Operation and Maintenance Manual for IDAMALAYAR Dam State of Kerala

Doc. No. DSO_O&M_IDAMALAYAR_DAM KSEBL_01_v1.0

Chief Engineer
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Front Cover Photograph: Downstream and Upstream view of Idamalayar dam

Government of Kerala

Operation and Maintenance Manual

Idamalayar Dam

KSEB

Prepared

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Kerala State Electricity Board Ltd
Pallom, Kottayam.

February 2019

Government of Kerala
Kerala State Electricity Board Ltd
Dam Safety Organisation

Disclaimer

This *Operation and Maintenance Manual for Idamalayar Dam* in no way restricts the dam operators in digressing from her/his responsibilities. The Dam Operators must exercise appropriate discretion and good judgement based on actual site condition when implementing and using the operation and maintenance manual for managing the workings of the dam and appurtenant structures.

The manual is developed for the purposes of organization and managing the operation, inspection and maintenance of the dam for reducing risk and optimizing performance of the dam as a general guide.

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Message

India has more than 5200 large dams. Their health and safety are of paramount importance for sustainable use of the valuable assets, besides providing protection to the people and property in the downstream areas. The Ministry of Water Resources, River Development & Ganga Rejuvenation through the Central Water Commission (CWC), with financial assistance from the World Bank, started the Dam Rehabilitation and Improvement Project (DRIP) to rehabilitate 198 large dam projects in seven states. Kerala State Electricity Board Ltd, through Government of Kerala participated in DRIP to rehabilitate 37 dams under 12 Hydro Electric Projects in the state.

For managing a dam in a sustainable and scientific manner, it is very crucial for each dam owner to have dam specific Operation and Maintenance Manual that lays down procedures for the daily upkeep of the dam. An Operation and Maintenance Manual for a dam is essential for ensuring its safe functioning and for deriving continued benefits. This Operation and Maintenance Manual for Dam has been prepared following the Guidelines for Preparation, Operation and Maintenance Manuals published by CWC in January 2018 under DRIP and covers requirements for project Operation, Inspection, Maintenance, Instrumentation and Monitoring the health of Dam both during monsoon and non-monsoon periods.

I recommend the dam officials to use this manual for the efficient and safe Operation and Maintenance of the Dams on regular basis.

I compliment all the experts who have contributed to the development of this manual and congratulate the Dam Safety Organisation, KSEB Ltd, Pallom and CWC for the initiation of such important policy protocol to address dam safety management in Kerala.

Bibin Joseph,
Director Generation (Civil),
KSEB Ltd,
Kerala.

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Foreword

Globally, the Operation and Maintenance (O&M) Manual of a dam is one of the most important documents which is supposed to be put in practice right from the initial filling of reservoirs. In order to address the operation and maintenance aspects, ongoing Dam Rehabilitation and Improvement Project (DRIP) has requisite scope to prepare new or update existing O&M manuals for all DRIP dams, which will become very helpful to Dam Owners in addressing the dam specific issues comprehensively in future.

This Operation and Maintenance (O & M) Manual developed is a detailed set of written descriptions with step-by-step procedures for ensuring that the dam is safely operated, frequently inspected and properly maintained. In this era of shrinking budgets, timely inspection and preventative maintenance is necessary for the safe functioning of the dam and continued productive use of the dam and reservoir.

The format of this manual is prepared following the principles published in 2018 CWC Guidelines for Operation and Maintenance of dams for the use by all Dam Owners in developing their own site-specific manuals. Each section of the document provides the necessary instructions to operate inspect and maintain their dams.

It is recommended that all dam officials in charge to use this manual for ensuring that the dam is operated and maintained in a sustainable manner and will continue to derive benefits.

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PREFACE

Operation and Maintenance (O & M) Manual is a detailed written document of procedures and protocols for ensuring that a dam is operated and maintained properly and timely to avoid further health deterioration and extend service life of these assets. An Operation and Maintenance Manual is essential for a dam for ensuring its safe functioning and for deriving desired benefits from it by describing all the elements systematically for its operation, inspection, maintenance, instrumentation and monitoring of the health.

Central Water Commission has published the Guidelines for the development of New Manual and Updating of Existing Manual vide CDSO_GUD_DS_03_v1.0 Page xii January 2018. Accordingly Kerala State Electricity Board is developing and updating the Operation and Maintenance Manual of Dams under their ownership for a healthy dam safety management system.

Idamalayar dam under KSEB Ltd has an Operation and Maintenance Manual which is not so comprehensive according to the present standards. Hence an attempt is being made here to revise the manual as per the new guidelines by CWC.

LIST OF ACRONYMS

The following acronyms are used in this publication:

AAR	**Alkali-Aggregate Reaction**
ACI	**American Concrete Institute**
ASTM	**American Society for Testing Materials**
CDSO	**Central Dam Safety Organization**
CWC	**Central Water Commission**
CWPRS	**Central Water and Power Research Station**
DDMA	**District Disaster Management Authority**
DHARMA	**Dam Health and Rehabilitation Monitoring Application**
DRIP	**Dam Rehabilitation and Improvement Project**
EAP	**Emergency Action Plan**
FSCT	**Federation of Societies for Coatings Technology**
HCC	**Hindustan Construction Corporation Ltd**
IS	**Indian Standard**
KERI	**Kerala Engineering Research Institute**
KDSA	**Kerala Dam Safety Authority**
KSEB Ltd	**Kerala State Electricity Board Ltd**
KWA	**Kerala Water Authority**
NCDS	**National Committee on Dam Safety**
NCSDP	**National Committee on Seismic Design Parameters**
PMF	**Probable Maximum Flood**
PMP	**Probable Maximum Precipitation**
RCC	**Reinforced Cement Concrete**
ROUV	**Remotely Operated Underwater Vehicle**
ROV	**Remotely Operated Vehicle**
SDSO	**State Dam Safety Organization**
SISF	**State Industrial Security Force**
UAV	**Unmanned Aerial Vehicle**
USBR	**United States Bureau of Reclamation**
USACE	**United States Army Corps of Engineers**

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General Information

1.1 Introduction

Idamalayar project is a Hydro Electric Scheme located in Ernakulam District of Kerala State. The river Idamalayar is a major tributary of Periyar originating from the Anamala Hills at about elevation 2520 m, meeting Periyar at about 1.65 km upstream of Bhoothathankettu barrage of Periyar Valley Irrigation Scheme.The access to the project is via Kothamangalam through Bhoothathankettu barrage. Nearest City is Kothamangalam which is 26 km from Idamalayar and nearest Airport is Cochin International Airport which is 81 km from Idamalayar. Nearest Rail head is Aluva which is 61 km from Idamalayar. The Project provides multipurpose utility towards irrigation, industrial and domestic water and salinity control in the lower reaches of Periyar simultaneously with power generation.

1.2 Purpose, Location, Description of the Project

The project comprises construction of a 102.4 m high concrete gravity dam across Idamalayar river and creation of a reservoir of 1089.80 MCM capacity at FRL. Water from this reservoir is diverted through a water conductor system consisting of 1564 m long tunnel and 151.5 m long Penstocks to the 75 (2 x 37.5) MW generating station located on the left bank of Idamalayar river to produce 331 Million units of power per annum, utilising the average gross head of 111 m with a firm power draft of 41m^3 /s.

The dam is 373 m long and has top width of 8.5 m. The tail water flows through Idamalayar River to reach Periyar for partial diversion at Periyar Valley Irrigation Barrage.

In addition to the firm power generation of 320 Million units, secondary power of about 11 Million units can also be derived, thus making the total production of power 331 Million units per annum. Simultaneous with this power generation, the firm power draft of 41 m^3 /s enables availability of a minimum discharge of 28.317 m^3 /s downstream of Bhoothathankettu Barrage in Periyar for salinity control, navigation facilities and effluent dilution plus another 14.158 m^3/s for domestic water supply and industrial uses throughout the year.

A location sketch is shown below as **Fig 1.1** and from Google map **Fig 1.2.**

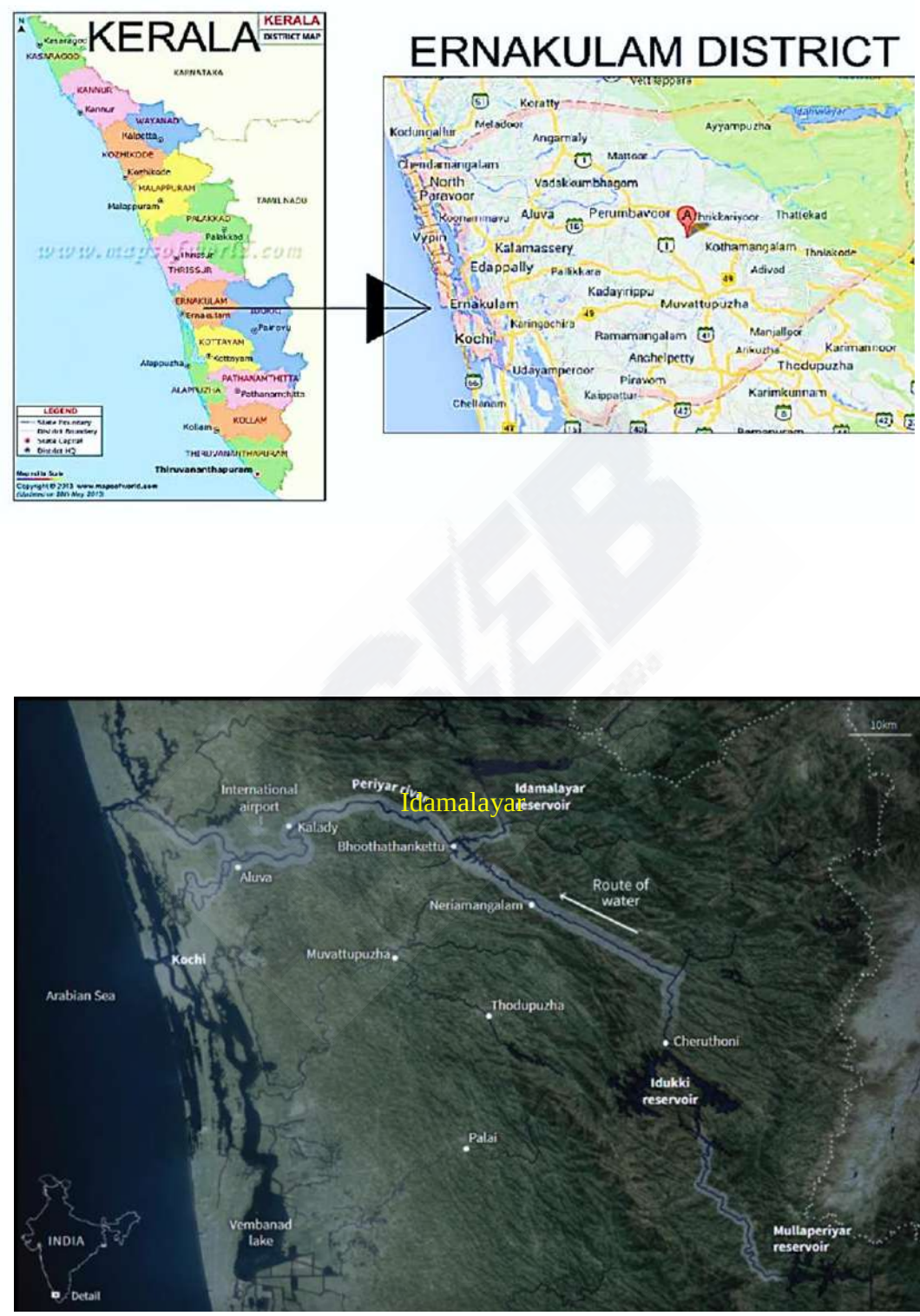


Fig 1.1 Location Sketch

Fig 1.2 Idamalayar Project From Google earth.

1.3 Background Details of the Project

Investigation for the Project was started in the year 1958. Preliminary works of the scheme were commenced as early as 1969, based on an ad-hoc sanction of the State Government. Works in respect of roads and buildings were going on steadily, but the tempo of works had to be slowed down or even stopped, due to various reasons, which include paucity of funds and labour unrest. Though the scheme was sanctioned as a Hydel Scheme by the Planning Commission in September 1973, sufficient funds were not allotted till late 1976 and in September 1975, it was directed to keep the power part of the Project in abeyance. The contract for the dam was awarded in September 1976 to M/s. Hindustan Construction Company Limited, Bombay. Green signal was also given by the Planning Commission for the power part also and the work for the supply of the Generating equipment was entrusted to M/s. Bharat Heavy Electricals Limited, Bhopal in 1977. The construction of the dam was taken up during 1976. On completion of work, the power tunnel was first filled by 1985. After rectifying the leakage at the inlet portion of the power tunnel, it was filled again and trial run of the machines was done satisfactorily in January 1987. The commissioning of the machines of the power house was done and they were put into commercial operation in February 1987.

a. Date of Starting the construction : 1976
b. Date of Completion : 1987
c. Name of Designing Agency : KSEBLtd
d. Name of Construction Agency : M/s. HCC
e. Major accidental events/incidents if any : No major accidents reported during construction

1.4 Salient Features of the Dam

Sl. No.	Items	Description
Location of Dam		
1	State	Kerala
2	District	Idukki
3	River	Idamalayar (tributary of Periyar)
4	Site:-	
	Idamalayar dam	Latitude : 10° 13' 15"

		Longitude : 76° 42' 30"
	Idamalayar Power Station	Latitude : 10° 12' 20"
		Longitude : 76° 42' 50"
Hydrology		
1	Catchment area	380.79 km^2 (excluding 101 km^2 of Nirar catchment diverted to Tamil Nadu)
2	Annual weighted rainfall	Maximum : 682.8 cm
		Minimum : 345.0 cm
		Average (26 Years) : 475.0 cm
3	Annual runoff (excluding 2.5 TMC for diversion to Tamil Nadu under Parambikkulam - Aliyar Project)	Maximum : 1925.5 Million m^3
		Minimum : 928.65 Million m^3
		Average : 1369.69 Million m^3
4	Original Design Flood	Peak design flood: 3851.0 m^3/s
		Maximum Outflow: 3248.76 m^3/s
Reservoir		
1	Full Reservoir Level	169.0 m
2	Maximum water level	171.0 m (original)
3	Minimum draw down level	115.0 m
4	Gross storage at MWL	1153.0 Million m^3
5	Gross storage at FRL	1089.8 Million m^3
6	Dead storage	72.0 Million m^3
7	Live storage at FRL	1017.8 Million m^3
8	Live storage up to top of the gates	1032.3 m^3
9	Water spread area at FRL	2830.0 Hectares
Dam		
1	Type of dam	Concrete gravity
2	General bed level at dam site	81.0 m

3	Deepest foundation level	70.4 m
4	Road level at top of dam	172.0 m
6	Height of dam above deepest foundation	102.4 m
7	Length of dam at top	373.0 m (Ch.160 to Ch.533)
8	Top width	8.5 m
Spillway (Block No 7 to 11)		
1	Crest level of spillway	161.0 m
2	Width of spillway	60.0 m (including 14 m width of piers)
3	Length of spillway	93.05 m from axis to lip of bucket
4	Type, No. and size of gates	Radial, 4 Nos. (11.5 m x 9.7 m) with rope drum hoists
5	Top level of gate	169.5 m
6	Maximum spillway discharge	3248 m^3/s at original MWL of El.171.0 m.
7	River Outlets	2 Nos 1500 mm dia. disperser valves (Maximum discharge 54.5 m^3/s each)
Power Intake (Block No 7, Ch. 296.00)		
1	Sill level	103.5 m
2	Size of intake opening	3100.00 mm x 4746.73 mm
3	Size of intake	4.2 m dia.
4	Intake gate	(3.1 x 4.7) m Electrically driven hoist
5	Trash Racks	Five sets (3 x 25) m
Low Pressure Pipe (L.P.P)		
1	Downstream of dam	
	(a) Length	114.40 m
	(b) Diameter	4.20 m
	(c) Additional steel lining as part of rectification works	80.0 m

2	River Outlets	2 Nos 1500 mm dia. disperser valves (Maximum discharge 54.5 m^3/s each) 30 m approx. from downstream face of dam along the intake (Block 7) route.
Head Race Tunnel		
1	Shape, Type and size	Circular, concrete, 5.2 m dia.
2	Approximate length	1564.0 m
3	Slope	1 in 250
4	Maximum flow	80 m^3/s
5	Maximum velocity of flow	3.77 m/s
Surge Shaft		
1	Size of surge tank	21.70 m dia., between elevation 184.40 m & 171.20 m.
		18.85 m dia., between elevation 171.20 m & 95.284 m.
2	Height	89.116 m
3	Orifices	2 Nos 2.4 m dia.
Low Pressure Pipe (L.P.P)		
1	Downstream of surge shaft	
	(a) Length (Approximate up to centre of Y piece)	138.25 m
	(b) Diameter	4.2 m
Valve House		
1	Size	25.80 m x 7 m x 13.2 m
2	Valves	2 Nos. Butterfly valves (2.93 m dia.)
Penstock		
1	Number of lines	Two
2	Diameter	2.93 m
3	Approximate length from centre	151.50 m

	of Y piece to centre of valve in Power House	
Power House		
1	Building	Concrete structure of size 52 m x 18 m
2	Lowest foundation level	31.50 m
3	Centre line of runner	39.00 m
4	Turbine floor	40.50 m
5	Generator floor	44.00 m
6	Generator top floor and service bay	48 .00 m
7	Overhead crane capacity	140 T/ 15 T
8	Rated net head	108.576 m
9	Average gross head	111.360 m
10	Maximum net head	126.75 m
11	Minimum net head	74.10 m
12	Main inlet valve	2 Nos. Butterfly valves 2400 mm dia.
13	No. of units/machines	2 Nos.
14	Capacity of each unit/machine	37.50 MW
15	Firm power draft /unit	41.06 m^3/s
16	Energy per annum including secondary power of 10.95 MU	331.04 Million units
17	Turbine	Francis Type (BHEL make)
18	Transformers	Bank of 3 single face transformers of 16 MVA II / 110 KV (TELK make)
19	Outgoing feeders	Kalamassery-1 and Chalakudy-1
20	Tail race weir crest level	39.0 m
21	Minimum tail race water level	39.0 m
22	Maximum tail race water level (Flood condition)	47.0 m
23	Tail race channel length	50.0 m

24	Draft tube gates	1 No Stop log gate for both draft tubes
25	Installed capacity of power house	2 x 37.5 MW
	i) Firm Power draft	82.12 m^3/s
	ii) Annual Generation	331 MU
Construction materials – consumption		
1	Cement (Bulk)	194500 Tonnes
2	Cement (Bagged)	23300 Tonnes
3	M. S. Rods	3600 Tonnes
4	Explosives	620 Tonnes
5	Pipes	1370 Tonnes
6	Gates, valves etc.	750 Tonnes

Idamalayar Dam

Idamalayar dam is a concrete gravity dam with spillway in the river portion. The dam has got 22 blocks. Block No.1 is 26 m in length. The blocks 2, 3, 4 & 7 are of 20 m in length and blocks 9, 10, 11, 12 & 18 are of 15 m in length. The blocks 6, 13 & 16 have a length of 18 m each while blocks 15, 19 & 20 have lengths of 16 m each. The block 5 is 22 m in length, block 8 is 17 m, block 14 is 19 m, block 17 is 14 m, block 21 is 10 m and block 22 is 8 m in lengths. The total length of the dam at elevation 172 m (TBL) is 373 m consisting of non-overflow lengths of 140.5 m on the left bank, 172.5 m on the right bank and an overflow section of 60 m in between.

The spillway (60 m long, Ch. 300.5 to 360.5) has 4 vents each of width 11.5 m, 5 concrete piers with two single piers at the end of width 1.75 m each and remaining three intermediate piers of width 3.5 m thick each. The maximum height of the dam above the deepest foundation level +70.40 m is 102.40 m and above river bed level 181 m, it is 91 m high. The top elevation of the dam is +172.00 m.

The dam has a foundation gallery of size 1.8 m x 2.5 m, starting at El 153.0 m on the left bank and ending at an elevation of 149.82 m at the right bank after going through the entire

length of the dam confirming to its profile and reaching down to lowest elevation +78 m. The portion of the gallery between elevations +78.5 m and +108.68 m where there is an abrupt rise in the profile of the dam due to shear zone is connected by a vertical shaft located at a chainage of about 445 m. The gallery is at a minimum distance of 4.7 m from the axis of the dam and with a minimum thickness of 1.5 m below the floor up to the rock surface. There are 5 adits to the gallery from the downstream face of the dam at elevation of 140.4 m, 103.2 m, 185.2 m, 116.2 m and at 138.5 m. There is also an inspection gallery of size 1.5 m x 2.3 m at an elevation of about 128 m. It starts in block 4 at an elevation of 128.025 m and ends in Block 18 at an elevation 127.4 m and is connected to the foundation gallery at these points.

An Elevator of 3000 kg capacity is also installed in the dam in Block No.12 for providing access to the galleries at elevation +128 m and +85.35 m. A sump pit is constructed at the lowest elevation +78 m for collecting the seepage water which is then pumped out of the dam using two 15 HP pumps installed in the pump chamber at an elevation +85.3 m.

The cross section (non-over flow section) and sectional elevation of Idamalayar dam are given in **Drg 1.1** and **Drg 1.2**. A schematic diagram of the project showing the components are shown in **Fig 1.3** and **Fig 1.4.**

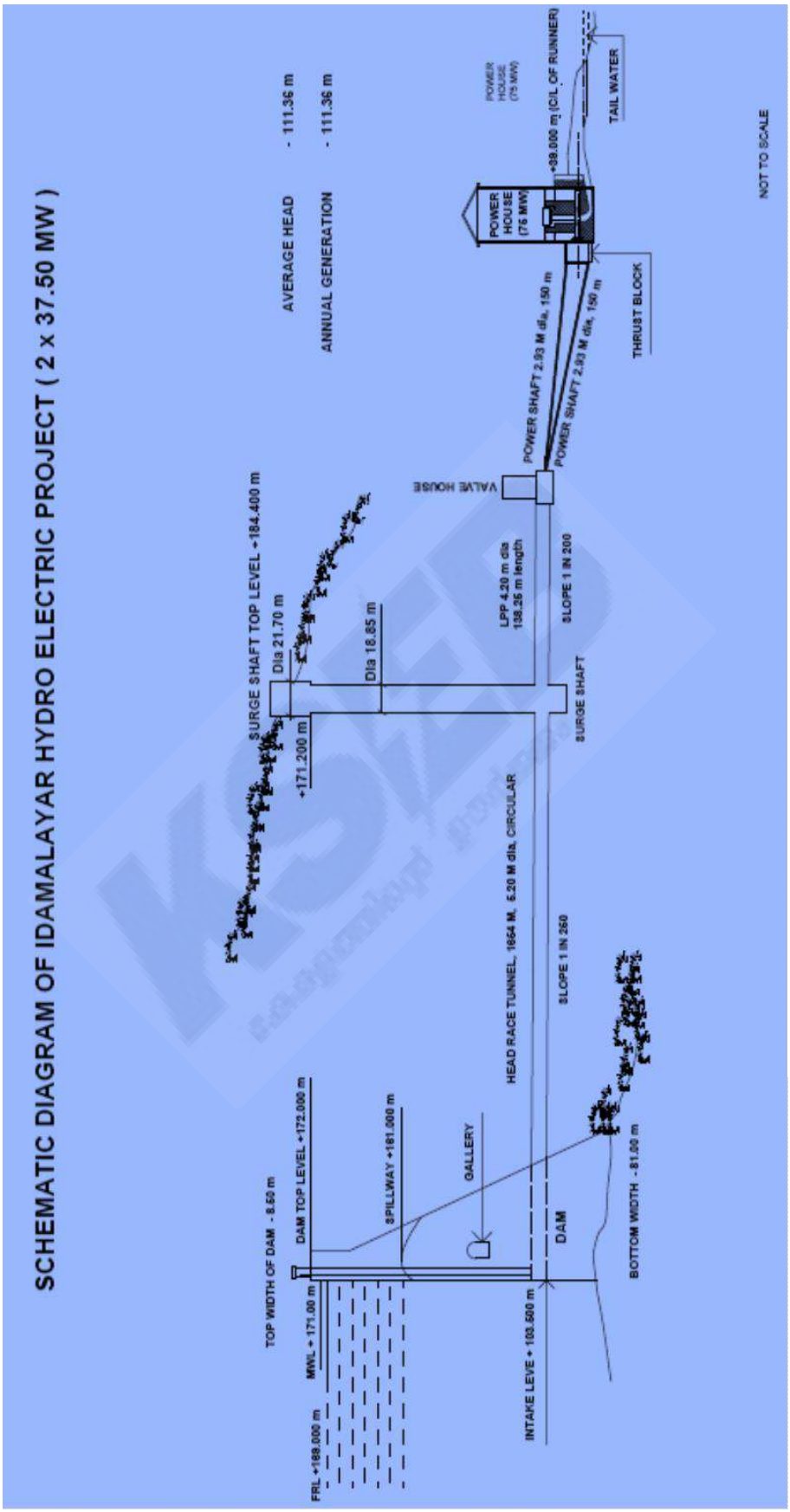


Figure 1.3 Schematic Diagram of the Project

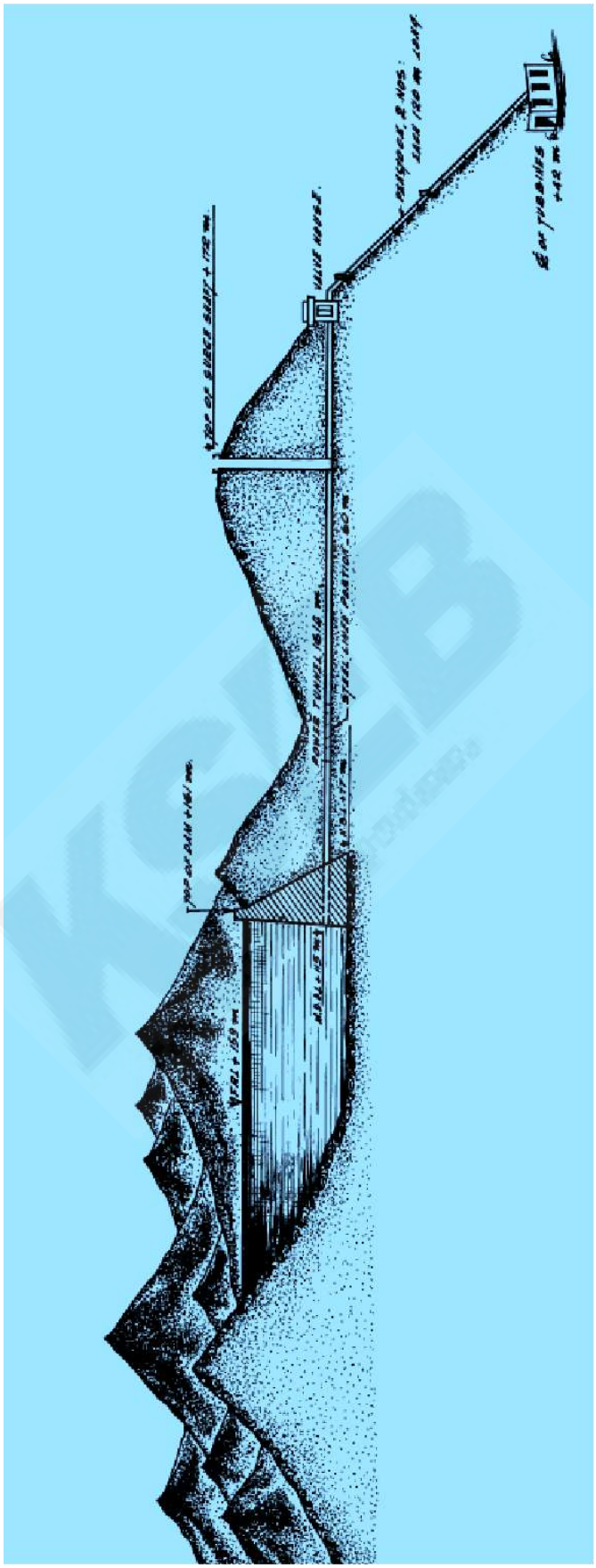


Figure 1.4 Schematic Diagram of the Project Elevation

1.5 Assignment of Responsibility

Kerala State Electricity Board Ltd is the owner and has the final authority and responsibility for the operation and maintenance of the dam. Identification of all areas of responsibilities connected with the operation and maintenance of the dam are covered in this section. The officer's responsibilities for the various functions are identified by their designation and, in particular, the responsibilities of operating personnel are specifically identified below and including the regularly scheduled duties which staff personnel are required to perform as outlined.

Project Administration Officer	-	Chairman & Managing Director, KSEB Ltd.
Chief Controlling Officer	-	Chief Engineer (Civil - DS & DRIP)
Authority of Spillway and Flood releases	-	Chief Engineer (Civil - DS & DRIP), KSEB Ltd
Authority for releases through HRT / Water Conductor System	-	Chief Engineer (Generation), KSEB Ltd
Operation and safety of the dam	-	Deputy Chief Engineer, Research & Dam Safety Organization, Pallom, KSEB Ltd.
Controlling and Operation Officer at dam site	-	Executive Engineer, Research & Dam Safety Division No. III, Idamalayar.
For HM and Electrical works	-	Executive Engineer, Research & Dam Safety Division No. III, Idamalayar.
Recording reservoir data, inspection, maintenance	-	Executive Engineer, Research & Dam Safety Division No. III, Idamalayar.
Dam Health Engineer	-	Executive Engineer, Research & Dam Safety Division No. III, Idamalayar.
Recording reservoir data, inspection, monitoring and maintenance at site	-	Assistant Executive Engineer, Research & Dam Safety Sub Division, Idamalayar
Dam operation, inspection, monitoring and maintenance at dam site	-	Assistant Engineer, Research & Dam Safety Sub Division, Idamalayar.

1.5.1 Roles and Responsibilities of the AEE and AE during Monsoon

Flood condition assessment, warning, flood mitigation, and other responsibilities

1. Coordinate with the concerned officers of TamilNadu regarding Nirar and Diversion from Poringalkuthu reservoir through Vachumaram Diversion. Get the information on inflow status, rainfall and to bring it to the notice of the EE/Dy. CE.

2. Assist the EE/ Dy. CE /CE to issue notification to the inhabitants downstream in Newspapers, Radio, and TV News channel to alert regarding the flood situation.

3. Assist the EE/ Dy. CE /CE to coordinate with the Revenue authorities (District Administration) to alert the downstream inhabitants to evacuate from the flood zone to prevent loss of life and livestock.

4. Assist the EE/ Dy. CE /CE to coordinate with the CWC flood monitoring authorities on the flood condition.

5. Maintain the reservoir water level gauge register and to update on hourly basis during floods and report to EE/ Dy. CE /Chief Engineer.

6. Assess the inflows in the reservoir as per the approved reservoir operation and to prepare proforma consisting of the status of the reservoir capacity and releases from the reservoir as per the standard Performa and to submit to the EE/ Dy. CE /CE.

7. Submit details to the EE/ Dy. CE /CE on the inflows and releases from the reservoir and status of the reservoir twice in the day.

8. Maintain the spillway crest gate operation log book.

9. Operate the Spillway crest gates for flood mitigation as per the instructions of the EE/ Dy. CE /CE and to update the Gate Operation Log book

10. Observe the seepages in the drainage Gallery with respect to the reservoir head and record the seepages in the infiltration gallery and to immediately bring to the notice of the EE/ Dy. CE /CE in case of excessive seepage/leakage in any specific blocks and porous drains.

11. Maintain the pump operation log books for the dewatering pumps in the drainage gallery and to submit to EE/ Dy. CE /Chief Engineer.

12. Observe the gates and to see that the drain holes are not clogged and floating debris is not deposited in the gate components.

13. Monitor the condition of the welding transformers, gas cutting sets, umbrellas, tool kits, torches, chain blocks, ropes, ballies etc. on daily basis and to see that things are in place to handle any emergency situation.

14. Observe the Gates, hoists and handling equipment during operation for the smooth movements and to immediately report any untoward excessive sounds in the motors, pumps or vibrations in the gate.

15. Observe the dam top, ensure that embankment, catwalk, approach roads are well maintained by housekeeping personnel.

16. Observe the performance of the Dam and its appurtenant structures / Gates and Hoists during flood water releases and to report to the EE/ Dy. CE /CE in case of any untoward incidents or malfunctioning of the gates of excessive seepages, leakages etc.

17. Assist EE/Dy. CE /CE to coordinate with the Generating staff of Idamalayar Powerhouse downstream in the operation and power generation.

18. Assist EE/Dy. CE /CE to share the flow data and the reservoir storage details to the Media on day to day basis during flood.

1.5.2 Roles and Responsibilities of the Dy. CE and EE during Monsoon

1. Conduct Periodical (Pre and Post Monsoon) inspections to assess the health of the Dam and to direct the Executive Engineer for the immediate repair and maintenance for the smooth operation. Submit the inspection reports to the Chief Engineer and upload in DHARMA.

2. Observe the performance of the Dam and its appurtenant structures / Gates and Hoists before and after monsoon and to issue necessary instructions to the Executive Engineer.

3. Coordinate with the concerned officers of TamilNadu regarding Nirar and inflow through Vachumaram diversion and to bring status, rainfalletcto the notice of the Dy. CE/ CE.

4. To issue notification to the inhabitants downstream in Newspapers, Radio, TV News channel to alert them regarding the flood situation.

5. Assist the CE to coordinate with the Revenue authorities (District Administration) to alert the downstream villagers to evacuate from the flood zone to prevent loss of life and livestock.

6. Assist the CE to coordinate with the CWC flood monitoring authorities on the flood condition.

7. Submit to the CE the daily inflows and releases from the reservoir and status.

8. Operate the Spillway crest gates for flood mitigation as per the instructions of the CE and to update the Gate Operation Log book.

9. Observe the seepages in the drainage Gallery with respect to the reservoir head and record the seepages in the infiltration gallery and to immediately bring to the notice of the CE in case of excessive seepage, leakage in any specific blocks and porous drains.

10. Observe the Gates, hoists and handling equipment during operation for the smooth movements and to immediately report any untoward excessive sounds in the motors, pumps or vibrations in the gate.

11. Observe the dam top, ensure that the embankment, catwalk, approach roads are well maintained by housekeeping personnel.

12. Observe the performance of the Dam and its appurtenant structures / Gates and Hoists during flood water releases and to report to the CE in case of any untoward incidents or malfunctioning of the gates of excessive seepages, leakages etc.

1.5.3 Roles and Responsibilities of the Chief Engineer during Monsoon

1. To issue sanction for flood release notification after discussing with Kerala Disaster Management Authority and Revenue Authority (District Administration).

2. Coordinate with the CWC flood monitoring authorities on the flood condition.

3. Issue necessary instructions to the engineers to operate the reservoir based on the in-flows, rainfall data, releases from the upstream reservoirs and status of the reservoir.

4. Observe the performance of the Dam and its appurtenant structures / Gates and Hoists during flood water releases and to issue necessary instructions to the Dy. CE/EE.

5. Coordinate with the Generation wing of KSEB Ltd regarding the power generation requirement.

1.6 Collection & Reporting of Dam and Reservoir Data

Dam Reservoir Data and vital information as below are collected, recorded and documented for the record.

- Reservoir water surface elevation.

- Reservoir inflow.
- Spillway outflow.
- River releases.
- Irrigation, water supply and hydropower releases.
- Weather related data
- Instrumentation data
- Water quality

MWL (m)	FRL (m)	Crest Level (m)	Present Water Level (m)	Previous Year Water Level	Percentage Storage	Rainfall (mm)	Generation (Mu)	Spill	Gate operation details

Table 1.1 Daily Reservoir Data

Date	Water Level	Previous Year Same day Water Level	Rainfall	Previous Year Rainfall	Storage	Generation	Gross Inflow	PH Discharge + Losses	Spill	Net Inflow	Remarks

Table 1.2 Daily Reservoir Status

Instruction is given to the Executive Engineer for daily collection and reporting of inflow and outflow data in a standard proforma as in **Table 1.1** above to the Deputy Chief Engineer. On collecting the details in the above format, a daily reservoir status is submitted to the Chief Engineer as in the **Table 1.2.**

Records/Logbooks of the operations at Idamalayar Dam are maintained in a chronological manner for reference. These records are helpful for identifying preventative maintenance measures that may need to be taken up, troubleshooting the cause of potential equipment failure and documenting development of any unusual conditions.

- Date and Time
- Attendance statement during normal operations – both during monsoon and non-monsoon periods.
- Operations of the spillway gates and outlet works.
- Operating hours of mechanical equipment.
- Testing/Operation of spillway gates and associated controls.
- Testing/operation of Power Outlet gates, valves and associated controls.

- Maintenance activities carried out.
- Reservoir and dam inspections.
- Unusual conditions or occurrences.
- Safety and special instructions.
- Names of officers and staff carrying out inspections and maintenance.

Periodical collection of Dam and Reservoir Data are done as follows:

Reservoir water surface elevation	This is collected daily
Reservoir inflow	This is calculated daily
Spillway outflow	This is calculated during spill
River releases	The tail water release is measured at power house and fed to Bhoothathankettu irrigation dam
Irrigation, water supply and hydropower releases	The reservoir water is used for power generation and the tail water is released to Irrigation and water supply.
Weather related data	Collected and reported daily
Surveillance/Security arrangements	Provided at three security check posts near dam. CCTV surveillance will be provided soon covering the dam and premises.
Water quality	The quality of water is tested at Regional analytical laboratory, Kakkanad, Ernakulam district.
Attendance statement during normal operations	Both during monsoon and non-monsoon period maintained at field office.
Operations of the spillway gates and outlet works	The spill way is designed for a safe discharge of 3248 m^3/s at MWL. There are 4 no of radial gates for spillway operation.
Operating hours of mechanical equipments	Maintained at field office
Testing/Operation of spillway gates and associated controls	The testing and operation are being carried out as per the manual and maintenance schedule. Other details maintained at field Office.
Testing/operation of Outlet gates, valves and associated controls	Maintained at field office
Maintenance activities carried out	Details maintained at field office

Reservoir and dam inspections	Periodically inspected and details maintained at field office
Unusual conditions or occurrences, including acts of vandalism	Details maintained at field office
Attendance statement at dam during emergency operations	Details maintained at field office
Changes to normal operating procedure	Details maintained at field office
Communication network checks	Regularly checked
Safety and special instructions	Safety equipments provided
Names and addresses of official visitors	Record of inspections maintained at office

1.7 Public Utilities and Safety

As safety of Project Staff is of prime concern, safety instructions & protection measures at the dam are to be followed by all staff / project personnel. Security personnel are located on the left and right abutment for providing public notices of events and status of security of the dam and downstream river conditions.

Access Roads: The access road to the township of Idamalayar Project starts at Kothamangalam in the Aluva-Munnar road. The road is the same up to Thundam, a place about 15 km from Kothamangalam where the road bifurcates to Vadattupara and Chakkimedu. The road is 26 km in length from Kothamangalam to Idamalayar Township via Chakkimedu and 25 km via Vadattupara. The road via Chakkimedu is blacktopped for the full length and the other road is blacktopped up to Vadattupara. The remaining length of about 4 km from Vadattupara is uncarpeted 'coupe' road. The road is maintained by state PWD up to Keerampara, a distance of about 6 km from Kothamangalam. From Keerampara up to Bhoothathankettu, it is under the control of the irrigation department. The rest of the road including the bifurcation from Thundam is maintained by KS E Board. The blacktopped access roads to the Power House, to the dam top and bottom and those of the colony are also maintained by KSEB Ltd.

Location of public conveniences: Inspection Bungalow and Canteen are located near the dam. Police station is located at Kuttampuzha, 15 km away from the dam. A private hospital is

available at Vadattupara, 5 km away from dam. A Government hospital is located at Kothamangalam, 30 km away from dam.

Safety equipment available at the dam: First aid kit and fire extinguisher is available.

1.8 Restricted Areas

Certain areas of the dam and reservoir are restricted for entry of the general public. The purpose is for security of the dam, public safety and uninterrupted safe operation of the dam. Sign boards are displayed at the prohibited areas. Restricted areas will include the following:

- Confined spaces such as adits, galleries, etc.
- Spillway approach areas, chutes and stilling basins.
- Control buildings and valve areas.
- Intake or outlet channels adjacent to hydraulic structures.

1.8.1 Dam safety surveillance

Security arrangements are already provided through private agency at three security check posts near dam. Also CCTV surveillance will be provided soon covering the dam and premises.

Security Arrangement Existing - Private agency

Recommended by SISF - Required strength – 21 No.
(Head Constable - 3 No and Police Constable - 18 No)

1.9 Staff position, Communication & Warning System

The number and description of operating unit personnel posted/placed at different locations of the dam are noted in supporting documents and referenced in this Manual. Means of communications both in normal and emergency situations are identified in the Communication Directory. Communication means available include landline, mobile and satellite phones and wireless sets. Basic facilities like siren are available.

A hierarchy of organizational structure for the control and safety of Idamalayar dam is outlined below in **Fig 1.5**.

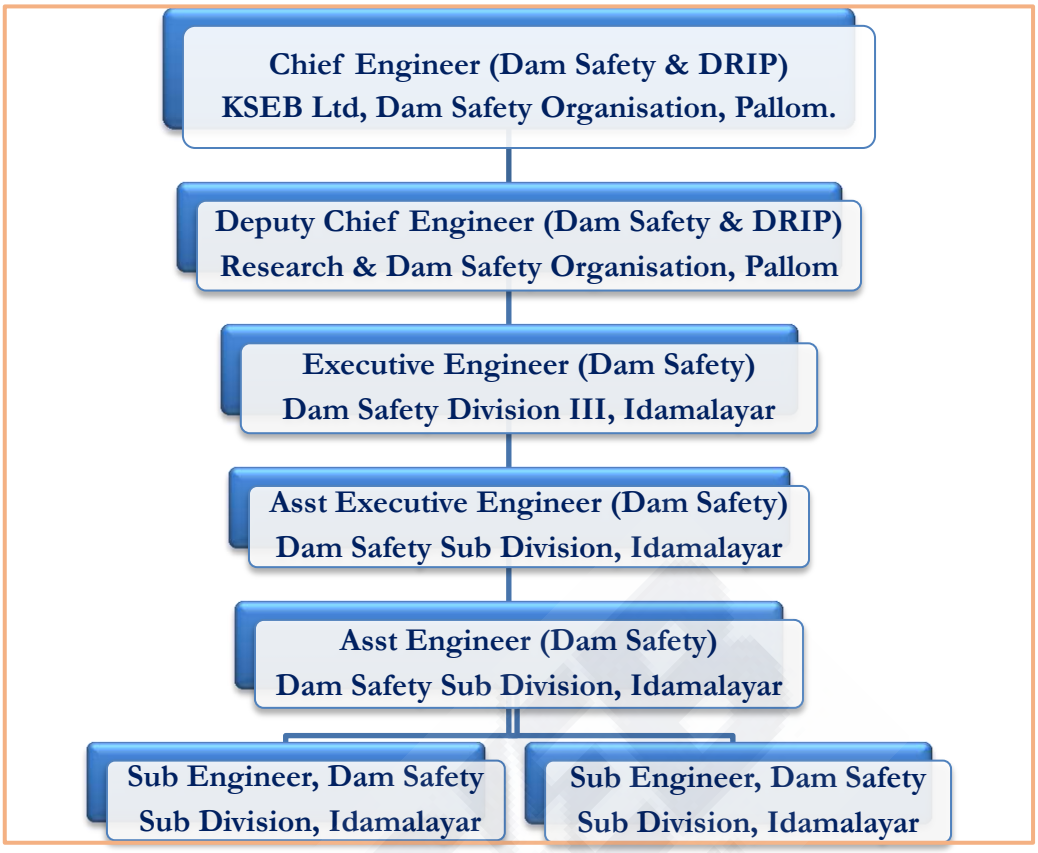


Fig 1.5 Dam Safety Organisation Structure for Idamalayar Dam

Present hierarchy of Controlling officers and their contacts are as below:

Designation and office address	Contact number and e-mail
Chief Engineer Civil (Dam safety & DRIP), KSEB Ltd, Dam Safety Organization, Pallom, Kottayam	Ph: 9446008005, 9446008964 e-mail: cedamsafety@kseb.in, cedamsafety@gmail.com
Deputy Chief Engineer, Research & Dam Safety Organization, Pallom, Kottayam	Ph: 9446008492, 0481-2432290, 9496011540 e-mail: dirroplm2@gmail.com
Executive Engineer, Dam Safety Division No. III, Idamalayar	Ph: 9446008426 e-mail: ddidamalayar@gmail.com
Assistant Executive Engineer, Dam Safety Sub Division, Idamalayar	Ph: 9496011977 e-mail: aeeds1idr@gmail.com
Assistant Engineer, Dam Safety Sub Division, Idamalayar	Ph: 9496011980

Warning System

Mike announcement, Newspaper and Television are used for providing warning to the downstream areas during floods.

Spillway flood releases

Idamalayar reservoir was being operated as per 'Guidelines for Operation of Reservoirs' (IS 7323:1994), for storage reservoirs for conservation purposes like power generation, no spilling of water over the spillway will normally be permitted until FRL is reached. During flood season, various alerts at specified levels for opening of spillway gates were given. The first warning as water level reaches 165.00 m, second warning as water level reaches 167.00 m and third warning as water level reaches 168.50 m are given for opening of spillway gates. After giving first warning at +165.00 m level, further warning is given in local media including TV etc. regarding the possible opening of spillway gates continuously up to +168.50 m level. Also intimations are given to Disaster Management, District Administration, Police Department etc. Following the Kerala flood 2018, the flood release strategy is revised based on Rule Levels as given in **Chapter 2**.

Releases for various purposes like irrigation, water supply and hydropower

Water from the reservoir is mainly used for power generation at a **2 x 37.5 MW** powerhouse of KSEB Ltd. The tail water from power house is used for irrigation, water supply etc by Irrigation Department, Water Authority etc. There is no water supply arrangement directly from the reservoir. The entire water after generation (average 1350 MCM per annum) is released to downstream from the reservoir.

Routine inspection

Usually monthlyinspection and quarterly inspections as per KDSA carried out by the operating/controlling officers. Premonsoon inspection and Post monsoon inspection as per CWC norms are carried out and reports intimated to CWC. The premonsoon and post monsoon reports are to be updated in DHARMA web site.

Maintenance

Routine maintenance is carried out for Spillway gates, Intake gates and HB valve before the onset of monsoon. Details are given under the Chapter **Project Maintenance**.

1.10 Distribution of Operation & Maintenance Manual

The following officers/ field staff at different levels in the Division under the supervision of Deputy Chief Engineer, Research & Dam Safety Organization, KSEB Ltd, Pallom and Administrative control of Chief Engineer, Dam Safety Organization, KSEB Ltd, Pallom are entrusted with the specific responsibility for carrying out O & M activities for Idamalayar dam.

1) Executive Engineer, Dam Safety Division No. III, Idamalayar
2) Asst. Executive Engineer, Dam Safety Sub Division, Idamalayar
3) Assistant Engineer, Dam Safety Sub Division, Idamalayar
4) Personnel in charge of works of the Dam

The offices/officers to which the O & M Manual of Idamalayar dam is to be distributed are:

1. Dam Safety Division No. III, Idamalayar
2. Dam Safety Sub Division, Idamalayar
3. Assistant Engineer, Dam Safety Sub Division, Idamalayar
4. Office of the Deputy Chief Engineer, Research & Dam Safety Organization, KSEB Ltd, Pallom
5. Office of the Chief Engineer, Dam Safety Organization, KSEB Ltd, Pallom

1.11 Supporting Documents & Reference Material

This O & M Manual is the key instruction document. Supporting documents and necessary instructions for all phases of the operation, inspection and maintenance of the dam, reservoir and appurtenant works shown below are available at the dam control room.

- Detailed drawings of the Project
- Emergency Action Plan (EAP)
- Latest Hydrology Review and DSRP Reports
- Flood forecasting and operating criteria
- Agreements with user agencies
- Power station operation plan
- Administrative procedures
- Maintenance schedules
- Gate Manufacturer's Manual and drawings

- Regional communication directory
- Instrumentation reports / results

1.12 Typical Schedule of Duties

Schedule of duties/inspections to be carried out for the operation and maintenance of the dam by the concerned official are tabulated below in **Table 1.3**.

Sl. No.	Component/ Duty	Frequency	Personnel
1	Visual inspection of dam including Crest of dam (Dam top), Upstream and downstream faces, visible portions of foundation and abutments, Galleries, Spillway and its energy dissipation arrangements, Power Intake etc.	Daily	Sub Engineer/Dam operators on contract
2	Record water surface elevation, reservoir inflow and spillway discharge.	Daily (Hourly basis during monsoon)	Sub Engineer/Dam operators on contract
3	Record meteorological data, Record releases from outlets /sluices	Daily	Sub Engineer/Dam operators on contract
4	Check security and safety devices, Complete logbook / site register which include the above information.	Daily	Assistant Engineer
5	Record seepage from drainage systems, gallery drains etc. and meteorological data.	Weekly	Sub Engineer/Dam operators on contract
6	Visual inspection of dam including Crest of dam (Dam top), Upstream and downstream faces, visible portions of foundation and abutments, Galleries, Spillway and its energy dissipation arrangements, Power Intake etc.	Weekly	Assistant Engineer
7	Check stand by generator (DG Sets), Drainage systems, Gallery drains etc.	Weekly	Assistant Engineer
8	Visual inspection of dam like Crest of	Fort nightly	Assistant Executive

	dam, Upstream and downstream faces, foundation & abutments, Galleries, Spillway and its energy dissipation arrangements, Power Intake etc.		Engineer
9	Check security and safety devices, logbook and site register which include the above information.	Fort nightly	Assistant Executive Engineer
10	Check stand by generator (DG Sets), Drainage systems, Gallery drains	Fort nightly	Assistant Executive Engineer
11	Measuring devices, communication devices, status of instruments, vegetation growth	Fort nightly	Assistant Executive Engineer
12	Check Sign/Warning display boards near vulnerable locations	Fort nightly	Assistant Executive Engineer
13	Visual inspection of dam including Crest of dam (Dam top), Upstream and downstream faces, visible portions of foundation and abutments, Galleries, Spillway and its energy dissipation arrangements, Power Intake etc.	Monthly	Executive Engineer
14	Check measuring devices/Instruments, Security and safety devices, Communication Devices, Status of Vegetation growth, rectification, if needed.	Monthly	Executive Engineer
15	Check Sign/Warning display boards near vulnerable locations	Monthly	Executive Engineer
16	Replace fuse light bulbs, Inspect to maintain ventilation system, cleaning of control panel boards.	Monthly	Assistant Engineer
17	Check Power outlet, updating operating instruction, check gate air vents, clean gate control switch boxes, check operation of gates, grease gate hanger/dogging	Quarterly	Executive Engineer

18	Check condition of trash rack of intake structure, Check condition of Outlet works & its Energy Dissipation Arrangement, Check operation of Valve house	Quarterly	Executive Engineer
19	Check condition of spillway, Check for debris in inlet channel, Check operation of gates, Check for damages in spillway glacis, energy dissipation arrangement, d/s area etc. Check and clear spillway bridge drains, Clean inside of motor control cabinet.	Quarterly	Executive Engineer
20	Check for adherence to instrumentation schedule, Record pertinent information in Operation of Gates, Check condition of V-notch/seepage measuring devices, Check hydro mechanical components.	Quarterly	Executive Engineer
21	Inspection of Spillway & outlet works, hydro mechanical components, Check paint on gates, Check lubrication of wire ropes and application of cardium compound, Check mechanical hoist bearings and flexible coupling bearings, Check gear systems, Exercise gates and valves, Check oil reservoir level in hydraulic system, Check pressure release valve, Check lubrication of gate rollers, Check rubber seals and seal clamp bar.	Half yearly (Pre and Post Monsoon)	Deputy Chief Engineer along with Executive Engineer in charge of dam
22	Submission of Inspection report to CWC and uploading into DHARMA.	Half yearly	Chief Engineer/ Deputy Chief Engineer
23	Inspections by Dam Safety Authority	Three Yearly	Dam Safety Authority along with Dam Owners
24	Inspect dam and gate structures, trash racks and stilling basin/energy dissipation arrangement, which normally are underwater (by dewatering or by divers/ROV as necessary). Review Dam	Five Yearly	Chief Engineer/ Deputy Chief Engineer

	operation procedures, EAP and update as necessary.		
25	Comprehensive inspection of performance of the dam, gate structures, reservoirs, trash racks and stilling basin /energy dissipation arrangement.	Ten Yearly	DSRP

Table 1.3 Schedule of duties/inspections

1.12 Hydro-Mechanical Inspections / Checks

Frequent inspections/checks for hydro-mechanical components are to be conducted and necessary action to be taken up during maintenance. Routine maintenance is carried out for Spillway gates and hoisting machinery as part of routine maintenance before the onset of monsoon. Details are given under the Chapter **Project Maintenance**.

Chapter 2

Project Operation

The operation of a dam will involve regulation of its reservoir as per project specific requirements, keeping records and ensuring public safety. Proper operation procedures are crucial for normal or day to day operation of a dam for maintaining a safe structure.

2.1 Basic Data

The Idamalayar operation plan consists of step-by-step instructions for operating the dam and reservoir during routine (normal) and emergency conditions. The operating procedures for normal operations are discussed in this chapter including operating criteria for the reservoir, spillway & outlets. The water from the reservoir is diverted through water conducting system consisting of tunnels and penstocks to generating station located on the left bank of Idamalayar River. The tail water of this project is discharged to Idamalayar River. The Idamalayar reservoir in addition to its own catchment area, receive water released from Nirar in Tamil Nadu and diversion from Poringalkuthu reservoir through Vachumaram diversion. The operation of the dam at Idamalayar involves regulation of its reservoir as per rule curve/project specific requirements.

2.1.1 Reservoir Capacities

The Gross storage of the reservoir is 1089.80 Million Cubic Meters and the live Storage is 1017.80 Million Cubic Meters at FRL of +169.00 m. The Dead storage of the reservoir is 72.00 Million Cubic Meters at +115.00 m (MDDL).

2.1.2 Area Capacity curves

The area capacity curve for Idamalayar reservoir in graphical form is shown in **Annexure 1 Drg 2.1.**

2.1.3 Elevation Storage curves.

The elevation storage curves for Idamalayar Dam in tabular and graphical form are shown in **Fig 2.1** and **Table 2.1**.

Elevation Capacity of IDAMALAYAR Reservoir

MDDL m	FRL m	MWL m	Dead Storage in Mm^3
115	169	171	72
Reservoir Level		**Gross Storage**	**Remarks**
in ft	in m	Mm^3	
262.47	80	0.75	Bed Level
311.68	95	8	
344.49	105	24	
377.3	**115**	**72**	**Minimum Draw Down Level**
380.58	116	78.25	
383.86	117	85.25	
387.14	118	93.5	
390.42	119	101.75	
393.7	120	110	
396.98	121	119.25	
400.26	122	128.5	
403.54	123	138	
406.82	124	148	
410.1	125	158.5	
413.39	126	169.5	
416.67	127	181	
419.95	128	192.5	
423.23	129	205.5	
426.51	130	219	
429.79	131	233.5	
433.07	132	248	
436.35	133	262.5	
439.63	134	277	
442.91	135	292	
446.19	136	307	
449.48	137	325	
452.76	138	343.5	
456.04	139	362	
459.32	140	381	
462.6	141	400.55	

465.88	142	419.9	
469.16	143	439.25	
472.44	144	458.6	
475.72	145	479	
479	146	500	
482.28	147	521	
485.56	148	543	
488.85	149	564.67	
492.13	150	587.34	
495.41	151	610.5	
498.69	152	633.66	
501.97	153	656.82	
505.25	154	680.48	
508.53	155	704.24	
511.81	156	728	
515.09	157	752	
518.37	158	777	
521.65	159	804	
524.93	160	832	
528.22	**161**	**860**	**Spillway Crest Level**
531.5	162	888.3	
534.78	163	916.8	
538.06	164	945.5	
541.34	165	974.3	
544.62	166	1003.1	
547.9	167	1031.9	
551.18	168	1060.8	
554.46	**169**	**1089.8**	**Full Reservoir Level**
557.74	170	1118.8	
561.02	**171**	**1147.8**	**Maximum Water Level**
561.68	171.2	1153	
564.3	172	1176.3	**Dam Top Level**

Table 2.1 Idamalayar Reservoir Elevation vs Capacity data

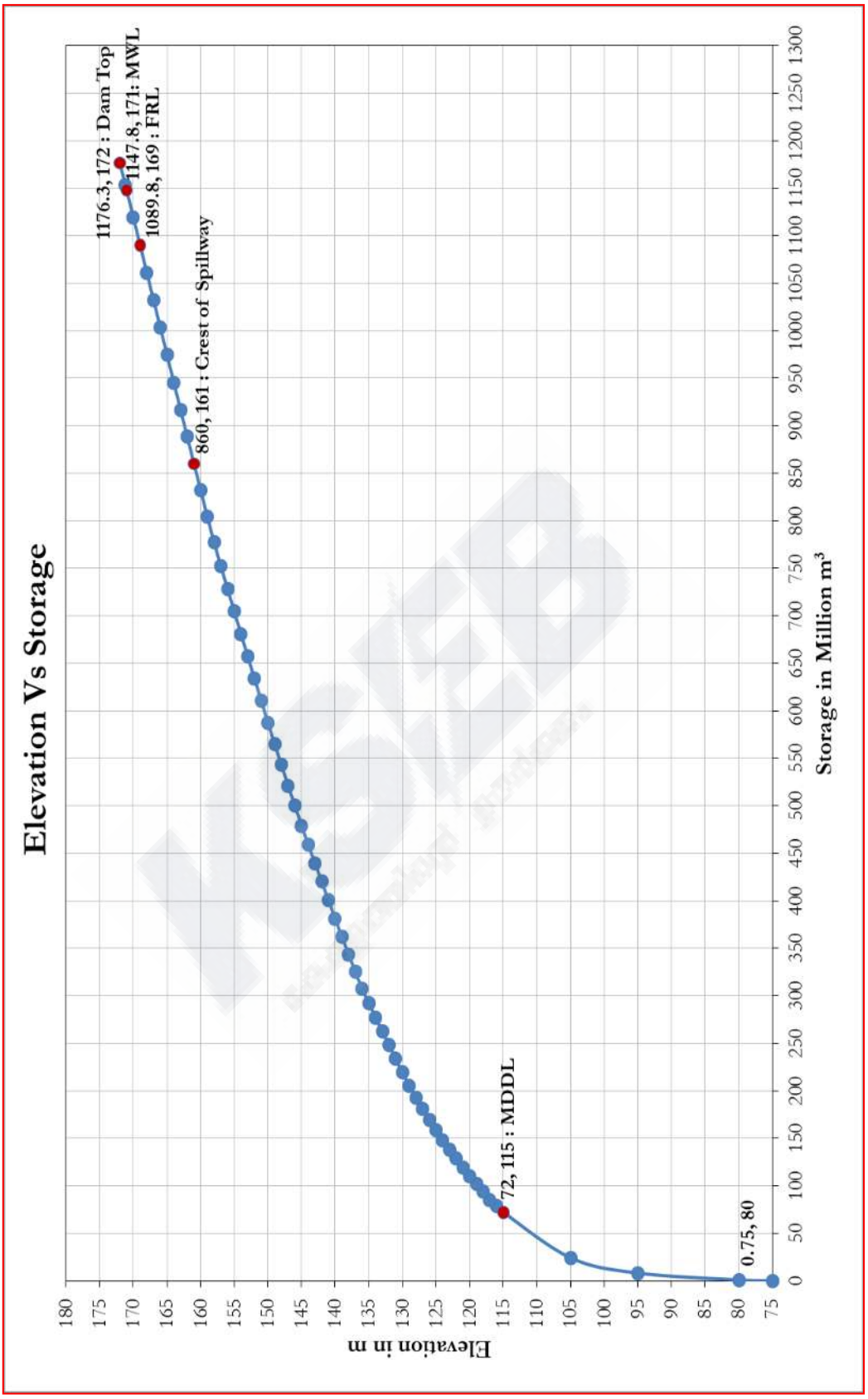


Fig 2.1 Elevation - Capacity Curve

2.2 Operation Plan

An effective operation plan and schedule is required for the safe project operation for which the project specific features shall be known. Salient features of the Reservoir including Elevation Vs Storage are given below.

Salient features.

Type of dam	-	Concrete gravity
River Bed Level	-	+81 m
Top level of dam	-	+172.00 m
Maximum Water Level (MWL)	-	+171.00 m (original)
Full Reservoir Level (FRL)	-	+169.00 m
Minimum Draw Down Level (MDDL)	-	+115.00 m
Height Above deepest foundation	-	102.40 m
Height Above river bed	-	91.00 m
Width of Spillway	-	60 m
No and size of radial gates	-	4 Nos (11.50 m x 9.70 m)
Crest level of spillway	-	+161.00 m
Maximum spillway discharge at MWL	-	3248 m^3/s at original MWL
Gross storage at FRL	-	1089.8 Mm^3
Live storage at FRL	-	1017.8 Mm^3
Dead storage	-	72 Mm^3
Water spread area at FRL	-	2830 ha

2.2.1 Data of the historic floods

As per historical records, the maximum flood observed in Western Ghats was during 1924. The centre of the storm was located at Devikulam in Kerala. Hydrological studies were carried out for the Idamalayar dam considering the rainfall data from 1943 – 1968. Flood hydrograph has been derived from the highest recorded flood of 1963.

An unprecedented flood occurred in the dam site during 29-30 of August 1993 also where the 24 hr. rainfall recorded on 30.08.1993 was 257 mm. This caused disturbance to the right bank side. A heavy earth slip and settlement occurred at the right bank about 50 m away on the

downstream side of the dam. This is detailed under Special problems in **Annexure 3**. Further, due to the rainfall in 2013, this slope again got disturbed.

The SW monsoon of the year 2018 in the State was similar to that of 1924 Devikulam storm and Kerala experienced an abnormally high rainfall from 1 June 2018 to 19 August 2018 which resulted in severe flooding in 13 out of 14 districts in the State. It is seen that the 2-day and 3-day rainfall depths of 15-17, August 2018 rainfall in Pamba, Periyar and Bharathapuzha sub-basins are almost comparable to the Devikulam storm of 16-18, July 1924. Out of 758.6 mm rainfall from 1 August 2018 to 19 August 2018, about 414 mm rainfall (Kerala average) occurred in just three days viz. 15-17, August 2018, which created severe flooding in the State, while the same during 16-18, July 1924 was 443 mm. The 3-day rainfall of 15-17, August 2018 as measured in a rain gauge at Idamalayar dam site was much more (595 mm).

The spillway shutters were opened during ***1992, 1994, 1998, 2005, 2007, 2013 & 2018***. Maximum inflow, maximum spill of the above years are tabulated below in **Table 2.2**. Also the rainfall details of the above years are included in **Annexure 4**.

Date	Water level in m	Rainfall for the day (mm)	Maximum Inflow in Mm^3	Spillway discharge in Mm^3
28-07-1992	155.93	131	49.746	0.00
10-10-1992	169.18	41.5	11.260	19.049
11-10-1992	169.03	29.5	18.330	17.458
06-09-1994	168.98	53	14.406	7.021
07-09-1994	169.12	23	18.061	8.813
14-07-1994	151.50	195	71.392	0.00
12-10-1998	166.25	157.5	38.32	0.00
18-10-1998	169.01	6.5	10.510	4.270
01-08-2005	157.47	109	48.991	0.00
11-09-2005	169.06	113.2	28.164	8.780
14-09-2005	169.00	17	25.480	19.868
02.07.2007	143.03	124.6	72.31	0.00
25-09-2007	169.11	99.5	18.367	5.981

26-09-2007	169.02	24	17.830	14.685
02-08-2013		148.2	63.223	0.00
04-08-2013	168.64	16.6	29.455	32.244
05-08-2013	169.07	154.6	50.429	24.955
06-08-2013	169.07	61	30.590	10.483
15-08-2018	169.15	170.00	62.96	50.20
16-08-2018	169.75	230.00	100.59	81.23
17-08-2018	168.96	195.00	86.97	109.88
09-08-2019	143.62	225.00	89.99	0.00

Table 2.2 Maximum Inflow and Spill Details

2.2.2 Design Flood and Features Related to Safety

Hydrology for the original designs as available in records is given below. The total catchment area of Idamalayar is 481.74 km^2 (186 sq. miles). Of this, the yield from 101.01 km^2 of Nirar catchment has been agreed to be diverted by Tamil Nadu under the Parambikkulam-Aliyar Project (P.A.P) Agreement. The agreement with Tamil Nadu provides that the entire flow from 75 km^2 (29 Sq miles) of the Upper Nirar weir and 2.5 TMC (70.79 Million m^3) of water from Lower Nirar catchment which is approximately 26 km^2 (10 sq. miles) is diverted to the P. A system. However natural flows from Upper Nirar catchment during the period from October to January both inclusive every year should be released in to the same river until all the reservoirs proposed in Periyar basin are completed. The average yield thus expected to be released from the Upper Nirar weir and Lower Nirar Dam after diversion to P.A project and available for utilization in the Periyarbasin under the Idamalayar scheme would be more than 57 Million m^3 (2 TMC). However, this flow was not included in the hydrological computations of this project.

For the purpose of hydrological studies, the balance catchment area of 380.7 km^2 (186 - 39 = 147 sq. miles) of the Idamalayar catchment was considered. The runoff data for the project was prepared using the well-known INGLIS' formula for Western Ghats i.e., runoff (in inches) =0.85* rainfall (in inches) - 12. The weighted average rainfall was found out by the Theissen Polygon method using the data from 15 rain gauge stations in and around the scheme catchment. From the runoff data prepared, the yield of the catchment area is calculated. From

the data prepared for the period from 1943 to 1968, the maximum yield is 1925.5 Million m^3 in the year 1961 and the minimum yield is 928.65 Million m^3 in the year 1965. The average over the 26 years from 1943 to 1968 works out to be 1369.69 Million m^3.

Flood hydrographs were plotted for the storm which occurred in the Puyamkutty Basin, since the year 1963. Unit hydrographs were derived for the selected flood, namely the flood that has occurred in 1964 and was the highest recorded flood. The compound flood hydrograph has been separated by judging the recession curve of the first limb. Antecedent precipitation being high the base flow contribution is considerable. The ordinate of the surface runoff determined from the hydrograph were then calculated. Corresponding values of the base flow were also found out. The volume of surface runoff was obtained as 6.54 inches. This is being very much higher than 1 inch the errors creeping in the derivation of unit hydrograph are considerably minimized. Making use of the unit hydrograph derived for the gauged Puyamkutty Basin, a synthetic unit hydrograph was constructed, for the ungauged catchment of the Idamalayar Basin. Using this unithydrographs, peak design flood was calculated to be 3851 m^3/s for the Idamalayar Basin at that time.

Hydrology review carried out in DRIP

As per BIS 11223-1985, the dam is classified as a large dam, i.e., Reservoir Capacity above 60 Mm^3 and Hydraulic head above 30 m. For large dams, spillways are to be designed for PMF. Hence, as a pre requisite for DRIP, the design flood was reviewed in 2014 and approved by CWC with a peak value of 6547 m^3/s.

The revised flood (PMF) is estimated assuming one-day rain fall value as 70 cm, which is the maximum value of PMP in the Kerala region based on PMP Atlas of CWC. On routing the revised flood hydrograph with peak 6547 m^3/s with impingement level as FRL, the water level in the reservoir reaches a maximum of 170.92 m, with maximum outflow of 3239.84 m^3/s. Latest design flood and flood routing study is maintained as a supporting document.

2.2.3 Spillway Operation

The spillway of Idamalayar dam **(Fig 2.2)** has four numbers of radial gates. The spillway consists of four spans of 11.5 m clear, with two single piers 1.75 m thick each and three double piers of thickness 3.5 m each. The single piers extend as guide walls throughout the spillway and as training walls below that up to Ch. 105.05 m downstream. The elevation of the crest of the spillway is 161 m and the FRL is 169 m, i.e. 8 m above the crest. The extra height of 0.5 m to

top of gate (169.50 m) above FRL serves as the margin for additional storage which could be utilized at times when the danger of flood has passed for certainty and inflows continue to be ample. The spillway section has an upstream face similar to the non-overflow section. The downstream face slope is 0.8 H in 1V below the point of tangency at top (El 152.05 m) to the tangent point at the bottom +86.957 m. The invert of the bucket is at an elevation of +80.20 m. The lip of the bucket is 2 m wide and has elevation of +83.28 m. A section through radial gate is shown in **Drg 2.2** and section through spillway bucket in **Drg 2.3**. Details of bucket and crest of spillway are shown in **Drg 2.4** and **Drg 2.5** respectively.

Fig 2.2 Idamalayar Spillway

2.2.4 Hoisting Arrangements for Radial Crest Gates

The main component of hoisting system (rope drum hoists) for operation of the crest gates of Idamalayar Dam spillway is mounted on the spillway hoist bridge downstream side (**Fig 2.3**). The spillway is provided with radial gates of size 11.5 m x 9.7 m which can be operated both by power and by manually. The gate operation platform is at an elevation of +174 m leaving a clearance of over 2 m above the gate in the lifted position. The gates are operated and tested in every season when the water is below the crest level. Periodical maintenance like painting, greasing, oiling etc. is done from time to time.

Fig 2.3 Radial Gates Hoist Bridge

The General arrangement showing hoisting mechanism, panel board and motor of all the four gates are given in **Fig 2.4**. Each control panel contains the necessary main line fuse and switch reversing contacts and relay, indicating lamps etc. Necessary inter-locking arrangement is provided to disengage the hoist machinery from electric circuit when manual operation is in progress. There is also a provision for operating the hoist manually in case of power failure. The gates must be operated as per the instructions and procedures as described in the gate operation manual included in **Annexure 2**.

Individual gate hoisting is given in **Fig 2.5a, Fig 2.5b, Fig 2.5c & Fig 2.5d**. The control panel arrangement of all the four radial gates and intake gate are as in **Fig 2.6**.

River outlet Works

There are no river outlet works for this dam as such. Instead, disperser valves are provided at an elevation of about +96 m for letting out water from the power tunnel through the two 1.828 m diameter pipes spaced at 3.172 m and having 1.5 m diameter outlets. These outlets have a maximum discharge capacity of 54.5m^3/s each. Section and Plan of disperser valve is given in **Drg 2.6.**

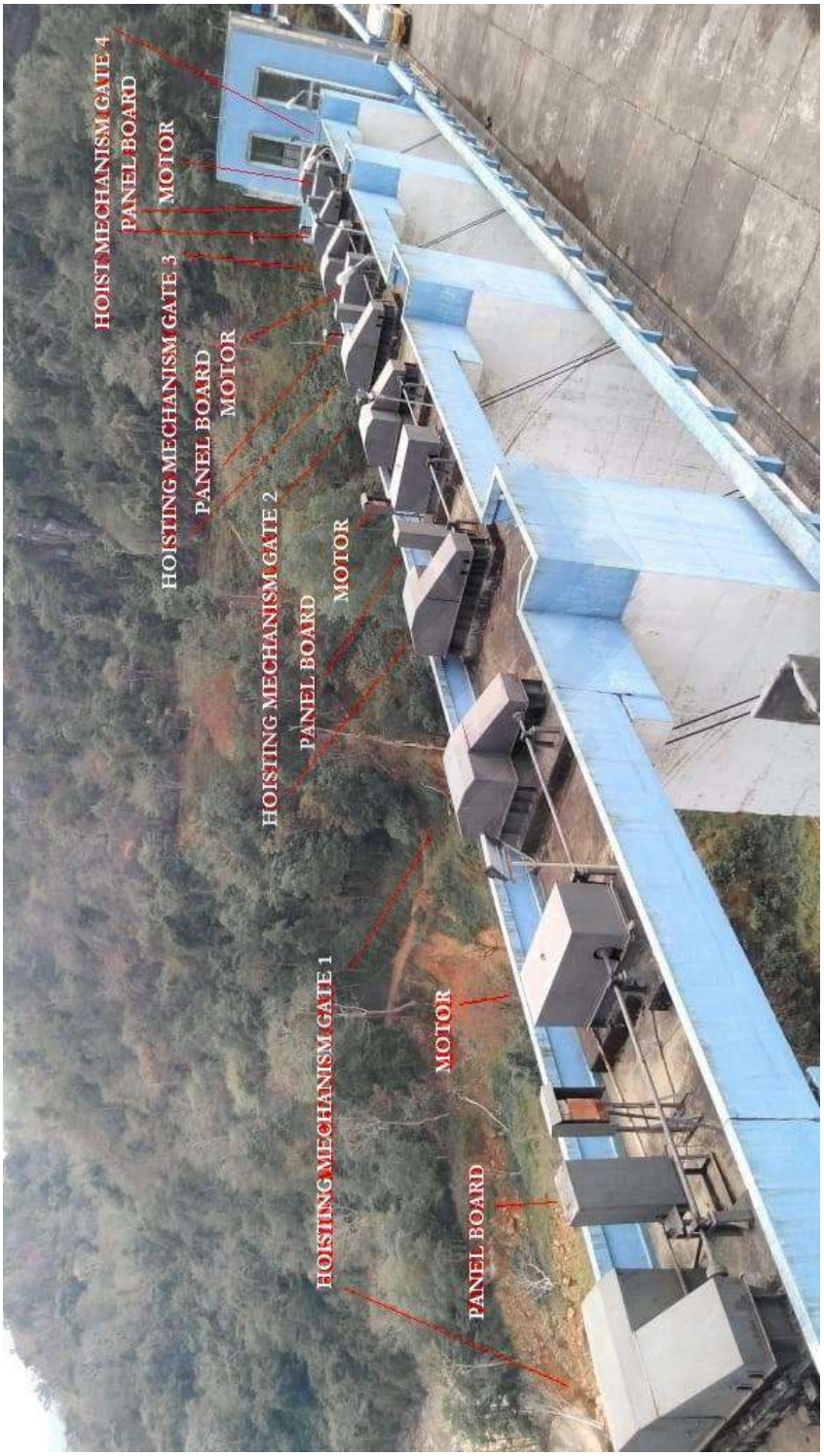
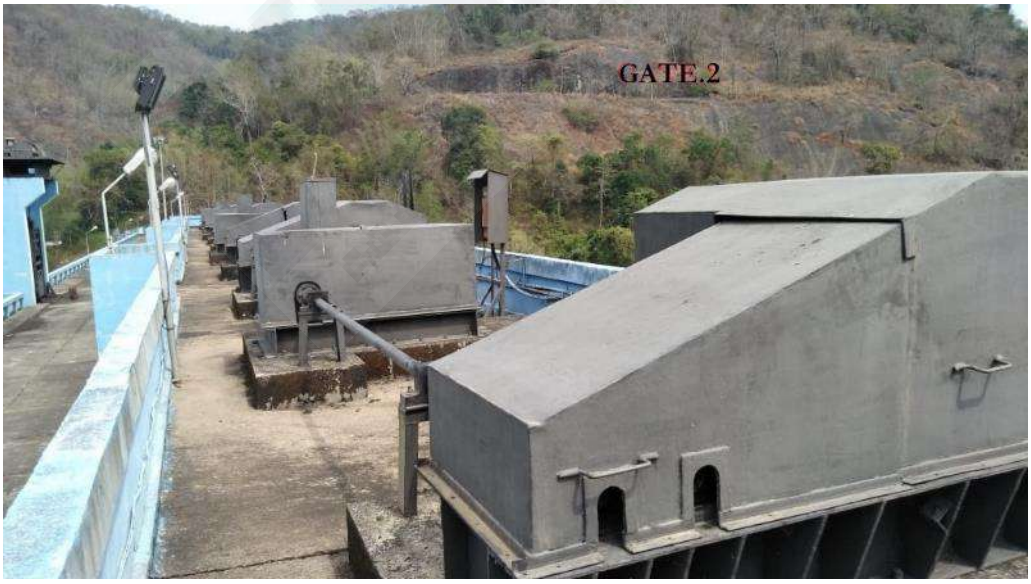


Fig 2.4 Idamalayar Dam Hoist Mechanism

(a)

(b)



(c)

(d)

Fig 2.5 Radial Gates Hoist Mechanism (a, b, c, d)

Fig 2.6 Control Panels

2.3 Normal Operation of the Reservoir

2.3.1 Operation of Control Mechanisms

The spillway gates hoist motors are having 10 HP capacity each and the intake hoist motor is having 40 HP capacity. Control mechanism and panel boards are as in **Fig 2.6**. The Operation manual of control mechanism and installation is attached **Annexure 2**.

2.3.2 Operation of the Reservoir

Idamalayar reservoir was being operated as per 'Guidelines for Operation of Reservoirs' (IS 7323:1994), for storage reservoirs for conservation purposes like power generation, no spilling of water over the spillway will normally be permitted until FRL is reached. Hence no rule curve was prepared for this dam. Flood release was done as explained in **Clause 1.9 Chapter 1**. Idamalayar reservoir F R L is **169.00 m** and spillway crest level is **161.00 m**. The total spillway discharge (free discharge) through spillway gates (4 Nos) for different reservoir levels under full opened condition is tabulated in **Table 2.3** and is given in **Fig 2.7**. Discharge (Rating) curve through single spillway for different reservoir levels with different gate openings is given in **Fig 2.8** and tabulated in **Table 2.4**.

Reservoir Level in m	Spillway discharge through one gate in m^3/s	Total Spillway discharge (4 gates) in m^3/s
161.00	0.00	0.00
162.00	39.74	158.95
163.00	93.50	374.01
164.00	158.03	632.12
165.00	231.55	926.19
166.00	312.88	1251.52
167.00	401.16	1604.66
168.00	495.73	1982.94
169.00	596.05	2384.21
170.00	701.67	2806.67
171.00	812.20	3248.78

Table 2.3 Spillway Free Discharge

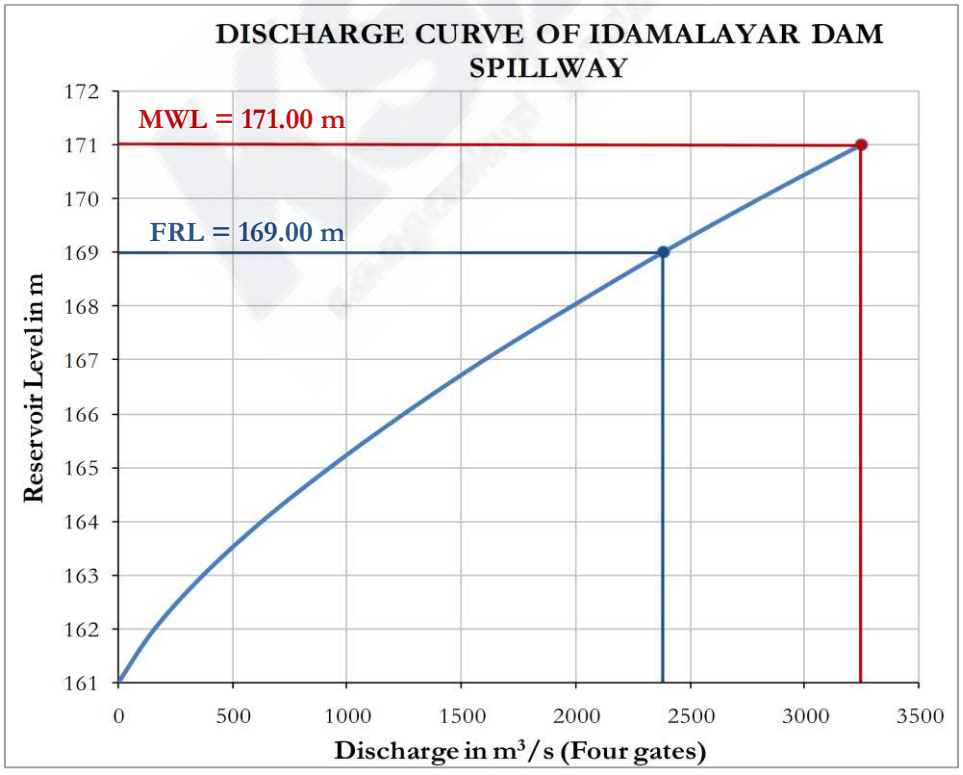


Fig 2.7 Free Discharge curve for Spillway Gates

	Idamalayar-Discharge through a single spillway gate for different gate openings and reservoir levels									
Reservoir Level (m)	Gate opening (+m) / Elevation of bottom of spillway gates (in m)									
	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
	161.50	162.00	162.50	163.00	163.50	164.00	164.50	165.00	165.50	166.00
161 Crest level	0.00									
162.00	21.98	39.74								
163.00	28.49	53.90	75.80	93.50						
164.00	33.70	64.86	93.25	118.57	140.40	158.03				
165.00	38.14	74.07	107.65	138.70	166.99	192.23	213.98	231.55		
166.00	42.06	82.15	120.15	155.96	189.42	220.36	248.55	273.70	295.37	312.88
167.00	45.60	89.39	131.31	171.25	209.12	244.80	278.14	308.97	337.06	362.12
167.50	47.25	92.77	136.48	178.32	218.19	256.00	291.61	324.90	355.67	383.71
168.00	48.83	96.00	141.43	185.07	226.83	266.64	304.37	339.93	373.15	403.87
168.50	50.35	99.10	146.18	191.53	235.09	276.78	316.52	354.19	389.67	422.84
169.00	51.82	102.09	150.74	197.74	243.01	286.50	328.11	367.77	405.37	440.80

	Idamalayar-Discharge through a single spillway gate for different gate openings and reservoir levels									
Reservoir Level (m)	Gate opening (+m) / Elevation of bottom of spillway gates (in m)									
	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00
	166.50	167.00	167.50	168.00	168.50	169.00	169.50	170.00	170.50	171.00
161 (Crest level)										
162.00										
163.00										
164.00										
165.00										
166.00										
167.00	383.71	401.16								
167.50	408.73	430.28	447.70							
168.00	431.86	456.83	478.35	495.73						
168.50	453.51	481.45	506.37	527.85	545.21					
169.00	473.91	504.52	532.41	557.29	578.73	596.05				

Table 2.4 Discharge through single spillway

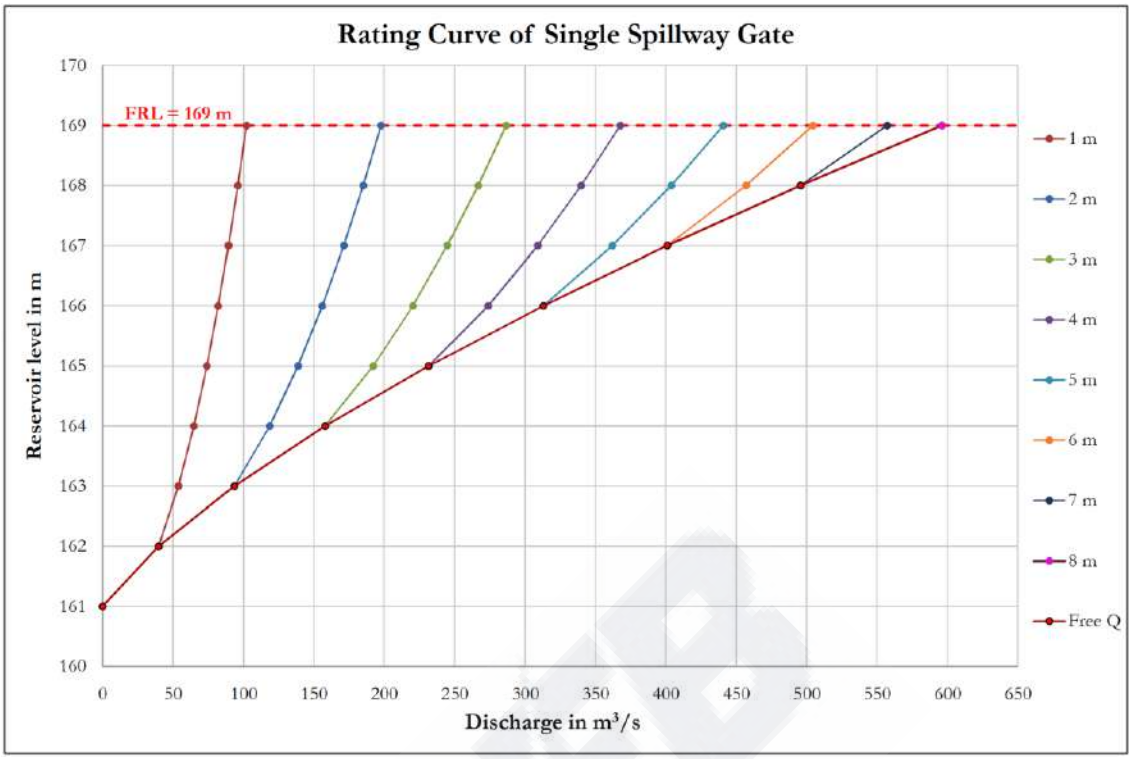


Fig 2.8 Discharge curves for Single Spillway Gate

2.3.3 Rule Curve

As per the Kerala flood study report of August 2018, CWC has recommended for reviewing the rule curves of all the reservoirs in Kerala. The rule curves need to be formulated for both conservation as well as operations during the flood, particularly for the reservoirs having the live storage capacity of more than 200 MCM in order to create some dynamic flood cushion for moderating the floods of lower return periods particularly in the early period of monsoon.

Accordingly, rule curves for Idamalayar reservoir have been arrived at by the committee of KSEB Ltd constituted vide Order (CMD) No 628/2018 (DGC-AEE-II/Flood/2018) TVPM, dated 20.10.2018 considering the historic inflows, power demands, evaporation losses and spills of the respective ten-daily periods. The rule curves for Idamalayar dam is shown in **Fig 2.9**.

Upper Rule Levels

The upper rule curve has been prepared considering 50% dependable inflows. Monsoon period from June 1st to November 20th has been considered for preparation of the same. It

has been attempted to keep the reservoir level at the end of monsoon i.e. on November 20th as 168.5 m. (FRL being El. 169.0 m). At the same time the reservoir level at the beginning of monsoon period has not been allowed to go below the spillway crest level of El. 161.0 m.

This curve is expected to provide flood control for floods occurring in the earlier part of the monsoon. The upper rule levels as worked out are shown in the **Table 2.5a** below.

Table 5.10.1 - Upper rule levels of Idamalayar reservoir					
Time Step	**Date**	**Upper Rule Levels**	**Rule storage**	**Flood space upto FRL**	**Percentage Gross Storage**
		m	**Mm3**	**Mm3**	**%**
1	June 10th	**161**	860	229.80	78.9%
2	June 20th	**161**	860	229.80	78.9%
3	June 30th	**161**	860	229.80	78.9%
4	July 10th	**161**	860	229.80	78.9%
5	July 20th	**162**	888.3	201.50	81.5%
6	July 31st	**164**	945.5	144.30	86.8%
7	Aug 10th	**166**	1003.1	86.70	92.0%
8	Aug 20th	**166.5**	1017.5	72.30	93.4%
9	Aug 31st	**166.5**	1017.5	72.30	93.4%
10	Sep 10th	**167**	1031.9	57.90	94.7%
11	Sep 20th	**167**	1031.9	57.90	94.7%
12	Sep 30th	**167**	1031.9	57.90	94.7%
13	Oct 10th	**168**	1060.8	29.00	97.3%
14	Oct 20th	**168**	1060.8	29.00	97.3%
15	Oct 31st	**168**	1060.8	29.00	97.3%
16	Nov 10th	**168.5**	1075.3	14.50	98.7%
17	Nov 20th	**168.5**	1075.3	14.50	98.7%
18	Nov 30th	**169**	1089.8	229.80	100%

Table 2.5a Upper Rule Levels of Idamalayar dam

Lower Rule Levels

The lower rule curve (which is primarily meant for conservation purposes) has been prepared considering 90% dependable inflows, as Idamalayar is a hydro-electric project. The entire water year i.e. from 10th June to 31st May of the following year has been considered for preparation of the same. The lower rule curve has been prepared by going backwards from 31st May in ten daily steps up to 10th June of the water year. On 31st May the reservoir level was assumed as El. 123 m which is inclusive of about one month power requirements of the project above the MDDL. The rule levels arrived at are tabulated below in **Table 2.5b**.

Table 5.11.1 - Lower rule levels of Idamalayar reservoir						
Date	**Rule Storage**	**Rule Level**	**90% Dependable Inflow**	**Water Spread Area**	**Reservoir Losses**	**P H Demand**
	Mm3	**m**	**Mm3**	**Sq km**	**Mm3**	**Mm3**
June 10th	478.85	**144.99**	11.464	20.690	0.088	49.21
June 20th	455.24	**143.82**	15.898	20.200	0.087	39.42
June 30th	432.93	**142.67**	22.758	19.720	0.086	44.98
July 10th	426.29	**142.33**	32.525	19.570	0.082	39.08
July 20th	428.68	**142.45**	46.455	19.620	0.082	43.99
July 31st	449.49	**143.52**	41.040	20.070	0.083	20.15
Aug 10th	474.10	**144.75**	40.902	20.590	0.088	16.20
Aug 20th	511.37	**146.54**	49.399	21.250	0.090	12.04
Aug 31st	545.17	**148.10**	52.650	21.810	0.091	18.76
Sep 10th	562.70	**148.90**	27.825	22.100	0.093	10.21
Sep 20th	564.50	**148.99**	19.472	22.130	0.093	17.58
Sep 30th	552.00	**148.41**	14.316	21.920	0.093	26.72
Oct 10th	550.33	**148.33**	14.585	21.900	0.102	16.16
Oct 20th	561.73	**148.86**	18.252	22.090	0.102	6.75
Oct 31st	565.10	**149.01**	15.314	22.140	0.102	11.84
Nov 10th	562.23	**148.88**	11.200	22.090	0.102	13.97

Nov 20th	563.19	**148.93**	8.464	22.110	0.102	7.40
Nov 30th	563.57	**148.94**	7.561	22.120	0.102	7.08
Dec 10th	547.07	**148.18**	4.796	21.840	0.115	21.19
Dec 20th	534.59	**147.61**	4.067	21.630	0.114	16.43
Dec 31st	509.42	**146.44**	3.524	21.210	0.113	28.58
Jan 10th	492.79	**145.65**	2.233	20.930	0.120	18.74
Jan 20th	480.29	**145.06**	2.162	20.710	0.119	14.55
Jan 31st	462.05	**144.16**	1.662	20.340	0.118	19.79
Feb 10th	443.68	**143.22**	1.902	19.950	0.131	20.14
Feb 20th	424.28	**142.22**	1.525	19.530	0.129	20.79
Feb 28th	404.72	**141.21**	1.066	19.110	0.127	20.50
Mar 10th	368.84	**139.35**	1.600	18.290	0.137	37.35
Mar 20th	325.79	**137.04**	1.535	17.180	0.131	44.45
Mar 31st	262.85	**133.02**	1.868	15.130	0.121	64.69
Apr 10th	222.16	**130.21**	3.252	13.610	0.100	43.84
Apr 20th	197.21	**128.36**	2.831	12.610	0.096	27.68
Apr 30th	174.74	**126.45**	2.729	11.580	0.092	25.11
May 10th	158.36	**124.98**	4.836	10.790	0.076	21.14
May 20th	146.97	**123.89**	3.878	10.270	0.075	15.20
May 31st	138.00	**123.00**	7.826	9.840	0.074	16.72

Table 2.5b Lower Rule Levels of Idamalayar dam

2.3.4 Safety Aspects

The spillway gates are operated step by step after assessing the reservoir water level and inflow. The sequence of gates operations is given in **Para 2.3.5**.

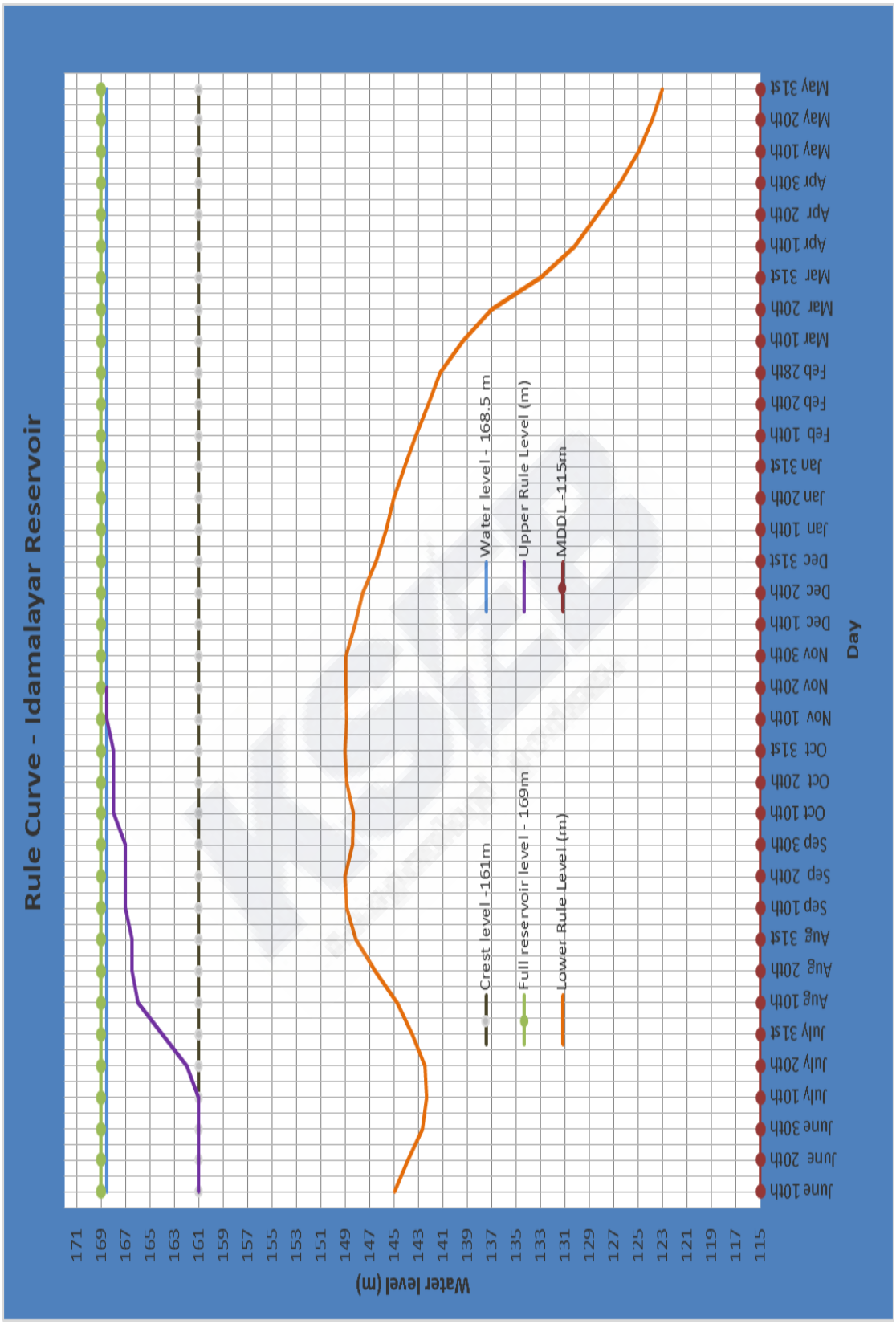


Fig 2.9 Rule Curve for Idamalayar Dam

2.3.5 Flood Release Procedure

The flood water is released through spillway gates based on the operation manual of gates and upper rule curve. There are four spillway gates. The sequence of opening of spillway gates is Gate No. 2, 3, 1, 4. i.e., the spillway gates No. 2 & 3 are opened first in steps of 0.3 m. Then No. 1 will be opened. Spillway gate No. 4 is opened last. Closing of gates is done in the reverse order.

The operations of Idamalayar dam based on rule levels are approved by the Board Vide B.O (FTD) No. 444/2019 (DGC/AEE-II/Dam Safety/2019 dt 03.06.2019. Accordingly, Alerts for spilling of flood water during **rising stage** are fixed as first warning **Blue** (1.5 m below rule level), second warning **Orange** (1.0 m below rule level) and third warning **Red** (0.5 m below rule level). As per the revised upper rule levels, it is proposed to keep the water level at or below 161 m (Crest Level) on June 10th and 169 m (FRL) on 30th November.

As per the approved (B O dt 03.06.2019 & G O dt 15.06.2019) upper rule levels vide Table 2.5a, it is proposed to keep the water level at or below 161.00 m (Close to Crest Level) on June 10th and 169.00 m (FRL) on 30th November. But CWC have adopted a more conservative approach in this rule levels and revised levels proposed. Accordingly KSEB Ltd on 08/08/2019 have adopted this modified upper rule levels as suggested by CWC for the time being in the wake of heavy rain experienced in Kerala which is given in Table 2.6 below.

Upper Rule Levels as Modified by CWC	
Time Step	**Upper Rule Levels (m)**
June 10th	161.00
June 20th	161.00
June 30th	161.00
July 10 th	161.50
July 20 th	161.75
July 31st	162.50
Aug 10 th	163.00
Aug 20 th	163.50
Aug 31st	164.00

Sep 10 th	165.00
Sep 20 th	166.00
Sep 30 th	166.30
Oct 10 th	166.60
Oct 20 th	166.80
Oct 31 st	167.00
Nov 10 th	168.50
Nov 20 th	168.50
Nov 30 th	168.50

Table 2.6 Modified Upper Rule Levels of Idamalayar dam

2.3.6 Climate

Idamalayar catchment receives comparatively good rains almost throughout the year. It is observed that the rains contributed by South-West monsoon are comparatively heavier than the rains precipitated during North-East monsoon.

2.3.7 Inflow forecasting/Methodology

There is no inflow forecasting system at present in Idamalayar dam. The methodology followed for working out the inflow is given in **Cl. 2.3.7.1.**

2.3.7.1 Inflow Computation

Inflow into reservoirs is normally estimated by the reservoir gauging method (also called the rise and fall method or inflow-outflow method). All the outflows are added together and to it the rate of rise in storage (Positive if the level rises, and negative if it falls) is added. Expressed as an equation, this will be.

Inflow (cumec) = Total outflow (cumec) + Rate of increase in storage (cumec)

The rate of increase or decrease in storage can be determined from the observed rate of increase or decrease in reservoir level and the elevation capacity tables. For easy computation a table can be developed showing the rate of change of storage in the Idamalayar reservoir for a rate of rise in reservoir level of 1 cm/hour. This table can be put to use for easy interpolation. Once the inflow is known the outflow and gate opening required to maintain the water level can be computed.

2.3.8 Summary of Flood Regulation Procedure

The flood regulation procedures at Idamalayar can be summarized in the following 5 steps:

1. Observe the reservoir level at 1 hour intervals.
2. Determine the total outflow through all outlets (including spillway, power intake)
3. Estimate the inflow
4. Determine the gate opening as the case maybe.
5. Open the required number of gates to the extent required to maintain constant reservoir level as per the upper rule curve i.e., with release equal to the inflow at the reservoir level corresponding to the upper rule curve.

2.3.9 Emergency Operation

The Emergency operation will be carried out following the Emergency Action Pan (EAP). The Emergency conditions are outlined in **Chapter 4** under **clause 4.2.1** on Immediate Maintenance. The EAP together with this Manual will be present at site at all times. Summary of alert conditions during Emergency are given in **Annexure 5**.

2.4 Power Generation

There are two generating units of 37.5 MW each. The turbines are of Francis type manufactured by BHEL.

2.4.1 Power Outlets

The intake structure is provided in the dam in block No.7 **(Drg 1.2)** with the invert level at +103.5 m. Bell mouth entry is provided for smooth transition and is protected with trash screens. The intake opening at the entry is rectangular and has a size of 3100 mm x 4746.73 mm which then transforms in to circular section of diameter 4.2 m. The intake gate provided at the entrance is operated by an electrically driven hoist (**Fig 2.10)** housed in a chamber over the shaft above the FRL. The general arrangement showing hoisting mechanism, panel board and motor of the intake gates is given in **Fig 2.11**. The sectional elevation at Ch. 296 of Idamalayar Dam is given in **Drg 2.7**. The sectional plan and elevation of intake is shown in **Drg 2.8.** The elevation and plan of trash-rack are given in **Drg 2.9** and **Drg 2.10.**

The gate is designed to withstand the unbalanced head against which it can close under gravity. A duct in the tower allows air to enter the tunnel on closure of the gate. An inspection

chamber of size 8 m x 1.83 m x 2.5 m connected to Adit No.2 is provided in the dam for inspecting the intake tunnel passing through the dam.

On completion of the work of power tunnel, trial run was done for one of the machines of power house during July 1985, after filling the power tunnel. Then at inlet portion of power tunnel, leakage of water was noticed through the cracks developed in the rock and in the concrete lining of the tunnel. Hence tunnel was emptied and rectification works were carried out in the tunnel. The tunnel was filled again and trial runs of machines taken successfully in January 1987.

The finished diameter of the power tunnel then changes from 4.2 m to 5.2 m after entering the rock at about 25 m from the point of entry. This diameter remains the same up to the surge shaft after which again the diameter changes to 4.2 m. The cross section has a driven area of 28.26 m^2 and a finished area of 21.23 m^2. The tunnel is about 1564 m long of which about 826 m is steel lined where the cover is less than 0.75 times the head. The lining is reinforced for a length of about 331 m where the cover available is between 1.0 H and 1.75 H. The tunnel is lined throughout with the cement concrete with an average thickness of 50 cm. The maximum discharge through the tunnel is 80 m^3/s with a velocity of 3.77 m/s.

Fig 2.10 Idamalayar Dam Vertical Gate

Fig 2.11 Idamalayar Dam Intake Gate Hoist Mechanism

River Outlet

As mentioned earlier, there is no water supply arrangement directly from the reservoir. The entire water after generation is released to downstream river from the power house tail race. But for meeting the emergencies during shortage of sufficient tail race water, one disperser valve house has been constructed at the downstream side of Idamalayar dam on the left bank and two numbers disperser valves of 1.5 m dia have been installed in the outlet pipes branching from the intake conduit pipe leading water to the power tunnel. The main purpose of these two valves is to release water to the river for salinity control, irrigation and water supply in the lower reaches of Periyar banks when sufficient water is not let out from the Idamalayar Power house due to breakdown / maintenance etc. of the machines. A sketch showing the location of Disperser valves and photograph of valve house with respect to dam is given in **Fig 2.12** and **Fig 2.13** respectively. Details of valves and operating procedures are given in the manufacture's manual. (See **Annexure 2**)

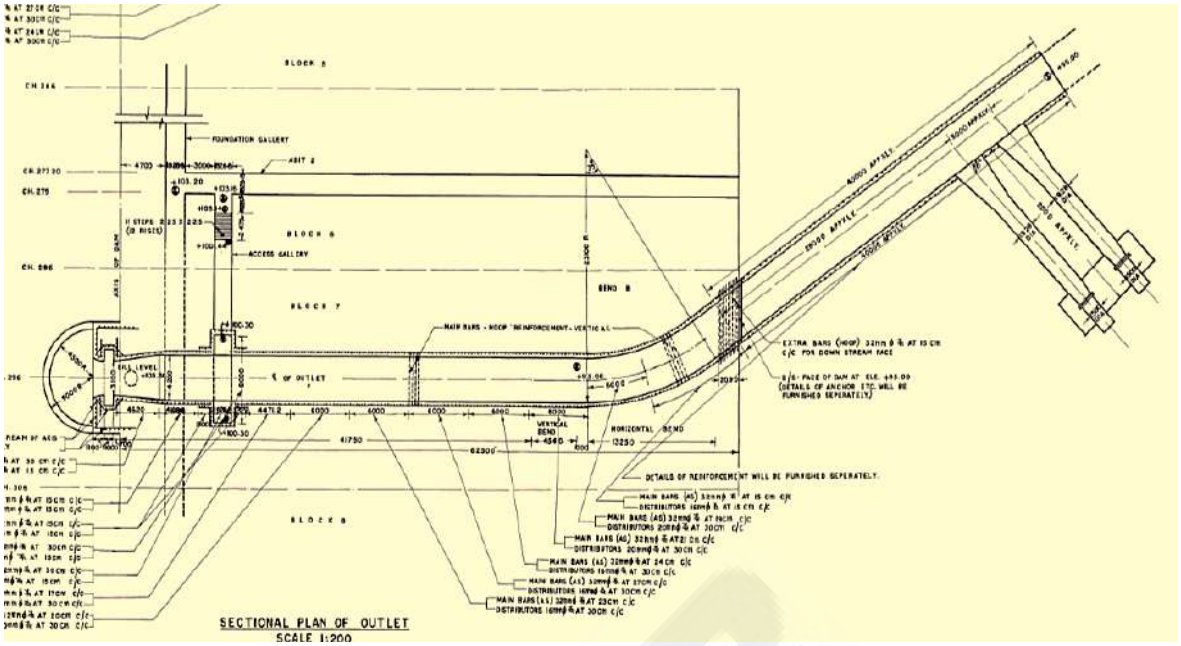


Fig 2.12 Idamalayar Dam Sectional Plan of River Outlet

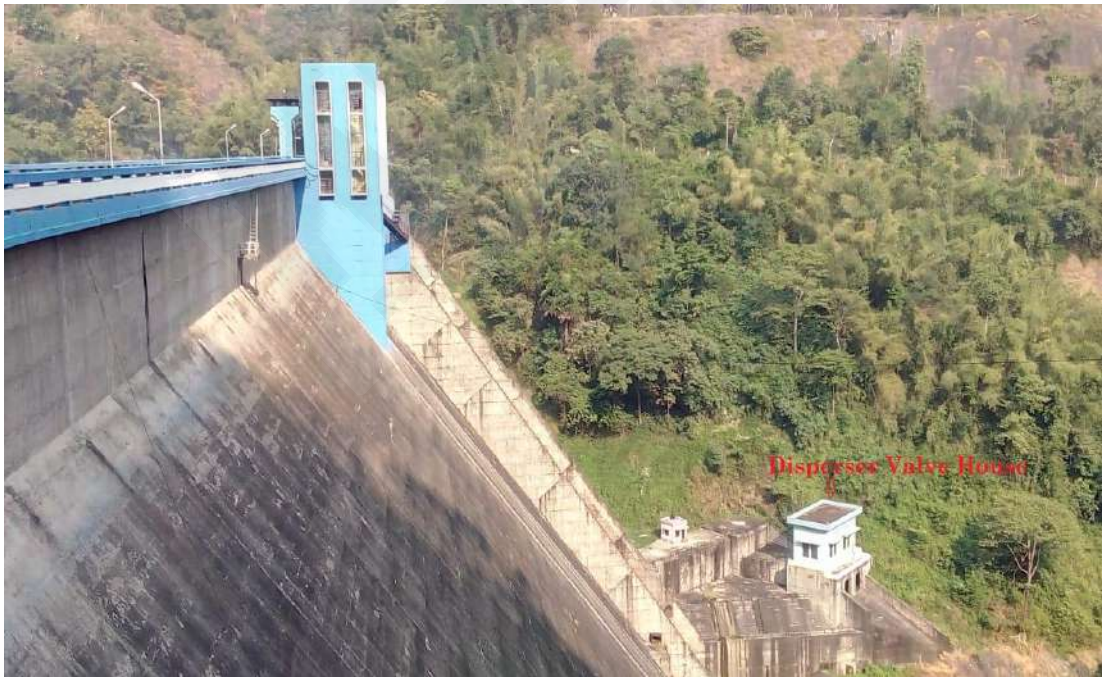


Fig 2.13 Idamalayar Dam Disperser Valve house

2.4.2 Surge Tank and Low Pressure Pipe

The surge shaft is of restricted orifice type with two orifices of 2.4 m diameter each. The ground level at the center of the surge shaft is 184.40 m. The invert level of the shaft is +95.284 m. The surge shaft barrel after lining has a diameter of 21.70 m between elevations 184.40 m & 171.20 m and a diameter of 18.85 m between elevations +171.20 m & +95.284 m.

From the surge tank one low pressure tunnel of 4.2 m diameter takes off. The length of this tunnel up to the center of 'Y' piece is 138.25 m. The low pressure pipe is then connected to two penstock pipes of internal diameters 2.93 m each, which are controlled by butterfly valves located at the valve house. They run down a distance of about 151.50 m along the prepared hill slopes to the power station. The penstocks are anchored to sound rock by means of concrete anchor blocks at the points where there is a change in slope. Expansion joints are provided for the pipes downstream of each anchor blocks. The entire length of the penstocks is constructed in low tensile steel with the pipe thickness increasing from 15 mm to 30 mm. The view of component structures (power tunnel, surge tank, valve house, penstocks and power house) with respect to Idamalayar dam is shown in **Drg 2.11.**

2.4.3 Initial Filling of Reservoir

The initial filling of the reservoir was carried out during 1985 based on relevant IS codes.

2.4.4 Power House

The Power House is located about 3 km downstream of the dam on the left bank of the Idamalayar River. Good rock was available for founding the machinery and the structure at this site. The power house is constructed as a reinforced concrete framed structure of size 52 m x 18 m. The lowest foundation level is +31.5 m with the turbine floor at elevation +40.50 m. The generator floor has an elevation of +44 m with the turbine runner level at +39.0 m. There are two generating units of 37.5 MW each. The turbines are of Francis type manufactured by BHEL. The production capacity is 331.04 Million units per annum including a secondary power of 10.95 Million units. The tail race has a channel length of 50 m with the maximum and minimum water levels being +47 m and +39 m respectively.

The control and auxiliary rooms of the power house are located in the main power house. The switch yard is located in front of the power house with two outgoing feeders, one to Kalamassery and the other to Chalakudy. Both the machines of the power house were commissioned and are under commercial operation since **February 1987**.

2.5 Record Keeping

The records regarding dam and appurtenant structures including detailed drawings and construction details are kept at the field office. Essential documents as per the dam safety guidelines are kept at the dam site office.

Following records of reservoir operations are being maintained:

1. Rainfall record on daily basis throughout the year.
2. Reservoir levels on daily basis during non-monsoon and hourly basis during monsoon.
3. Depth of outflow over the spillway on hourly basis during monsoon.
4. Estimated spillway outflows during monsoon on hourly basis.
5. Power releases.
6. Water audit register to be maintained for estimating the inflows on hourly basis during monsoon and daily basis during non-monsoon by accounting all the releases/outflows and the incremental change in storage in the reservoir.
7. All operating procedures

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Chapter 3
Project Inspection

An effective inspection program is essential to identify problems and to keep a dam in a good and healthy condition. Inspection details and suggestions are kept at field office and reports send to higher offices. The current practice of Inspection at Idamalayar dam envisages the Deputy Chief Engineer in presence of Executive Engineer at site to carryout pre-monsoon and post-monsoon inspections as per CWC guidelines in the format issued by CWC earlier **(Annexure 6)**. The Deputy Chief Engineer will submit the inspection report to the Chief Engineer for onward transmission to CWC. The Executive Engineer at site will conduct quarterly inspections and will prepare health reports as per KDSA. The format followed as per CWC is now revised during January 2018 and new guidelines issued vide Doc No. CDSO_GUD_DS_07_ v1.0, CWC 2018 for Safety Inspection of Dams. Now since the health reports are to be uploaded in DHARMA, the inspection reports are prepared in the new format incorporated in DHARMA. Detailed description on project inspections is available in the Guideline for Safety Inspection of dams. However, an overview of the various types of inspections to be carried out at Idamalayar dam is given below. For uploading Inspection Data into DHARMA, the Inspection Instructions & Forms given in the above mentioned Guideline for Safety Inspection of Dams must be used. This Chapter provides guidance on carrying out other inspections.

3.1 Types of inspections

Four different types of dam safety inspections are available for being carried out at Idamalayar Dam. These include, but not limited, to the following:

1. Comprehensive evaluation inspections
2. Scheduled inspections (Pre & Post monsoon inspections & other scheduled inspections)
3. Special (Un scheduled) inspections
4. Informal inspections.

The frequency of each type of inspection depends on the condition of the dam and dam safety regulations, etc. Typical inspection elements and the detail of the safety inspections are provided below. More detailed descriptions are given in the 'Guideline for Safety Inspection of Dams' (CWC 2018). A comprehensive health checklist **(Annexure 7)** for recording the status

of each item being inspected and the overall condition of the equipment along with any consequential risks on the health of the dam is also to be maintained.

3.2 Comprehensive Evaluation Inspections

For comprehensive dam safety evaluation for each dam an independent panel of experts known as Dam Safety Review Panel (DSRP) needs to be constituted for determining the condition of the dam and appurtenant works. The panel will undertake evaluation of the dam once in 10 years or on occurrence of any extreme hydrological or seismic event or any unusual condition of the dam or in the reservoir rim. The terms of reference of the comprehensive dam safety evaluation shall include but not be limited to;

- General assessment of hydrologic and hydraulic conditions, review of design flood, flood routing for revised design flood and mitigation measures.
- Review and analysis of available data of dam design including seismic safety, construction, operation, maintenance and performance of dam structure and appurtenant works.
- Evaluation of procedures for operation, maintenance and inspection of dam and to suggest improvements / modifications.
- Evaluation of any possible hazardous threat to the dam structure such as dam abutment slope stability failure or slope failures along the reservoir periphery.

A comprehensive evaluation inspection of Idamalayar dam consists of five major parts:

1. Review of project records (i.e. study of all design / construction records/drawings, history of the dam's performance, past inspection notes/reports, notes on distress observed/ any rehabilitation measures undertaken earlier, instrumentation data and its interpretation including.
2. Inspection of the dam and its appurtenant works.
3. To review the results and reports of additional field investigations & laboratory testing.
4. Review of design studies, review of design flood, checking of the adequacy of Spillway capacity, freeboard requirements, dam stability and any special study.
5. Preparation of a detailed report of the inspection.

3.2.1 Details to be provided to DSRP before inspection.

All relevant details / data / drawings for the dam project to be examined by the DSRP shall be provided at least 3 months in advance of the proposed visit. This will include

- General information and Scope of the Project
- Emergency preparedness
- Details of key personnel
- Hydrology - (both Original and design flood review study)
- Reservoir operation and regulation plan are to be handed over in detail
- Basic data and Issues related to safety of dam
- Problems if any during construction
- Drawings of dam, spillway, gates and appurtenant structures
- Seismicity
- Status of the instrumentation
- Construction History
- Geological Report including Special problems at site and their treatment
- Field Inspection- Observation & recommendation regarding Remedial Measures
- Dam Incidents and Reservoir filling

Dam Incidents and Reservoir filling

Partial storage in the reservoir was commenced during December 1983 and water released from the reservoir for the irrigation and salinity control from 1984 onwards. After rectification works of the leakage of the Power Tunnel during its first filling in 1985, the tunnel was filled again and trial run of the machines was done successfully in January 1987. The commissioning of the machines of the Power House was done and they were put into commercial operation in February 1987. Date of first full impoundment: 1987.

3.3 Scheduled Inspections

Scheduled inspections shall consist of Pre-monsoon & Post-monsoon inspection and any other inspections carried out by the State Dam Safety Organisation/any Expert panels constituted by the dam owner. These inspections are performed to gather information on the current condition of the dam and its appurtenant works. This information is then used to establish needed repairs and repair schedules, and to assess the safety and operational adequacy of the dam. Scheduled inspections are also performed to evaluate previous repairs.

Scheduled inspections include the following components as a minimum:

- Review of past inspection reports, monitoring data, photographs, maintenance records, or other pertinent data as may be required
- Visual inspection of the dam and its appurtenant works
- Preparation of a report or inspection brief, with relevant documentation and photographs.

The report should be filed in the dam owner's project files.

3.3.1 Pre- and Post-Monsoon Checklist and Example of Report Proforma

Detailed checklists are required to ensure the health of the dam and to ensure that it continues to operate in satisfactory and safe condition. The proforma to be used for inspection should be the one enclosed in the Doc No. CDSO_GUD_DS_07_ v1.0, CWC 2018 in the Guidelines for Safety Inspection of Dams.

Pre-monsoon Inspection to be carried out during	:	April - May
Post-monsoon Inspection to be carried out during	:	December - January
Inspecting Officers	:	Deputy Chief Engineer along with SPMU Executive Engineer, Field Executive Engineer, Concerned field Assistant Executive Engineer and Assistant Engineer
Preparation of Inspection Report	:	Executive Engineer, Field (Dam Health Engineer)
Submission of Pre-monsoon Inspection Report	:	Before June 30th
Submission of Post-monsoon Inspection Report	:	Before January 15th
Checking and approval of report	:	Chief Engineer (DS & DRIP)
Uploading corrected document in DHARMA	:	Executive Engineer, Field

3.4 Special (Unscheduled) Inspections

Special inspections may need to be performed to resolve specific concerns or conditions at the site on an unscheduled basis. Special inspections are not regularly scheduled activities, but are usually made before or immediately after the dam or appurtenant works have been subjected to unusual events or conditions, such as an unusually high flood or a significant earthquake. These inspections are to be carried out by teams to be constituted by state DSO after an initial assessment based on informal inspection carried out by project personnel reveal

dam safety related concerns like cracking in the dam, damages, erosion/ scour, undermining/ piping/ sink holes/ liquefaction or any such undesirable feature. A special inspection may also be performed during an emergency situation, such as an impending dam breach, to evaluate specific areas or concerns. They are also made when the ongoing surveillance program identifies a condition or a trend that appears to warrant a special evaluation. Special inspections should focus on those dam components that are affected by the unusual event and should include at least three elements:

1) Review of relevant files or data,
2) Visual inspection, and
3) Report preparation.

More detailed site investigations / studies may be required (such as drilling, surveys, or seepage flow estimates) if the special inspection reveals the need for the same. Photographic documentation is to be included as part of the inspection.

3.5 Informal Inspections

The last type of inspection, an informal inspection, is a continuing effort by on-site personnel (dam owners/operators and maintenance personnel) performed during their routine duties. Informal inspections are critical to the proper operation and maintenance of the dam. They consist of frequent observations of the general appearance and functioning of the dam and appurtenant structures.

Operators, maintenance crews, or other staffs who are posted at Idamalayar dam site conduct informal inspections. These people are the 'first-line of defense' in assuring safe dam conditions, and it is their responsibility to be familiar with all aspects of the dam. Their vigilance in walking the dam, checking the operating equipment, and noting changes in conditions may prevent serious mishaps or even dam failures.

Informal inspections are important and are performed at every available opportunity. These inspections may only cover one or two dam components as the occasion presents itself, or they may cover the entire dam and its appurtenant structures. The informal inspections are not as detailed as comprehensive evaluation, scheduled, and special inspections and will only require that a formal report is submitted to the dam owner's project files if a condition is detected that might endanger the dam. Report is to be submitted detailing the condition discovered along with photographs, time, reservoir water level etc.

Chapter 4

Project Maintenance

A good maintenance program is required to protect a dam against deterioration, prolong its life and reduce the chance of failure. Maintenance program for a dam should be developed primarily based on systematic and frequent inspections. Nearly all the components of a dam and its materials are susceptible to damage and deterioration if not well maintained. Moreover, the cost of a proper maintenance is small compared to the costs of major repairs, loss of life and litigation.

4.1 Maintenance Plan

A basic maintenance schedule for the various monitoring components prepared for Idamalayar dam based on manual of operating parts, frequent inspections, priority, and interval for Idamalayar dam is arrived showing the tasks to be performed and how frequently that is to be inspected/observed and repaired. See **Annexure 8**.

4.2 Maintenance Priorities

Maintenance activities need to be prioritized. In order of prioritize they need to be classified under the heads immediate maintenance & preventive maintenance.

4.2.1 Immediate Maintenance

The following conditions are critical and call for immediate attention & reservoir lowering, if warranted. These conditions may include, but are not limited to:

- The dam is about to be overtopped or being overtopped during high flood.
- The damshowing signs of failure due to aging/cracking, sliding, overturning etc.
- The dam showing signs of piping or internal erosion along shear zones, faults etc indicated by increasingly cloudy seepage or other symptoms.
- The spillway being blocked or with some inoperable gates.
- Evidence of excessive seepage as seen in the gallery/on downstream face of the dam.

An EAP is to be activated when any of the above conditions are noted.

4.2.2 Preventive Maintenance

This can be further classified as Condition based Maintenance and Routine Maintenance.

4.2.2.1 Condition Based Maintenance

The following maintenance works are to be undertaken as soon as possible after the defective condition is noted. These include but are not limited to:

- Remove all vegetation and bushes from the dam and restoring any eroded areas.
- Repair of defective gates, valves, and other hydro-mechanical equipment.
- Repair any concrete or metal components that have deteriorated.
- Cleaning of the choked drainage holes in the dam body/ foundations in concrete dams.
- Repair any damages on spillway glacis, piers, energy dissipaters, training/divide walls, downstream areas etc.
- Controlling any heavy seepage in the foundation/ inspection galleries in Concrete dam from drainage holes.
- Repairs of any cracks in concrete dam structures.

However many of these works will require the services of experienced engineers/expert panels.

4.2.2.2 Routine Maintenance

Several tasks should be performed on a continuous basis. These include but are not limited to the following:

- Any routine repair to concrete or metal component.
- Observation of any springs or seepage areas in shear zones, faults etc. comparing quantity and quality (clarity) with prior observations.
- Monitoring of downstream development which could have an impact on the dam and its hazard category.
- Maintenance of Electrical & Hydro-Mechanical equipment and systems e.g. servicing of spillway gates, hoisting arrangements, disperser valves- hoist gate & gantry crane, intake gates/hoist of power outlet works & stand by generator.
- Maintaining proper lighting at dam top, galleries, etc.
- Monitoring of seepage in galleries.
- Monitoring/ cleaning & removal of leached deposits in porous concrete / formed drains in dam body and foundation drainage holes.

- Maintenance of all dam roads & access roads.
- Operation of electrical and mechanical equipment and systems including exercising gates & valves.
- To keep the gate slots clear of silt/debris.
- Maintenance/testing of monitoring equipment (instruments) and safety alarms.
- Testing of security equipment.
- Testing of communication equipment.
- Any other maintenance considered necessary.

4.3 Procedures for Routine Maintenance

4.3.1 Controlling Damage from Vehicular Traffic

Vehicles, except for maintenance, are restricted on the dam top and kept out by fences or barricades. Any damages are repaired as soon as possible**.** Also vehicles are to be permitted only after security checking at check posts.

4.3.2 Controlling Vegetation

Removal of vegetation around the dam and premises is done 2 times in a year.

4.3.3 Trash Racks

Trash racks at intakes that have become clogged with debris or trash reduce their discharging capacity. The head losses through clogged trash racks also increase. Maintenance of trash racks includes periodic inspections for rusted and broken sections and repairs are made as needed. Trash racks should be checked during and after floods to ensure that they are functioning properly and to remove accumulated debris periodically as per site requirements.

4.3.4 Vertical lift Gates

Vertical lift gates are provided in intake tower of the Idamalayar dam for controlling the flow. The aspects to be inspected and maintained periodically for ensuring proper operation of these gates are as under;

i) The gate slot and bottom platform/sill beam should be cleaned periodically. Scales formed over the embedded parts should be removed. Second stage concrete should be

checked for any development of cracks/leakages and repairs should be attended to immediately.

ii) The gate leaf should be thoroughly cleaned and repainted as and when necessary according to the procedure or guidelines- indicated in IS: 14177 or as per the recommendations of the paint manufacturer. All drain holes provided in the gate assembly should be cleaned.

iii) Rubber seals should be smoothened, if required, for proper alignment. All nuts and bolts fixing the seal to the gate should be tightened uniformly. Seals, if found damaged or found leaking excessively should be adjusted, repaired or replaced as considered necessary.

iv) The wheel shall be rotated to check their free movement. Gate roller bearings and guide roller bushes should be properly lubricated. Whenever necessary these should be opened for rectifications of defects, cleaning and lubrication and should thereafter be refitted. These may be replaced if repairs are not possible.

v) Hoisting connection of the gate leaf should be lubricated where necessary and defects if any should be rectified.

vi) All nuts, bolts, check nuts and cotter pins of the lifting devices should be checked periodically.

vii) All components should be greased and lubricated. Recommended and approved oils and grease only should be used.

viii) Roller assembly should be adjusted by the eccentricity arrangement to ensure all rollers rest uniformly on the track plates particularly in the closed position of the gate.

ix) All welds shall be checked for cracks/damages. Any weld that might have become defective should be chipped out and redone following the relevant codal provisions. Damaged nuts, bolts, rivets, screws etc. should be replaced without delay.

x) The guide-assemblies, wheel-assemblies and sealing-assemblies shall be cleared off grit, sand or any other foreign material.

xi) The wheel pin shall be coated with corrosion resistant compound.

xii) All nuts and bolts shall be tightened.

4.3.5 Spillway Radial Gates & Hoisting Equipment

The safe and satisfactory operation of Idamalayar Dam depends on proper operation of its Gates & Hoisting Equipment. Maintaining spillway gates in working condition is critical for

dam safety and is to be assigned the highest priority. If routine inspection of the Hydro-Mechanical Equipment reports the need for maintenance, the work should be completed as soon as possible.

The gates are to be operated through their full range twice annually (before monsoon & after monsoon keeping a gap of at least six months). Because operating gates under full reservoir pressure can result in large discharges, exercising of gates should preferably be carried out during dry conditions or lean times of the year.

The aspects to be inspected and maintained periodically for ensuring proper operation of gates in general are as given below: The O & M manuals of the gates manufacturer's would however govern the overall maintenance of Gates & Hoists whenever there is any contradiction with the instructions given in the Manual.

i) The gate slot and bottom platform/sill beam should be cleaned periodically. Scales formed over the embedded parts should be removed. Second-stage concrete should be checked for any development of cracks / leakages and repairs should be attended to immediately.

ii) The gate leaf should be thoroughly cleaned and repainted as and when necessary according to the procedure or guidelines - indicated in IS: 14177 or as per the recommendations of the paint manufacturer. All drain holes provided in the gate assembly should be cleaned.

iii) Rubber seals should be smoothened, if required, for proper alignment. All nuts and bolts fixing the seal to the gate should be tightened uniformly to required torques. Seals, if found damaged or found leaking excessively should be adjusted, repaired or replaced as considered necessary.

iv) The guide wheel shall be rotated to check their free movement. Gate guide roller bushes should be properly lubricated. Whenever necessary these should be opened for rectifications of defects, cleaning and lubrication and should thereafter be refitted. These may be replaced if repairs are not possible.

v) Hoisting connection of the gate leaf should be lubricated where necessary and defects if any should be rectified.

vi) All nuts, bolts, check nuts and cotter pins of the lifting devices should be checked periodically.

vii) All components should be greased and lubricated. Recommended and approved oils and grease only should be used.

viii) All welds shall be checked for cracks/ damages. Any weld that might have become defective should be chipped out and redone following the relevant codal provisions. Damaged nuts, bolts, rivets, screws etc. should be replaced without delay.

ix) The guide-assemblies and sealing-assemblies shall be cleared off grit, sand or any other foreign material.

x) The guide wheel pin shall be coated with corrosion resistant compound.

xi) All nuts and bolts shall be tightened.

The aspects to be inspected and maintained periodically for ensuring proper operation of these gates are as under:

a) **Rubber Seals**: i) Seals shall be inspected for leakages. Locations of excessive leakages shall be recorded for taking remedial measures. Weeping or slight flow in localized area will not require immediate remedial measures. However, measures like tightening of bolts are carried out. Further adjustment is carried out during annual maintenance.

b) **Trunnion block assembly and anchorages:**

i. All the nuts and bolts of Trunnion block assembly and its anchorages shall be checked for tightness.

ii. Check all the welds for soundness and rectify defects.

iii. Check whether the Yoke girder and thrust block is covered or not. If not, cover it with mild steel plates.

iv. Cover the trunnion pin with anti- corrosive jelly.

v. Remove all dirt, grit etc. from trunnion assembly and lubricate trunnion bearings of the gate with suitable water resisting grease as recommended by bearing manufacturers.

c) **Gate structures:**

i. Check all the welds for soundness and rectify defects.

ii. Check welds between arms and horizontal girders as well as between latching bracket and skin plate with the help of magnifying glass for cracks/defects and rectify the defects.

iii. Clean all drain holes including those in end arms and horizontal girders.

iv. Check all the nuts and bolts and tighten them. Replace damaged ones.

v. Check upstream face of skin plate for pitting, scaling and corrosion. Scaling may be filled with weld and grinded. Corroded surface shall be cleaned and painted.

d) **Embedded Parts:**

i) All the sill beams and wall plates shall be inspected for crack, pitting etc. and defects shall be rectified.

ii) The guide roller pins shall be lubricated.

e) **General Maintenance:**

Defective welding should be chipped out and it should be re-welded duly following the relevant codal provision (IS: 10096, Part-3).

i) Damaged nuts, bolts, rivets, screws etc. should be replaced.

ii) Any pitting should be filled up by welding and finished by grinding if necessary.

iii) The gate leaf, exposed embedded metal parts, hoists and hoist supporting structure etc., should be thoroughly cleaned and repainted when required keeping in view the original painting system adopted and as per the guidelines contained in IS: 14177.

iv) Trunnion bearing should be greased as and when required. Keeping trunnion bearings in perfect working condition is very important. All other bolted connections should also be checked up for proper tightness.

v) Bolts and trunnion bearing housing should be tightened wherever required.

vi) The seals of the gate should be checked for wear and tear and deterioration. These should be adjusted/replaced as and when necessary.

vii) The wall plates, sill beams shall be checked and repaired if necessary

viii) Wire ropes should be properly lubricated.

ix) Oil level in the worm reduction unit should be maintained by suitable replenishment. Oil seals should also be replaced if required. Lubrication of other parts of hoists such as chains, position indicators and limit switches should also be done.

x) The stroke of the brake should be reset to compensate for lining wear. Worn out brake linings should be replaced in time.

xi) Flexible couplings should be adjusted if required.

xii) Repairs and replacements of all electrical relays and controls should be attended to.

xiii) Maintenance of alternative sources of Power such as Diesel Generating sets and alternative drives wherever provided should be carried out.

xiv) The list of essential spare parts to be kept available should be reviewed and updated periodically. The condition of spares should be checked periodically and protective coating given for use.

4.3.6 Maintenance of Electrically operated fixed hoists

General Instructions:

a. Never open any bolt or nut on motor, gear boxes, rope drums and other load carrying hoist components when the gate is in raised position. The gate should be fully closed or rested on the gate latches before carrying out any work on hoist components including motor brake and other electrical equipment.

b. The aspects to be inspected and maintained periodically for ensuring proper operation of Rope drum hoists are as under;

   i. Entrance to all hoist platforms shall be kept locked. All keys shall remain with the shift supervisor.

   ii. A cursory daily inspection shall be made of hoist and gate to ensure that there is no unusual happening.

   iii. Clean all hoisting equipment and hoist platform.

   iv. Check oil level in gearboxes and replenish as and when required with oil of proper grade.

   v. Apply grease of suitable grade by grease gun.

   vi. Lubricate all bearings, bushings, pins, linkages etc.

   vii. Check all the fuses on the power lines.

   viii. All bolts and nuts on gear boxes, hoist drum and shaft couplings should be checked for tightness.

   ix. Check the supply voltage.

   x. Drain sample gear oil from each of the gear boxes. If excessive foreign particles or sludge is found, the gear box shall be drained, flushed and filled with new oil.

   xi. All the geared couplings shall be greased.

   xii. Raise and lower the gate by hoist motor and check for smooth, and trouble free operation of gate without excessive vibration.

   xiii. Observe current drawn by motor at the time of lifting and check if it is more than normal. If so, stop the hoist and investigate the cause and rectify.

   xiv. Check the condition of painting of various components and remove rust wherever noticed and repaint the portion after proper cleaning as per painting schedule.

   xv. All trash, sediments and any other foreign material shall be cleared off the lifting rope and lifting attachment.

xvi. All ropes shall be checked for wear and tear and if broken wires are noticed, the rope shall be replaced.

xvii. All the wire ropes shall be checked and all visible oxidation shall be removed.

xviii. All wire ropes shall be greased with cardium compound.

xix. Check the overload relays for proper functioning.

xx. Check all the nuts, bolts, rivets, welds and structural components for hoisting platform and its supporting structure for wear, tear and damage. All damages shall be rectified. All bolts shall be tightened. The portion with damaged painting shall be touched up.

xxi. Check the pulleys, sheaves and turn-buckles.

xxii. Raise and lower the gate for its full lift several times (at least three to four) and observe the following:

a) Check the limit switches and adjust for design limits.

b) The effectiveness and slip of the breaks shall be checked by stopping the gate in raising and lowering operations. The brakes shall be adjusted if needed.

c) When the gate is operated, there should not be any noise or chatter in the gears.

xxiii. Adjust the rope tension of wires if unequal. Check for all gears and pinions for uneven wear and adjust for proper contact. Grease the gears.

xxiv. Repaint the hoist components, hoisting platform and its supporting structures as per requirement.

xxv. The periodic maintenance of commercial equipment like motors, brakes, thrusts etc. shall be carried out as per manufacturers operation and maintenance manual.

4.3.7 Maintenance of Electrical components of Fixed Rope Drum Hoists:

a) The Electrical components to be inspected and maintained periodically are as under;

i) Starters should be cleaned free of moisture and dust.

ii) Each individual contactor should be tried by hand to make sure that it operates freely.

iii) All wearing parts should be examined in order to take note of any wear which may have occurred during operation.

iv) If the contactor hums, the contact faces should be cleaned.

(v) Examine all connections to see that no wires are broken and no connections are loose.

vi) Clean the surface of the moving armature and magnet core which comes together when the contactor closes, free of dust or grease of any kind.

vii) Examine the mechanical interlocks between the reversing contactor and see when the contact tips of one of the contactor units are touching, it is impossible to get the contact tips of the other unit to touch.

viii) The contact tips should be kept free from burns or pits by smoothening with fine sand paper or emery paper.

ix) Replace the contact tips which have worn away half-way.

x) Do not lubricate the contacts.

xi) Blow out windings thoroughly by clean and dry air to clear air passage in the stator and the rotor of any accumulated dirt. The air pressure shall not be too high to damage the insulation.

xii) Examine earth connections and motor leads.

xiii) Examine motor windings for overheating

xiv) Examine control equipment

xv) Examine starting equipment for burnt contacts

xvi) Check and tighten all nuts and bolts

xvii) Clean and tighten all terminals and screw connections all contact surfaces shall be made clean and smooth.

xviii) Lubricate the bearings

xix) Overhaul the controllers

xx) Inspect and clean circuit breakers.

xxi) Wipe brush holders and check bedding of brushes.

xxii) Blow out windings thoroughly by clean and dry air. The pressure shall not be so high that insulation may get damaged.

xxiii) Check the insulation resistance of the motor between any terminal and the frame. If the measured resistance is less than the prescribed value, then steps shall be taken to dry- out the motors either by passing a low voltage current through the windings or by placing the stator and rotor only in a warm dry place for a day or so.

WARNING: The complete motor shall never be put in an oven for drying as that may melt the grease out of bearings.

xxiv) Coat the windings with an approved high temperature resisting insulation enamel or varnish.

xxv) Over haul the motor, if required.

xxvi) Check the switch fuse units and renew, if required.

xxvii) Check resistance or earth connections.

xxviii) Check air gap.

b) Solenoid Operated Brakes

i) All fixing bolts shall be checked and tightened at least once in three months.

ii) The magnet stroke should be reset to compensate for wear.

iii) Re-adjust the brake when the magnet stroke reaches the value given on the instruction plate.

iv) Brake lining should be checked and replaced when required.

v) Examine all electrical leads and connections.

vi) Rubber bushes or couplings should be checked and replaced if defective.

vii) The pins should be tightened.

4.3.8 Maintenance of Metal Gate Components

All exposed, bare ferrous metal of an outlet installation, whether submerged or exposed to air, will tend to rust. To prevent corrosion, exposed ferrous metals must be either appropriately painted (following the paint manufacturer's directions) or heavily greased in respect of moving parts & on surfaces like guides & track seats on which there is movement of gates. When areas are repainted, it should be ensured that paint is not applied to gate seats, wedges, or stems (where they pass through the stem guides), or on other friction surfaces where paint could cause binding. Heavy grease should be applied on friction surfaces to avoid binding. As rust is especially damaging to contact surfaces, existing rust is to be removed before periodic application of grease. Painting and lubrication works for the maintenance of various metal components are given under **Annexure 8 Maintenance Schedule.**

4.3.9 Access Roads

For a dam to be operated and maintained there must be a safe means of access to it at all times. Access road surfaces must be maintained to allow safe passage of automobiles and any required equipment for servicing the dam in any weather conditions. Routine observations of any cut and fill slopes along the sides of the road should be made. If unstable conditions develop assistance of experienced Engineers/Expert Panels should be obtained and remedial measures initiated. Drains are required to be provided and maintained along roads to remove surface and subsurface drainage. This will prolong the life of the road and help reduce deterioration from rutting. Road surfacing should be repaired or replaced as necessary to

maintain the required traffic loadings. In most cases, specialized contractors will be required to perform this maintenance.

4.3.10 General Cleaning

As already suggested, for proper operation of spillways, sluiceways, approach channels, inlet and outlet structures, stilling basin / energy dissipation arrangements, discharge conduit, dam slopes, trash racks, debris control devices etc., regular and thorough cleaning and removal of debris is necessary. Cleaning is especially important after large floods, which tend to send more debris into the reservoir. The dam has two horizontal galleries. The dam top road and these galleries are to be cleaned regularly.

4.4 Materials and Establishment Requirements during Monsoon

Materials required during monsoon period for both immediate maintenance and preventive maintenance must be stocked in adequate quantities for emergency situations that may arise. Materials normally required to be stocked in sufficient quantity are:-

- Gunny Bags
- Sand
- Boulders/Wire crates
- Bamboos/Balli's
- Baskets
- Ropes
- Petromax Lamps with Spares
- Torches with spare cells
- Kerosene Oil
- Match Boxes
- Rain Coats
- Gum Boots
- Warning sign indicator
- Danger zone lights

At Idamalayar Dam, round the clock patrol is to be carried out during monsoon period. At the same time the manpower requirements during monsoon period are to be enhanced. An Organisation Structure of the Control Unit is given in **Chapter 1.**

4.5 Preparation of O & M budget

The O & M budget for Idamalayar dam should essentially include but not be limited to the following items:

i) **Establishment Cost of Regular Staff** - Salaries and allowances, Bonus, Medical Reimbursement, LTC, Leave Encashment, pension benefits, etc. (as applicable).

ii) **Establishment Cost of Work charged Staff** - Salaries and allowances, Bonus, Medical Reimbursement, LTC, Leave Encashment, Pension benefits, TA and DA, etc. (as applicable).

iii) **Establishment Cost of Daily wage Staff** - Salaries and allowances, TA and DA etc. (as applicable)

iv) **Office Expenses** –Telephone/Mobile/any other Telecommunication bills, Electricity bills, water bills, Office stationery, Day to day office requirements.

v) **Motor Vehicles** - Running and Maintenance cost of inspection vehicles, Cost of hiring of vehicles as required

vi) **Maintenance of Colony** - Maintenance of staff quarters, colony roads, Electricity, Sanitary and Water supply systems etc

vii) **T&P** –The T&P requirements for offices, colony, works etc. as applicable.

viii) **Works** -Painting, oiling, greasing, overhauling of HM equipment's, Repair/replacement of gates seals & wire ropes, POL (Petrol Oil Lubricants) for pumps & generator sets, Electricity charges and maintenance of Electric systems of dam site, vegetation removal, maintenance/cleaning of drains in dam, maintenance of lift/elevators in dam maintenance of access roads & basic facilities, provision for flood contingency works during monsoon, specific requirements for all Civil, H.M & Electrical maintenance works, unforeseen events/items (about 10% of the cost of works) etc.

A summary table for the O & M budget is given below in **Table 4.1**.

Sl. no.	Budget item	Previous year cost (Rs)	Current year budget (Rs)	Remarks
a.	**Establishment**			
1	Salary of regular staff including all other benefits			
2	Travel expenses			
3	Office expenses			

4	Vehicle expenses			
5	Maintenance of office & colony complex			
	Sub-total - a			
b.	**Works**			
1	**Civil works**			
1.1	Concrete / masonry dam			
1.2	Approach / inspection roads within dam area			
2	**Hydro-Mechanical works**			
2.1	Spillway gates & hoists			
2.2	Power Outlets/ gates & hoists			
2.3	Disperser Valves			
3	**Electrical works**			
3.1	Electrical fittings, motors, controls for all gate hoists			
3.2	Power supply lines			
3.3	Elevator			
3.4	Electrical fittings on dam top, dam galleries, etc.			
3.5	Standby power / diesel generator			
3.6	Remote control			
4	**Instrumentation**			
5	**Miscellaneous works**			
6	**Salary of work charged staff including all benefits**			
7	**Materials to be stored before monsoon**			
	Sub-total - b			
c.				
1	**Contingency (10%) on Sub-total of a & b**			
2	**Tools & Plants**			
	Sub-total - c			
	Total Annual Cost			

Table 4.1 Summary Table for Annual O&M Budget

4.6 Maintenance Records

Maintenance records are of utmost importance. A record shall be kept for all maintenance activities, both immediate and preventive maintenance works. Information that must be recorded includes, but not limited to, the following:

- Date and time of maintenance
- Weather conditions
- The type of maintenance
- Name of person or contractor performing maintenance
- Description of work performed
- The length of time it took to complete the work with dates
- Equipment and materials used
- Before and after photographs.

The data should be recorded by the person responsible for maintenance.

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Chapter 5

Instrumentation and Monitoring

A dam's instrumentation furnishes data for deciding if the structure is functioning as intended and provides continuous monitoring to warn of any unsafe developments or phenomena that can lead to dam failure by drawing information from a wide spectrum of instruments and procedures, ranging from simple to complex. The program must be based on prevailing geotechnical conditions at the dam, and must include consideration of the hydrologic and hydraulic factors present before and after the project is in operation.

5.1 Instrument Types and Usage

With a view to watching the structural behavior of the dam with reference to design assumptions, and also for collecting improved data for better design criteria in future a systematic instrumentation has been provided in the dam. This consists of observations stations for theodolites, levels etc., for deformations at top, plumb bob installations for deflections and uplift measurement services. Moreover, the stress distribution is measured from the strain meters installed at areas at various points in the dam. Joint meters are provided for gauging movements at the contraction joints. Some resistance thermometers and pore pressure meters are also installed in the dam for monitoring of the dam. The readings from these instruments are taken monthly and are reported.

The instruments installed and present status of functioning is as below in **Table 5.1**.

LIST OF INSTRUMENTATIONS INSTALLED IN IDAMALAYAR DAM					
Sl. No.	**Name of Instrument**	**Parameters monitored**	**Total No installed**	**Functioning**	**Frequency**
1	Single V - notch	Seepage	1	1	Monthly (weekly during monsoon)
2	Double V - notch	Seepage	1	1	Monthly (weekly during monsoon)
3	Upright Pendulum	Movements and deformation	3	3	Monthly
4	Joint Meter	Movements and deformation	32	2	Monthly

5	Strain Meter	Deformation	32	25	Monthly
6	Pore Pressure Meter	Pore pressure and uplift pressure	14	3	Monthly
7	Resistance Thermometer	Temperature	19	17	Monthly
8	Water Level Gauge	Water level			Daily - 2 times During monsoon - hourly

Table 5.1 Instrumentation present status

The locations of the instruments installed in the dam are shown in **Drg 5.1, Drg 5.2a** and **Drg 5.2b**. The various locations are detailed in **Annexure 9.**

The instruments installed in Idamalayar dam are pendulum, joint meter, strain meter, pore pressure meter, thermometers and water level gauge. Water level gauge is provided at the left bank of the dam. The quality of water including pH value is tested monthly at Regional Analytical laboratory, Ernakulam. The leaching of cement is calculated on the basis of this report. Cracks were not noticed. The Seismic observatory installed at Idamalayar is not working. Hence new digital seismic observatory at Dam site as well as accelerographs for the Dam galleries for measuring local tremors is required and proposed under DRIP. Now the rainfall data are measured with rain gauge located at dam top. But a full equipped weather station can sense all weather conditions. Automated weather station and other instrumentation for real time health monitoring is proposed under DRIP.

5.2 Data Processing, Evaluation, Interpretation and Performance Evaluation reports

The instrumentation monitoring is done periodically as above and monthly reports are prepared for evaluation. Data interpretation being done yearly is now proposed quarterly by CWC.

Chapter 6

Previous Rehabilitation Efforts

6.1 Issues with the dam

6.1.1 Re constructing the damaged portion of Training wall and clearing the river course

Following the flood of 1993, an unprecedented flow of water infiltrated through the downstream right bank filled up earth portion (of about 30 ft height) and caused failure of concrete spillway training wall for a length of 18.5 m towards the river course. Even though a portion of the training wall has been thus damaged completely, no damage was caused either to the top of the spillway bucket or to any portion of the main dam or any appurtenant works. But large sized boulders blocked a part of the river course downstream of energy dissipation arrangement. Subsequently, during the flood of 2013, the slope again got disturbed. The smaller particles including fines and screeds were washed away leaving the boulders blocking a part of river course constricting the flood route. Due to this the flood water got deflected and started damaging the right and left flank. In view of this, DSRP has recommended that the flood route has to be cleared for free flow of water.

Existing rock out crop beyond the bucket is higher than the general river bed causing non uniform flow in the channel. Due to its proximity with the concrete structures, its excavation is fraught with many problems. The river channel should be properly trained by removing these boulders. The recent unusual flood of 2018 has again stabilised the slope, but left the huge boulders and disturbed the damaged part of the training wall. This is being addressed under DRIP.

6.1.2 Leakage in to inspection gallery near block joint 15/16

A leak was noticed during 9/2011 in the intermediate gallery near the block joint 15/16 at about EL+129.5 m. The leak was getting reduced with the reduction in water level till the level reached +129.80. When the water level reached +129.8 m on 12.06.12, the leak stopped. On inspection of the upstream face of the dam (Water level 128.83) it is noticed that there is a lift joint at this level which was honey combed to a large extent. The dam face was also seen wetted

at some points of the honey combs even after the water level has receded. The leak is seen again when the water level goes above +129.8 and stops when the WL drops to +129.7

On analysis, it was observed that the leak was due to the water entering the dam through the honey combs at the level +129.8. The honey comb near Block joint 15/16 is severe and water was seen oozing out from this even after the water level has receded and the surrounding areas have become dried. The fact that this honey comb was at the level +129.8 m and is nearest to the leak also substantiates this possibility. Hence this honey comb was suspected to be the main leak source and not the clogging of the Formed drains as suspected before.

So these honey combs were treated with M-seal on 17.7.2012 and 18.7.2012 to study the effect on leak. It was found to be effective as the leakage got reduced when compared with the previous values until the water level reached an elevation of about +138. But the leak was found to be increasing at a higher rate than the previous values with further increase in the water level. This shows that the effect of M-Seal treatment ceased from this point onwards. This may be due to the dislodging of M-seal from the dam body or cracking of the same under pressure and due to the widening of the leak path as a result of leaching. But the rate of increase is seen to be reducing from 19.9.2012. This may be due to the dislodged particles clogging the leak path. Hence it needs to be ascertained that this honey comb is the source of the leak by monitoring changes in seepage.

Remedial Measures

As this leak had to be stopped at the earliest, it was proposed to seal these honey combs at upstream face covering all the surrounding area of honey combs near block joint with special compounds which can resist higher water pressure. Block joint 15/16 near the honey combed area was also to be treated using special sealant materials and membrane.

Accordingly under DRIP Phase I, raking out and filling the expansion joint at block 15/16 for a height of 15 m (from the elevation of expected least minimum water level of this year to a height of 15 m from that level) by inserting hydrophilic back up materials, filling the joint by polyurethane sealant and then fixing EPDM membrane and aluminium strip was carried out. After chipping and cleaning honey combed concrete surface, the area was treated with cementitious special priming coat. Thereafter, 10 mm thick high strength repair mortar was applied for an area of 15 m x 10 m size around the block joint 15/ 16 in between elevation +125.00 to +135.00. Nozzle grouting was also carried out in this area.

Rehabilitation works

The above works were carried out under DRIP Phase I and completed on 30.06.2018. The upstream honeycomb/eroded concrete surface treatment surrounding block joint 15/16 of Idamalayar Dam for leakage control was to be executed between the water level +125 m to +140 m. As the water level could not be lowered up to +125 m during commencement, the work was executed from the level +140 m expecting that due to power generation the water level may get down to +125 m on or before 31.05.2018. The contractor carried out the work satisfactorily up to +128.6 m within which the affected area +129.8 m lies. On reaching the +128.6 m level monsoon started unexpectedly on 27.05.2018 and the water level began to rise. Hence the contractor was unable to carry out the work up to +125 m level.

Leakage before the work: The leakage in the block joint before carrying out the work at nearby levels of +150 m is as shown in **Table 6.1.**

Year & Date	Water Level	Leakage ltr/min
08.11.2012	150.04	10.05
04.07.2013	150.00	11.58
02.08.2014	151.06	8.68
31.08.2015	150.01	7.094
22.08.2016	150.35	6.426
06.02.2017	150.15	6.686
05.03.2018	150.69	6.118

Table 6.1 Leakage in the block joint Level +150m

Leakage after the work: The leakage after carrying out the work on 13.07.2018 at water level 151.91 m is 0.0149 litre/min. This leakage is very negligible compared to the leakage before carrying out the rectification work.

(a)

(b)

Fig 6.1 Leakage in Gallery 2 (a) and Gallery 1(b)

6.2 Other Rehabilitation Work under DRIP

6.2.1 Reaming of Foundation drain holes

Due to calcinations, the foundation drain holes were either fully or partially chocked. To make them functional, it is necessary to ream and clean these drain holes periodically. The reaming of the holes was done earlier during 1992. The experts including DSRP who visited the dam during 2014 had suggested reaming of foundation drain holes and this has been arranged

as part of DRIP works at Idamalayar dam. Accordingly reaming was done for the vertical foundation drain holes.

6.2.2 Providing catwalk connecting Spillway radial gate trunnions

There was no access to spillway gates trunnion for inspection, maintenance and repairs. A steel catwalk bride is provided in 2017 under DRIP. See **Fig 6.2**.

Fig 6.2 Catwalk connecting Radial gate trunnions

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Chapter 7

Updating the Manual

Whenever features of the dam and appurtenant structures change, the O & M Manual must be edited and portions rewritten to reflect these changes. This task is often ignored. Updating information in the O & M Manual should be done whenever major changes like construction of an additional spillway, construction of dam on the upstream etc take place.

Aspects to be considered when updating include: Increase/decrease in the frequency of an inspection or the maintenance routine based on additional data/ experience acquired, Changes in the operation and/or maintenance procedures based on additional data/experience acquired, Alterations to the project data because of changes/modifications in the dam by way of additional spillway etc.

It is recommended that the O & M Manuals may be reviewed / updated after every 10 years by the respective Dam Owners.

References

1. **CWC Guidelines for preparing O & M Manual of Dams DSO_GUD_DS_03_v1.0 Page xii January 2018**
2. **CWC Guidelines for Safety Inspection of Dams CDSO_GUD_DS_07_v2.0 PageB4-B45 January 2018**
3. **'Guidelines for Operation of Reservoirs' (IS 7323:1994)**
4. **'Hydraulic Design of High Ogee Overflow Spillways' (IS 6934:1998)**
5. **Criteria and Guidelines for Evacuating Storage Reservoirs, Sizing Low Level Outlets and Initial Filling of Reservoir**
6. **Notification for Strengthening of Alarm and Warning System for Safety of People from Sudden Release of Water from Dams Issued by National Disaster Management Authority (October 2015).**
7. **Report on Rule Levels of Major Reservoirs of KSEB Ltd May 2019**
8. **Project Screening Template**