards. One Range Officer would be employed to supervise the operation of these check-posts and ensure that poaching does not

10.5.7 Greenbelt Development

The green belt on either side of the reservoir will reduce the sedimentation and ensure protection of the reservoir area from any other human activity that could result in the reservoir catchment damage. On moderately steep slopes tree species will be planted for creation of green belt which are indigenous, economically important, soil binding in nature and an thrive well under high humidity and flood conditions. In addition greenbelt is recommend around permanent colony for the project.

10.5.8 Public Health Delivery System

- The site selected for habitation of workers shall not be in the path of natural drainage.
- Adequate drainage system to dispose storm water drainage from the labour colonies shall be provided.
- Adequate vaccination and immunization facilities shall be provided for workers at the construction site.
- The labour camps and resettlement sites shall be at least 2 km away from a main water body or quarry areas.

- Clearing of river basins, shoreline, mats and floating debris, etc. to reduce the proliferation of mosquitoes.
- Development of medical facilities in the project area and near labour camps

- Implementation of mosquito control activities in the area.

Temporary first aid posts shall be provided at major construction sites. These will be constructed with asbestos sheets, bamboo, etc.

10.5.9 Maintenance of Water Quality

The sewage generated from the labour camps, as mentioned earlier, is proposed to be treated in sewage treatment plant prior to disposal. In the project operation phase, a plant colony with about 50 quarters is likely to be set up. The sewage so generated would be treated through a sewage treatment plant, equipped with secondary treatment units.

10.5.10 Control of Noise

a) Noise due to construction equipment

The contractors will be required to maintain properly functioning equipment and comply with occupational safety and health standards. The construction equipment will be required to use available noise suppression devices and properly maintained mufflers.

- Vehicles to be equipped with mufflers recommended by the vehicle manufacturer.
- Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible.
- Notification will be given to residents within 100 m of major noise generating activities. The notification will describe the noise abatement measures that will be implemented.
- Monitoring of noise levels will be conducted during the construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to stop work and remedy the situation prior to continuing construction.

The following Noise Standards for DG sets are recommended for the running of DG sets during the construction:

- The maximum permissible sound pressure level for new diesel generator sets with rated capacity upto 1000 KVA shall be 75 dB(A) at 1 m from the enclosure surface.
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.
- The Acoustic Enclosure should be made of CRCA sheets of appropriate thickness and structural/ sheet metal base. The walls of the enclosure should be insulated with fire retardant foam so as to comply with the 75 dBA at 1m sound levels specified by CPCB, Ministry of Environment & Forests.
- The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB(A) Insertion Loss or for meeting the ambient noise standards, whichever is on the higher side.
- The DG set should also be provided with proper exhaust muffler.
- Proper efforts to be made to bring down the noise levels due to the DG set, outside its premises, within the ambient noise requirements by proper siting and control measures.
- A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

b) Noise due to crusher

Based on literature review, noise generated by a crusher is in the range of 79-80 dB(A) at a distance of 250 ft or about 75 m from the crusher. Thus, noise level at a distance of 2 m from the crusher shall be of the order of 110 dB(A). The exposure to labour operating in such high noise areas shall be restricted upto 30 minutes on a daily basis. Alternatively, the workers need to be provided with ear muffs or plugs, so as to attenuate the noise level near the crusher by atleast 15 dB(A). The exposure to noise level in such a scenario to be limited upto 4 hours per day.

It is known that continuous exposure to noise levels above 90 dB(A) affects the hearing of the workers/operators and hence has to be avoided. Other physiological and psychological effects have also been reported in literature, but the effect on hearing acuity has been specially stressed. To prevent these effects, it has been recommended by international specialist organizations that the exposure period of affected persons be limited as specified in Table-10.5.

The contractors will be required to maintain properly functioning equipment and comply with occupational safety and health standards. The construction equipment will be required to use available noise suppression devices and properly maintained mufflers.

- Vehicles to be equipped with mufflers recommended by the vehicle manufacturer.
- Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible.
- Notification will be given to residents within 100 m of major noise generating activities. The notification will describe the noise abatement measures that will be implemented.
- Monitoring of noise levels will be conducted during the construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to stop work and remedy the situation prior to continuing construction.

10.5.11 Control of Air Pollution

a) Control of Emissions

Minor air quality impacts will be caused by emissions from construction vehicles, equipment and DG sets, and emissions from transportation traffic. Frequent truck trips will be required during the construction period for removal of excavated material and delivery of select concrete and other equipment and materials. The following measures are recommended to control air pollution:

- The contractor will be responsible for maintaining properly functioning construction equipment to minimize exhaust.

- Construction equipment and vehicles will be turned off when not used for extended periods of time.
- Unnecessary idling of construction vehicles to be prohibited.
- Effective traffic management to be undertaken to avoid significant delays in and around the project area.
- Road damage caused by sub-project activities will be promptly attended to with proper road repair and maintenance work.

b) Air Pollution control due to DG sets

The Central Pollution Control Board (CPCB) has issued emission limits for generators upto 800 KW. The same are outlined in Table-6, and are recommended to be followed.

TABLE-10.6
Emission limits for DG sets prescribed by CPCB

Parameter	Emission limits (gm/kwhr)
NOx	9.2
HC	1.3
CO	2.5
PM	0.3
Smoke limit*	0.7

Note : * Light absorption coefficient at full load (m^{-1})

The above standards needs to follow by the contractor operating the DG sets.

The other measures are recommended as below:

- Location of DG sets and other emission generating equipment should be decided keeping in view the predominant wind direction so that emissions do not effect nearby residential areas.
- Stack height of DG sets to be kept in accordance with CPCB norms, which prescribes the minimum height of stack to be provided with each generator set to be calculated using the following formula:

$$H = h + 0.2 \times \sqrt{KVA}$$

H = Total height of stack in metre

h = Height of the building in metres where the generator set is installed

KVA = Total generator capacity of the set in KVA

c) Dust Control

The project authorities will work closely with representatives from the community living in the vicinity of project area to identify areas of concern and to mitigate dust-related impacts effectively (e.g., through direct meetings, utilization of construction management and inspection program, and/or through the complaint response program).

To minimize issues related to the generation of dust during the construction phase of the project, the following measures have been identified:

- Identification of construction limits (minimal area required for construction activities).
- When practical, excavated spoils will be removed as the contractor proceeds along the length of the activity.
- When necessary, stockpiling of excavated material will be covered or staged offsite location with muck being delivered as needed during the course of construction.
- Excessive soil on paved areas will be sprayed (wet) and/or swept and unpaved areas will be sprayed and/or mulched. The use of petroleum products or similar products for such activities will be strictly prohibited.
- Contractors will be required to cover stockpiled soils and trucks hauling soil, sand, and other loose materials (or require trucks to maintain at least two feet of freeboard).
- Contractor shall ensure that there is effective traffic management at site. The number of trucks/vehicles to move at various construction sites to be fixed.
- Dust sweeping - The construction area and vicinity (access roads, and working areas) shall be swept with water sweepers on a daily basis or as necessary to ensure there is no visible dust.

10.6 Resettlement and Rehabilitation Plan

About 16 ha. of private land is to be acquired for various project appurtenances. Based on the present level of investigations, the number of project affected families is not available. The number of families likely to lose land will be finalized. In

addition, information of any family losing homestead or other private properties shall also be ascertained. Socio-economic survey for the Project Affected Families (PAFs) will be conducted. Based on the findings of the survey an appropriate Resettlement and Rehabilitation Plan will be formulated as per the norms and guidelines of R&R Act 2013.

10.7 Infrastructure Development under Local Area Development Committee (LADC)

A lump-sum budget @ 0.5% of the Project Cost has been earmarked for construction of Infrastructure and Local Area Development Committee works. The activities envisaged are given as below:

- Education Facilities
- Strengthening of existing PHSCs/ Health Care Facilities
- Bus Stops
- Approach Roads and Widening of Existing Road
- Infrastructure and Community Development
- Drinking Water Supply and Restoration of Dried Up Sources
- Miscellaneous activities

10.8 Environmental Monitoring Programme

The Environmental Impact Assessment is basically an evaluation of future events. It is necessary to continue monitoring certain parameters identified as critical by relevant authorities under an Environmental Monitoring Programme. This would anticipate any environmental problem so as to take effective mitigation measures. An Environmental Monitoring Programme will be formulated for implementation during project construction and operation phases. The cost estimates and equipment necessary for the implementation of this programme shall also be covered as a part of the Comprehensive EIA study.

The Environmental monitoring programme for implementation during construction and operation phases is given in Tables-10.7 and 10.8 respectively.

TABLE-10.7

**Summary of Environmental Monitoring Programme during
Project Construction Phase**

S. No.	Item	Parameters	Frequency	Location
1.	Effluent from septic tanks	pH, BOD, COD, TSS, TDS	Once every month	Before and after treatment from Sewage Treatment plant
2.	Water-related diseases	Identification of water related diseases, adequacy of local vector control and curative measure, etc.	Three times a year	Labour camps and colonies
3.	Noise	Equivalent noise level (L_{eq})	Once in three months	At major construction sites.
4.	Air quality	PM ₁₀ SO ₂ and NO ₂	Once every season	At major construction sites

TABLE-10.8

**Summary of Environmental Monitoring Programme during
Project Operation Phase**

S. No.	Items	Parameters	Frequency	Location
1.	Water	pH, Temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates, Nitrates, DO. COD, BOD, Iron, Zinc,	Thrice a year	1 km upstream of dam site - Reservoir area 1, 5 and 10 km downstream of Tail Race discharge

S. No.	Items	Parameters	Frequency	Location
		Manganese		
2.	Effluent from Sewage Treatment Plant (STP)	pH, BOD, COD, TSS, TDS	Once every week	Before and after treatment from Sewage Treatment Plant (STP)
3.	Erosion & Siltation	Soil erosion rates, stability of bank embankment, etc.	Twice a year	-
4.	Ecology	Status of afforestation programmes of green belt development	Once in 2 years	-
5.	Water-related diseases	Identification of water-related diseases, sites, adequacy of local vector control measures, etc.	Three times a year	Villages adjacent to project sites
6.	Aquatic ecology	Phytoplanktons, zooplanktons, benthic life, fish composition	Once a year	1 km upstream of dam site - Reservoir area 1, 5 and 10 km downstream of Tail Race discharge
7.	Landuse	Landuse pattern using satellite data	Once in a year	Catchment area
8.	Soil	pH, EC, texture, organic matter	Once in a year	Catchment area

10.9 Cost Estimates

The total amount to be spent for implementation of Environmental Management Plan (EMP) is Rs. 257 million. The details are given in Table-10.9.

TABLE-10.9

Cost for Implementing Environmental Management Plan

S. No.	Item	Cost (Rs. Lacs)
1.	Compensatory Afforestation NPV, Bio-diversity conservation	280
2.	Public health delivery system	100
3.	Environmental Management in labour camp	80
4.	Muck management	80
5.	Restoration and Landscaping of construction sites	30
6.	Air pollution control	50
7.	Noise control measures	20
8.	Water pollution control	15
9.	Resettlement and Rehabilitation Plan	550
10.	Fund for Local Area Development Activities @ 0.5% of project cost	1335
11.	Environmental Monitoring during construction phase	30
	Total	2570

Note: Cost for NPV, Biodiversity Conservation shall be in addition to above and to be finalised at the time of Forest Clearance.

CHAPTER-11: POWER EVACUATION

CHAPTER – 11

11. POWER EVACUATION

11.1 Introduction

The power generated at Idukki Extension Scheme (IES) H.E. Project, 800 MW (4x200 MW) will be integrated with National grid and mostly be utilized in the peaking hour.

11.2 Power Evacuation Arrangement

The proposed Idukki Extension Scheme H.E. Project is of the installed capacity of 800 MW which consists of 4 unit of 200 MW each. Therefore, the proposed power evacuation scheme is detailed as follows considering the Six 220 kV feeders:

- IES - New Pallom
- IES – Kothamangalam
- IES – Aluva I
- IES – Aluva II
- IES – Kalamasserry I
- IES – Kalamasserry II

11.3 Proposed construction of Transmission lines:

The following strengthening of existing transmission line is envisaged to evacuate the power of Idukki Existing HEP and proposed Idukki Extension HEP as per discussions with KSEB. The same shall be finalised at DPR stage.

- Existing Idukki – Pallom Single Circuit feeder may be converted to Double Circuit Feeder. One feeder connected to Idukki & the other feeder connected to IES.
- After charging of Pallivasal – Kothamangalam 220 kV feeder, the Idukki – Madakkathara 220 kV feeder to be converted to 4 Nos. 220 kV feeders on

Multi Towers upto Karukadam. From Karukadam, one feeder each from Idukki & IES connected to 220 kV Sub Station, Kothamangalam.

- Construction of 220 kV DC feeder from Karukadam to Nellimolam along the existing Right of Way of Idukki - Madakkathara feeder. At crossing point of Kothamangalam – Aluva 66 kV feeder, take the Right of Way of Kothamangalam - Aluva feeder on Multi Circuit Multi Voltage towers.
- Construction of existing Idukki – Kalamasserry I & II feeders as 4 Nos. of 220 kV feeders on Multi Circuit Towers with two feeders each connected to Idukki & Idukki Extension Scheme.

CHAPTER-12: COST ESTIMATE

CHAPTER – 12

12. COST ESTIMATE

12.1 Project Cost

A summary of the cost estimate, including direct and indirect charges for the Civil & Electro-mechanical works at August, 2021 Price Level has been worked out as given below:

Item	Estimated Cost (₹. Lacs)
Civil Works	₹ 130967.12
Electro-mechanical Works	₹ 136000.00
Total	₹ 266967.00

The estimate has been prepared to arrive at the capital cost of Idukki Extension Scheme Hydro Electric Project, Kerala. The estimate is of Feasibility Report level and has been prepared on the basis of “Guide Lines for preparation of cost estimates for River Valley Projects” published by Central Water Commission, Govt. of India, New Delhi. The Abstract of Estimated Cost along with cost estimation of civil all components is enclosed at **Annexure-12**. The above cost does not include the cost of Transmission.

12.2 Basis of Estimate

The estimate for Civil & Hydro-mechanical civil works have been prepared based on following:

- I. The basic material and labour rates has been adopted as per “Schedule of Rates 2012” published by Public Works Department (Govt. of Kerala) along with relevant cost index escalation released by KSEBL w.e.f. from 27.08.2021 for Idukki District. During DPR studies, as per recent guidelines by KSEB, DSR 2021 released by CPWD will be adopted.

- II. The rates which were not available in the above SoR, have been adopted by updation to current price level from the recently approved H.E. Projects having similar parameters and working conditions.
- III. The rates of materials are inclusive of GST as applicable.
- IV. Interest and escalation during construction period is not considered.

Quantity estimate have been carried out by calculating the quantities of different work items involved. Unit rate corresponding to major item of works have been worked out by analysis of rate based on prevailing market rates. Some rates of major item of works, lump sum provision have been made based on the other similar projects. The following guidelines have been referred for the preparation of this cost estimate:

- “Guidelines for Formulation of Detailed Project Reports for Hydro Electric Schemes, their Acceptance and Examination for Concurrence” dated January, 2015 (Revision 5) by Central Electricity Authority, Govt. of India
- “Guidelines for preparation of estimates for the river valley projects” issued by CWC and Indian Standard IS: 4877 “Guide for Preparation of Estimate for River Valley Projects”.

12.3 Classification of Civil Works into Minor Head/Sub Heads

The cost has been classified into direct and indirect charges and covered under the following minor heads:

A. Direct Charges

I. Works

- A - Preliminary
- B - Land
- C - Works
- J - Power Plant Civil Works
- K - Buildings
- M - Plantation

- O - Miscellaneous
- P – Maintenance during construction
- Q - Special T&P
- R - Communications
- S - Power Plant and Electro- Mechanical system
- X - Environment and ecology
- Y - Losses on stock

Total I-Works

- II. Establishment
- III. Tools and Plants
- IV. Suspense
- V. Receipts and Recoveries on Capital Account

Total (A) – Direct Charges**B. Indirect Charges**

- I. Capitalized Value of Abatement of Land Revenue
- II. Audit and Account Charges

Total (B) – Indirect Charges**Total Cost (A+B)****12.3.1 Direct Charges****I –Works**

Current Cost = ₹. 1,22,818.53 Lacs

The minor head I-Works has been subdivided in to the following detailed subheads:

A-Preliminary

Current Cost: ₹ 2,012.03 Lacs

Under this head provision has been made for surveys and investigations to be conducted at DPR stage and later to arrive at the optimum of the project

components. Provision for in-house Design & Engineering and consultancy charges has been kept under this head as 2% of cost of C & J Works.

B-Land

Current Cost: ₹ 10,595.77 Lacs

This covers the provision for Acquisition of land, rehabilitation & resettlement including compensation for property, Interest charges, Solatium charges, demarcation & measurement charges etc. Estimation for B-Land charges as per actual requirements.

C- Works

Current Cost: ₹ 1,208.34 Lacs

This sub-head covers the cost of the Head works viz. Coffor Dam. Other than coffer dam, no other head work is being constructed for the proposed scheme.

J- Power Plant Civil Works

Current Cost ₹ 99,393.38 Lacs

This This covers the cost of Civil Works of Power Tunnel Intake structures, Head Race Tunnel, Surge Shaft, Pressure Shaft, Power House, Transformer Cavern & Tail Race Tunnel & Channel etc. along with associated Hydro-mechanical equipments.

K- Buildings

Current Cost: ₹ 2,012.03 Lacs

A provision @ 2% of C-J Works has been made towards temporary and permanent buildings (both residential and non-residential) proposed to be built in colonies for various locations of the project area. The buildings included under the permanent category are all those buildings, which will be subsequently utilized during the state of running and maintenance of the project.

M- Plantation

Current Cost: ₹ 10.00 Lacs

The provisions under this head cover the plantation programme including Gardens etc. required for beautification as considered necessary downstream of Dam and appurtenances around Power House and other important structure.

Lump Sum provision under this head includes cost of plantation in colonies, along approach roads, landscaping and improvements of area around powerhouse.

O- Miscellaneous

Current Cost: ₹ 2,012.03 Lacs

Under this head provision is generally made to cover the cost of the following miscellaneous works:

- a) Capital cost of electrification, water supply, sewage disposal, firefighting equipment etc.
- b) Repair and maintenance of electrification water supply, sewage disposal, medical assistance, recreation, post office telephone office security arrangements, firefighting, inspection vehicles, schools, transport of labour etc.
- c) Other services such as laboratory testing, R&M of Guest House and transit camps, Community center and photographic instruments as well as R&M charges etc.

As the estimate is of Feasibility Report level, percentage provision @ 2% of C-J works has been considered towards head O- Miscellaneous.

P- Maintenance

Current Cost: ₹.1,026.14 Lacs

For maintenance of buildings, roads and other structures during construction period, provision @ 1% of C-works, J-Power Plant civil works, K- buildings have been kept.

Q- Special T&P

Current Cost: ₹ 227.27 Lacs

It is assumed that the work will be carried through Contracts and accordingly nominal provision for procurement of necessary equipment for taking up the work at the earliest by the contractor have been made. The total expenditure towards this will be recovered from the contractors and the same is credited under receipt and recoveries.

Adequate provision is made for inspection vehicles and cost for resale of vehicles is accounted for under receipt and recoveries.

R-Communication

Current Cost: ₹. 1,495.00 Lacs

Provision under this head covers the cost of construction of roads and bridges for project works. The provision is Lump sum only at this stage based on preliminary assessments as detailing shall be done later on.

X-Environment and Ecology

Current Cost: ₹. 2,570.00 Lacs

This sub head is intended to cover the provisions for environmental and ecological measure like compensatory afforestation, public health measures, fuel for employees & restoration of land in construction areas by filling, grading etc. Provision for prevention of soil erosion and preservation of flora and fauna including measure for enforcing anti-poaching laws etc. have also been made. Land to be acquired may affect some habitation and as such necessary provision for compensation and rehabilitation has been made in the estimate. The estimate details can be referred from Table 10.9.

Y-Losses on Stock

Current Cost: ₹ 256.53 Lacs

The provision under this head have been made @ 0.25% of the cost of I-Works less A-Preliminary, B-Land, Q-Miscellaneous, M-Plantation, P-Maintenance, Q-Special T&P and Environment and Ecology.

II-Establishment

Current Cost: ₹ 7,488.91 Lacs

Provision for establishment including establishment of cost control cell at the project and Head Quarter Level has been made as per “Guidelines for Formulation of Detailed Project Reports for Hydro Electric Schemes, their Acceptance and Examination for Concurrence” by CEA @ 60 Cr + 4% of I-Works less B-Land exceeding 750 Cr. For projects having Cost of Civil works (I – B) between 750 Cr. To 1500 Cr.

III- Tools &Plants

Current Cost: ₹.200.00 Lacs

The provision is distinct from that under Q-Special T&P and is meant to cover cost of survey instruments, camp equipment and other small tools & plants. As per the CEA guideline, a token provision of Rs. 1-2 crores under this head may be adequate. A provision of 2 cr. has been kept under this head.

IV-Receipt &Recoveries

Current Cost's. (-) ₹ 112.27 Lacs

The provision under this head cover the estimated recoveries by way of resale of temporary buildings, transfer of construction equipment, inspection vehicles, generators etc. Provision @ 75% of Q- Special T&P has been considered towards IV=Receipt & Recoveries.

12.3.2 Indirect Charges

Current Cost: ₹. 571.94 Lacs

Provisions under this head have been made for capitalized value of abatement of land revenue. Besides, provision for Audit & Account Charges has been made at 0.25 % of the cost of I-Works.

12.4 Electro-Mechanical Works

Current Cost: ₹ 1,36,000.00 Lacs

The total cost of Electro-Mechanical works at August, 2021 level works out to be: ₹ 136000.00 Lacs, which includes, the cost of main Electro-Mechanical equipment (excluding the transmission system) such as turbines, generators, transformers etc. based on the prevailing market prices in India and abroad. Suitable provision for transportation, erection and commissioning charges, freight and insurance etc. have been adequately made as per general guidelines issued by CEA. Provision for establishment and Audit and Account charges for the electro-mechanical works have also been made under this cost separately.

Annexure - 12

IDUKKI EXT. SCHEME

GENERAL ABSTRACT OF COST

Sl. No.	DETAILED HEAD OF WORKS	Amount (Rs. Lacs)
A	CIVIL WORKS	
1	DIRECT CHARGES	
	I-WORKS	
	A-Preliminary	2012.03
	B-Land	10595.77
	C-Works	1208.34
	J-Power Plant Civil Works including H-M Works	99393.38
	K-Building (2% of C-J Works)	2012.03
	M-Plantation LS	10.00
	O-Miscellaneous (2% of C-J Works)	2012.03
	P-Maintenance during construction @1% of C, J & K	1026.14
	Q-Special T&P	227.27
	R-Communication	1495.00
	X-Environment & Ecology	2570.00
	Y-Losses on Stock @0.25% of C,J & K	256.53
	Total of I-Works	122818.53
	II-ESTABLISHMENT	7488.91
	III-TOOLS & PLANTS	200.00
	IV-SUSPENSE	0.00
	V-RECEIPT & RECOVERIES (-)	-112.27
	Total of Direct Charges	130395.18
2	Indirect Charges	
	(a) Capitalised value of abatement of land revenue @ 5% of cost of culturable land	264.89
	(b) Audit & Account Charges (@ 0.25% of I-Works)	307.05
	Total of Indirect Charges	571.94
	Total Cost (Direct charges + Indirect Charges)	130967.12
	Total Cost Civil Works	130967.12
A	Civil Works	130967.12
B	Electo-Mechanical Works	136000.00
	Total Cost	266967.12

IDUKKI EXTENSION SCHEME			
Abstract of Rates for Principal Construction Materials			
Sl.No	Description of Item	Unit	Rate a in Rs.
1	Loose or unconsolidated excavation other than trenches	cum	761
2	Material excavated from rocky ground through blasting	cum	1383
3	Removal of Material arising from overbreak	cum	566
4	Concrete M15 (Pumped concrete)	cum	6322
5	Concrete M20 (Pumped concrete)	cum	6389
6	Concrete M25 (Pumped concrete)	cum	6791
7	Concrete-M30 (Pumped Concrete)	cum	7190
8	Concrete M35 (Pumped Concrete)	cum	7589
9	Shotcrete Plain	cum	8929
10	Shotcrete with Steel Fibre	cum	16187
11	Earthfill Material for Coffe Dam	cum	921
12	Stone Pitching	cum	2524
13	Rock Bolting-25mm dia including Drilling	m	1475
14	Rock Bolting-32 m dia including Drilling	m	1518
15	Drilling of grout holes	m	408
16	Drilling of Drainage hole	m	1520
17	Mild steel reinforcement (Mild steel round and tor steel)	MT	110836
18	ASTM-537 Gr. II Steel Liner for Penstock	MT	222605
19	ASTM-517 Gr. F Steel Liner for Penstock	MT	361302
20	Rock Excavation- in tunnel Underground	cum	2604
21	Pressure Shaft Excavation (Raise Borer)	cum	3282
22	Contact Grouting	MT	18619
23	Consolidation Grouting	MT	18619
24	PVC Rubber Water Stop	m	2281
25	Wire Mesh 2"	sq.m	994
26	Fabrication & Erection - Steel supports	MT	120188
27	Surge Shaft Excavation (Raise Borer)	cum	2464
28	Precast lagging	cum	12900
29	Crushed sand	cum	931
30	Fabrication and Erection of Trash Rack	MT	120188
31	75 mm dia G I pipe	m	945
32	Cement	MT	9599
33	Cable Anchor	RM	20000
34	ISMB 250 Steel Ribs	MT	83690
35	Road 10 m formation width	km	32143530

A-PRELIMINARY					
Sl. No.	Item	Quantity	Unit	Rate Rs.	Amount
1	Cost of surveys and investigation including geological investigation, hydrological investigation, preliminary construction materials surveys, access paths and roads etc. at PFR stage	LS @ 2% of the cost of C-J Works			2012.03
2	Topographical & other surveys for HRT, TRT & Powerhouse etc.				
3	Geological Investigation				
4	Drilling & Drifting				
5	Construction Material Survey				
6	Hydrological and meteorological observations				
7	Geophysical survey, seimological study				
8	Hydraulic model studies				
9	Charges for preliminary consultancy & specialists				
10	Training of Engineers during Investigation				
11	Instuments and equipments for S & I works				
12	Stationary, writing of completion report & history of project				
					2012.03

C-WORKS		
ABSTRACT OF COST		
Sr. No.	Item	Amount (Rs. Lacs)
1	Coffer Dam	1208.34
	Total for C-Works	1208.34
	Say	1208
J-WORKS		
ABSTRACT OF COST		
Sr. No.	Item	Amount (Rs. Lacs)
1	Intake	2299
2	Intake Gate Shaft	1275
3	Intake Tunnel and HRT	14621
4	Surge Shaft	2922
5	Inclined Pressure Shaft	25983
6	Penstock	3629
7	Main Access Tunnel	6470
8	Power House	11792
9	Transformer Cavern with Bus Tunnel	7621
10	Adit to Surge Shaft, Middle of Pressure Shaft and CAT	6347
11	Tail Race Tunnel	12329
12	Tail race Channel	2278
13	H&M Works for J-works	1827
	Total Cost of J-Works	99393
	Say	99393

C - CIVIL WORKS					
ABSTRACT					
S. No	Description				Total Amount (INR In Lakh)
1	COFFER DAM				1208.34
	Total of C-Works				1208.34
DETAILED COST ESTIMATE					
S.No.	Description	Quantity	Unit	Unit Rate INR	Total Amount (INR in Lakh)
1.0	COFFER DAM				SECTION-1
a)	Construction of Coffe Dam				
1	Common Excavation	12600	m ³	761	95.91
2	Stone Pitching	6860	m ³	2524	173.15
3	Filter	6860	m ³	3155	216.43
4	Impervious Material	20580	m ³	1151	236.92
5	Earthfill Material	153738	m ³	921	1415.88
				A - TOTAL	722.41
b)	Deassembling Coffe Dam				
1	Breaking	188037.50	m ³	100	188.04
2	Transportation	188038	m ³	100	188.04
				B - TOTAL	376.08
	Sub total Coffe Dam				1098.49
a	Dewatering @ 5% of sub total II			5%	54.92
b	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.			5%	54.92
	TOTAL FOR COFFER DAM				1208.34

J-Works

Reservoir Inlet					
SI No.	Item Details	Quantity	Unit	Rate Rs.	Amount (Rs. Lacs)
1	Cleaning, Grubbing & Stripping	LS			5.00
2	Excavation- soil	3360.00	cum	761.21	25.58
3	Excavation - Rock	33600.00	cum	1382.86	464.64
4	Concrete (M25)	10309.79	cum	6791.00	700.14
5	Precast Lagging	0.00	cum	12900.00	0.00
6	Reinforcement	809.32	MT	110836.00	897.02
7	Rock Bolt 25 mm dia	0.00	cum	1474.85	0.00
8	Rock Bolt 32 mm dia	298.67	m	1517.61	4.53
9	Normal Shortcrete	56.00	cum	8929.00	5.00
10	Trashrack (MT)	21.93	MT	120188.28	26.35
11	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				106.41
12	Dewatering @ 3%				63.85
	Total				2298.52
	G. Total				Say 2299

INTAKE GATE SHAFT With Transition on Both Sides					
SI No.	Item Details	Quantity	Unit	Rate Rs.	Amount (Lakh)
1	Open Excavation- soil	0	cum	761	0.00
2	Open Excavation- Rock	919	cum	1383	12.71
3	Shaft Excavation- Rock	9191	cum	2464	226.51
4	Non-Core Drilling for Consolidation Grouting	1238	m	408	5.05
5	Grouting Material (Cement)	15	MT	18619	2.88
6	Lining Concrete (M20)	2431	cum	6389	155.32
7	Backfill Concrete M-15	1325	cum	6322	83.78
8	Reinforcing Steel	191	MT	110836	211.52
9	Waterstop	198	m	2281	4.52
10	SFRS	474	cum	16187	76.71
11	Rockbolt 32 mm dia	25173	m	1518	382.03
12	Rockbolt 25 mm dia	2010	m	1475	
13	Drilling for Drainage Holes	180	m	1520	2.74
14	Precast Lagging	127	cum	12900	16.37
15	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				59.01
16	Dewatering @3%				35.40
				Total	1274.56
	Say				1275

HRT					
SI No.	Item Details	Quantity	Unit	Rate Rs.	Amount (Rs. Lacs)
1	Excavation	96354	cum	2604	2509.09
2	Overbreak in Underground Excavation	9635	cum	1383	133.24
3	Steel Ribs	803	MT	83690	672.11
4	Rock bolt				
	32 mm dia	235835	m	1518	3579.05
	25 mm dia	69457	m	1475	1024.39
5	SFRS	6738	cum	16187	1090.73
6	Drilling Drain holes	4343	m	1520	66.02
7	Consolidation & Contact Grouting Holes	29819	m	408	121.67
8	Pressure Grouting with Cement	373	MT	18619	69.40
9	Concrete of grade M-15 in backfill	10443	cum	6322	660.21
10	Lining Concrete(M-25)	21995	cum	6791	1493.66
11	Steel Reinforcement	1727	MT	110836	1913.67
12	Precast Lagging	1590	cum	12900	205.08
13	Dewatering @ 3%				406.15
14	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				676.92
				Total	14621.37
				G. Total	14621

Surge Shaft					
SI No.	Item Details	Quantity	Unit	Rate Rs.	Amount (Rs. Lacs)
1	Excavation	14339	cum	3282	470.68
2	Overbreak in Underground Excavation	1434	cum	1383	19.83
3	Steel Ribs	70	MT	83690	58.85
4	Rock bolt				
	32 mm dia	54530	m	1518	827.55
	25 mm dia	2096	m	1475	30.91
5	SFRS	1493	cum	16187	241.69
6	Drilling Drain holes	290	m	1520	4.41
7	Consolidation & Contact Grouting Holes	1991	m	408	8.13
8	Pressure Grouting with Cement	25	MT	18619	4.63
9	Concrete of grade M-15 in backfill	1812	cum	6322	114.58
10	Lining Concrete(M-25)	3814	cum	6791	258.99
11	Steel Reinforcement	573	MT	110836	635.22
12	Precast Lagging	230	cum	12900	29.73
13	Dewatering @ 3%				81.16
14	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				135.26
				Total	2921.63
				G. Total	2922

Circular Inclined Pressure Shaft					
SI No.	Item Details	Quantity	Unit	Rate Rs.	Amount (Rs. Lacs)
1	Excavation	36622	cum	3282	1202.10
2	Overbreak in Underground Excavation	3662	cum	1383	50.64
3	Steel Ribs	635	MT	83690	531.74
4	Rock bolt				
	32 mm dia	186958	m	1518	2837.30
	25 mm dia	77357	m	1475	1140.89
5	SFRS	3466	cum	16187	561.07
6	Drilling Drain holes	4150	m	1520	63.09
7	Consolidation & Contact Grouting Holes	28497	m	408	116.27
8	Pressure Grouting with Cement	356	MT	18619	66.32
9	Concrete of grade M-15 in backfill	16998	cum	6322	1074.59
10	Lining Concrete(M-25)	0	cum	6791	0.00
11	Steel Reinforcement	0	MT	110836	0.00
12	Precast Lagging	1262	cum	12900	162.79
13	ASTM 517 Grade F Liner	2331	MT	361302	8420.87
14	ASTM 537 Class 2 Liner	3518	MT	222605	7830.80
15	Dewatering @3%				721.75
16	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				1202.92
	Total				25983.16
	G. Total				25983

Horizontal Circular Penstock					
SI No.	Item Details	Quantity	Unit	Rate Rs.	Amount (Rs. Lacs)
1	Excavation	3437	cum	2604	89.50
2	Overbreak in Underground Excavation	344	cum	1383	4.75
3	Steel Ribs	76	MT	83690	63.40
4	Rock bolt				
	32 mm dia	22278	m	1518	338.09
	25 mm dia	9120	m	1475	134.51
5	SFRS	411	cum	16187	66.49
6	Drilling Drain holes	620	m	1520	9.43
7	Consolidation & Contact Grouting Holes	4257	m	408	17.37
8	Pressure Grouting with Cement	53	MT	18619	9.91
9	Concrete of grade M-15 in backfill	1843	cum	6322	116.54
10	Lining Concrete(M-25)	0	cum	6791	0.00
11	Steel Reinforcement	0	MT	110836	0.00
12	Precast Lagging	150	cum	12900	19.35
13	ASTM 517 Class F Liner	689	MT	361302	2490.45
14	ASTM 537 Class 2 Liner	0	MT	222605	0.00
15	Dewatering @3%				100.79
16	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				167.99
	Total				3628.57
	G. Total Say				3629

Power House					
Sr. No.	DESCRIPTION OF ITEMS	QUANTITY	UNIT	Rate Rs.	Amount (Rs. Lacs)
1	Excavation	124753	cum	2604	3248.62
2	Overbreak	12475	cum	761	94.96
3	Concrete				
	M15	10214	cum	6322	645.74
	M25	5504	cum	6791	373.80
	M35	8243	cum	7589	625.53
4	Rock bolt				
	32 mm dia	85680	m	1518	1300.29
5	SFRS	0	cum	16187	0.00
6	Normal Shotcrete	4170	cum	8929	372.35
7	Drilling Drain holes	14256	m	1520	216.74
8	Lenngth of cable anchor	4380	RM	20000	876.00
9	Strucutral Steel for Truss	642	MT	120188	772.09
10	Steel Reinforcement	2158	MT	110836	2392.15
11	Dewatering @3%				327.55
12	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				545.91
	Total				11791.73
	Say				11792

Transformer Cavern and Bus Tunnel

Sr. No.	DESCRIPTION OF ITEMS	QUANTITY	UNIT	Rate Rs.	Amount (Rs. Lacs)
1	Excavation	77327	cum	2604	2013.62
2	Overbreak	7733	cum	761	58.86
3	Concrete				
	M15	6051	cum	6322	382.54
	M25	9467	cum	6791	642.90
	M35	0	cum	7589	0.00
4	Rock bolt				
	32 mm dia	39244	m	1518	595.57
5	SFRS	560	cum	16187	90.59
6	Normal Shotcrete	3307	cum	8929	295.25
7	Drilling Drain holes	7547	m	1520	114.74
8	Length of cable anchor	3504	RM	20000	700.80
9	Consolidation and Contact Grouting Holes	3240	RM	408	13.22
10	Pressure Grouting with Cement	40	MT	18619	7.54
11	Structural Steel for Truss	374	MT	120188	449.22
12	Steel Reinforcement	1486	MT	110836	1647.36
13	Steel Ribs	49	MT	83690	40.74
14	Precast Lagging	59	cum	12900	7.58
15	Dewatering @3%				210.37
16	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				350.61
	Total				7621.48
	Say				7621

MAIN ACCESS TUNNEL					
SI No.	Item Details	Quantity	Unit	Rate Rs.	Amount (Rs. Lacs)
1	Excavation	69618	cum	2604	1812.86
2	Overbreak in Underground Excavation	6962	cum	761	52.99
3	Steel Ribs	415	MT	83690	347.13
4	Rock bolt				
	32 mm dia	42898	m	1518	651.02
	25 mm dia	15273	m	1475	225.26
5	SFRS	3659	cum	16187	592.26
6	Drilling Drain holes	2094	m	1520	31.83
7	Consolidation & Contact Grouting Holes	14379	m	408	58.67
8	Pressure Grouting with Cement	180	MT	18619	33.46
9	Concrete of grade M-15 in backfill	0	cum	6322	0.00
10	Lining Concrete(M-25)	12950	cum	6791	879.45
11	Steel Reinforcement	1017	MT	110836	1126.75
12	Precast Lagging	1390	cum	12900	179.31
13	Dewatering (3%)				179.73
14	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				299.55
				Total	6470.28
				G. Total	6470

Adits (Surge Shaft, Middle fo Pressure Shaft and CAT)					
SI No.	Item Details	Quantity	Unit	Rate Rs.	Amount (Rs. Lacs)
1	Excavation	70764	cum	2604	1842.71
2	Overbreak in Underground Excavation	7076	cum	761	53.87
3	Steel Ribs	482	MT	83690	403.25
4	Rock bolt				
	32 mm dia	99666	m	1518	1512.55
	25 mm dia	35634	m	1475	525.54
5	SFRS	4687	cum	16187	758.63
6	Drilling Drain holes	2780	m	1520	42.26
7	Consolidation & Contact Grouting Holes	19089	m	408	77.89
8	Pressure Grouting with Cement	239	MT	18619	44.43
9	Concrete of grade M-15 in backfill	6321	cum	6322	399.59
10	Lining Concrete(M-25)	0	cum	6791	0.00
11	Steel Reinforcement	0	MT	110836	0.00
12	Precast Lagging	1615	cum	12900	208.30
14	Dewatering @3%				176.07
15	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				302.25
				Total	6347.32
				G. Total	6347

Trail Race Tunnel (D-Shaped)					
SI No.	Item Details	Quantity	Unit	Rate Rs.	Amount (Rs. Lacs)
1	Excavation	81231	cum	2604	2115.29
2	Overbreak in Underground Excavation	8123	cum	761	61.83
3	Steel Ribs	665	MT	83690	556.17
4	Rock bolt				
	32 mm dia	194962	m	1518	2958.77
	25 mm dia	86031	m	1475	1268.83
5	SFRS	5454	cum	16187	882.86
6	Drilling Drain holes	2930	m	1520	44.55
7	Consolidation & Contact Grouting Holes	20119	m	408	82.09
8	Pressure Grouting with Cement	251	MT	18619	46.82
9	Concrete of grade M-15 in backfill	4028	cum	6322	254.68
10	Lining Concrete(M-25)	18518	cum	6791	1257.53
11	Steel Reinforcement	1454	MT	110836	1611.15
12	Precast Lagging	2135	cum	12900	275.40
13	Dewatering @3%				342.48
14	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.				570.80
	Total				12329.25
	G. Total				12329
Tail Race Channel					
S. No.	Description	Units	Quantity	Unit Rate (Rs.)	Total Amount (Rs.) in lakhs
1	Surface Excavation				
	(a) Common Excavation	cum	72514	761	551.98
	(b) Rock Excavation	cum	72514	1383	1002.77
2	Concreting				
3	Concrete lining M-20	cum	4229	6389	270.18
4	Steel Reinforcement	MT	165.98	110836	183.97
5	Weep/Darinage Holes	m	467	1520	7.10
6	Miscellaneous works like boulder piching etc.	5%			100.80
7	Dewatering	3%			60.48
8	Add for contingencies @ 3% and work-charged established @ 2% (Total 5%)except L.S.	5%			100.80
	Total				2278.09

HYDRO-MECHANICAL EQUIPMENTS (J - Works)					
S. No.	Description	Quantity	Unit	Unit Rate (INR)	Total Amount (INR In Lakh)
1	Intake Gates				
a	Gates	62	MT	1,95,000.00	120.90
b	Hoisting Arrangement	30	MT	1,95,000.00	58.50
2	Intake Emergency gates				
a	Gates	62	MT	1,95,000.00	120.90
b	Hoisting Arrangement	29	MT	1,95,000.00	56.55
c	Liner for gate	40	MT	1,70,000.00	68.00
3	Surge Shaft gates				
a	Gates	110	MT	1,95,000.00	214.50
b	Hoisting Arrangement	31	MT	1,95,000.00	59.48
c	Liner for gate	15	MT	1,70,000.00	25.50
4	Surge Chamber Gate				
a	Gates	150	MT	1,95,000.00	292.50
b	Hoisting Arrangement	60	MT	1,95,000.00	117.00
5	Outlet Service Gate				
a	Gates	79	MT	1,95,000.00	154.05
b	Hoisting Arrangement	34	MT	1,95,000.00	66.30
6	Outlet Emergency Gate				
a	Gates	79	MT	1,95,000.00	154.05
b	Hoisting Arrangement	30	MT	1,95,000.00	58.50
c	Liner for gate	21	MT	1,70,000.00	35.70
	Miscellaneous				
	Instrumentation and remote control with complete automation		LS	2,00,00,000.00	200.00
	D.G Set		LS	25,00,000.00	25.00
	TOTAL				1827.43
	GRAND TOTAL FOR HYDRO-MECHANICAL EQUIPMENTS				1827.43

R-COMMUNICATION					
Sl. No	Description	Unit	Qty	Rate (INR.)	Total Amount (INR In Crore)
A	<u>Roads</u>				
1	Construction of Approach road for Surge Shaft Adit	km	0.8	32143530	257.15
2	Widening of Roads for Adit to Surge Shaft	km	5.4	8035883	433.94
3	Improvement of Existing ROads	km	10	8035883	803.59
	Sub-Total		16.2		1494.67
	Total Cost for R- Communication			INR In Lakh	1495

CHAPTER-13: ECONOMIC EVALUATION

CHAPTER – 13

13. ECONOMIC EVALUATION

13.1 General

The economic and financial evaluation of the Idukki Extension Scheme H.E. Project, Kerala has been considered as per the standard guidelines issued by Central Electricity Authority and the norms laid down by the Central Electricity Regulatory Commission (CERC) for Hydro projects have been kept in view in this regard.

13.2 Project Benefits

The scheme would afford energy generation of 1301.27 GWh annually. For assessing the tariff, design energy generation of 1236.21 GWh, calculated with 95% capacity availability in a normal dependable year, has been adopted. The project would provide 800 MW of 4 hours daily peaking capacity benefits

13.3 Capital Cost

The project cost has been estimated at ₹ **2669.67 Crores** excluding IDC at August 2021 Price Level. The breakup of cost is as follows:

1.	Cost of Civil Works	=	₹. 1309.67 Crores
2.	Cost of Electrical/Mechanical works	=	₹. 1360.00 Crores
	Total	=	₹. 2669.67 Crores

13.4 Mode of Financing

The project is proposed to be financed with a debt equity ratio of 70:30. An interest rate of 9.0% per annum on the loan component has been considered for the financial analysis of the project. The interest on the working capital is taken as 10.50%.

13.5 Phasing of Expenditure

The project is scheduled to be completed in 5 years. The phasing of the expenditure worked out on the basis of proposed construction programme is summarized in

Table 13.1.

Table 13.1: Phasing of Expenditure

Year	Capital Expenditure (₹. Crores)
Up-to 1 st Half Year	66.51
2 nd Half Year	101.87
3 rd Half Year	174.15
4 th Half Year	348.48
5 th Half Year	359.45
6 th Half Year	508.92
7 th Half Year	458.43
8 th Half Year	403.80
9 th Half Year	383.27
10 th Half Year	257.20
Total	3062.08

13.6 Financial Analysis

13.6.1 Basic and Normative Parameters

The following normative parameters have been adopted for working out the financial analysis of the project.

- The estimated capital cost of ₹. 3062.08 Crores including the Interest During Construction as ₹. 392.41 Crores
- Annual gross energy generation of 1301.27 GWh considering 365 days generation in a year.
- Operation & maintenance expenses (including insurance) @ 3.5% of the project hard cost in the first year with 4.77% escalation every year.

- iv. Depreciation allowed @ 5.28 % of the project cost for first 14 years and remaining depreciation is spread over the balance life i.e. 26 years on an average basis keeping 10% salvage value of the assets.
- v. Auxiliary consumption i.e. quantum of energy consumed by auxiliary equipments of the generating station and transformer loss @ 1.25 % of the energy generated.
- vi. Interest on working capital @ 10.50%.
- vii. Interest during construction has been worked out based upon the interest rates @ 9.0 %. The computations are given in **Annexure-13.1** for present day capital cost.
- viii. Return on equity @ 16.50%.
- ix. MAT @ 17.01 %
- x. Corporate Tax – 25.17% (Base tax of 22%, Surcharge of 10% and Cess of 4%)
- xi. Tax Holiday – 10 Years

13.6.2 Assessment of Tariff

Based upon the parameters given above, the sale rate of energy at bus bar has been computed in **Annexure-13.2** for project life of 40 years. As per CERC guideline, for hydropower projects, 40 year project life is to be considered for tariff calculation.

The sale rate applicable in the first year and levelised tariff is indicated below.

Table 13:2

Sl. No.	First Tariff (₹/kWh)	40 Year Levelized Tariff (₹/kWh)
1	5.19	4.67

Annexure - 13.1

IDUKKI EXTENSION SCHEME (4x200=800 MW)

INTEREST DURING CONSTRUCTION (IDC)

1	Cost of Civil Works	INR	1309.67	Cr.	
2	Cost of E&M Works	INR	1360.00	Cr.	
3	Total Cost of the Project	INR	2669.67	Cr.	
4	Interst Rate on Loan		9.0	%	per annum
5	Equity		30.0	%	
6	Loan		70.0	%	
7	CERC Gudelines followed		2019-24		

Period	Expenditure Civil		Expenditure E&M		Total Expenditure	Equity available	Loan	IDC	IDC for Loan component	IDC for Equity component	Outstanding
	Phasing of expendtiure	Hard Cost	Phasing of expendtiure	Hard Cost							
Half year	%	INR Cr.	%	INR Cr.	INR Cr.	INR Cr.	INR Cr.	INR Cr.	INR Cr.	INR Cr.	INR Cr.
1	5.00	65.48			65.48	19.65	45.84	1.03	0.72	0.31	46.56
2	7.50	98.23			98.23	29.47	68.76	3.64	2.55	1.09	117.87
3	7.50	98.23	5.00	68.00	166.23	49.87	116.36	7.92	5.55	2.38	239.77
4	15.00	196.45	10.00	136.00	332.45	99.74	232.72	16.03	11.22	4.81	483.70
5	15.00	196.45	10.00	136.00	332.45	99.74	232.72	27.00	18.90	8.10	735.32
6	15.00	196.45	20.00	272.00	468.45	140.54	327.92	40.47	28.33	12.14	1091.56
7	10.00	130.97	20.00	272.00	402.97	120.89	282.08	55.47	38.83	16.64	1412.47
8	10.00	130.97	15.00	204.00	334.97	100.49	234.48	68.84	48.19	20.65	1695.13
9	7.50	98.23	15.00	204.00	302.23	90.67	211.56	81.04	56.73	24.31	1963.42
10	7.50	98.23	5.00	68.00	166.23	49.87	116.36	90.97	63.68	27.29	2143.45
	100.00	1309.67	100.00	1360.00	2669.67	800.90	1868.77	392.41	274.69	117.72	

Hard Cost	INR	2669.67	Cr.	Equity	INR	918.62	Cr.
IDC	INR	392.41	Cr.	Loan	INR	2143.45	Cr.
Total Capital Cost	INR	3062.08	Cr.	Total Capital Cost	INR	3062.08	Cr.

Annexure - 13.2

CHAPTER-14:

CONCLUSION & RECOMMENDATION

CHAPTER – 14

14. CONCLUSION AND RECOMMENDATION

Present report is prepared based on the limited available data which was collected and subsequently analysis and studies were carried out by WAPCOS.

Following conclusions are drawn and recommended for further consideration by the competent authority:

14.1 Technical Merits of the Project:

- The proposed Idukki Extension Scheme is planned after due diligence and based on the available data using latest guidelines and techniques recommended by CEA and CWC.
- Based on the preliminary geological studies it can be concluded that No geological surprise is envisaged. Geological setup is conducive for underground works.
- No interference is envisaged with hydrological regime of the Idukki Reservoir due to the fact that water is being relocated to proposed scheme for generation during peak hours.
- Land requirement of 127 Ha. is on lower side considering the size of the project of 800 MW.
- Based on preliminary stage studies, it is envisaged that the majority of land is forest and minimum private land is expected.
- Based on the present level of studies no major R&R issues seem to be involved.
- The per MW cost is approx. ₹ 3.33 Cr. only which is very attractive.

14.2 Need of Idukki Extension Scheme

- The Idukki Extension Scheme H.E. Project (4 x 200 MW) is proposed as a hydroelectric peaking station by sharing the daily water drawl from the existing Idukki reservoir. The off-peak generation of the existing Moolamattom power station is planned to be reduced and the water thus saved will be utilized at the Idukki Extension scheme during peak hours. Thus an additional capacity of 800 MW can be achieved during peak hours, resulting in the corresponding power purchase at higher rates during peak time. The Idukki Extension Scheme will generate 1301 Mu of electricity annually. The advantages of Idukki Extension Scheme are as follows.
- KSEB Ltd can increase the share of Peak Hour demand by in house hydro generation, thus reducing the expenditure for peak hour power purchase. Since no additional reservoir is formed, the environmental issues are less and hence the statutory clearances will be a comparatively easier task.
- The extension power house operation is in line with the Load Curve of the State Grid. Cost of head works is eliminated since existing dam and reservoir are used.
- More availability of machines for crisis management.
- Gives flexibility for shut down for planned and forced shut downs
- To meet the power demand during morning peak & evening peak.
- To meet the requirement of flywheel effect during power system disturbances
- To provide reactive power when the solar power generation increases considerably.
- Easy variation of the power from 10 % to 100 % by using Pelton Wheel.
- As a redundant station when Idukki Power Station goes for total renovation
- Based on the available data it can be said that in view of overall trend of generation planning and demand, Kerala would be needing source to

generate peak power to improve Hydro: Thermal Mix and provide much needed balance to renewable in year 2025-26 .

Idukki Extension Scheme H.E. Project involves minimum and simple civil works and could be completed in 5 years. The project would afford an annual design energy generation of 1301 GWh per year. The cost per MW installed works out as approx. ₹3.33 crore / MW.