



# OPERATION AND MAINTENANCE MANUAL

## KUTTIYAR DIVERSION WEIR



**Doc. No. O&M/Kuttiyar Weir/KSEBL/25**

**Kerala State Electricity Board Limited**

**Chief Engineer (Civil-Dam Safety & DRIP)**

**January 2024**

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# Operation and Maintenance Manual

## Kuttiyar Diversion Weir



**Approved**

**Chief Engineer (Civil-Dam Safety & DRIP)**

**Kerala State Electricity Board Ltd.**

**Pallom, Kottayam.**

**January 2024**

**Government of Kerala**  
**Kerala State Electricity Board Ltd**  
**Dam Safety Organisation**

**DISCLAIMER**

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

The manual is developed for the purposes of organizing and managing the operation, inspection and maintenance of the dam for reducing risk and optimizing performance of the weir 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.

**Director (Generation Civil)**  
**Kerala State Electricity Board Limited**

## **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, on-going 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.

**Smt. Supriya S**  
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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. Dam Safety Act, 2021 also mandates that the dam owner shall ensure that a well-documented operation and maintenance manual is kept at each of the specified dams and are followed at all times. Accordingly, Kerala State Electricity Board Limited is developing and updating the Operation and Maintenance Manual of Dams under their ownership for a healthy dam safety management system.

Operation and Maintenance Manual of Kuttiyar diversion Scheme under KSEBL is prepared as per the guidelines by CWC. The Kuttiyar project was commissioned on 2009.

**This Operation and Maintenance Manual is prepared for the Kuttiyar Diversion Weir under Kuttiyar Project (An augmentation scheme of Idukki HEP).**



## CONTENTS

<b>Chapter 1 General Information .....</b>	<b>1</b>
<b>1.1 Introduction .....</b>	<b>1</b>
<b>1.2 Purpose, location and Description of the Project .....</b>	<b>1</b>
<b>1.3 Background Details of the Project .....</b>	<b>3</b>
<b>1.4 Salient Features .....</b>	<b>3</b>
<b>1.5 Major components .....</b>	<b>6</b>
<b>1.6 Assignment of Responsibility .....</b>	<b>11</b>
1.6.1 Roles and Responsibilities of the AE and AEE during Monsoon .....	12
1.6.2 Roles and Responsibilities of the EE and DyCE .....	12
1.6.3 Roles and Responsibilities of the Chief Engineer during Monsoon .....	13
<b>1.7 Collection &amp; Reporting of Data .....</b>	<b>13</b>
<b>1.8 Public Utilities and Safety .....</b>	<b>15</b>
1.8.1 Security Arrangements .....	15
1.8.2 Access Roads .....	15
<b>1.9 Organogram .....</b>	<b>15</b>
<b>1.10 Warning system .....</b>	<b>17</b>
<b>1.11 Releases through Spillway .....</b>	<b>17</b>
<b>1.12 Distribution of Operation &amp; Maintenance Manuals .....</b>	<b>18</b>
<b>1.13 Supporting Documents &amp; Reference Material .....</b>	<b>18</b>
<b>1.14 Typical Schedule of Duties .....</b>	<b>19</b>
 <b>Chapter 2 : Project Operation .....</b>	 <b>22</b>
<b>2.1 General .....</b>	<b>22</b>
<b>2.2 Operation Plan .....</b>	<b>22</b>
2.2.1 Data of Historical Flood .....	22
2.2.2 Design Flood Studies .....	22
<b>2.3 Normal Operations .....</b>	<b>23</b>

2.3.1 River Outlets .....	23
2.3.2 Operating Procedure of gates.....	23
2.3.3 Operation of scour gates during flooding .....	24
2.3.4 Rule Curve.....	24
<b>2.4 Emergency Action Plan .....</b>	<b>24</b>
<b>2.5 Record Keeping .....</b>	<b>24</b>
<b>Chapter 3: Project Inspection .....</b>	<b>26</b>
<b>3.1 Types of inspections .....</b>	<b>26</b>
<b>3.2 Comprehensive Evaluation Inspections .....</b>	<b>26</b>
<b>3.3 Scheduled Inspections .....</b>	<b>27</b>
3.3.1 Pre and Post-Monsoon Inspection .....	27
3.3.2 Special (Unscheduled) Inspections.....	27
<b>3.4 Informal Inspections .....</b>	<b>28</b>
<b>Chapter 4 : Project Maintenance .....</b>	<b>29</b>
<b>4.1 Maintenance Plan .....</b>	<b>29</b>
<b>4.2 Maintenance Priorities .....</b>	<b>29</b>
4.2.1 Immediate Maintenance .....	29
4.2.2 Preventive Maintenance.....	29
<b>4.3. Procedure for Routine Maintenance.....</b>	<b>30</b>
4.3.1 Maintenance to the vertical lift gates.....	30
4.3.2 Maintenance to Trash Racks .....	32
4.3.3 Trash Rack Cleaning.....	32
4.3.4 Maintenance of Access roads.....	32
4.3.5 Maintenance of Electrical systems .....	32
4.3.6 General cleaning.....	32
<b>4.4 Materials and establishment requirements during monsoon.....</b>	<b>33</b>
<b>4.5 Preparation of O&amp;M Budget .....</b>	<b>33</b>
<b>4.6 Maintenance Records.....</b>	<b>34</b>

<b>Chapter 5 : Instrumentation and Monitoring .....</b>	<b>35</b>
<b>5.1 Instrument Types and Usage .....</b>	<b>35</b>
5.1.1 Water Level.....	35
5.1.2 Seismic Activity .....	35
<b>5.2 Dam Performance Evaluation.....</b>	<b>35</b>
<b>5.3 Methods of Behavior Prediction .....</b>	<b>36</b>
5.3.1 Visual Observations.....	36
5.3.2 Monitoring Results .....	36

### List of Figures

Fig 1.1 Idukki HEP Index Map.....	2
Fig 1.2 Kuttiyar Diversion Weir- Google View .....	2
Fig 1.3 Location Map of the Project .....	5
Fig 1.4 Kuttiyar Reservoir – Google View.....	6
Fig 1.5 Google terrain view of the Different Augmentation Schemes.....	6
Fig 1.6 Kuttiyar Diversion Weir - Google view .....	7
Fig 1.7 Kuttiyar Diversion Weir - Photograph.....	8
Fig 1.8 Kuttiyar Diversion Weir – Trash rack at Intake .....	9
Fig 1.9 Kuttiyar Diversion Weir – Tunnel Exit.....	10
Fig 1.10 Kuttiyar Diversion Weir – Tunnel Exit .....	10
Fig 1.11: Flow path of spill water .....	17
Drg. 1: Kuttiyar Diversion Weir - Plan.....	40
Drg. 2: Kuttiyar Diversion Weir -Upstream Elevation .....	41
Drg. 3: Kuttiyar Diversion Weir- Sections of Weir .....	42
Drg. 4: Kuttiyar Diversion Weir Details of Foundation Grouting.....	43
Drg. 5: Kuttiyar Diversion Weir – Details of Duct .....	44
Drg. 6: Kuttiyar Diversion Weir – CS of Tunnel .....	45

**List of Tables**

Table 1.1: Officers and their responsibilities .....	11
Table1.2: Daily Reservoir Data .....	13
Table1.3: Daily Reservoir Status .....	13
Table 1.4: Contact details of officials.....	17
Table 1.5: Schedule of duties/inspections .....	21

**List of Annexures**

ANNEXURE I - DRAWINGS .....	39
ANNEXURE II – Rainfall Details.....	47
ANNEXURE III– GLOSSARY .....	53

## LIST OF ACRONYMS

The following acronyms are used in this publication:

AE	Assistant Engineer
AEE	Assistant Executive Engineer
CWC	Central Water Commission
DDMA	District Disaster Management Authority
DHARMA	Dam Health and Rehabilitation Monitoring Application
DRIP	Dam Rehabilitation and Improvement Project
Dy CE	Deputy Chief Engineer
EAP	Emergency Action Plan
EE	Executive Engineer
IS	Indian Standard
KSEBL	Kerala State Electricity Board Ltd
KWA	Kerala Water Authority
NDSA	National Dam Safety Authority
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RCC	Reinforced Cement Concrete
SDSO	State Dam Safety Organization

## References

1. Guidelines for preparing O&M Manual of Dams (DSO\_GUD\_DS\_03\_v1.0 January 2018) published by CWC.
2. CWC Guidelines for Safety Inspection of Dams (CDSO\_GUD\_DS\_07\_v2.0 January 2018)
3. Guidelines for Operation of Reservoirs (IS 7323:1994), Bureau of Indian Standards code IS 7323-1994 RA 2018
4. Hydraulic Design of High Ogee Over flow Spillways (IS Code 6934-2014 RA 2020)
5. Technical Completion Report of Kuttiyar SHEP

## Chapter 1 General Information

### 1.1 Introduction

Idukki Hydro Electric Project is the largest hydroelectric project of Kerala State located in Idukki District. The project is aimed for power generation. This project, on Periyar river basin, envisages creation of a reservoir by constructing three dams viz. Idukki Arch dam, Cheruthoni dam and Kulamavu dam. Water from the reservoir is diverted to an underground power house with an installed capacity 780 MW located at Moolamattom through tunnel/penstock etc. The reservoir is augmented by diverting water from adjacent streams Viz. Kallar and Erattayar under Idukki HEP – Stage III. There are also diversions from adjacent catchments like Azhutha, Vazhikkadavu, Kuttiyar, Narakakkanam, Vadakkeppuzha etc. to Idukki reservoir for augmentation considering the effective utilization of water on the potential head consideration and water demand for unit wise.

### 1.2 Purpose, location and Description of the Project

The Kuttiyar diversion scheme envisages diversion of an average quantity of 33.2 Mm<sup>3</sup> waters from a catchment area of 10.42 sqkm. of Kuttiyar to the Idukki reservoir through a diversion tunnel for additional power generation at the Idukki Power Station to the tune of 37 Mu. Kuttiyar diversion structure is located at latitude 9°43'56.06"N: 76°53'6.39"E in Idukki District, Peerumedu Taluk, Vagamon Village and in Elappara Panchath. The diversion weir site is about 35km by road from Kuttikanam located in the Kottayam – Kumily Road. The site is also accessible from Erattupetta via Vagamon. Erattupetta is connected by tarred road from Palai and Kanjirappally.

The nearest city is Kochi, nearest railway station is Kottayam about 65 km from Weir site and nearest airport is CIAL, Nedumbasserry about 100 km from dam site. The index map and route map of IHEP are given in Fig 1.1 and Fig 1.2.

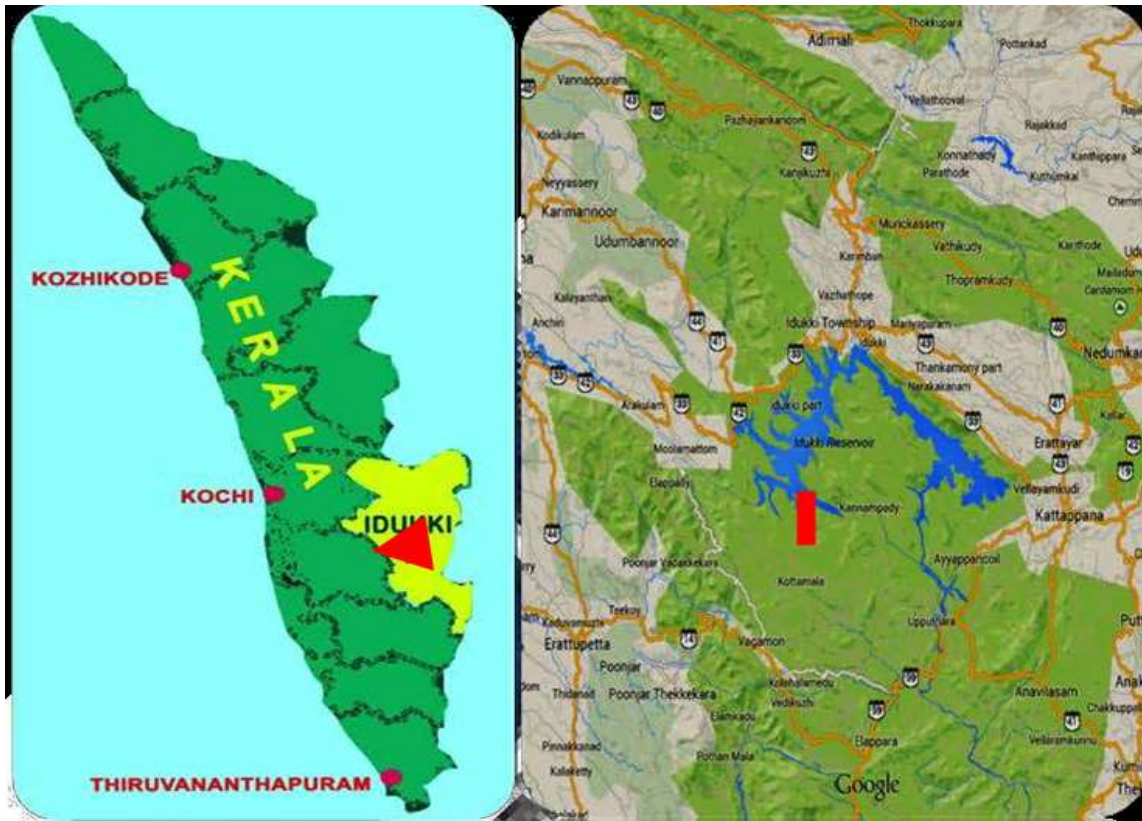


Fig 1.1 Idukki HEP Index Map



Fig 1.2 Kuttiyar Diversion Weir- Google View

### 1.3 Background Details of the Project

The augmentation scheme involving simple civil works, linked to existing power stations assume importance on account of their capability to add more energy in a short time at the present juncture of acute power shortage. Because the water regulation and power generation are done availing the facilities of the existing scheme, the unit cost of energy is cheaper than that of a medium independent Hydel Scheme even.

The other diversion schemes for Idukki HEP are Kallar Erattayar diversion (376 Mu), Narakakkanam (7 Mu), Azhutha (57 Mu) and Vadamkuzha (12 Mu), Vazhikkadavu etc.

### 1.4 Salient Features

<b>RESERVOIR</b>	
Full Reservoir Level (FRL)	+795.50 m above MSL
Maximum Water level (MWL)	+798.00m above MSL
Effective Storage at FRL	0.35Mm <sup>3</sup>
Effective Storage above +792.00	0.225 Mm <sup>3</sup>
Water Spread Area at FRL	7.75 Ha.
Water Spread Area at MWL	9.86 Ha
<b>HYDROLOGY</b>	
Catchment Area	10.42Sqkm
Average Annual Rainfall	4800.00mm
<b>DIVERSION WEIR</b>	
Type	Straight Concrete Gravity
Nominal Bed Level	+786.00m
Deepest Foundation Level	+778.61.00m
Crest Elevation of Over flow section	+795.50m
Length of Over flow Section	30.00 m
Length of overflow section at left bank	13.00 m
Length of overflow section at right bank	22.00 m
Length of core wall at left bank	33.00 m
Total length of the Dam	65.00m
Top of Dam	+799.00



Maximum Height of overflow section	16.90 m
Maximum Height of Non-overflow section	15.40m
Type of the Spillway	Un gated
Maximum Discharge Capacity	268.00 cumecs
River Sluice	750 mm Dia
<b>INTAKE STRUCTURE</b>	
Location	
Sill Level of the Intake	+792.00m
<b>DIVERSION TUNNEL</b>	
Type of the Tunnel	Unlined
Size and Shape	2.5m 'D' shaped
Area of Cross Section	5.66 Sqm
Length of the Tunnel	2696.00 m
Slope of the Tunnel	1 in 300
Maximum Discharge	7.00 cumecs
Maximum velocity	1.24 m/s
Inlet sill level	+792.00
Exit Sill level	+783.00
ADIT Tunnel	1.00 No
ADIT Tunnel length	85.00m

Table 1.1 – Salient Features of the Project



○

Fig 1.3 Location Map of the Project

### 1.5 Major components

#### Reservoir

The reservoir for Kuttiyar Diversion scheme has a small storage of 0.35 Mm<sup>3</sup>. The reservoir is formed by constructing a diversion weir of 65 m length at Kuttiyar stream. A Google map view of the reservoir is also given in Fig 1.5.



Fig 1.4 Kuttiyar Reservoir – Google View

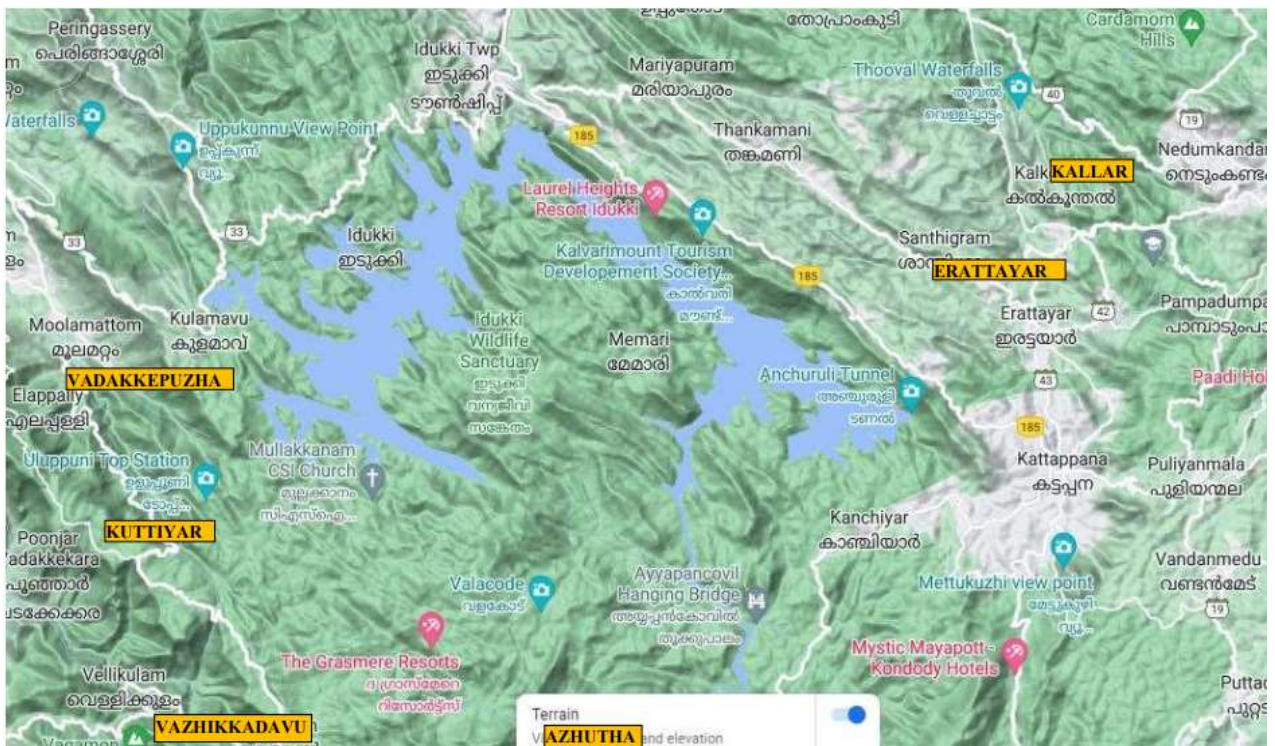


Fig 1.5 Google terrain view of the Different Augmentation Schemes



### The Diversion Weir

Kuttiyar Weir is a small diversion weir constructed across Kuttiyar River in Elappara Panchayath of Vagamon Village of Idukki District in Kerala, India. The Kuttiyar weir is constructed for augmenting water to the Idukki Hydro Electric Project.

The weir has a height of 16.90 meters from the deepest foundation and a length of 65 meters at latitude of  $9^{\circ}43'56.06''\text{N}$ :  $76^{\circ}53'6.39''\text{E}$  across a Kuttiyar River. It is an overflow type concrete weir having a storage of  $0.35 \text{ Mm}^3$ . The site is 35 km from Kuttikkanam in Kottayam Kumily Road. The overflow section has been designed as an un-gated ogee shaped overflow spill way.



Fig 1.6 Kuttiyar Diversion Weir - Google view

### Non Over Flow Section

The 30.00 m of over flow portion is flanked by 13.00 m non-over flow portion on the left bank and 22.00 m on the right bank. Total length of the weir at elevation +798.50 is 65.0015.40 m. The deepest foundation level is +778.61m. MWL is fixed at elevation +798.00. The maximum height of non over flow section above deepest foundation is 15.40 m. 2.5m widths are provided at top of the non over flow section. Upstream section of the non over flow section is vertical.



Fig 1.7 Kuttiyar Diversion Weir – Photograph

### **Scour Sluice**

750 mm dia pipe is provided as scour sluice. Two Nos of Rectangular Vertical lift gate is provided on the U/S side to operate the sluice to remove the silt periodically.

### **Water Conductor System**

The water conductor system of the Kuttiyar Diversion Scheme consists an Intake on the right flank of the river; 2.5m “D” Shaped unlined Tunnel 2996 m long. The Tunnel has an area of 5.66 Sqm. and has a slope of 1 in 300. The maximum discharge of the tunnel is 7 cumecs and maximum velocity is 1.24 m/s. The inlet sill level of Tunnel is +792.00 and exit sill level is +783.00. One Number 85.00 m length ADIT is also provided for the tunnel system for facilitating the easy driving. A trash rack is provided at the Intake to prevent debris to entering the tunnel. A stop log gate arrangements are also provided at the intake to close the tunnel. Provisions for hooking arrangements are incorporated. The stop logs are placed in position by manual means.



Fig 1.8 Kuttiyar Diversion Weir – Trash rack at Intake (Inlet)





Fig 1.9 Kuttiyar Diversion Weir – Tunnel Exit

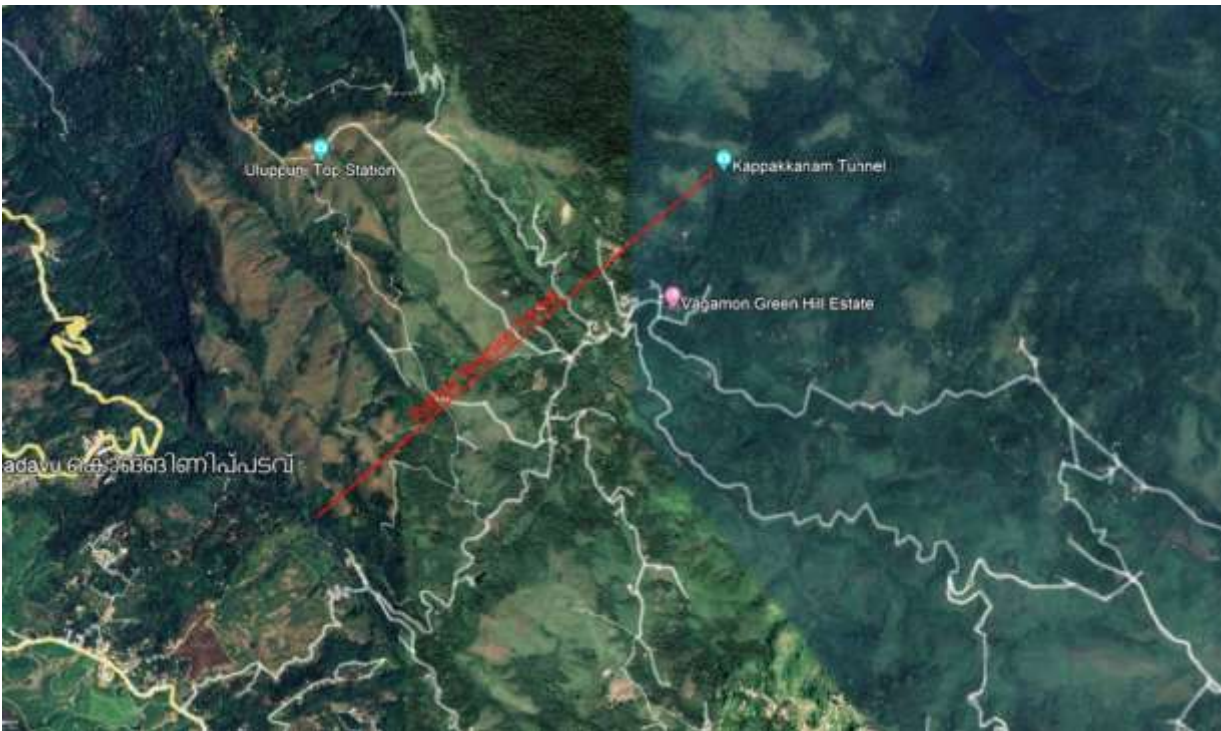


Fig 1.10 Kuttiyar Diversion Weir – Tunnel Exit

## 1.6 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 Weir. 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 (civil, mechanical, electrical, instrumentation etc.) are identified by their designation and, in particular, the responsibilities of operating personnel are specifically identified including the regularly scheduled duties which staff personnel are required to perform as outlined.

Dam Owner	Kerala State Electricity Board Limited
Project Administration Officer	The Director (Generation – Civil), KSEB Ltd.
Chief Controlling Officer	Chief Engineer (Civil–Dam Safety & DRIP)
Authority of Spillway operations and Flood releases	Chief Engineer (Civil– Dam Safety &DRIP), KSEB Ltd
Operation and safety of the dam	Deputy Chief Engineer, Research & Dam Safety Organization, Pallom, KSEB Ltd.
Controlling/Operation Officer at dam site	Executive Engineer, Research & Dam Safety Division, Vazhathope.
Reservoir operations, inspection & maintenance	Executive Engineer, Research & Dam Safety Division, Vazhathope.
Dam Health Engineer	Executive Engineer, Research & Dam Safety Division, Vazhathope.
Recording reservoir data, inspection, monitoring and maintenance at site	Assistant Executive Engineer, Research & Dam Safety Sub Division No.I, Vazhathope.
Handling Dam operations, inspection, monitoring and performing duties and Maintenance- Officer at dam	Assistant Engineer, Research & Dam Safety Sub Division No.I, Vazhathope.
Competent Authority for the dam safety unit	Executive Engineer, Research & Dam Safety Division, Vazhathope.
Competent engineers for the dam safety unit	Assistant Executive Engineer/Assistant Engineer, Research & Dam Safety Sub Division No.I, Vazhathope.
Reviewing Authority for the dam safety unit	Deputy Chief Engineer, Research & Dam Safety Organization, Pallom, KSEB Ltd.

Table 1.2: Officers and their responsibilities



### **1.6.1 Roles and Responsibilities of the AE and AEE during Monsoon**

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

1. Collect rainfall information in the catchment, inflow status, reservoir level and to bring it to the notice of the EE/ DyCE.
2. Assist the EE/DyCE/CE to coordinate with the Revenue authorities (District Administration), to alert the downstream inhabitants and to alert DDMA to evacuate from the flood zone to prevent loss of life and livestock.
3. Assist the EE/DyCE/CE to coordinate with the CWC flood monitoring authorities on the flood condition.
4. Maintain the reservoir water level gauge register and to update on hourly basis during floods and report to EE/DyCE/Chief Engineer.
5. Submit (details) to the EE/DyCE/CE on the inflows and outflows from the reservoir and status of the reservoir at 3 hr interval during flood or at interval as decided by competent authority/ DDMA.
6. Monitor the condition of the umbrellas, toolkits, torches etc. to see that things are in place to handle any emergency situation.
7. Observe and ensure that the dam top, approach roads are well maintained.
8. Observe the performance of the Dam and its appurtenant structures/scour Gates and Hoists during flood water releases and to report to the EE/DyCE/CE in case of any untoward incidents or malfunctioning of the scour gates, excessive seepages, leakages etc. noticed.

### **1.6.2 Roles and Responsibilities of the EE and DyCE**

1. Conduct Periodical (Pre and Post Monsoon) to assess the health status of the Dam and appurtenant structures to attend 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 Hydro Mechanical components of the Dam project such as Gates and Hoists before and after monsoon and to issue necessary instructions to the field officers.
3. Coordinate with the field Engineers to get the information in respect of rainfall and inflow status and to bring to the notice of the CE.
4. Assist the CE to coordinate with the Revenue authorities (District Administration) to alert the downstream villagers and DDMA to initiate evacuation from the flood zone to prevent any loss of life and livestock.
5. Assist the CE to coordinate with the CWC flood monitoring authorities on the flood condition.
6. Submit to the CE the status of inflows and releases from the reservoir daily or as instructed.

7. Observe the dam top, embankment, approach roads are well maintained.
8. Observe the performance of the dam and its appurtenant structures, including scour gates and hoists, during floodwater releases. Report any untoward incidents or malfunctions of the gates, excessive seepages, leakages, etc., to the Chief Engineer

**1.6.3 Roles and Responsibilities of the Chief Engineer during Monsoon**

1. Coordinate with the CWC flood monitoring authorities on the flood condition.
2. Observe the performance of the Dam and its appurtenant structures/Scour Gates and Hoists during flood water releases and to issue necessary instructions to the DyCE/EE.
3. Coordinate with the Generation wing of KSEBL regarding the power generation requirement.

**1.7 Collection & Reporting of Data**

Following data are collected, recorded and documented.

- Reservoir water surface elevation.
- Rainfall data etc.

Executive Engineer is responsible for daily collection and reporting of inflow and outflow data to the Deputy Chief Engineer in the following format.

MWL (m)	FRL (m)	Crest Level (m)	Present Water Level (m)	Previous Year Water Level	Percentage Storage	Rainfall (mm)	Generation (Mu)	Spill (m <sup>3</sup> /Sec)	Sluice Gate operation details

Table1.4: 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

Table1.3: Daily Reservoir Status

On collecting the details in the above format, a daily reservoir status shall be submitted to the

Chief Engineer as in the **Table 1.4**.

Records/Logbooks of the operations for the following activities shall be 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.

- Record the date and time
- Attendance statement during normal operations– both during monsoon and non-monsoon periods.
- Operations of the intake / scour outlet.
- Operating hours of mechanical equipment.
- Testing/operation of Outlet gates 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.

The data collection and reporting shall be done as follows:

Reservoir water surface elevation	This is collected daily
Spillway out flow	This is calculated during spill
Weather related data	Collected and reported daily
Water quality	Shall be tested once in 6 months
Attendance statement	Both during monsoon and non-monsoon period maintained at field office.
Operations of outlet gates	Shall be recorded
Operating hours of mechanical equipment	Maintained at field office
Testing/operation of Outlet gates, 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, Circle and CEs office

Manual for O&M of Kuttiyar Diversion Weir Unusual conditions or occurrences, including acts of vandalism	Details maintained (at field office.) January 2024
Attendance statement at dam during emergency operations	Details shall be maintained at field office
Changes to normal operating procedure	Details shall be maintained at field office
Communication	Available at Dam site.
Safety and special instructions	Safety equipment shall be provided
Names and addresses of official visitors	Record of inspections maintained at office.

## 1.8 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.

Sufficient accommodation facilities are available at nearby Town Vagamon which is around 10 km from Weir Site. The Kuttiyar Diversion Weir is close to the Kuttiyar Pullikkanam Road.

Distances to the nearest medical assistance is available at Vagamon. Government General Hospital is located at Pala (around 50 kilometers from Kuttiyar). Police station is also located at Vagamon. Private Hospitals with medical facilities are also available at Erattupetta, Elappara etc. Minor medical assistance are available at Vagamon itself.

### 1.8.1 Security Arrangements

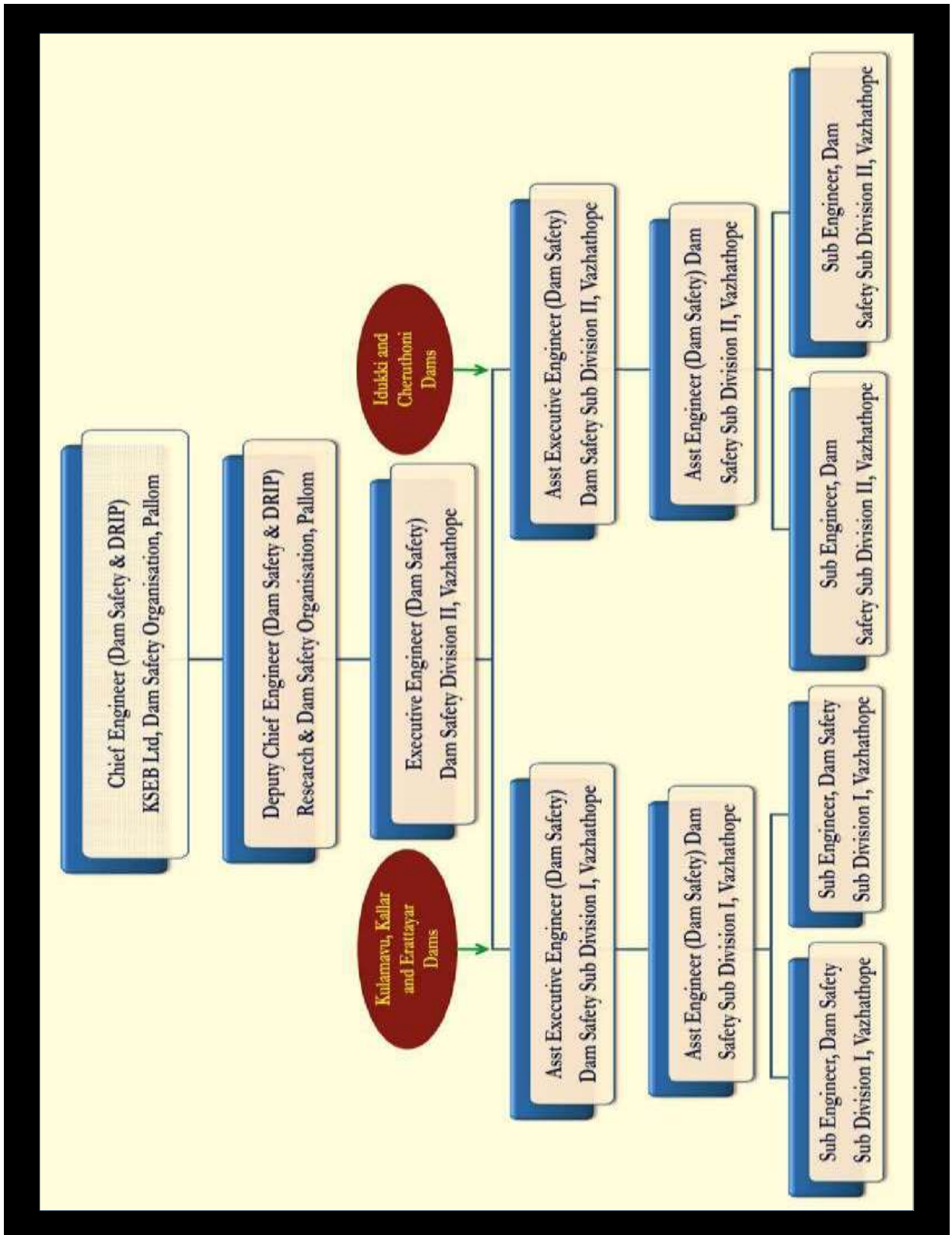
Security arrangements are provided near dam at security check post at the dam top on left bank.

### 1.8.2 Access Roads

The Kuttiyar diversion Weir can be accessed from Vagamon Pullikkanam road from Chottupara jn. (Approximately two km.)

## 1.9 Organogram

The organogram of the officials under Dam Safety Wing responsible for the operation and maintenance of the weir and their contact details is shown below;



Designation and office address	Contact number and e-mail
Chief Engineer Civil (Dam safety & DRIP), KSEB Ltd, Dam Safety Organization, Pallom, Kottayam	Ph:9496018719 e-mail: <a href="mailto:cedamsafety@gmail.com">cedamsafety@gmail.com</a>
Deputy Chief Engineer, Research & Dam Safety Organization, Pallom, Kottayam	Ph:9446008492,0481-2432290, 9496011540 e-mail: <a href="mailto:dirroplm2@gmail.com">dirroplm2@gmail.com</a>
Executive Engineer, Dam Safety Division No.II, Vazhathope	Ph: 9446008425 e-mail: <a href="mailto:ddrdskkds@gmail.com">ddrdskkds@gmail.com</a>
Assistant Executive Engineer, Dam Safety Sub Division No.1, Vazhathope	Ph: 9496011802 e-mail: <a href="mailto:aeedssd1@gmail.com">aeedssd1@gmail.com</a>
Assistant Engineer, Dam Safety Sub Division No.1, Vazhathope	Ph: 9847415401 e-mail: <a href="mailto:aeedssd1@gmail.com">aeedssd1@gmail.com</a>

Table 1.5: Contact details of officials

### 1.10 Warning system

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

### 1.11 Releases through Spillway

Spillway of the weir is ungated. Water will flow freely through the spillway when the reservoir level reaches FRL/Spillway crest level. The spill water will flow through Kuttiyar River and join with the tail water released from Power House of Idukki HEP at Moolamattom.



Fig 1.11: Flow path of spill water

### **1.12 Distribution of Operation & Maintenance Manuals**

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 Kuttiyar Diversion weir.

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

The offices/officers to which the O & M Manual of Kuttiyar Diversion weir is to be distributed are:

1. Dam Safety Division No. II, Vazhathope
2. Dam Safety Sub Division No.1, Vazhathope
3. Assistant Engineer, Dam Safety Sub Division No.1, Vazhathope
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

### **1.13 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 indicated below are available for reference.

- Detailed drawings of the Project
- Emergency Action Plan (EAP)
- Latest Hydrology Review Report
- Power station operation plan
- Administrative procedures
- Maintenance schedules
- Regional communication directory



### 1.14 Typical Schedule of Duties

Schedule of duties/inspections to be carried out for the operation and maintenance of the dam by the concerned officials are tabulated below in **Table1.6**.

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, Spillway and its energy dissipation arrangements, Power Intake	Weekly	Sub Engineer/Dam operators on contract
2	Record water surface elevation, reservoir in flow and spillway discharge.	Daily (as decided during	Sub Engineer/Dam operators on
3	Record meteorological data, Record releases from outlets/sluices.	Daily	Sub Engineer/Dam operators on
4	Check security and safety devices, Complete logbook/site register which include the above information. Replace fuse light bulbs.	Weekly	Assistant Engineer
6	Visual inspection of dam including Crest of dam (Dam top), Upstream and downstream faces, visible portions of foundation and abutments, Spillway and its energy dissipation arrangements, Power Intake	Fortnightly	Assistant Engineer/ AEE
7	Check security and safety devices, logbook and site register which include the above information.	Monthly	Assistant Executive Engineer
8	Measuring devices, communication devices, instruments, status of vegetation growth	Monthly	Assistant Executive Engineer
9	Visual inspection of dam including Crest of dam (Dam top), Upstream and downstream faces, visible portions of foundation and abutments Spillway and its energy dissipation arrangements, Power Intake	Monthly	Executive Engineer



10	Check measuring devices/Instruments, Security and safety devices, Communication Devices, Status of Vegetation growth,– rectification, if needed.	Monthly	Executive Engineer
11	Check Sign/Warning display boards near vulnerable locations	Monthly	Executive Engineer
12	Cleaning of control panel boards.	Monthly	Assistant Engineer
13	Check outlet works, updating operating instruction, check gate air vents, clean gate controls witch boxes, check operation of gates, grease gate hanger/ dogging	Quarterly	Executive Engineer
14	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
15	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 drains.	Quarterly	Executive Engineer
16	Check for adherence to instrument at action schedule, Record pertinent information in Operation of Gates.	Quarterly	Executive Engineer
17	Inspection of outlet works, hydro mechanical components,	Half yearly (Pre and Post Monsoon)	Deputy Chief Engineer along with Executive Engineer in charge of dam
18	Submission of Inspection report to State DSO, CWC and uploading into DHARMA.	Half yearly	Chief Engineer/Deputy Chief Engineer
19	Comprehensive inspections	Annually	SDSO along with Dam Owners

20	Inspect dam and gate structures, trash racks and stilling basin/energy dissipation arrangement, which normally are under water (by dewatering or by divers/ ROV as necessary). Review Dam operation procedures and EAP and update as necessary.	Five Yearly	Chief Engineer/Deputy Chief Engineer
21	Comprehensive inspection of performance of the dam and gate structures and reservoirs, trash racks and Energy dissipation arrangement.	Ten Yearly	Dam Safety Review Panel

Table 1.5: Schedule of duties/inspections

## Chapter 2 : Project Operation

### 2.1 General

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

The Kuttiyar weir is an ungated overflow weir and the water level is to be monitored daily. No Control arrangements are provided for the releases through spillway. The diversion weir is constructed across the river in four blocks. The total length of the weir is 65.00 m out of which 35.00 m length is non-overflow section 13.00 m in left bank and 22.00m in the right bank) and the middle 30.00 m length is overflow section. The top levels of non-overflow portion and overflow portion are +799.00 & +795.50 respectively.

### 2.2 Operation Plan

#### 2.2.1 Data of Historical Flood

As per historical records, the maximum flood observed in Western Ghats was during 1924. The centre of the storm of the 1-day rainfall of 17th July 1924 and 2-day rainstorm of July 16- 17 was located at Devikulam in Kerala in which rainfall of 484 mm and 751 mm respectively was recorded.

The second historical flood occurred during August 14 to 17 in 2018 is the highest flood recorded in the reservoir. The SW monsoon of the year 2018 in the State was similar to that of 1924 Devikulam storm. Kerala experienced abnormally high rainfall from 1 June 2018 to 19 August 2018 which resulted 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 in Pamba, Periyar and Bharathapuzha sub-basins are almost comparable to the Devikulam storm of 16-18, July 1924. For the entire Kerala, out of 758.6 mm rainfall from 1 August 2018 to 19 August 2018, about 414 mm rainfall 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 at Idukki dam site was 812 mm.

#### 2.2.2 Design Flood Studies

##### Design Flood

Revised flood is worked out and comes to 210.00 Cumecs.

## 2.3 Normal Operations

The operating procedures developed for normal or day-to-day operation of a dam shall include the following:

- Instructions for operating control mechanisms.
- Instructions for operating the reservoir in accordance with reservoir operation rule curve.
- General instructions for the safe operation of the dam and appurtenances.

### 2.3.1 River Outlets

Scour outlet, 750 mm dia is provided at an elevation of +790.00 in block 1. Two Nos vertical lift gate was provided at the upstream portion to operate the scour outlet. The gate is operated using the chain block pully arrangements provided at dam top.

### 2.3.2 Operating Procedure of gates

All the gates shall be properly maintained for proper functioning.

#### Procedure

- i. Periodically grease the wheels through the grease nipple in each wheel shaft.
- ii. Keep the wheel treads and wheel tracks free of grease/oil.
- iii. Store the gate leaf in the gate slot using the dogging beams to protect the seals against the heat of the sun.
- iv. Periodically inspect the seals for any damage.

#### Safety

- i. Only experienced operators shall be allowed to operate the gates.
- ii. The operators shall strictly use hand protection gloves.
- iii. The gate hook can be fitted on any hooking link with the help of dogging pin.
- iv. Original Dogging frame shall be used while adding or removing dogging links.
- v. The chain shall not be tied to any member for lifting.
- vi. The hoist and hoisting structure shall be strictly used for handling vertical loads only.
- vii. The gate slots shall always be covered with cover plates unless any lifting operations are carried out.
- viii. Ensure the hoists are not lifting any load beyond its safety headroom.

#### Annual Maintenance

All hydraulic gates shall be thoroughly inspected during the summer period preferably in the beginning of April every year. Annual shutdown is necessary for inspection of gate grooves, gate sluices, and bell mouths. Painting of metal inserts provided along the path of sluice opening such as bell mouth skin plates, gate embedded parts etc. shall be carried out during the shutdown period.

Painting, repairing work of gate, changing of rubber seal, greasing, inspection of wheels, chain blocks, travelling trolley, servicing of electric motors, electric connections etc. shall be carried out through experienced agencies.

The inside of gate sluices shall be cleared off silt, pebbles and other debris.

### **Routine Maintenance**

The gates shall be lifted and lowered for testing purpose once in every 3 months. The greasing of wheels, chains and other visual inspection shall be carried out during this operation. Emergency gates may be used at the time of routine maintenance to prevent the loss of water from reservoir.

### **Lubricants**

Regular application of lubricant is necessary for the smooth functioning and long lasting of the moving parts such as Chain, Sprockets, Wheels etc. of Chain Hoists.

#### **2.3.3 Operation of scour gates during flooding**

The gates are designed for operation in unbalanced condition. So they can be opened against full water thrust from the upstream side. Closing can be done against water

- i. There are two gates. One is normally kept closed while the other one is in dogged condition.
- ii. Periodically grease the wheels through the grease nipple in each wheel shaft.
- iii. Keep the wheel treads and wheel tracks free of grease/oil.
- iv. Periodically inspect the seals for any damage.

#### **2.3.4 Rule Curve**

Rule curves with dynamic flood cushion for moderating the floods of lower return periods are provided for reservoirs having a storage of more than 200 MCM only. Hence No Rule curve is adopted for Kuttiyar pondage.

## **2.4 Emergency Action Plan**

Emergency Action Plan (EAP) is not prepared.

## **2.5 Record Keeping**

The records regarding dam and appurtenant structures including detailed drawings and construction details shall be kept at the field office and DSO. Also documents as per the dam safety guidelines and DSA 2021 shall be kept at the dam site office. Following records of reservoir operations shall be maintained:

1. Data of Rain gauges in the catchment area.
2. Reservoir levels on daily basis during non-monsoon and at short interval as decided during monsoon.

3. Depth of out flow over the spillway during monsoon.
4. Spillway outflows.
5. Power house releases.
6. All operating procedures.

## 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 Deputy Chief Engineer in the presence of Executive Engineer and field officers shall carryout pre-monsoon and post-monsoon inspections as per CWC guidelines in the format issued by CWC. The Deputy Chief Engineer shall submit the inspection report to the Chief Engineer for onward transmission to CWC. The Executive Engineer at site shall conduct quarterly inspections and inform any remedial measures to be taken to higher ups. The inspection reports are to be uploaded in DHARMA. Also SDSO conducts pre monsoon & Post monsoon inspections. The dam comes under the specified dam category as per Dam Safety Act 2021.

### 3.1 Types of inspections

Safety inspections are to be carried out for Kuttiyar Diversion Weir as this is a specified dam as per DSA 2021. These include, but not limited, to the following:

1. Comprehensive dam safety evaluation shall be done as per DSA 2021
2. Scheduled inspections (Pre & Post monsoon inspections & other scheduled inspections)
3. Special (Unscheduled) inspections
4. Informal inspections.

The frequency of each type of inspection depends on the condition of the weir and State DSO regulations, etc. A comprehensive health checklist for recording the status of each item being inspected and the overall condition of the structures along with any consequential risks on the health of the weir and appurtenant structures is required 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 safety evaluation of weir and appurtenant structures. The panel will undertake evaluation of the dam and appurtenant structures 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 limited to;

- General assessment of hydrologic and hydraulic conditions, review of 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, appurtenant works etc.

- 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 consists of five major parts:

- 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.
- Inspection of the weir and its appurtenant works.
- To review the results and reports of additional field investigations & laboratory testing.
- Review of design studies, review of design flood, checking of the adequacy of Spillway capacity, freeboard requirements, dam stability and any special study.
- Preparation of a detailed report of the inspection.

### **3.3 Scheduled Inspections**

Scheduled inspections by dam owner include pre and post monsoon inspections which include;

- 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 and also to be forwarded to NDSA & SDSO.

#### **3.3.1 Pre and Post-Monsoon Inspection**

The form and checklist provided as Annexure B to the Guidelines for Safety Inspection of Dams published by Central Water Commission, shall be followed for conducting scheduled inspections including Pre and Post Monsoon Inspections.

#### **3.3.2 Special (Unscheduled) Inspections**

Special inspections may need to be performed to resolve specific concerns or conditions at the site on a non-scheduled 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 SDSO after an initial assessment based on informal inspection carried out by project personnel reveal dam safety



related concerns like cracking in the weir, damages, erosion/scour, undermining /piping/ sinkholes/liquefaction or any such undesirable feature. A special inspection may also be performed during an emergency, 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 available relevant files or data,
2. Visual inspection of all components of the project and surroundings, and
3. Report preparation covering status of project and recommendations.

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.

### **3.4 Informal Inspections**

An informal inspection, is a continuing effort by on-site personnel (dam owners and maintenance personnel) performed during their routine duties. Informal inspections are critical specially to keep an eye on the proper operation and maintenance of the dam. These inspections 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 Kuttiyar Diversion Weir site are supposed to conduct informal inspections on routine basis. 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 while walking across the dam for inspection / surveillance, 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 case may be, or they may cover the entire dam and its appurtenant structures in one stretch. 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, other features etc.

## Chapter 4 : Project Maintenance

A good maintenance program is required to protect a dam against deterioration, prolong its life and greatly 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, property and litigation. If maintenance of a dam is neglected the consequences and costs could be enormous.

### 4.1 Maintenance Plan

A basic maintenance schedule for the hydro mechanical components prepared based on manual of operating parts is included in Chapter 2 - Project operation and section 4.4.2 Routine Maintenance. This shows tasks to be performed and how frequently to be inspected/observed and repaired.

### 4.2 Maintenance Priorities

Maintenance activities need to be prioritized. In the order of priority, they need to be included under the heads immediate maintenance & Preventive maintenance.

#### 4.2.1 Immediate Maintenance

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

- The dam is about to be overtopped or being over topped during high flood.
- The dam showing signs of piping or internal erosion along faults, weak zone etc. indicated by increasingly cloudy seepage or other symptoms.
- A dam showing signs of failure due to aging/cracking, sliding, overturning etc.
- The spillway being blocked.
- 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 noticed.

#### 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 by roots from the dam surfaces, 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 / masonry dams.
- Repair any damages on spillway glacis, piers, energy dissipaters, training walls, downstream area etc.
- Repairs on u/s face of dams in case the lift joints is damaged resulting in increased seepage.
- Controlling any heavy seepage in the foundation
- Repairs of any cracks/ cavities/ joints in concrete structures.
- De siltation of the reservoir

However, many of these works will require the services of experienced engineers/ experts.

#### **4.2.2.2 Routine Maintenance**

Several tasks should be performed on a continuous basis. These include but 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 (muddy) 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 etc. Servicing of gates (Intake and Emergency gates), hoisting arrangements of gates, valves of outlet works/slucices
- Maintaining proper lighting at dam top.
- Maintenance of access roads.
- Operation of electrical and mechanical equipment and systems.
- To keep the gate slots, clear of silt/debris.
- Maintenance/testing of monitoring equipment and safety alarms.
- Testing of security equipment.
- Testing of communication equipment.
- Any other maintenance considered necessary.

### **4.3. Procedure for Routine Maintenance**

#### **4.3.1 Maintenance to the vertical lift gates**

Vertical lift gates are provided at the intake of the weir for controlling the flow to penstock and

scour outlet. The aspects to be inspected and maintained periodically for ensuring proper operation of these gates are as under,

1. 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.
2. The gate leaf should be thoroughly cleaned and repainted at 5 year interval or 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.
3. 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.
4. 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.
5. Hoisting connection of the gate leaf should be lubricated where necessary and defects if any should be rectified.
6. All nuts, bolts, check nuts and cotter pins of the lifting devices should be checked periodically.
7. All components should be greased and lubricated. Recommended and approved oils and grease only should be used.
8. 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.
9. 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.
10. The guide-assemblies, wheel-assemblies and sealing-assemblies shall be cleared off grit, sand or any other foreign material.
11. The wheel pin shall be coated with corrosion resistant compound.
12. All nuts and bolts shall be tightened.
13. 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 re painted, 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. 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.

#### **4.3.2 Maintenance to 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 frequently to ensure that they are functioning properly and to remove accumulated debris periodically as per site requirements.

#### **4.3.3 Trash Rack Cleaning**

Regular trash rack cleaning is necessary in monsoon days for the proper functioning of diversion tunnel and avoid spilling.

#### **4.3.4 Maintenance of Access roads**

Access road surfaces must be maintained to allow safe passage of automobiles and any required equipment for servicing the dam in all weather conditions. Routine observations of any cut and fill slopes along the sides of the road should be made. In case of unstable conditions/ slopes developing blockage of the road, protective works including retaining walls shall be provided as remedial measures. Drains are required to be provided and maintained a long road for proper drainage. This will prolong the life of the road. Road surfacing should be repaired or replaced as per requirement.

#### **4.3.5 Maintenance of Electrical systems**

Electricity is typically used at a dam for lighting and to operate the gates, hoists, recording equipment, and other miscellaneous equipment. It is important that the Electrical system be well maintained, including a thorough check of fuses and a test of the system to ensure that all parts are properly functioning. The system should be free from moisture and dirt, and wiring should be checked for corrosion and mineral deposits. All necessary repairs should be carried out immediately and records of the works kept. Maintain generators used for auxiliary emergency power - change the oil, check the batteries and antifreeze and make sure fuel is readily available. Monitoring devices usually do not need routine maintenance. Open areas are particularly susceptible to vandalism. As such all electrical fittings like bulbs, lights, loose wires etc. in open areas should be checked routinely and replaced/repared where needed. The recommendations of the manufacturer should also be referred to.

#### **4.3.6 General cleaning**

For proper operation of spillways, inlet and outlet structures, energy dissipation arrangements,

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 in to the reservoir.

#### **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. The requirements of annual and monsoon establishment for the operation and maintenance of a dam is to be decided by the Dam Owners on a case to case basis. Details of man power/organizational structure are given in Chapter-1.

Following materials are required for handling the situations during monsoon period;

- 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

#### **4.5 Preparation of O&M Budget**

The O&M budget for should essentially include the following items:

- i) **Establishment Cost of Regular Staff** - Salaries and other eligible allowances,
- ii) **Establishment Cost of Work charged Staff** - salaries and other eligible allowances,
- iii) **Office Expenses** – Telephone/Mobile/any other Telecommunication facility, Electricity bills, water bills, Office stationery, Day to day office requirements.
- iv) **Motor Vehicles** - Running and Maintenance cost of inspection vehicles, Cost of hiring of vehicles as required etc.



- v) **Maintenance of Colony** -Maintenance of staff quarters, colony roads, Electricity, sanitary and Water supply systems etc.
- vi) **T&P** –The T&P requirements for offices, colony, works etc. As applicable.
- vii) **Works** - Painting, oiling, greasing, overhauling of HM equipment's, Repair/replacement of gates seals, POL for pumps & generator sets, Electricity charges and maintenance of Electric systems of dam site, specific requirements for all Civil, H.M & Electrical maintenance works, vegetation removal, maintenance/cleaning of drains in dam, maintenance of access roads & basic facilities, provision for flood contingency works during monsoon, unforeseen events/ items etc.

#### 4.6 Maintenance Records

Maintenance records are of utmost importance. A record register 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 time taken to complete the work with dates,
- Equipment and materials used, and
- Before and after photographs.
- Due date for next maintenance.

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

## 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. Monitoring physical phenomena that can lead to a dam failure may draw information from a wide spectrum of instruments and procedures ranging from simple to complex.

### 5.1 Instrument Types and Usage

A wide variety of instruments and procedures are used to monitor dam behavior. The minimum number of set of instrumentation for monitoring the performance of dams as per regulations under Section 54 (2) of Dam Safety Act, 2021 includes:

- movements (horizontal, vertical, rotational and lateral);
- pore pressure and uplift pressures;
- water level;
- seepage/leakage flow;
- Temperature
- Crack and joint movement
- seismic activity;
- Stress-strain

However, since each dam is unique, the additional instruments, if required shall be installed considering site conditions and using engineering judgement.

#### 5.1.1 Water Level

Kuttiyar Diversion weir is a small weir with free overflow spillway. Galleries are not provided. Reservoir water level is monitored daily.

#### 5.1.2 Seismic Activity

The project area falls in zone No. III of the seismic zone map of India. The weir is designed for seismic stability for Zone III as per BIS 6512 . Historical significant earthquake events in the near vicinity areas are noted below which occurred before the construction of the weir. Nearest Seismic observatory is at Kulamavu.

Event 1: Date: November 1998, Epicenter: Nedumkandam, Magnitude : 4.5 and

Event 2 : Date: 12/12/2000, Epicenter: Erattupetta, Magnitude: 5

### 5.2 Dam Performance Evaluation

Performance evaluation is to be conducted for safe normal operation before and after monsoon.

## **5.3 Methods of Behavior Prediction**

### **5.3.1 Visual Observations**

Observations by onsite inspection of officials (dam owners/operators and maintenance personnel) may be the most important and effective means of monitoring the performance of a dam.

An officer should examine visually by walking along the dam alignment to see if any leakages, any distress, wet spots on the surface of weir, seepage from foundation etc. is there.

### **5.3.2 Monitoring Results**

Analysis and observation of the water level, leakages, and other parameters can ascertain the behavior of the dam. Any deviation from the normal behavior needs to be resolved critically by taking required remedial measures in consultation with senior / experienced engineers.

## **Chapter 6 : Previous Rehabilitation Works**

No major rehabilitation works are done yet

## Chapter 7: Updating the Manual

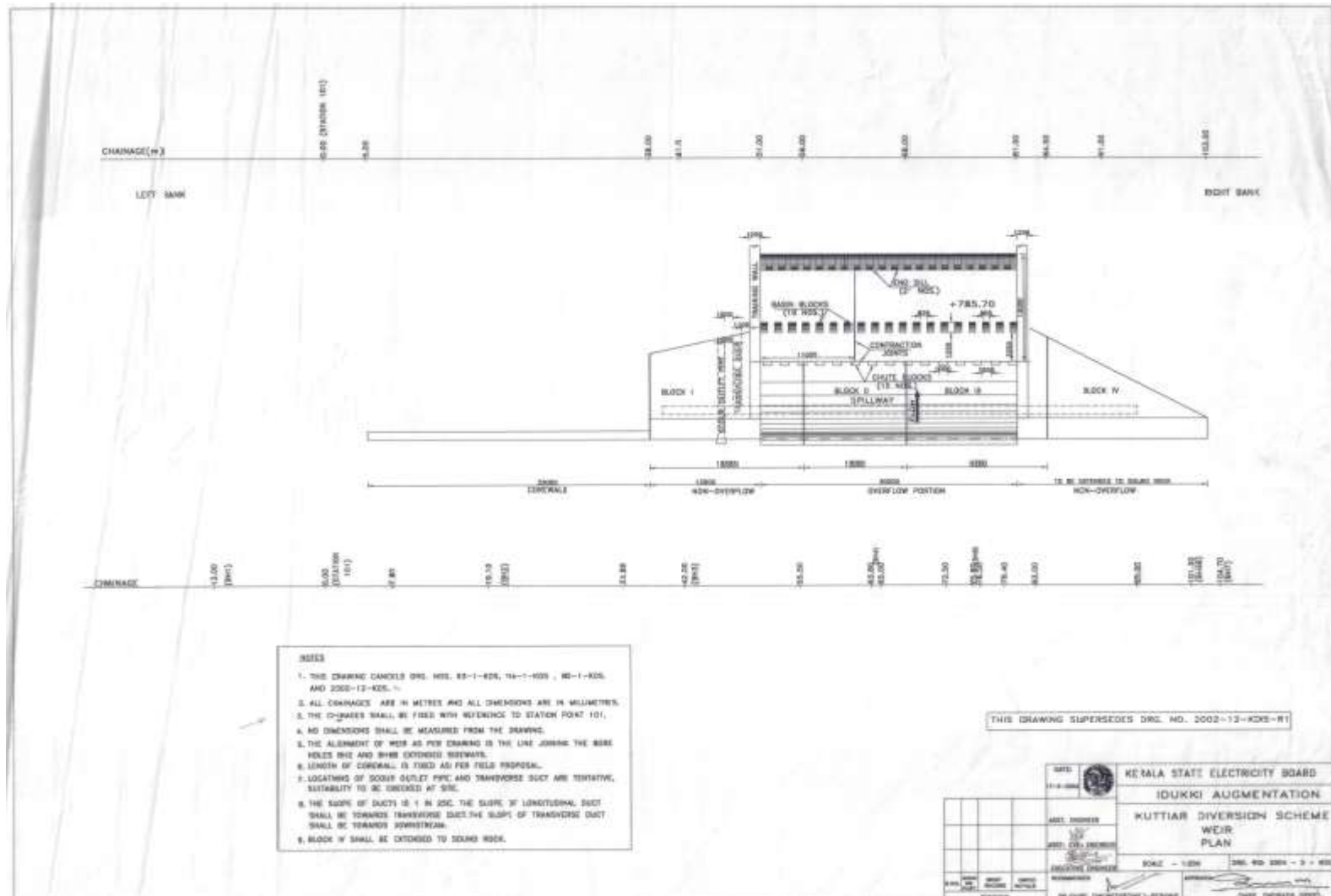
Whenever features of the dam and appurtenant structures change, the O & M Manual must be edited and portions rewritten to reflect these changes. This task is often ignored. Updating information in the O&M Manual should be done whenever major changes like construction of an additional spillway, construction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

Aspects to be considered when updating the Manual must 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.

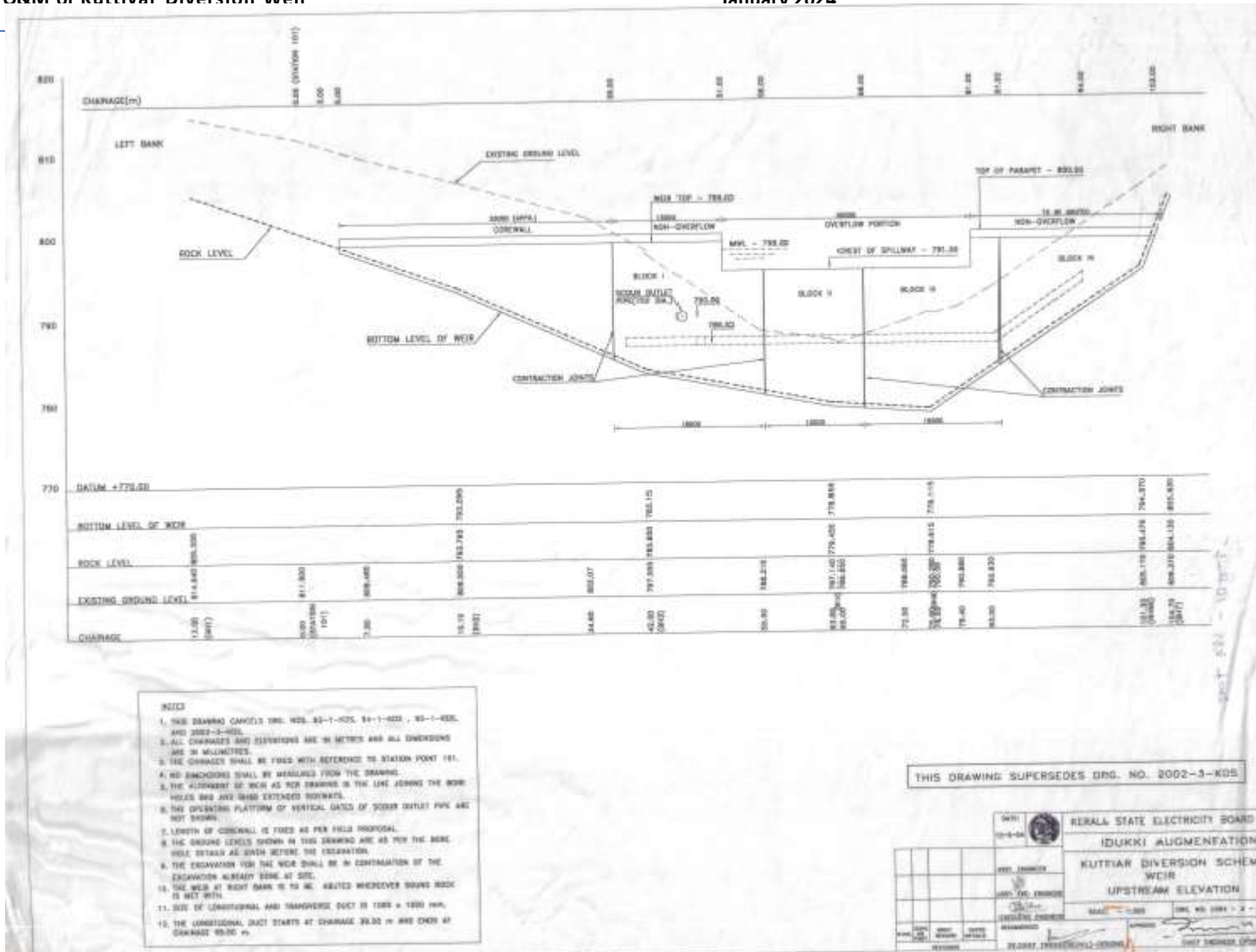
***It is recommended that the O&M Manuals maybe reviewed/ updated after every 10 years or whenever there is any change in the information given in the Manual needs updation by the respective Dam Owners.***

**ANNEXURE I - DRAWINGS**

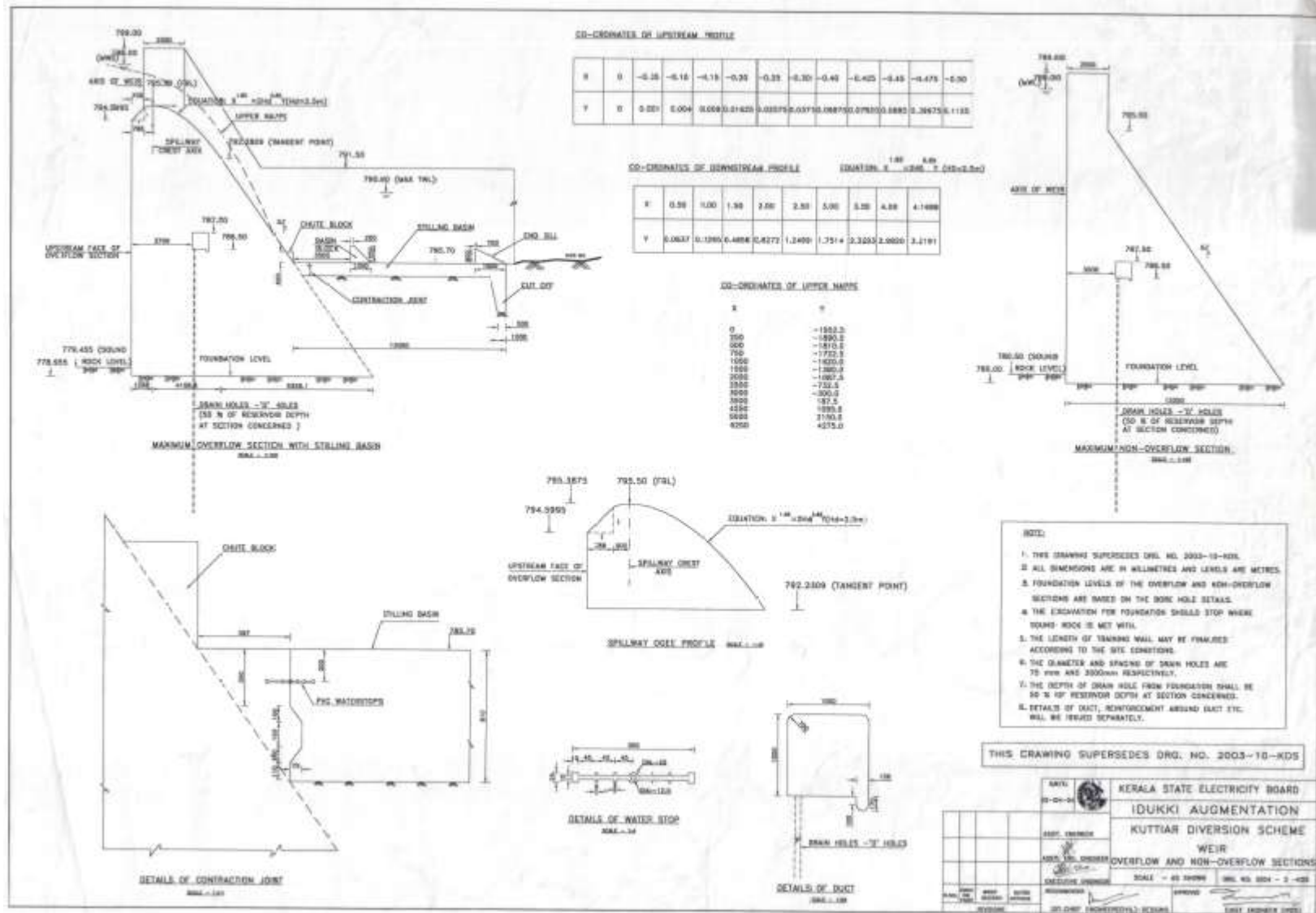




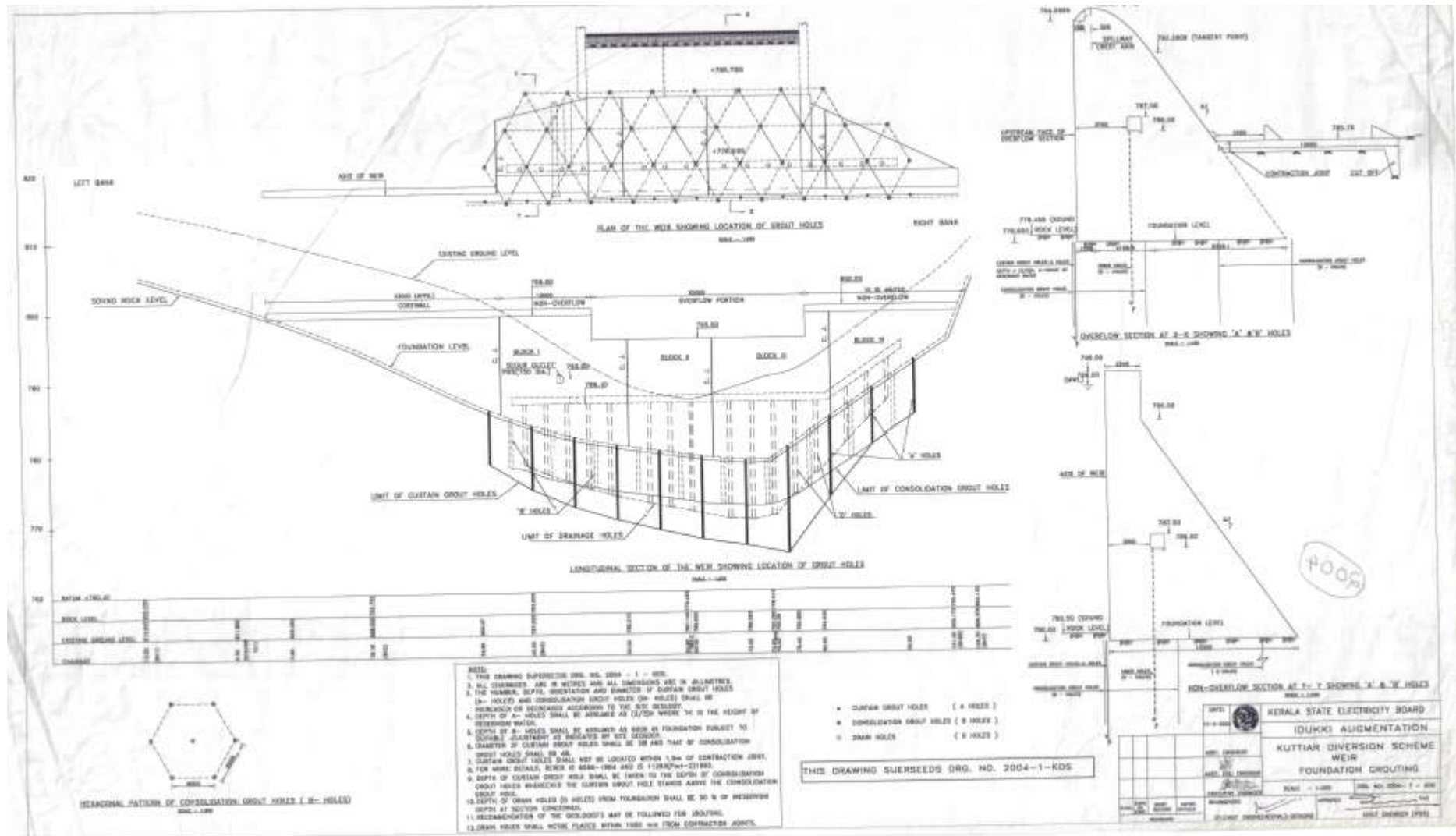
Drg. 1: Kuttiyar Diversion Weir - Plan



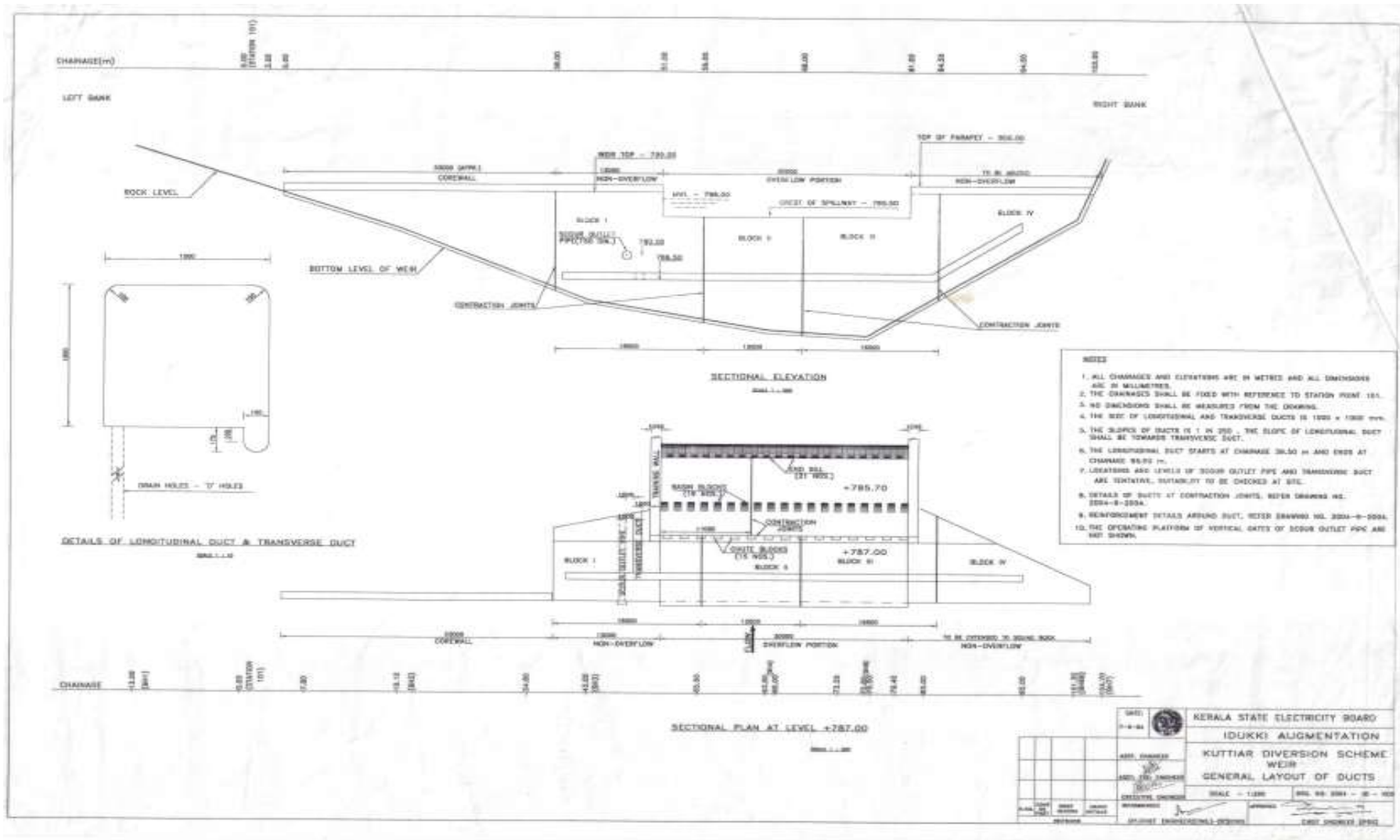
Drg. 2: Kuttivar Diversion Weir -Upstream Elevation



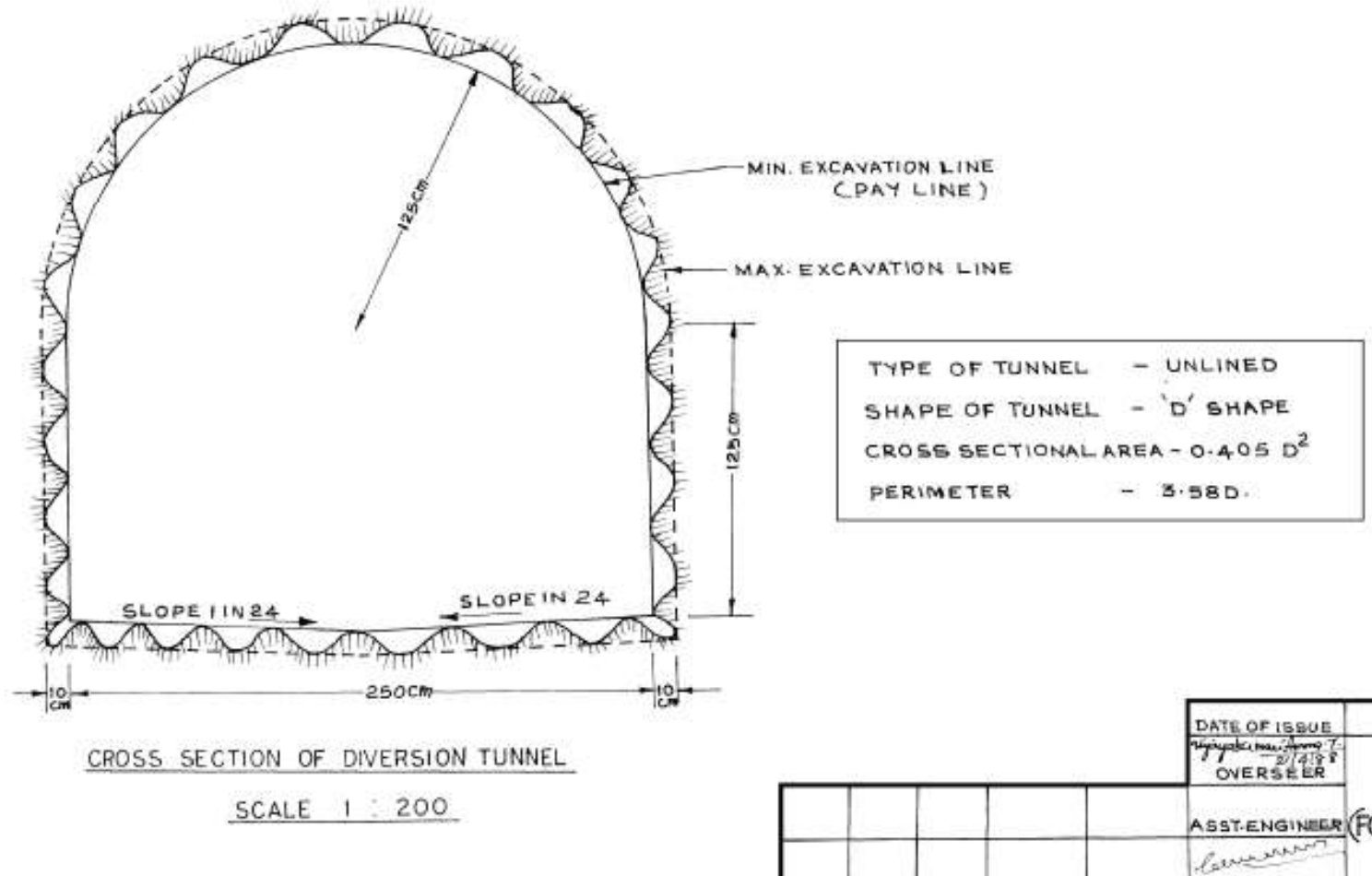
Drg. 3: Kuttiyar Diversion Weir- Sections of Weir



Dr. 4: Kuttiyar Diversion Weir Details of Foundation Grouting

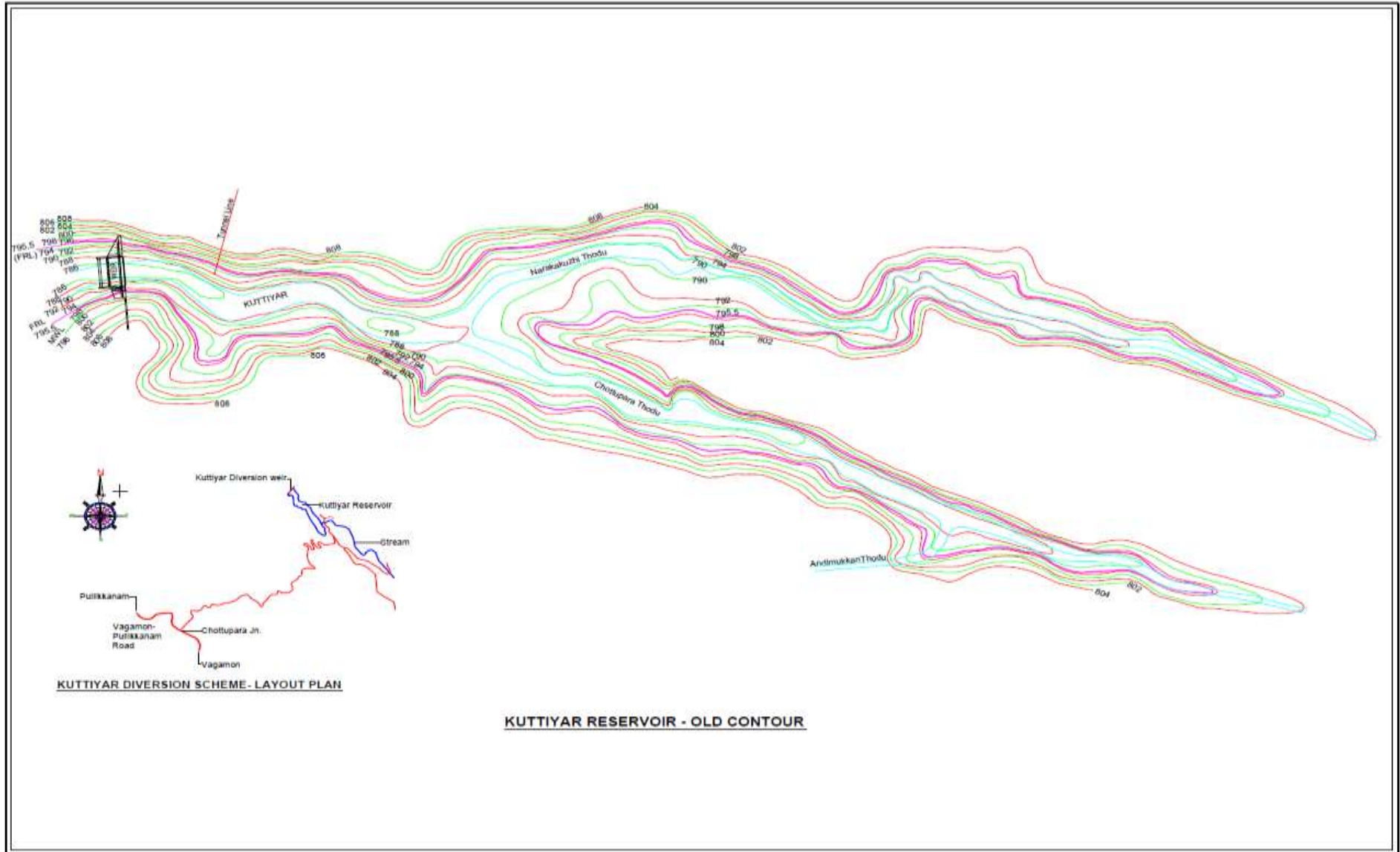


Drg. 5: Kuttiyar Diversion Weir – Details of Duct



Drg. 6: Kuttiyar Diversion Weir – CS of Tunnel





Drg. 7: Kuttiyar Diversion Weir – CS of Tunnel

**ANNEXURE II – Rainfall Details**

RAIN FALL DEALS FOR THE MANSOON YEAR 2018-19												
Basin - Muvattupuzha, Raingauge - Kulamavu												
Date	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
1	17.0	1.0	32.2	24.6	9.0	55.0	0.0	0.0	0.0	0.0	0.0	1.2
2	0.0	33.0	13.2	0.0	8.2	11.8	0.0	0.0	0.0	0.0	0.0	0.0
3	5.4	46.0	14.0	0.0	18.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	21.4	1.8	32.0	0.0	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	17.2	0.0	15.2	0.0	30.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	10.0	1.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
7	20.0	1.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0	0.0
8	53.0	28.2	172.4	0.0	17.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	37.8	107.2	57.0	0.0	44.2	0.0	0.0	0.0	0.0	1.0	0.0	0.0
10	75.6	108.0	154.2	0.0	17.8	7.2	0.0	0.0	2.0	2.0	3.4	0.0
11	172.4	116.4	52.0	0.0	81.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
12	135.6	58.2	21.2	1.4	6.8	7.8	0.0	0.0	0.0	0.0	0.0	0.0
13	51.2	53.4	79.6	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0
14	78.4	73.0	22.0	0.0	11.8	7.8	0.0	0.0	0.0	0.0	0.0	13.0
15	8.2	98.2	248.0	0.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
16	9.8	221.0	269.0	0.0	4.8	5.2	0.0	0.0	1.8	0.0	0.0	3.0
17	47.2	72.0	207.8	28.6	43.8	115.4	0.0	0.0	16.0	0.0	0.0	0.0
18	11.0	120.6	137.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.6
19	22.0	39.6	84.0	14.8	76.4	0.0	0.0	0.0	0.0	0.0	32.2	0.0
20	56.4	64.8	42.0	24.4	1.0	0.0	0.0	0.0	0.0	0.0	23.2	0.0
21	51.5	29.4	38.0	9.0	57.6	13.2	0.0	0.0	0.0	0.0	26.8	0.0
22	41.6	9.6	8.0	0.0	8.4	13.8	0.0	0.0	0.0	0.0	0.0	0.0
23	36.0	37.2	8.2	0.0	4.4	1.0	0.0	0.0	0.0	0.0	12.4	0.0
24	40.2	116.0	6.0	36.2	1.4	5.4	0.0	0.0	0.0	0.0	12.4	0.0
25	3.6	175.2	3.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0	13.8	0.0
26	41.4	171.8	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
27	18.0	26.6	14.0	6.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	2.2
28	61.0	6.4	33.6	19.6	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
29	21.0	84.0	39.2	20.6	0.0	0.0	29.0	0.0		0.0	0.0	0.0
30	19.6	17.2	2.2	34.6	0.0	0.0	0.0	0.0		0.0	0.0	7.0
31		60.8	6.8		3.0		0.0	0.0		0.0		0.0

RAIN FALL DEALS FOR THE MANSOON YEAR 2019-20												
Basin - Muvattupuzha, Raingauge - Kulamavu												
Date	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
1	9.4	0.0	0.0	16.0	12.0	24.6	0.0	0.0	0.0	0.0	0.0	28.6
2	0.3	1.0	1.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	1.0	16.8	0.0	56.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	8.6	29.0	1.0	28.0	0.0	27.6	0.0	0.0	0.0	0.0	0.0	0.0
5	7.8	33.0	20.0	74.0	0.0	4.8	0.0	0.0	0.0	7.4	0.0	0.0
6	10.0	29.4	76.0	40.0	0.0	0.0	0.0	0.0	0.0	0.4	24.6	0.0
7	11.8	19.2	132.0	63.0	0.0	18.4	0.0	0.0	0.0	0.0	20.4	8.0
8	2.2	17.0	158.0	18.0	0.4	9.0	0.0	0.0	0.0	0.0	0.0	1.0
9	1.0	14.4	238.0	13.0	0.0	25.6	0.0	0.0	0.0	0.0	5.0	0.0
10	57.0	22.0	57.0	27.0	1.0	21.0	0.0	0.0	0.0	19.0	25.4	0.0
11	20.0	5.6	71.0	2.0	5.0	0.0	0.0	0.0	0.0	0.0	4.4	10.0
12	19.0	1.0	57.0	62.0	19.4	12.0	22.0	0.0	0.0	1.0	0.0	5.6
13	21.0	14.0	56.0	9.0	37.4	0.0	0.0	0.0	0.0	0.0	0.0	12.2
14	42.0	0.0	111.0	20.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	22.0
15	4.8	19.6	43.4	4.4	11.4	0.0	0.0	0.0	0.0	0.0	0.0	15.0
16	12.6	2.0	6.0	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.4
17	0.0	12.2	64.0	16.4	33.8	0.0	0.0	0.0	0.0	0.0	8.6	0.0
18	10.0	16.0	1.0	16.8	25.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2
19	2.4	227.0	16.6	40.0	21.0	0.0	0.0	0.0	0.0	0.0	0.0	48.6
20	9.4	162.0	30.2	4.0	6.4	0.0	0.0	0.0	0.0	28.6	0.0	33.0
21	23.0	112.0	46.6	1.0	61.0	0.0	0.0	0.0	0.0	2.0	0.0	1.0
22	47.2	73.0	27.4	8.4	6.0	0.0	0.0	0.0	0.0	7.2	5.6	14.6
23	30.2	70.6	24.6	12.4	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	23.0	43.0	14.0	108.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	8.6	21.6	27.0	4.0	9.6	0.0	0.0	0.0	0.0	0.6	0.0	25.0
26	5.0	33.0	51.4	8.8	13.0	0.0	0.0	0.0	0.0	2.0	0.0	21.0
27	0.0	3.8	47.0	0.4	1.0	0.0	0.0	0.0	0.0	0.0	28.0	0.0
28	0.0	0.0	8.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6
29	0.0	0.0	43.6	0.0	4.0	0.0	0.0	0.0	0.0	0.0	18.6	9.0
30	0.0	1.0	63.2	16.0	15.6	0.0	0.0	0.0		0.0	0.0	0.0
31		0.0	17.2		16.0		0.0	0.0		0.0		15.2

RAIN FALL DEALS FOR THE MANSOON YEAR 2020-21												
Basin - Muvattupuzha, Raingauge - Kulamavu												
Date	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
1	0.0	4.0	66.6	24.4	6.0	2.0	0.0	2.0	0.0	0.0	3.4	0.0
2	18.0	2.0	32.2	2.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	11.8
3	3.2	44.0	102.0	6.0	0.0	8.2	4.2	0.0	0.0	0.0	0.0	23.2
4	28.2	36.0	118.6	14.6	0.0	8.2	6.4	0.0	0.0	0.0	0.0	22.2
5	50.4	28.2	126.0	4.8	0.0	4.0	14.0	0.0	0.0	0.0	0.0	0.0
6	44.4	23.2	16.0	16.0	0.0	7.0	22.4	0.0	0.0	0.0	0.0	0.0
7	19.2	37.2	188.4	28.0	24.4	0.0	16.2	38.4	0.0	0.0	14.2	19.2
8	0.0	28.0	162.0	6.0	18.0	0.0	0.0	18.0	0.0	0.0	3.2	5.4
9	0.0	18.0	178.0	22.0	46.4	0.0	0.0	8.8	0.0	0.0	0.0	0.0
10	4.6	44.6	132.0	44.4	0.0	0.0	0.8	12.0	0.0	0.0	0.0	26.4
11	22.0	0.0	22.0	22.0	42.0	0.0	0.0	6.4	0.0	7.2	1.4	6.6
12	32.2	21.0	28.4	34.6	16.4	0.0	0.0	2.0	0.0	0.0	16.6	0.0
13	5.6	0.0	2.0	56.0	52.4	0.0	0.0	0.0	0.0	0.0	14.2	0.0
14	32.0	8.0	12.0	28.4	28.4	2.0	0.0	32.4	0.0	0.0	5.0	78.2
15	52.2	0.0	2.0	8.0	32.0	0.0	0.0	0.0	0.0	0.0	12.0	110.8
16	26.0	22.0	0.0	12.6	48.2	2.0	4.4	0.0	0.0	0.0	36.4	106.2
17	21.2	76.0	0.0	15.2	6.0	4.0	0.0	0.0	0.0	0.0	8.8	56.4
18	24.0	24.0	0.0	14.0	2.0	22.4	0.0	2.0	0.0	0.0	0.0	27.2
19	1.0	17.6	3.0	38.4	0.0	0.0	0.0	0.0	0.0	0.0	25.0	13.4
20	31.6	0.0	8.2	128.2	4.0	0.0	0.0	0.0	0.0	0.0	42.6	55.8
21	6.0	27.4	6.2	88.0	2.0	0.0	0.0	0.0	8.4	0.0	0.0	23.0
22	93.0	24.0	0.0	63.2	12.0	0.0	0.0	0.0	6.0	1.0	0.0	23.2
23	19.0	12.4	12.0	22.0	0.0	0.0	2.0	0.0	2.0	2.0	2.4	32.6
24	0.0	0.0	4.0	4.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0
25	27.0	19.0	0.0	2.0	0.0	0.0	8.4	0.0	0.0	0.0	0.0	5.8
26	23.2	0.0	0.2	8.2	0.0	28.5	0.0	0.0	10.2	0.0	5.2	220.0
27	32.4	0.0	0.0	4.0	0.0	8.0	0.0	0.0	4.0	0.0	35.4	80.0
28	8.0	0.0	0.0	14.6	4.0	2.0	0.0	0.0	0.0	0.0	4.8	26.8
29	25.4	27.0	0.0	0.0	28.2	0.0	0.0	0.0		0.0	0.0	26.8
30	105.0	122.0	0.0	2.0	8.2	0.0	0.0	0.0		2.0	0.0	6.6
31		22.2	0.0		0.0		2.0	0.0		0.0		7.0

RAIN FALL DEALS FOR THE MANSOON YEAR 2021-22												
Basin - Muvattupuzha, Raingauge - Kulamavu												
Date	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
1	106.2	0.0	41.2	26.8	78.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	36.2	46.4	24.4	2.0	0.0	0.0	0.0	0.0	0.0	0.0
3	26.4	25.2	28.8	45.2	20.2	0.0	27.2	0.0	0.0	0.0	12.4	28.2
4	0.0	0.0	35.8	0.0	40.8	14.6	0.0	0.0	0.0	0.0	8.2	0.0
5	104.2	44.6	27.2	54.2	18.2	0.0	24.6	0.0	0.0	0.0	0.0	48.2
6	63.6	17.8	113.6	72.4	16.8	74.8	36.8	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	115.2	46.6	37.0	0.0	17.6	0.0	0.0	0.0	12.6	22.2
8	0.0	76.2	98.4	21.2	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	47.0	13.8	71.8	0.0	149.6	124.0	0.0	0.0	0.0	0.0	43.4	29.8
10	47.0	130.4	25.4	0.0	10.8	0.0	0.0	0.0	0.0	0.0	62.2	82.4
11	18.4	99.4	0.0	0.0	41.2	0.0	0.0	0.0	0.0	0.0	12.8	123.4
12	0.0	12.6	110.6	62.4	129.4	201.0	0.0	0.0	0.0	0.0	46.6	23.2
13	110.4	65.6	13.8	82.8	43.2	20.6	0.0	0.0	0.0	0.0	49.4	87.4
14	163.8	59.2	62.2	59.4	45.4	96.8	0.0	0.0	0.0	0.0	12.2	43.6
15	78.8	98.6	57.2	29.2	46.8	4.6	0.0	0.0	0.0	0.0	0.0	77.4
16	115.4	124.8	26.6	32.4	282.8	34.6	0.0	0.0	0.0	0.0	0.0	53.6
17	130.6	72.2	29.4	18.6	238.2	38.4	0.0	0.0	5.4	0.0	33.2	18.8
18	59.2	141.8	37.2	17.4	176.6	20.8	0.0	0.0	0.0	0.0	15.6	89.6
19	0.0	66.6	72.2	0.0	44.8	76.8	0.0	0.0	0.0	0.0	18.4	86.8
20	26.2	14.8	0.0	0.0	88.8	32.0	0.0	0.0	0.0	48.6	11.6	46.6
21	30.8	23.4	0.0	0.0	113.8	0.0	0.0	0.0	0.0	14.4	0.0	106.2
22	0.0	62.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.0
23	0.0	64.2	0.0	0.0	40.8	12.6	0.0	0.0	0.0	0.0	4.2	42.8
24	116.2	109.4	36.2	0.0	8.4	28.6	0.0	0.0	0.0	0.0	27.6	31.0
25	0.0	92.8	0.0	96.2	13.2	0.0	0.0	0.0	0.0	28.2	0.0	17.6
26	7.4	66.4	0.0	9.8	0.0	49.4	0.0	0.0	0.0	0.0	0.0	13.8
27	81.2	22.2	94.4	96.4	134.6	0.0	0.0	0.0	0.0	0.0	0.0	10.4
28	27.2	29.8	74.8	98.8	0.0	50.8	0.0	0.0	0.0	13.4	0.0	26.4
29	0.0	44.6	127.4	22.6	0.0	0.0	0.0	0.0		0.0	19.4	61.8
30	28.6	0.0	98.6	9.4	6.4	0.0	0.0	0.0		0.0	11.6	0.0
31		43.4	0.0		21.4		0.0	0.0		4.2		0.0

RAIN FALL DEALS FOR THE MANSOON YEAR 2022-23												
Basin - Muvattupuzha, Raingauge - Kulamavu												
Date	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
1	72.8	100.6	94.2	29.6	0.0	1.0	12.4	0.0	0.0	0.0	0.0	42.4
2	12.6	77.8	228.6	6.0	1.0	5.0	0.0	0.0	0.0	0.0	0.0	5.0
3	23.8	85.0	129.6	6.8	42.0	45.0	0.0	0.0	0.0	0.0	0.0	9.0
4	36.4	109.2	152.4	3.0	13.0	29.0	0.0	0.0	1.0	0.0	2.6	5.0
5	10.2	72.8	168.4	47.8	78.0	11.0	0.0	0.0	0.0	0.0	1.2	0.0
6	18.6	62.4	55.8	28.0	15.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
7	23.2	64.4	37.4	43.8	1.0	12.0	0.0	0.0	0.0	0.0	0.0	28.0
8	0.0	82.2	39.8	48.2	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
9	48.8	21.4	61.4	34.0	0.0	24.6	0.0	0.0	0.0	0.0	0.0	4.0
10	30.6	85.0	8.4	56.0	12.6	0.0	3.4	0.0	0.0	0.0	26.4	29.0
11	46.4	28.6	0.0	39.2	0.0	0.0	45.0	0.0	0.0	0.0	0.0	0.0
12	0.0	40.0	12.0	16.2	1.0	3.8	36.0	0.0	0.0	0.0	0.0	19.4
13	43.6	6.2	0.0	20.0	21.0	0.0	9.6	0.0	0.0	0.0	0.0	1.6
14	16.4	36.6	2.0	11.6	30.4	0.0	1.6	0.0	0.0	0.0	0.0	0.0
15	0.0	27.6	0.0	3.0	40.2	0.0	5.4	0.0	0.0	0.0	0.0	10.6
16	61.0	51.6	0.0	0.0	50.0	0.0	0.0	0.0	0.0	48.0	0.0	0.0
17	44.8	60.2	0.0	0.0	9.0	0.0	0.0	0.0	0.0	33.0	0.0	0.0
18	52.4	92.8	6.2	15.0	69.4	40.6	0.0	0.0	0.0	21.0	0.0	0.0
19	0.0	76.2	43.0	31.0	29.6	1.0	0.0	0.0	0.0	9.6	0.0	0.0
20	0.0	14.8	14.8	19.0	29.0	0.0	0.0	0.0	0.0	5.8	0.0	2.2
21	83.0	51.6	13.0	0.0	28.4	0.0	0.0	0.0	0.0	0.0	0.0	5.0
22	37.4	3.4	20.6	0.0	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	15.6	55.0	101.4	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	33.8	61.6	58.8	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
25	80.4	3.8	40.4	0.0	0.0	0.0	0.0	16.0	0.0	6.0	8.0	49.0
26	26.4	0.0	47.2	22.0	0.0	0.0	10.0	0.0	0.0	36.4	32.0	17.2
27	0.0	0.6	79.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2	7.4
28	0.0	52.2	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	3.0
29	128.6	38.6	156.0	0.0	0.0	28.6	0.0	0.0		2.4	37.0	0.0
30	84.4	0.0	69.4	0.0	3.0	14.0	0.0	0.0		0.0	40.6	5.0
31		76.0	30.0		0.0		0.0	0.0		58.0		0.0



**ANNEXURE III– GLOSSARY**

**Abutment** - that part of a valley side against which a dam is constructed. Right and left abutments are those on respective sides of the observer looking downstream.

**Air Vent Pipe** - a pipe designed to provide air to the outlet conduit to reduce turbulence during release of water and safeguard against damages due to cavitation.

**Appurtenant Structures** - ancillary features of a dam, such as the outlet, spillway, energy dissipation arrangement powerhouse, tunnels, etc.

**Base Width (Base Thickness)** - the maximum width or thickness of a dam measured horizontally between upstream and downstream faces and normal (perpendicular) to the axis of the dam but excluding projections for outlets, etc.

**Construction Joint** - the interface between two successive placing or pours of concrete where a bond, not permanent separation, is intended.

**Core Wall** - a wall built of impervious material, usually concrete or asphaltic concrete, in the body of an embankment dam to prevent leakage.

**Crest Length** - the length of the dam at its crest (dam top) top of a dam, including the length of the spillway, powerhouse, navigation lock, fish pass, etc., where these structures form part of the length of a dam. If detached from a dam, these structures should not be included.

**Crest of dam** - Used to indicate the "top of dam". To avoid confusion to indicate the crest of spillway and top of dam may be used.

**Culvert** - a drain or waterway built under a road, railway, or embankment, usually consisting of a pipe or covered conduits.

**Dam** - any artificial barrier including appurtenant works constructed across rivers or tributaries thereof with a view to impound or divert water; includes barrage, weir and similar water impounding structures but does not include water conveyance structures such as canal, aqueduct and navigation channel and flow regulation structures such as flood embankments, dikes, and guide bunds.

**Dam failure** - failures in the structures or operation of a dam which may lead to the uncontrolled release of impounded water resulting in downstream flooding affecting the life and property of the people.

**Dam incident** - all problems occurring to a dam that has not degraded into „dam failure“ and including the following: a) Structural damage to the dam and appurtenant works; b) Unusual readings of instruments in the dam; c) Unusual seepage or leakage through the dam body; d) Change in the seepage or leakage regime; e) Boiling or artesian conditions noticed below an earth dam; f) Stoppage or reduction in seepage or leakage from the foundation or body of the dam into any of the galleries, for dams with such galleries; g) Malfunctioning or inappropriate operation of gates; h) Occurrence of any flood, the peak of which exceeds the available flood discharge capacity or 70% of the approved design flood; i) Occurrence of a flood, which resulted in encroachment on the available free-board, or the adopted design freeboard; j) Erosion in the near vicinity, up to five hundred meters, downstream of the spillway, waste weir, etc.; and k) Any other event that prudence suggests would have a significant unfavorable impact on dam safety.

**Dam inspection** - on-site visual examination of all components of dam and its appurtenances by one or more persons trained in this respect and includes investigation of the non-overflow portion, spillways, abutments, stilling basin, piers, bridge, down-stream toe, drainage

galleries, operation of mechanical systems (including gates and its components, drive units, cranes), interior of outlet conduits, Instrumentation records, and record-keeping arrangements.

**Dam owner** - the Central Government or a State Government or public sector undertaking or local authority or company and any or all of such persons or organizations, who own, control, operate or maintain a specified dam.

**Dam safety** - the practice of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe function is not explicitly determined by its original design and construction. It also includes all actions taken to identify or predict deficiencies and consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate to the extent reasonably possible, any unacceptable risks.

**Dead storage** - the storage that lies below the invert of the lowest outlet and that, therefore, cannot be withdrawn from the reservoir.

**Decommission** - Taking a dam out of service in an environmentally sound and safe manner or converting it to another purpose.

**Design flood** - see spillway design flood.

**Design life** - the intended period that the dam will function successfully with only routine maintenance; determined during design phase.

**Distress condition** - the occurrence or potential development of such conditions in the dam or appurtenance or its reservoir or reservoir rim, which if left unattended to, may

impede the safe operation of dam for its intended benefits or may pose unacceptable risks to the life and property of people downstream.

**Diversion channel**, - a waterway used to divert water from its natural course. These terms are generally applied to temporary structures such as those de-signed to bypass water around a dam site during construction. "Channel" is normally used instead of "canal" when the waterway is short. Occasionally these terms are applied to permanent structures.

**Documentation** - all permanent records concerning investigation, design, construction, operation, performance, maintenance and safety of dams and includes design memorandum, construction drawings, geological reports, reports of specialized studies simulating structural and hydraulic response of the dam, changes made in design and drawings, quality control records, emergency action plan, operation and maintenance manual, instrumentation readings, inspection and testing reports, operational reports, and dam safety review reports.

**Drainage area** - an area that drains naturally to a point on a river.

**Drainage layer or blanket** - a layer of permeable material in a dam to relieve pore pressure or to facilitate drainage of fill.

**Drawdown** - the lowering of water surface level due to release of water from a reservoir.

**Emergency gate** - a standby or reserve gate which is lowers only for repairing / servicing of the service gate.

**Emergency spillway** - see spillway.

**Face** - the external surface of a structure, e.g., the surface of a wall of a dam.

**Failure** - the uncontrolled release of water from a dam.

**Fixed wheel gate (fixed-roller gate, fixed axle gate)** - a gate having wheels or rollers mounted on the end posts of the gate. The wheels move against rails fixed in side grooves or gate guides.

**Flap gate** - a gate hinged along one edge, usually either the top or bottom edge.

Examples of bottom-hinged flap gates are tilting gates and belly gates, so called due to their shape in cross-section.

**Flood routing** - the determination of the attenuating effect of storage on a flood passing through a valley, channel, or reservoir.

**Flood surcharge** - the volume or space in a reservoir between the controlled retention water level (Full Reservoir Level) and the maximum water level. Flood surcharge cannot be retained in the reservoir but will flow over the spillway until the controlled retention water level is reached.

**Flood plain** - an area adjoining a body of water or natural stream that has been, or may be, covered by flood water.

**Flood plain management** - a management program to reduce the consequences of flooding, either by natural runoff or by dam failure, to existing and future properties in a floodplain.

**Foundation of dam** - the natural material on which the dam structure is placed.

**Freeboard** - the vertical distance between a stated reservoir level and the top of a dam. Normal freeboard is the vertical distance between Full Reservoir Level (FRL) and the top of the dam. Minimum freeboard is the vertical

distance between the Maximum Water Level (MWL) and the top of the dam.

**Full Reservoir Level (FRL)/Normal water level** - for a reservoir with un-gated spillway it is the spillway crest level. For a reservoir, whose outflow is controlled wholly or partly by movable gates, siphons or other means, it is the maximum level to which water can be stored under normal operating conditions, exclusive of any provision for flood surcharge.

**Gate** - a device in which a leaf or member is moved across the waterway from an external position to control or stop the flow.

**Gravity dam** - a dam constructed of concrete, masonry, or both that relies on its weight for stability.

**Hazard Classification** - a system that categorizes dams according to the degree of adverse incremental consequences of a failure or improper operation of the dam. CWC classifies dam hazards as "low", "significant", or "high".

**Height above lowest foundation** - the maximum height from the lowest point of the general foundation to the top of the dam.

**Hydraulic height** - the height to which water rises behind a dam and the difference between the lowest point in the original streambed at the axis of the dam and the maximum controllable water surface.

**Hydrograph** - a graphic representation of discharge, stage, or other hydraulic property with respect to time for a point on a stream. (At times the term is applied to the phenomenon the graphic representation describes; hence a flood hydrograph is the passage of a flood discharge past the observation point.)

**Internal Erosion** - see piping.

**Inundation map** - a map delineating the area that would be inundated in case of a failure.

**Leakage** - Uncontrolled loss of water by flow through a hole or crack.

**Low-level outlet (bottom outlet)** - an opening  
**Maintenance** - the recurring activities necessary to retain or restore a dam in a safe and functioning condition, including the management of vegetation, the repair or replacement of failed components, the prevention or treatment of deterioration, and the repair of damages caused by flooding or vandalism.

**Maximum cross-section of dam** - a cross section of a dam at the point of its maximum height.

**Maximum water level** - the maximum water level, including flood surcharge, the dam is designed to withstand.

**Minimum operating level** - the lowest level to which the reservoir is drawn down under normal operating conditions.

**Outlet** - an opening through which water can be freely discharged from a reservoir.

**Outlet gate** - a gate controlling the outflow of water from a reservoir.

**Overflow dam** - a dam designed to be overtopped.

**Parapet Wall** - a solid wall built along the top of a dam for ornament, for the safety of vehicles and pedestrians, or to prevent overtopping.

**Peak Flow** - the maximum instantaneous discharge that occurs during a flood. It coincides with the peak of a flood hydrograph.

**Piping** - the progressive development of internal erosion by seepage, appearing

downstream as a hole or seam discharging water that contains soil particles.

**Primary Spillway (Principal Spillway)** - the principal or first-used spillway during flood flows.

**Probable Maximum Flood (PMF)** - a flood that would result from the most severe combination of critical meteorologic and hydrologic conditions possible in the region.

**Probable Maximum Precipitation (PMP)** - the maximum amount and duration of precipitation that can be expected to occur on a drainage basin.

**Program** — any authorized activity used to implement and carry out goals, actions, and objectives contained within the authorizing legislation.

**Regulating dam** - a dam impounding a reservoir from which water is released to regulate

**Rehabilitation** - the completion of all work necessary to extend the service life of the practice or component and meet applicable safety and performance standards.  
, damaged, or failed dam or its component to an acceptable by meeting functional condition.

**Reservoir area** - the surface area of a reservoir when filled to controlled retention level.

**Reservoir routing** - the computation by which the interrelated effects of the inflow hydrograph, reservoir storage, and discharge from the reservoir are evaluated.

**Reservoir surface** - the surface of a reservoir at any level.

**Riprap** - a layer of large stones, broken rock, or precast blocks placed randomly on the

upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel as a protection against wave action. Large riprap is sometimes referred to as armouring.

**Risk assessment** - as applied to dam safety, the process of identifying the likelihood and consequences of dam failure to provide the basis for informed decisions on a course of action.

**Seepage** - the interstitial movement of water that may take place through a dam, its foundation, or its abutments.

**Service Life** - the actual period after construction of a dam, during which the practice functions adequately and safely with only routine maintenance; determined by onsite review.

**Service/Regulating gate (regulating valve)** - a gate or valve that operates under full pressure and flow to throttle and vary the rate of discharge.

**Sill** - (a) A submerged structure across a river to control the water level upstream. (b) The crest of a spillway. (c) A horizontal gate seating, made of wood, stone, concrete or metal at the invert of any opening or gap in a structure, hence the expressions gate sill and stop log sill.

**Slope** - (a) the side of a hill or mountain. (b) The inclined face of a cutting or canal or embankment. (c) Inclination from the horizontal. In the United States, it is measured as the ratio of the number of units of horizontal distance to the number of corresponding units of vertical distance. The term is used in English for any inclination and is expressed as a percentage when the slope is gentle, in which case the term gradient is also used.

**Slope Protection** - the protection of a slope against wave action or erosion.

**Sluiceway** - see low-level outlet.

**Spillway** - a structure over or through which flood flows are discharged. If the flow is controlled by gates, it is a controlled spillway;

if the elevation of the spillway crest is the only control, it is an uncontrolled spillway.

**Storage** - the retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of over-flow areas, as in the progression of a flood crest through a natural stream channel.

**Tail water Level** - the level of water in the tailrace at the nearest free surface to the turbine or in the discharge channel immediately downstream of the dam.

**Tailrace** - the tunnel, channel or conduit that conveys the discharge from the turbine to the river, hence the terms tailrace tunnel and tailrace canal.

**Toe of Dam** - the junction of the downstream face of a dam with the ground surface, referred to as the downstream toe. For an embankment dam the junction of upstream face with ground surface is called the up-stream toe.

**Top of Dam** - the elevation of the upper-most surface of a dam, usually a road or walkway, excluding any parapet wall, railings, etc.

**Top Thickness (Top Width)** - the thickness or width of a dam at the level of the top of the dam. In general, "thickness" is used for gravity and arch dams, "width" for other dams.

**Transition Zone (Semi-pervious Zone)** - a part of the cross section of a zoned embankment dam comprising material of intermediate size between that of an impervious zone and that of a permeable zone.

**Trash rack** - a screen located at an intake to prevent the ingress of debris.

**Under seepage** - the interstitial movement of water through a foundation.

**Uplift** - the upward pressure in the pores of a material (interstitial pressure) or on the base of a structure.

**Valve** - a device fitted to a pipeline or orifice in which the closure member is either rotated or moved transversely or longitudinally in the waterway to control or stop the flow.

**Water stop** - a strip of metal, rubber or other material used to prevent leakage through joints between adjacent sections of concrete.

**Weir** - (a) a low dam or wall built across a stream to raise the upstream water level, called fixed-crest weir when uncontrolled. (b) A structure built across a stream or channel for measuring flow, sometimes called a measuring weir or gauging weir. Types of weir include broad-crested weir, sharp-crested weir, drowned weir, and submerged weir.



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