सत्यमेव जयते

Dam Safety Act, 2021

National Committee on Dam Safety

Agenda Papers of 3rd Meeting

5th December, 2023
10:30 hours
209, 2nd Floor Committee Room
Central Water Commission, New Delhi

Ministry of Jal Shakti
Government of India
NDSA Secretariat
New Delhi

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AGENDA FOR 3rd MEETING OF THE NATIONAL COMMITTEE ON DAM SAFETY

DATE : 5th December, 2023
VENUE : 2nd Floor, Committee Room, Central Water Commission, New Delhi
TIME :10:30 Hrs.

Agenda Point 3.0: Confirmation of the minutes of 2nd NCDS Meeting

The 2nd meeting of the National Committee on Dam Safety (NCDS) was held on 6th June, 2023 at CWC, New Delhi. The approved minutes of the 2nd meeting were circulated vide letter No. T-20078/3/2023-DSD-2 dated 30.06.2023. The Committee may confirm the minutes of the 2nd meeting of NCDS.

Agenda Point 3.1: Formulation of RULES and REGULATIONS under Section 54(2) of Dam Safety Act, 2021

Decision Taken in the 2nd NCDS Meeting:

The following 7 prioritized draft Regulations out of the 19 listed in Section 54 (2) of DSA, 2021 was approved by NCDS. The name of 7 prioritized regulations are as follows-

1. *54 (2) (c) "the details and form pertaining to the maintenance of log books or database under sub-section (1) of section 18";*
2. *54 (2) (d) "the qualifications, experience and training of the individuals responsible for safety of specified dams under section 23";*
3. *54 (2) (e) "the employment of competent engineers and their qualifications and experience for the purpose of investigation, design and construction of specified dams under sub-section (3) of section 26";*
4. *54 (2) (g) "the level of competent engineers for the dam safety units under section 30";*
5. *54 (2) (h) "the guidelines and check-lists for inspection of specified dams under clause (a) of sub-section (3) of section 31";*
6. *54 (2) (o) "time interval for updating the emergency action plan under clause (b) of sub-section (1) of section 36";*
7. *54 (2) (q) "the mandatory review of design flood of existing specified dams under clause (b) of sub-section (2) of section 38";*

In addition, draft regulations on 6 other subjects have been prepared and shared with members of NDSA and will be shared with NCDS members and State/UTs/CPSUs for review and comments. The name of these regulations are as under:

1. *54 (2) (i) "the minimum number of set of instrumentations in the specified dams and the manner of their installation under sub-section (1) of section 32";*
2. *54 (2) (j) "the form, manner and time interval for forwarding the analysis of readings to the State Dam Safety Organization under sub-section (2) of section 32";*
3. *54 (2) (k) "the data requirements of hydro-meteorological stations in the vicinity of specified dams under sub-section (1) of section 33";*
4. *54 (2) (l) "the data requirements of seismological stations in the vicinity of specified dams under sub-section (1) of section 34";*
5. *54 (2) (m) "the suitable location and manner of collection, compliance, process and storage of data under sub-section (2) of section 34";*
6. *54 (2) (r) "the mandatory site-specific seismic parameter studies of existing specified dams under clause (c) of sub-section (2) of section 38";*

Present Status:

There are 19 subjects under Section 54(2) of the Dam Safety Act, for which regulations are to be framed by the NDSA. As decided in the NCDS meeting, NDSA has submitted the 7 prioritized regulations (c,d,e,g,h,o,q) to the DoWR, MoJS for further action and for placing before each house of the parliament vide NDSA letter no. T-20017/3/2023-DSD-2 Dated 21.06.2023 and subsequent clarifications thereon vide even letter dated 18.09.2023 which is placed at **Annexure I**.

Further, additional 9 draft regulations have been prepared by NDSA and shared with expert members of NCDS i.e Prof. C.V.R. Murty and Sh. D.K. Sharma, State/UT WRD Secretaries, SCDS & SDSOs of states for comments. These draft regulations were also shared with Members of NCDS for their comments. The details of these regulations are attached at **Annexure-II**. The response has been received from SDSOs of Tamil Nadu, Karnataka, Maharashtra, Uttarakhand, Prof CVR Murty, Sh. D.K. Sharma, Member (Regulation) NDSA, Member (D&R) NDSA, NDMA and IMD; which are placed at **Annexure-III**. The list of 9 regulations are as below: -

1. *54 (2) (i) "the minimum number of set of instrumentations in the specified dams and the manner of their installation under sub-section (1) of section 32";*
2. *54 (2) (j) "the form, manner and time interval for forwarding the analysis of readings to the State Dam Safety Organization under sub-section (2) of section 32";*
3. *54 (2) (k) "the data requirements of hydro-meteorological stations in the vicinity of specified dams under sub-section (1) of section 33";*
4. *54 (2) (l) "the data requirements of seismological stations in the vicinity of specified dams under sub-section (1) of section 34";*
5. *54 (2) (m) "the suitable location and manner of collection, compliance, process and storage of data under sub-section (2) of section 34";*
6. *54 (2) (r) "the mandatory site-specific seismic parameter studies of existing specified dams under clause (c) of sub-section (2) of section 38";*
7. *54 (2) (a) "the guidelines, standards and other directions for achieving the satisfactory level of dam safety assurance under sub-section (1) of section 16";*
8. *54 (2) (n) "the time interval of risk assessment studies to be carried out under sub-section (2) of section 35";*
9. *54 (2) (p) "the time interval for the comprehensive safety evaluation of specified dams under sub-section (1) of section 38";*

These 9 regulations will be placed before the committee for discussion and approval.

The remaining 3 regulations shall be taken up by NDSA in due course, which are as under:

1. *54 (2) (b) "the vulnerability and hazard classification criteria of specified dams under section 17";*
2. *54 (2) (f) "the quality control measures for the purpose of dam construction under sub-section (5) of section 26";*
3. *54 (2) (s) "the measures necessary to ensure dam safety by every owner of dam other than specified dams under section 46";*

Agenda Point 3.2: Technical Documentation – National Registry of Specified Dams

Decision Taken in the 2nd NCDS Meeting:

Chairman, NCDS directed that the list of specified dams needs to be updated at the earliest including details pertaining to salient features. He also advised that the matter may be taken up with the Principal Secy/Addl. Chief Secy of WRDs and SDSOs from which the information is pending.

The Committee also advised that a presentation should be delivered on DHARMA portal after finalization of beta version. It should be ensured that DHARMA tool may be linked with various aspects of the dam safety (Hydraulic, Hydrologic, Structural Engg. & Earthquake Safety, Hydro mechanical, Electrical, Geological-Geo-physical & Geo-technical, Instrumentation etc).

Present Status:

The National Register for Large (Specified) Dams (NRLD), 2023 was published by Hon'ble Vice President of India Sh. Jagdeep Dhankhar during the International Conference on Dam Safety held in Jaipur, Rajasthan in Setember,2023. As per the document, there are 6138 constructed specified dams in the country and 143 specified dams are under construction. The document is under further update. The state-wise distribution of specified dams is placed at **Annexure-IV**. The beta version of DHARMA is under finalization.

Agenda Point 3.3: Comprehensive Dam Safety Evaluation Procedures

Decision Taken in the 2nd NCDS Meeting:

Chairman NCDS advised to finalize the list of Dam Safety Experts immediately and share with State SDSOs so that they can proceed further in direction of Comprehensive Dam Safety Evaluation. He also advised that States may be directed to chalk out a roadmap for conducting comprehensive evaluation of the dams to be taken on priority.

Present Status:

The list of Dam Safety Experts empaneled under NDSA has been finalized and uploaded on the website. The list has been circulated vide letter dated 09.08.2023 among various States through Regional Directors of NDSA. The copy of letter is placed at **Annexure-V**. The link for accessing the list of empaneled experts is given below: - https://cwc.gov.in/empanelment-dam-safety-experts-ndsa

Further, the States present may inform action taken in this regard.

Agenda Point 3.4: Emergency Action Plan and Disaster Management Initiatives

Decision Taken in the 2nd NCDS Meeting:

The States to develop in-house capability for preparation of Emergency Action Plan using GIS and for that high resolution maps of NRSC, Hyderabad may be utilized.

The regulation as per provision of 54 (2) (o) of DSA, 2021 pertaining to "time interval for updating the action plan under clause (b) of sub-section (1) of section 36 was finalized.

Present Status:

As reported by dam owning agencies, emergency action plan has been prepared for 421 dams. The agency-wise detail of Emergency Action Plan prepared is placed at **Annexure-VI**.

Regular follow up with States being done by NDSA for the same.

States present may inform action taken in this regard.

Agenda Point 3.5: Operation and Maintenance

Decision Taken in the 2nd NCDS Meeting:

Committee directed that guideline/manuals prepared under DRIP for preparation of Operation and Maintenance Manual may be shared with all SCDS/SDSOs.

Present Status:

The guidelines/manuals pertaining to dam safety prepared under DRIP were shared with all SDSOs through mail on 8th June, 2023. The copy of email is placed at **Annexure-VII.**

As reported by dam owning agencies, O&M manual for 465 dams has been prepared. The status of O&M Manuals prepared by respective State is placed at **Annexure-VIII**.

Regular follow up being done by NDSA for the same.

States present may inform action taken in this regard.

Agenda Point 3.6: Reports of Safety related to specific dams submitted by SCDS

Decision Taken in the 2nd NCDS Meeting:

The following draft regulations related to above have been prepared by NDSA:

- *the qualifications, experience and training of the individuals responsible for safety of specified dams under section 23;*
- *the employment of competent engineers and their qualifications and experience for the purpose of investigation, design and construction of specified dams under sub-section (3) of section 26;*
- *the level of competent engineers for the dam safety units under section 30;*

Present Status:

The regulations pertaining to above were approved by NCDS in 2nd meeting and the same has been forwarded to PR wing of DoWR for further action as stated under agenda item 3.1.

Agenda Point 3.7: Establishment of Dam Safety Unit

Decision Taken in the 2nd NCDS Meeting:

The regulation as per provision of 54 (2) (g) of DSA, 2021 pertaining to "the level of competent engineers for the dam safety units under section 30" was finalized.

Present Status:

As reported by dam owning agencies, 4229 Dam Safety Units have been established so for. The status of Dam Safety Units established is placed at **Annexure-IX**.

Regular follow up being done by NDSA with the states where dam safety units are yet to be established.

States present may inform action taken in this regard.

Agenda Point 3.8: Pre and Post-Monsoon Inspection of Dams

Decision Taken in the 2nd NCDS Meeting:

The Committee was informed about the status of post monsoon-2022 and pre monsoon inspections. In this context, NCDS advised to take up the matter with concerned SDSOs for remedial interventions to be taken for Category-I dams (2 UP + 2 Odisha) reported during pre-monsoon inspections. Committee also directed that detailed note from SDSO Odisha and UP may also be taken for the rehabilitation measures adopted on Category-I dams.

The NCDS also desired that list of Category-II dams shall be prepared which are proposed for rehabilitation under DRIP Phase-II and III.

Present Status:

During the pre-monsoon season of 2023, 6414 dams were inspected by dam owners of various States/UTs. Till 23.11.2023, post monsoon inspections of 460 dams have been completed. The state-wise details of inspections are placed as **Annexure-X**.

Earlier four dams (2 UP + 2 Odisha) were reported under Category-I dams, however, as per latest pre-monsoon inspections, only two (2) dams of UP has been reported under Category-I, and rehabilitation of both dams is proposed under DRIP Phase-II & III. Also, there are 183 dams under category-II based on 2023 pre-monsoon inspections. Of these 183 dams, 94 dams are proposed for rehabilitation under DRIP Phase-II and III. The list of these dams is placed as **Annexure-XI**.

Further, 7 dams (Bihar-1, Goa-2, Odisha-1, Telangana-1 & Uttarakhand-2) have been reported under category II dams during post-monsoon inspection 2023. These seven dams have been already reported as Category-II during pre-monsoon inspection.

Agenda Point 3.9: Instrumentation of Dams, establishment of hydro-meteorological Station & Installation of seismological stations

Decision Taken in the 2nd NCDS Meeting:

Chairman, NCDS advised to ensure that provisions for installations of minimum number of instrumentations in the dams are kept in the Project Screening Template (s) of dams under DRIP Phase-II.

The committee was briefed by Member Secretary, NCDS that draft regulation pertaining to minimum number of set of instrumentations in the specified dams and the manner of their installations have been prepared. In this context, it was decided that this regulation may be shared with committee members for review and suggestions.

Present Status:

The draft regulation (*54 (2) (i) the minimum number of set of instrumentations in the specified dams and the manner of their installation under sub-section (1) of section 32)* pertaining to ensuring minimum number of instruments was shared with concerned officials/experts as stated in agenda point 3.1. The status is placed at **Annexure-XII.**

Regular follow up being done by NDSA for the same.

States present may inform action taken in this regard.

Agenda Point 3.10: Formation of Sub-Committees

Decision Taken in the 2nd NCDS Meeting:

It was decided that **nine** Sub-Committees of the National Committee on Dam Safety shall be formed. These nine sub-committees are:

1. *Dam Safety Management*
2. *Hydraulic safety*
3. *Hydrological safety*
4. *Structural engineering and earthquake safety*
5. *Geological, Geophysical and Geotechnical Safety*
6. *Hydro-Mechanical and Electrical Systems Safety*
7. *Monitoring and Instrumentation*
8. *R&D and Standards development*
9. *Capacity development*

Present Status:

The constitution order pertaining to sub-committee(s) on Structural Engineering & Earthquake Safety of Dams and Capacity Development was issued on 18.10.2023. The copy of order is placed as **Annexure-XIII.**

In addition to above, two sub-committee(s) have also been proposed to be constituted namely "Dam Safety Management" and "Monitoring and Instrumentation". The composition and Terms of Reference (ToR) of both the sub-committee(s) are given below as: -

A. Composition of Sub-committee on "Dam Safety Management":

1	Dr. R K Gupta, Formerly Chairman, CWC	Chairman
2	Representative of NIH (Sh Sanjay Jain, Sc-F, NIH Roorkee)	Member
3	Representative of IIT (Prof S K Mishra, Dept. of WRD & Management, IIT Roorkee)	Member
4	Representative of State (Sh Vivek Kapadia, CE, WRD, Gujarat)	Member
5	Representative of NHPC (Sh Y K Chaube, Formerly ED, NHPC)	Member
6	Director NDSA/CWC	Member-Secretary

Terms of References (ToR)

i) To prepare guideline on Dam Inspection
ii) To prepare guideline on Emergency Action Plan (EAP)
iii) To prepare guideline on Risk Classification
iv) To prepare draft regulation as per section 54(2)(a) of the Dam Safety Act-2021: "The guidelines, standards and other directions for achieving the satisfactory level of dam safety assurance under sub-section (1) of section 16".
v) Render technical advice on any other related matter as & when referred to it by NCDS.

B. Composition of Sub-committee on "Monitoring and Instrumentation":

1	Sh J C Iyer, Formerly Chairman, CWC	Chairman
2	Representative of CSMRS (Sh S L Gupta, Formerly Director, CSMRS/ Sh Hari Dev, Scientist-E, CSMRS)	Member
3	NDSA Expert (Prof. Samit Ray Chaudhuri, Dept. of Civil Engg., IIT Kanpur)	Member
4	Representative of CWPRS (Sh PD Kamalasekaran, Scientist-E, CWPRS, Pune)	Member
5	Representative from AIMIL/NIRM	Member
6	Director NDSA/CWC	Member-Secretary

Terms of References (ToR)

i) To prepare guideline for Monitoring and Instrumentation of dams.
ii) Preparation of draft regulations as per section 54(2) of the Dam Safety Act-2021 on the "the minimum number of set of instrumentations in the specified dams andthe manner of their installation under sub-section (1) of section 32";
iii) Render technical advice on any other related matter as & when referred to it by NCDS.

Agenda Point 3.11: Activities performed by NDSA

- Ministry of Jal Shakti through NDSA and CWC, has organized outreach program at the iconic dam sites across the country with community participation under "Azadi Ka Amrit Mahotsav (AKAM)'' for promoting Dam Tourism. After 2nd NCDS meeting, these outreach programs were conducted at 21 selected dams. The details of dams is placed at **Annexure-XIV**.
- The list of guidelines/manuals prepared under DRIP were shared with SDSOs vide email dated 08.06.2023.
- Three (3) committee(s) were constituted comprising officials from NDSA, CWC and CSMRS vide order dated 21.06.2023 to visit the sites of Category-I dams reported during pre-monsoon inspection 2023.
- The details of virtual meeting conducted with the States SDSOs are placed at **Annexure-XV**.
- Three training programs on Dam Safety have been organized at National Water Academy (NWA) for the officers of Central/State Govts in the month of May'23, Sep'23 & Nov'23. Webinar on Legal and Institutional framework of DSA, 2021 from 25-26 July, 2023 was also organized.
- Two Trainings on Dam Break Analysis (DBA) and Emergency Action Plan (EAP) was conducted for officers of UP at Lucknow in May & June 2023.

- International Conference on Dam safety (ICDS) 2023 was organized at Jaipur during 14-15 September, 2023. The conference was based on theme "Safe & Secure Dams for Nations's Prosperity". Around 800 national and international delegates attended the conference. Over 130 technical papers were received from Central/State Govt. Organisations, PSUs, Technical Institutes, and National/International Experts and 15 poster paper presentation were done during the Conference.
- Advisory for creating awareness regarding dams to the local population issued to all SDSO vide Member(P&R) office letter No TE-30/1/2023-NDSA-MOWR/I/85234/2023 dated 23.06.2023. In addition to this, directions/advisory have been issued to SDSOs/dam owning agencies by Members of NDSA from time to time to implement the various provisions of Dam Safety Act, 2021 to safe guard the dams.

Agenda Points 3.12: Dam Failure/Incidents reported during year 2023

The dam incidents/failures reported during year 2023 are given in the table below: -

S. No	Name of the project	Issues/Incident details	Date of incident/ accident	Current Status
1.	Malana-II HEP, Himachal Pradesh	The Malana-II dam was overtopped as all the radial gates jammed because of slush and boulders. Scouring took place on left bank.	24/07/2023	The jammed gates were opened on 10th October after 45 days of overtopping. The dam is safe and its rehabilitation work is to be taken up. A team of dam safety officials, constituted by Govt. of Himachal Pradesh visited the site for examination. The report is awaited.
2.	Pondi Jaitgarh Tank, District Damoh, Madhya Pradesh	Due to heavy rainfall between 23/07/23-24/07/23 the water in the reservoir reached FTL and started to spill out from waste weir. Seepage started from 24/07/2023 evening which was increasing at fast rate. Dam breached on 25/07/2023 morning between RD 220 m and RD 270 m	25/07/2023	Dam breached and nonfunctional as of now. No loss of life reported.
3.	Kaddam Dam, Telangana	Excessive inflow occurred in Kaddam Dam	27/07/2023	Details awaited.

4	Teesta Basin dams (Teesta III dam, Teesta-V dam, TLDP-III Dam, TLDP-IV Dam), Sikkim and West Bengal	Sudden outburst in South Lhonak Glacial Lake in Sikkim lead to Flooding (GLOF) in Teesta River on the night of 03-04 October 2023 lead to washing way of Teesta –III dam and heavy damages to Teesta-V dam. TLDP-II dam and TLDP-IV dam are also affected but no major damage has been reported.	04/10/2023	A team of officers of NDSA visited the Teesta basin on 05-06 October 2023 and preliminary report has been submitted to the Ministry of Jal Shakti. The copy of preliminary report is enclosed. A committee has also been constituted by NDSA under Schedule-II clause-8 of DSA-21 to examine the effect of GLOF on the Projects located on Teesta River. The copy of order is placed as **Annexure-XVI.**
5	Medigadda (Lakshmi) Barrage, Telangana	Settlement of pier of Medigadda Barrage on the night of 21/10/2023 lead to sudden release of 2.7lakh cusec. Construction of the Barrage was completed in 2019.	21/10/2023	A team of officers of NDSA visited the site on 23 October 2023 and the report is prepared and forwarded to Irrigation & CAD, Telangana. The copy of report is enclosed.
6	Subansiri Lower HEP, Assam	Major Landslide occurred at the site of the Subansiri Lower HEP in Assam thereby blocking the Diversion Tunnel and obstructing water flow through the river.	27/10/2023	A letter dated 03/11/23 has been sent to SDSO Assam to provide the status report/detailed report of the incident and the distress caused to the dam. The information is awaited.

Agenda Point 3.13: Any other Agenda with the Permission of Chair

सत्यमेव जयते

Dam Safety Act, 2021

National Committee on Dam Safety

Annexures of Agenda for 3rd Meeting

5th Dec, 2023
10:30 hours
209, 2nd Floor Committee Room
Central Water Commission, New Delhi

Ministry of Jal Shakti
Government of India
NDSA Secretariat
New Delhi

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Annexure I

File No.T-20017/3/2023-DSD-2

राष्ट्रीय बाँध सुरक्षा प्राधिकरण
भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

आज़ादी का अमृत महोत्सव

To,

Sr. Joint Commissioner,
Peninsular River Wing,
Department of Water resources, RD & GR,
Krishi Bhawan, New Delhi

Sub: Seven regulations prepared under section 54 (2) of Dam Safety Act, 2021-reg.

Ref: Secretary, DoWR, RD and GR), MoJS meeting dated 15.06.2023.

Sir,

As per section 54 (2) of Dam Safety Act, 2021, the following seven regulations have been prepared and concurred by National Committee on Dam Safety (NCDS) in its 2nd meeting held on 06.06.2023 at New Delhi:

54(2)(c) *the details and form pertaining to the maintenance of log books or database under sub-section (1) of section 18;*

54(2)(d) *the qualifications, experience and training of the individuals responsible for safety of specified dams under section 23;*

54(2)(e) *the employment of competent engineers and their qualifications and experience for the purpose of investigation, design and construction of specified dams under sub-section (3) of section 26;*

54(2)*(g) the level of competent engineers for the dam safety units under section 30;*

54(2)(h) *the guidelines and check-lists for inspection of specified dams under clause (a) of sub-section (3) of section 31;*

54(2)(o) *time interval for updating the emergency action plan under clause (b) of sub-section (1) of section 36;*

54(2)(q) *the mandatory review of design flood of existing specified dams under clause (b) of sub-section (2) of section 38;*

2. Further, as per the directions of Secretary, DoWR, RD & GR in the review meeting held on 15.06.2023, the above seven regulations are hereby attached and sent for your kind information and further needful on the matter.

This issues with approval of competent authority.

Office of Director (P & R), NDSA, 4th Floor (South), Sewa Bhawan, R.K.Puram-66

Encl: 7 Regulations

Yours sincerely,

Signed by Rakesh Kumar Gautam
Date: 21-06-2023 13:31:11
Reason: Approved

(R K Gautam)
Director, NDSA
Phone: 011-29583362
e-mail: dsd2dte-cwc@nic.in

Copy for kind information:

1. PPS to Chairman, CWC and Chairman, NCDS, New Delhi.
2. PPS to Chairman, NDSA & Member (D&R), CWC, New Delhi.
3. JS (RD & PP), D/o WR, RD and GR, Krishi Bhawan, New Delhi.

Office of Director (P & R), NDSA, 4th Floor (South), Sewa Bhawan, R.K.Puram-66

File No.T-20017/3/2023-DSD-2

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
राष्ट्रीय बाँध सुरक्षा प्राधिकरण

Corrigendum

Sub: Seven regulations prepared under section 54 (2) of Dam Safety Act, 2021-reg.

Ref: Letter no: T-20017/3/2023-DSD-2 dated 21.06.2023

Kind reference is invited to the above cited letter vide which seven regulations finalized under section 54 (2) (c, d, e, g, h, o & q) of Dam Safety Act, 2021 were shared for needful action. In this regard, in the narrative of regulation ***54(2)(h)***, a typographical error has occurred.

Hence, description of regulation 54(2)(h) may be read as: "*Dam safety inspection is mandatory for every dam as per the schedule and conditions specified in the Act. These inspections shall be undertaken as per the guidelines and check-lists for inspection of specified dams approved by NDSA*" in place of "*Dam safety inspection is mandatory for every dam as per the schedule and conditions specified in the Act. These inspections shall be undertaken as per the guidelines of Operation & Maintenance manual approved by NDSA*".

Signed by Rakesh Kumar Gautam
Date: 27-07-2023 17:15:06
Reason: Approved

(Rakesh Kumar Gautam)
Director
email: dsd2dte-cwc@gov.in
Phone: 011-29583362

To,

Sr. Joint Commissioner (PR), D/o WR, RD and GR, Krishi Bhawan.

Copy for kind information: -

1. PPS to Chairman, CWC and NCDS.
2. PPS to Chairman, NDSA and Member (D&R), CWC.
3. PS to JS (RD & PP), D/o WR, RD and GR, Shram Shakti Bhawan.
4. PS to CE (DSO) and Member (P&R), NDSA.

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
राष्ट्रीय बाँध सुरक्षा प्राधिकरण

आज़ादी का अमृत महोत्सव

To,

Sr. Joint Commissioner,
Peninsular River Wing,
Department of Water resources, RD & GR,
Krishi Bhawan, New Delhi.

Sub: Clarification on draft regulations sought by Legislative Department, MoLJ.

Ref: Email dated 09.08.2023 of SJC (PR), D/o WR, RD and GR.

Sir,

Kind reference is invited to above cited email vide which necessary information/clarification was sought by Legislative Department, Ministry of Law and Justice on two (2) regulations i.e. 54 (2) (c) and 54 (2) (o) of DSA, 2021. In view of clarifications sought, the point-wise reply is given below for your information and needful: -

S.no.	Regulation	Clarification sought	Compliance
1.	54(2)(c) 'the details and form pertaining to the maintenance of log books or database under sub-section (1) of section 18.	Request to provide the "proforma for Salient Features of the Dam" for finalization of this regulation.	The proforma for salient feature of the dam & barrage/weir is enclosed herewith as Annexure-I.
2.	54(2)(o) 'the time interval for updating the emergency action plan under clause (b) of sub-section (1) of section 36"	Request to provide the clear time interval for updating the emergency action plan, without linking it to the EAP Manual.	It is proposed that the time interval for updating the emergency action plan may be kept at five (5) years. Further, the copy of regulation is enclosed herewith as Annexure-II.

This issues with approval of competent authority.

Yours sincerely,

Encl: A/a

Signed by Rakesh Kumar Gautam
Date: 18-09-2023 13:26:50
Reason: Approved

(R K Gautam)
Director, NDSA
Phone: 011-29583362
E-mail: dsd2dte-cwc@nic.in

Copy for kind information:

1. PPS to Chairman, CWC and Chairman, NCDS, New Delhi.
2. PPS to Chairman, NDSA & Member (D&R), CWC, New Delhi.
3. PS to Member (P & R), NDSA & CE (DSO), CWC, New Delhi.
4. PS to JS (RD & PP), D/o WR, RD and GR, New Delhi.

Annexure-I

SALIENT FEATURE OF DAM

S.No.	Title	Details
1.	Name of Dam	
2.	State	
3.	District	
4.	Nearest Rail Head	
5.	Nearest airport	
6.	Dam owner	
7.	Name of river on which dam is constructed	
8.	Basin	
9.	Location	
	(i). Latitude	
	(ii). Longitude	
10.	Nearest City	
11.	Dam type	
12.	Year of completion	
13.	Dam purpose	
14.	Earthquake zone as per IS 1893	
15.	Height of the dam (m)	
	(i). above deepest foundation	
	(ii). above deepest river bed Elevation	
16.	Storage Capacity (MCM)	
	(i). Gross Storage	
	(ii). Live Storage	
17.	Total length of dam (m)	
18.	Total Length & No. of Overflow Blocks	
19.	Total Length & No. of Non-overflow Blocks	
20.	Top width of dam (m)	
21.	Reservoir Surface Area (at FRL) (in sq. km.)	
22.	Reservoir Surface Area (at MWL) (in sq. km.)	
23.	Catchment Area (in sq. km.)	
24.	Spillway type	
25.	Spillway Gates	
	(i). Sluice gate Type, Number and size (W x H)	
	(ii). Surface Crested gate Type, Number and size (W x H)	
26.	Total spillway capacity (Cumec)	
27.	Design Flood adopted (PMF/SPF/ any other) (m^3/s)	

28.	Type of Energy dissipater	
29.	Stilling Basin	
	(i). Floor Elevation of stilling basin	
	(ii). Length	
	(iii). Width	
30.	Bucket Type	
	(i). Invert Elevation	
	(ii). Lip angle and Elevation	
	(iii). Radius	
31.	Plunge Pool	
	(i). Bottom Elevation	
	(ii). Length and Width	
32.	Important Controlling Elevation (m)	
a)	Top Bund Elevation (TBL)	
b)	Maximum Water Level (MWL)	
c)	Full Reservoir Level (FRL)	
d)	Spillway Crest elevation	
	(i). Sluice Type	
	(ii). Overflow Type	
e)	Minimum Draw Down Level (MDDL)	
f)	Lowest River bed Elevation	
g)	Deepest foundation elevation	
h)	Top of upstream parapet solid parapet wall RL	
i)	Maximum Tail Water Elevation	
j)	Minimum Tail Water Elevation	
k)	Average Tail Water Elevation	
33.	**Earthen/ Rockfill/Masonry/Concrete Dam**	
a)	Type	
b)	Upstream Slope	
c)	Downstream Slope	
d)	No. of berms, width and Elevations	
e)	Core	
	(i). Top Elevation	
	(ii). Upstream Slope	
	(iii). Downstream Slope	
f)	Cutoff	
	(i). Type	
	(ii). Maximum Depth	
34.	**Power generation (if applicable)**	
a)	HRT Intake structure	
	(i). No. of intake & Type	

	(ii). Size (m) & Shape	
	(iii). Design discharge per unit (m^3/s)	
	(iv). Invert Elevation	
	(v). Design head (m)	
b)	Head Race Tunnel (HRT)	
	(i). No. of HRT	
	(ii). Size (m) & Shape	
	(iii). Design discharge for each (m^3/s)	
c)	Surge Shaft	
	(i). No. & Type	
	(ii). Size (m) & Shape	
	(iii). Top Elevation	
	(iv). Bottom Elevation	
	(v). Height of Surge Shaft	
	(vi). Gate Type, Number and size (W x H)	
d)	Pressure Shaft	
	(i). No. of Pressure Shaft	
	(ii). Size (m) & Shape	
	(iii). Design discharge for each (m^3/s)	
e)	Unit Pressure Shaft/Penstock	
	(i). No. of Pressure Shaft	
	(ii). Size (m) & Shape	
	(iii). Design discharge for each (m^3/s)	
f)	Powerhouse	
	(i). Type (Underground/ Surface)	
	(ii). Installed Capacity (MW)	
	(iii). Number & Type of Turbine	
	(iv). Power House Size (W X L X H)	
	(v). Rated discharge (m^3/s)	
g)	Tail Race	
	(i). Number & Type	
	(ii). Size (m) & Shape	
	(iii). Design discharge	
	(iv). Length (m)	
	(v). Highest Flood Level (HFL) at TRT outlet	
35.	**Irrigation (If Applicable)**	
a)	Head Regulator (Left)	
	(i). No. of Bays & Size of Gate (Width (W) X Height (H)	
	(ii). Sill Elevation	
	(iii). Discharging Capacity	
b)	Head Regulator (Right)	
	(i). No. of Bays & Size of Gate (Width (W) X Height (H)	
	(ii). Sill Elevation	
	(iii). Discharging Capacity	
c)	Gross Command Area (Ha.)	

d)	Culturable Command Area (Ha.)	
e)	Irrigation Intensity	
f)	Canal	
	(i). No. & Size	
	(ii). Shape	
	(iii). Discharge Capacity	
	(iv). Length	

SALIENT FEATURE OF BARRAGE/ WEIR (AS APPLICABLE)

Sl. No.	Title	Details
1.	Name of Barrage/ Weir	
2.	State	
3.	Barrage owner	
4.	River on which barrage is constructed	
5.	Basin	
6.	Location	
	(i). Latitude:	
	(ii). Longitude:	
7.	Nearest City	
8.	Year of completion	
9.	Earthquake zone as per IS 1893	
10.	Height of the Barrage (m) (above deepest foundation)	
11(a)	No. of Under sluice Bays	
	(i). Crest/ Sill Elevation	
	(ii). Gate Size (Width X Height)	
	(iii). Length	
11(b)	No. of Spillway Bays	
	(i). Crest/ Sill Elevation	
	(ii). Gate Size (Width X Height)	
	(iii). Length	
12.	Design discharge capacity (Cumec)	
13.	Design Flood adopted (PMF/SPF/ any other) (m^3/s):	
14.	Energy Dissipater	
	Details of Stilling Basin:	
	(i). Length	
	(ii). Width	
	(iii). Top elevation	
	(iv). Top of Training wall	
	(v). Length of Downstream apron	
15.	Details Cut off	
	(i). Bottom elevation of Upstream Cut off	
	(ii). Bottom elevation of Downstream Cut off	
16.	Barrage Parameters	
a)	Number and Width of Piers	

b)	Number and Width of Double Piers	
c)	Total Water Way (m)	
d)	Clear Water Way (m)	
e)	Upstream Floor Level	
f)	Downstream Floor Level	
g)	Pond Level (m)	
h)	Highest Flood Level (HFL) (m)	
i)	River Bed Elevation (m)	
j)	Top of bridge at Barrage (m)	
k)	Maximum Tail water level (m)	
l)	Afflux	
m)	Freeboard	
n)	Flare out wall	
	(i). Length	
	(ii). Top Level	
	(iii). Width	
o)	Flank out wall	
	(i). Length	
	(ii). Top Level	
	(iii). Width	
p)	Upstream Guide Bund	
	(i). Length	
	(ii). Top Level	
	(iii). Width	
q)	Afflux Bund	
	(i). Length	
	(ii). Top Level	
	(iii). Width	
r)	Downstream Guide Bund	
	(i). Length	
	(ii). Top Level	
	(iii). Width	
s)	Top of Abutments	
17.	Divide Wall	
	(i). Upstream - Length, Width & Elevation	
	(ii). Downstream - Length, Width & Elevation	
18 (a)	Head Regulator (Left)	
	(i). No. of Bays	
	(ii). Number and width of pier	

	(iii). Length	
	(iv). Size of Gate (Width (W) X Height (H))	
	(v). Sill Level	
	(vi). Discharging Capacity	
	(vii). Top of Head Regulator	
(b)	Canal	
	(i). FSL of canal	
	(ii). Discharge Capacity of Canal	
	(iii). Bed Level of Canal	
19 (a)	Head Regulator (Right)	
	(i). No. of Bays	
	(ii). Number and width of pier	
	(iii). Length	
	(iv). Size of Gate (Width (W) X Height (H))	
	(v). Sill Level	
	(vi). Discharging Capacity	
	(vii). Top of Head Regulator	
(b)	Canal	
	(i). FSL of canal	
	(ii). Discharge Capacity of Canal	
	(iii). Bed Level of Canal	
20	Protection works	
	(i). Length of Upstream Concrete block works	
	(ii). Length of Downstream Concrete block works	
	(iii). Length of Upstream Loose Stone Protection (Apron) works	
	(iv). Length of Downstream Loose Stone Protection (Apron) works	
	(v). Safe Exit gradient	
21	Fish Ladder Provided (Y/N) * If yes, provide details in separate sheet	
22	Navigation Lock (Y/N) * If yes, provide details in separate sheet	
23	Irrigation Parameters	
	(i). Gross Command Area (GCA) (Ha.)	
	(ii). Culturable Command Area (CCA) (Ha.)	
	(iii). Irrigation Intensity	
24.	Power generation (if applicable)	
(a)	HRT Intake structure	
	(i). No. of intake & Type	

	(ii). Size (m) & Shape	
	(iii). Design discharge per unit (m^3/s)	
	(iv). Invert Elevation	
	(v). Design head (m)	
(b)	Head Race Tunnel (HRT)	
	(i). No. of HRT	
	(ii). Size (m) & Shape	
	(iii). Design discharge for each (m^3/s)	
(c)	Surge Shaft	
	(i). No. & Type	
	(ii). Size (m) & Shape	
	(iii). Top Elevation	
	(iv). Bottom Elevation	
	(v). Height of Surge Shaft	
	(vi). Gate Type, Number and size (W x H)	
(d)	Pressure Shaft	
	(i). No. of Pressure Shaft	
	(ii). Size (m) & Shape	
	(iii). Design discharge for each (m^3/s)	
(e)	Unit Pressure Shaft/Penstock	
	(i). No. of Pressure Shaft	
	(ii). Size (m) & Shape	
	(iii). Design discharge for each (m^3/s)	
(f)	Powerhouse	
	(i). Type (Underground/ Surface)	
	(ii). Installed Capacity (MW)	
	(iii). Number & Type of Turbine	
	(iv). Power House Size (W X L X H)	
	(v). Rated discharge (m^3/s)	
(g)	Tail Race	
	(i). Number & Type	
	(ii). Size (m) & Shape	
	(iii). Design discharge	
	(iv). Length (m)	
	(v). Highest Flood Level (HFL) at TRT outlet	

54(2)(o) Regulation on *"the time interval for updating the emergency action plan under clause (b) of sub-section (1) of section 36"*

Clause (b) of sub-section (1) of section 36: *In respect of the dam which is constructed and filled before the commencement of this Act, prepare emergency action plan within five years from the date of commencement of this Act and thereafter update such plans at regular intervals as may be specified by the regulations.*

- The EAP of all specified dams shall be prepared within 5 years from the date on which the Act became effective. Thereafter, it should be updated every five years.

Details of 9 Draft Regulations prepared under Section 54(2) of DSA

54 (2) (i) *The minimum number of set of instrumentations in the specified dams and the manner of their installation under sub-section (1) of section 32;*

Section 32. (1) Every owner of a specified dam shall have a minimum number of such instrumentations at each specified dam, and installed in such manner as may be specified by the regulations for monitoring the performance of such dam.

Minimum number of set instrumentation for monitoring the performance of specified dam:

Type	Feature	Visual observation	Movements	Uplift and pore pressure	Water levels and flow	Seepage flows	Water quality	Temperature measurement	Crack and joint measurement	Seismic measurement	Stress-strain measurement
Embankment Dams	Upstream slope	●	●	●	●	–	–	–	–	●	–
	Downstream slope	●	●	●	–	●	●	●	●	●	–
	Abutments	●	●	●	–	●	●	●	–	●	–
	Crest	●	●	●	–	–	–	–	●	●	–
	Internal drainage system	–	–	●	–	●	●	●	–	–	–
	Relief Drain	●	–	●	–	●	●	–	–	–	–
	Riprap and other slope protection	●	–	–	–	–	–	–	–	–	–
Concrete and Masonry Dams	Upstream slope	●	●	–	●	–	–	●	●	●	●
	Downstream slope	●	●	●	–	–	–	●	●	●	●
	Abutments	●	●	●	–	●	●	–	–	●	●
	Crest	●	●	●	–	–	–	●	●	●	●
	Internal drainage system	–	–	●	–	●	–	–	●	–	–
	Relief Drain	●	–	●	–	●	–	–	–	–	–
	Galleries	●	●	–	–	–	–	–	●	●	●
Spillways	Approach channel	●	●	–	●	–	–	–	–	–	–
	Inlet/outlet structure	●	●	●	●	●	–	–	●	●	–
	Stilling basin	●	–	–	●	–	–	–	●	–	–
	Discharge conduit/ channel	●	–	●	●	–	–	–	–	–	–
	Gate controls	●	–	–	–	–	–	–	–	–	–
	Erosion protection	●	–	–	–	–	–	–	–	–	–
	Side slopes	●	●	●	–	●	–	–	–	–	–

Type	Feature	Visual observation	Movements	Uplift and pore pressure	Water levels and flow	Seepage flows	Water quality	Temperature measurement	Crack and joint measurement	Seismic measurement	Stress-strain measurement
Outlets & Drains	Inlet/outlet structure	●	●	●	●	–	–	–	●	●	–
	Stilling basin	●	–	–	–	–	–	–	–	–	–
	Discharge conduit/channel	●	●	●	●	–	–	–	●	–	–
	Trash rack/debris controls	●	–	–	–	–	–	–	–	–	–
	Emergency systems	●	–	–	–	–	–	–	–	–	–
General Areas	Reservoir surface	●	–	–	–	–	●	–	–	–	–
	Mechanical/ electrical systems	●	–	–	●	–	–	–	–	–	
	Shoreline	●	–	–	–	–	●	–	–	–	–
	Upstream watershed	●	–	–	–	–	●	–	–	–	–
	Downstream channel	●	–	–	–	●	●	–	–	–	–
Barrages	Upstream of the barrage axis	●	–	–	●	–	–	–	–	–	–
	Downstream of the barrage axis	●	–	–	●	–	–	–	–	–	–
	Representative Bays	●	–	●		–	–	–	–	–	–
	Concrete, Reinforcement and in foundation Soil	●	–	–	–	–	–	–	–	–	●
	Joints between the toe of abutments and the first and last barrage bay floor	●	●	–	–	–	–	–	–	–	–

Note: Following criteria has been adopted for minimum instrumentation in dams:

- The minimum set of required instruments as specified above shall be applicable, however, since each dam is unique, the required actual instruments shall be installed considering site conditions and using engineering judgement.
- The re-instrumentation in the existing dams should be done as governed by the site requirement, local conditions and without causing damage to the structure.

- The suggested instrumentation is minimum in general. However, the instrumentation may NOT be limited to above and desired instruments may be installed keeping overall functional requirements and importance of structure.

Manner of installation of instruments:

- Installation of instrumentation shall be done in consultation and coordination of Designers/Engineering consultants with instrument manufacturers or suppliers as they will provide assistance with instrument selection, installation, calibration, maintenance and future troubleshooting.
- Manufacturers shall provide the necessary training/demonstration related to installation, operation and maintenance of the instruments to those persons responsible for data monitoring to ensure that the Instrumentation fulfill its mandated purpose.
- Technical documentation shall include the technical requirements of the instruments, calibration requirements, installation report, servicing requirements and methods.
- The Installation report shall contain the following basic information:
    - Details of location of instruments
    - Serial numbers/ Identification number of installed instruments
    - Initial calibration readings Initial field readings with associated data (e.g. headwater and tail-water elevations, temperature, antecedent rainfall, weather conditions etc.)
    - Plans and sections sufficient to show instrument numbers and locations
    - Appropriate surface and sub-surface strata graphic and geotechnical data
    - Descriptions of instruments and readout units including manufacturer's literature and performance specifications (photographs are often helpful)
    - Details of calibration procedures
    - Details of installation procedures (photographs are often helpful) as well as the steps necessary for operation (i.e. troubleshooting concerns, connection to data loggers, etc)
    - Initial readings of the installed instruments.

54 (2) **(j)** *The form, manner and time interval for forwarding the analysis of readings to the State Dam Safety Organisation under sub-section (2) of section 32;*

Section 32. (2) Every owner of the specified dam shall maintain a record of readings of the instrumentations referred to in sub-section (1) and forward the analysis of such readings to the State Dam Safety Organisation, in the form, manner and at such interval as may be specified by the regulations.

Record of readings of the instrumentations:

a) Manual readings collection from instruments or stand alone data loggers:

- Readings shall be recorded either in a field book or on specially prepared field data sheets.
- Project name, instrument type, date, time, observer, readout unit number, instrument number, readings, remarks, weather, temperature, construction activity, and any other factors that might possibly influence the readings may be clearly indicated in the format for collection of readings.
- The latest readings shall be compared immediately with previous readings so that changes can be verified as real or as errors caused by misreading or instrument malfunction.
- Raw data shall be copied and the copied & original data is to be stored in separate safe places to guard against loss.
- Registers of records for all instruments properly indexed, indicating page numbers shall be maintained at safe location with responsible project personnel.
- All the instrumentation data recorded manually, is to be digitized for storage, analysis and retrieval.

b) Automatic Data Acquisition System:

The frequency of data acquisition shall be set as per requirement of each data set. The frequency of data acquisition may be reviewed to incorporate any abnormal/abrupt changes in the concerned parameters.

The form and manner of readings/data:

After collection and digitization, the observed data shall always be summarized in graphical form so that trends and real changes may be represented.

Interval to forward the analysis of such readings to the State Dam Safety Organisation (SDSO):

a) Existing dams: An interpretation report may be prepared by the dam unit containing the data plots for all the instrumentation of the dam indicating variations and possible causes thereof on a half yearly basis. However, in case of an emergent situation, when there are abnormalities in the observed data or otherwise, calling for an immediate action/remedial measure, the SDSO may be reported immediately, and on real time basis, thereafter.

b) Under Construction dams: For these dams, the frequency of forwarding of analysis may be according to monitoring schedule governed by the design & construction requirement and stage of the project.
In this case also, if there is sudden change or abnormality in the observed data or otherwise, which may require an immediate attention, the frequency of observation shall be increased as per the field requirement, depending on the emergency condition.

54 (2) ***(k)*** *The data requirements of hydro-meteorological stations in the vicinity of specified dams under sub-section (1) of section 33;*

Section 33 (1) Every owner of a specified dam shall establish a hydro-meteorological station in the vicinity of each specified dam capable of recording such data as may be specified by the regulations.

For safe operation of any hydraulic structure following hydro-meteorological data are required:

1. Rainfall
2. Water level
3. Discharge
4. Temperature
5. Humidity
6. Evaporation
7. Wind velocity and direction
8. Snowfall, as applicable
9. Reservoir sedimentation data through bathymetric survey at 10 to 15 years interval

Accordingly, the following hydro-meteorological observation instruments shall be required:

1. Ordinary Rain Gauge at dam site and Self Recording Rain Gauge (SRRG) in the free catchment area of the dam
2. Digital Water level recorder or Staff gauge for stage measurement at dam site
3. Inflow forecast for the reservoir shall be carried out using rainfall and /or discharge data, as applicable. Releases into the reservoir from upstream projects, if any, shall be considered.
4. Minimum and Maximum thermometer at dam site
5. Dry and wet bulb thermometers at dam site
6. Evaporation pan at dam site
7. Anemometer and wind-vane at dam site
8. Snow gauge, as applicable, in the free catchment area of the dam

54 (2) (l) *The data requirements of seismological stations in the vicinity of specified dams under sub-section (1) of section 34;*

Section 34. (1): In the case of every specified dam, having a height of thirty metres or above or falling under such seismic zone, as may be specified by the regulations, the owner of the specified dam shall establish a seismological station in the vicinity of each such dam for recording micro and strong motion earthquakes and such other data as may be specified by the regulations.

Strong-motion accelerographs (SMA) for recording potentially destructive ground shaking and resulting dam vibrations; and seismographs for determining the local seismicity are required to be installed at each specified dams as described below:

S. No.	Seismic Zone(as per IS code 1893 (Part-1) 2016)	Dam Height (H) meters	No. of Strong Motion Accelerograph (SMA)	No. of Seismograph
1.	**II and III**	H≤15	At least one (1) nos. instrument as mentioned below. For dams of height 15m or less, where earthquake forces were not considered in the original design, has significant hazard potential (as specified in Regulation "b" of section 54 of Dam Safety Act, 2021) and/ or special foundation conditions like potential liquefaction, the SMA may be provided at the foundation level (in the gallery or at the d/s toe, if the gallery is not present)	A single station near vicinity of the dam (nearest possible location, if possible within 1 Km from dam). If at least 10 events with magnitude above 1.0 are recorded within 50 km distance and within a year, a local network of at least 5 stations should be operated for at least three years. These observations will have to be continued if such seismic events with similar frequency observed even after three years.
		15<H<60	At least four (4) nos. instruments as mentioned below. One at foundation gallery/ a location at the d/s toe of the dam (if the foundation gallery is not present) and the other at the top of the dam and one in the free-field (3-4 times dam height i.e. H from dam body or base, preferably on the upstream side) and one on either abutment have to be installed.	A single station near vicinity of the dam (nearest possible location, if possible within 1 Km from dam). If at least 10 events with magnitude above 1.0 are recorded within 50 km distance and within a year, a local network of at least 5 stations should be operated for at least three years. These observations will have to be continued if such seismic events with similar frequency observed even after three years.
		60≤H<100	At least six (6) nos. instruments as mentioned below. For dams between 60 m and 100 m of height, three instruments may be put in the highest section of the dam (base, middle and top), one in the free-filed (3-4 times dam height i.e.	A single station near vicinity of the dam (nearest possible location, if possible within 1 Km from dam). If at least 10 events with magnitude above 1.0 are recorded within 50 km distance and within a year, a local

			H from dam body or base, preferably on the upstream side), and one on each abutment.	network of at least 5 stations should be operated for at least three years. These observations will have to be continued if such seismic events with similar frequency observed even after three years.
		H≥100	All dams with H≥100 m should be instrumented comprehensively as per the schemes indicated in the Figure 1, Figure2 &Figure3, below for Arch, Gravity &Embankment dams respectively.	A single station near vicinity of the dam(nearest possible location, if possible within 1 Km from dam). If at least 10 events with magnitude above 1.0 are recorded within 50 km distance and within a year, a local network of at least 5 stations should be operated for at least three years. These observations will have to be continued if such seismic events with similar frequency observed even after three years.
2.	**IV and V**	H<30	At least four (4) nos. instruments as mentioned below. One at the foundation gallery and one at the top of the dam at the block/ RD having maximum height from the deepest foundation and one in the free-field (3-4 times dam height i.e. H, from dam body or base, preferably on the upstream side) may be installed for a dam up to 30 m of height and one on either abutment.	A single station near vicinity of the dam. (nearest possible location, if possible within 1 Km from dam). If at least 100 events with magnitude above 1.0 are recorded within 50 km distance in a year, a local network of at least 5 stations should be operated for at least three years. These observations will have to be continued if such seismic events with similar frequency observed even after three years.
		30≤H<60	At least six (6) nos. instruments as mentioned below. For dams between 30 m and 60 m of height, three instruments may be put in the highest section of the dam (base, middle and top), one in the free-field (3-4 times dam height i.e. H, from dam body or base, preferably on the upstream side), and one on each abutment.	A single station near vicinity of the dam. (nearest possible location, if possible within 1 Km from dam). If at least 100 events with magnitude above 1.0 are recorded within 50 km distance in a year, a local network of at least 5 stations should be operated for at least three years. These observations will have to be continued if such seismic events with similar frequency observed even after three years.
		H≥60	For dams of height more than 60m, at least one spillway monolith of greatest height should be chosen. If there are any special foundation conditions with concerns of sliding/ slope instability, such locations should also be provided with one SMA at the base of the slope/ at the foundation feature. All dams with H≥60 m should be	A single station near vicinity of the dam (nearest possible location, if possible within 1 Km from dam). If at least 100 events with magnitude above 1.0 are recorded within 50 km distance in a year, a local network of at least 5 stations should be operated for at least three years. These observations will have to be continued if such seismic events with similar frequency observed even after three years.

			instrumented comprehensively as per the schemes indicated in the Figure 1, Figure2 &Figure3 below for Arch, Gravity& Embankment dams respectively.	If dam height (H) ≥100m or Reservoir capacity >1BCM Minimal network of 5 seismographs can be deployed for Micro earthquake studies. For a new project network should be deployed for a period of at least one year during DPR stage and should be continued even after commissioning, with relocation of seismographs wherever required. Further, for existing project also such network should be established.

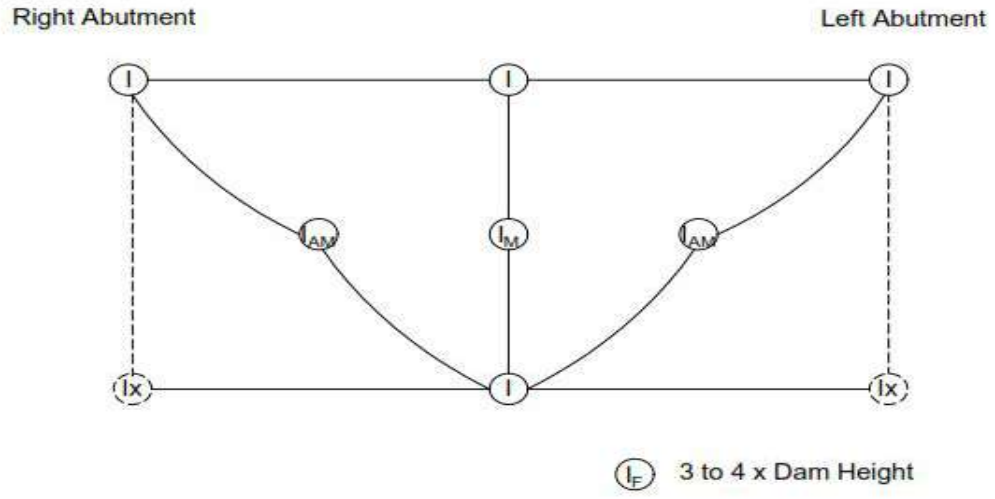
For planning of instruments in the dam above table may be referred. However, if length of the dam is more than 500m then additional instrument may be installed as described below:

(i) For every 500m increase in length of the dam one additional Strong Motion Accelerographs (SMAs) may be installed on dam top and correspondingly one more Strong Motion Accelerographs (SMAs) may be installed in gallery.

In such cases, wherein the dam layout comprises of independent dams of different types across multiple channels with intervening abutments, then each of them should be considered as independent dams for applicability of provisions according to the criteria specified above.

1.1 Arch dams

Instrumentation schemes: Total no. of **Strong Motion Accelerographs (**SMAs**)** instruments nine (9) as shown in Figure 1 for Arch dams.

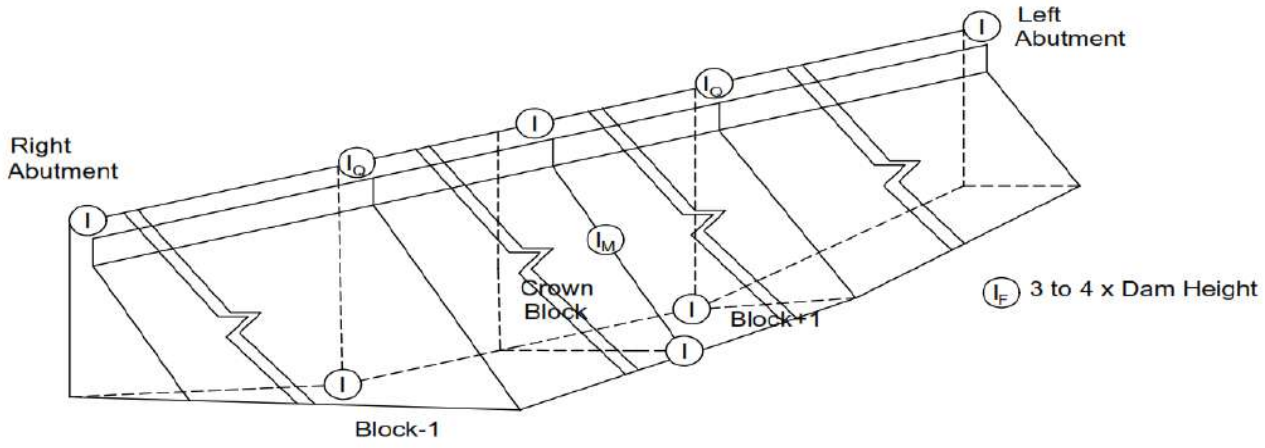


I: Strong Motion Accelerographs (SMA)
Ix:Strong Motion Accelerographs (SMA) either on left abutment side or right abutment side
I_F: Free Field Motion Strong Motion Accelerographs (SMA), to be placed at 3 to 4 times of Dam Height (H) from Dam body or base
I_M: Strong Motion Accelerographs (SMA), to be placed in the middle height portion of Dam (preferably having deepest section)
I_{AM}: Strong Motion Accelerographs (SMA), to be placed in the middle height portion of Dam Abutment

Figure- 1. Accelerograph arrays for arch dams (Downstream View)

1.2 Gravity dams

Instrumentation schemes: Total no. of **Strong Motion Accelerographs (**SMAs**)** instruments ten (10) as shown in Figure 2 for Gravity dams.

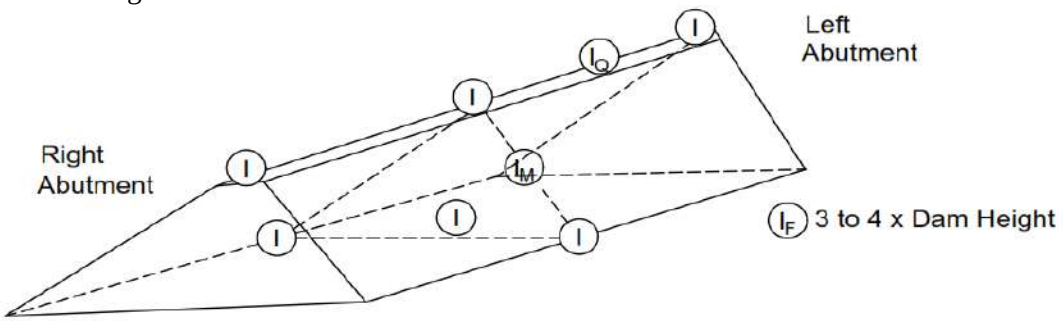


I: Strong Motion Accelerographs (SMA)
I_F: Free Field Motion Strong Motion Accelerographs (SMA), to be placed at 3 to 4 times of Dam Height (H) from Dam body or base
I_Q: Strong Motion Accelerographs (SMA), to be placed at quarter block (symmetrical to the central block)
I_M: Strong Motion Accelerographs (SMA), to be placed in the middle height portion of deepest block

Figure 2 - Accelerograph arrays for gravity dams

1.3 Embankment dams:

Instrumentation (schemes): Total no. of **Strong Motion Accelerographs (**SMAs**)** instruments nine (9) as shown in Figure 3 for embankment dams.



I: Strong Motion Accelerographs (SMA)

I_F: Free Field Motion Strong Motion Accelerographs (SMA), to be placed at 3 to 4 times of Dam Height (H) from Dam body or base

I_Q: Strong Motion Accelerographs (SMA), to be placed at quarter point either from Left Abutment or Right Abutment

I_M: Strong Motion Accelerographs (SMA), to be placed in the middle height portion of Dam (preferably having deepest section)

Figure 3 - Accelerograph arrays for embankment dams

54 (2) (m) *The suitable location and manner of collection, compliance, process and storage of data under sub-section (2) of section 34;*

Section 34 (2): Every owner of a specified dam shall collect, compile, process and store data referred to in sub-section (1) at such suitable location and in such manner as may be specified by the regulations.

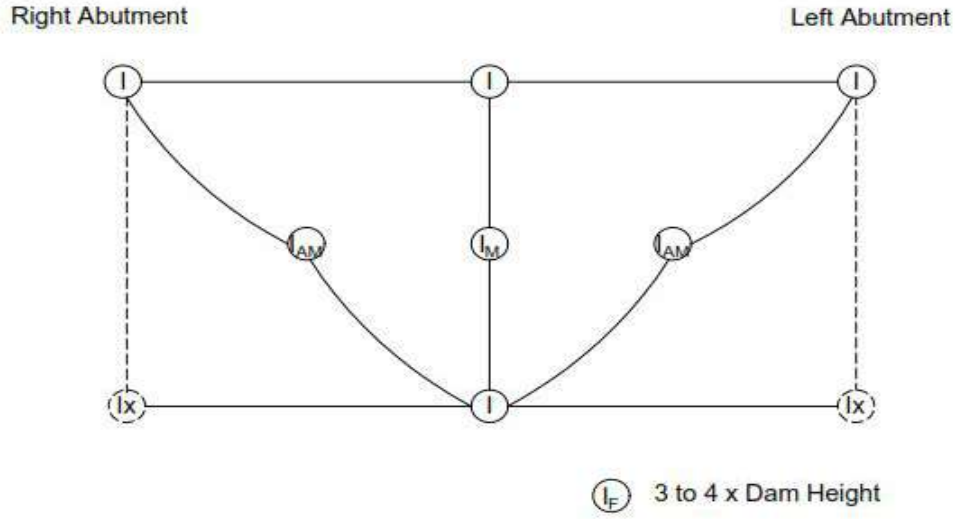
1 Suitable Location

S. No.	Seismic Zone(as per IS code 1893 (Part-1) 2016)	Dam Height (H) meters	Suitable Location of Strong Motion Accelerograph (SMA)	Suitable Location of Seismograph
1.	**II and III**	H<100	Refer Regulation (l), (to be) issued under clause 54 of Dam Safety Act 2021.(The data requirements of seismological stations in the vicinity of specified dams under sub-section (*1*) of section 34)	Refer Regulation (l), (to be) issued under clause 54 of Dam Safety Act 2021.(The data requirements of seismological stations in the vicinity of specified dams under sub-section (*1*) of section 34)

		H≥100	All dams with H≥100 m should be instrumented comprehensively as per the schemes indicated in the Figure 1, Figure 2 & Figure 3, below for Arch, Gravity & Embankment dams respectively.	Refer Regulation (l), (to be) issued under clause 54 of Dam Safety Act 2021.(The data requirements of seismological stations in the vicinity of specified dams under sub-section (*1*) of section 34)
2.	**IV and V**	H<60	Refer Regulation (l), (to be) issued under clause 54 of Dam Safety Act 2021.(The data requirements of seismological stations in the vicinity of specified dams under sub-section (*1*) of section 34)	Refer Regulation (l), (to be) issued under clause 54 of Dam Safety Act 2021.(The data requirements of seismological stations in the vicinity of specified dams under sub-section (*1*) of section 34)
		H≥60	All dams with H≥60 m should be instrumented comprehensively as per the schemes indicated in the Figure 1, Figure 2 & Figure 3 below for Arch, Gravity & Embankment dams respectively.	Refer Regulation (l), (to be) issued under clause 54 of Dam Safety Act 2021.(The data requirements of seismological stations in the vicinity of specified dams under sub-section (*1*) of section 34)

1.1 Arch dams

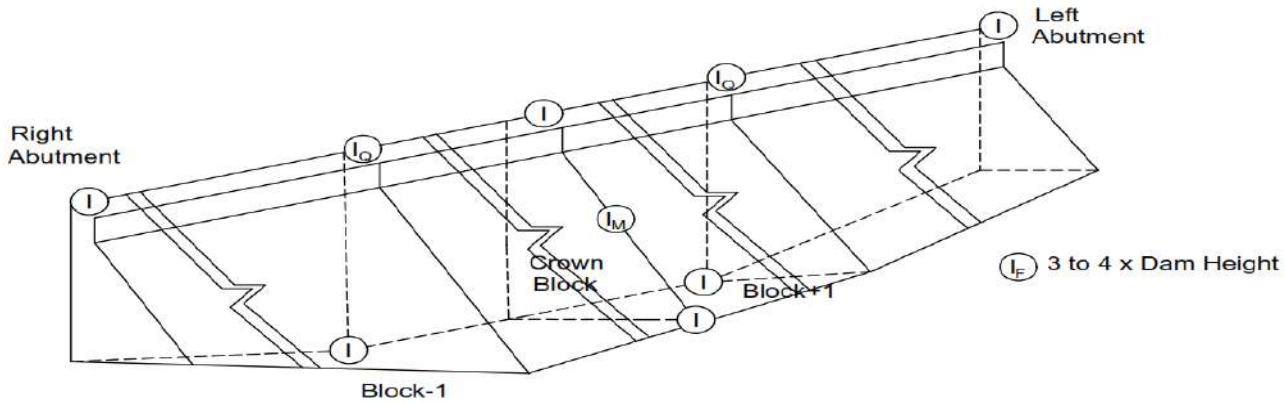
Instrumentation schemes: Instrumentation schemes: Total no. of **Strong Motion Accelerographs (**SMAs**)** instruments nine (9) as shown in Figure 1 for Arch dams.



I: Strong Motion Accelerographs (SMA)
Ix:Strong Motion Accelerographs (SMA) either on left abutment side or right abutment side
I_F: Free Field Motion Strong Motion Accelerographs (SMA), to be placed at 3 to 4 times of Dam Height (H) from Dam body or base
I_M: Strong Motion Accelerographs (SMA), to be placed in the middle height portion of Dam (preferably having deepest section)
I_{AM}: Strong Motion Accelerographs (SMA), to be placed in the middle height portion of Dam Abutment

Figure- 1. Accelerograph arrays for arch dams (Downstream View)

1.2 Gravity dams Instrumentation schemes: Total no. of **Strong Motion Accelerographs (**SMAs**)** instruments ten (10) as shown in Figure 2 for Gravity dams.

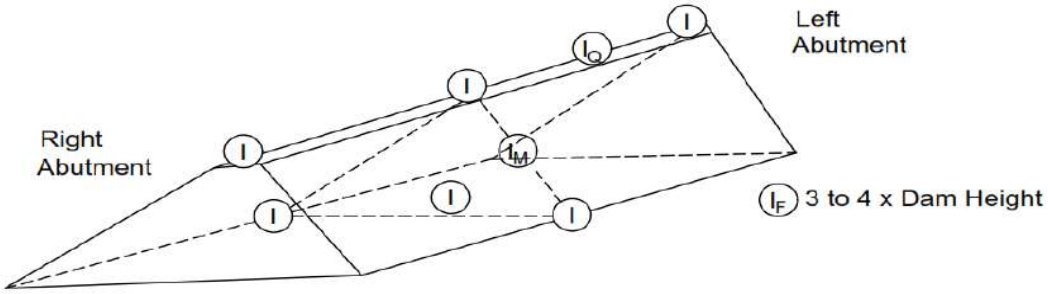


I: Strong Motion Accelerographs (SMA)
I_F: Free Field Motion Strong Motion Accelerographs (SMA), to be placed at 3 to 4 times of Dam Height (H) from Dam body or base
I_Q: Strong Motion Accelerographs (SMA), to be placed at quarter block (symmetrical to the central block)
I_M: Strong Motion Accelerographs (SMA), to be placed in the middle height portion of deepest block

Figure 2 - Accelerograph arrays for gravity dams

1.3 Embankment dams:

Instrumentation (schemes): Total no. of **Strong Motion Accelerographs (**SMAs**)** instruments nine (9) as shown in Figure 3 for embankment dams.



I: Strong Motion Accelerographs (SMA)

I_F: Free Field Motion Strong Motion Accelerographs (SMA), to be placed at 3 to 4 times of Dam Height (H) from Dam body or base

I_Q: Strong Motion Accelerographs (SMA), to be placed at quarter point either from Left Abutment or Right Abutment

I_M: Strong Motion Accelerographs (SMA), to be placed in the middle height portion of Dam (preferably having deepest section)

Figure 3 - Accelerograph arrays for embankment dams

2. Manner of collection

All the **Strong Motion Accelerographs (**SMAs**), and Seismographs** should be connected to a central recording station for real time monitoring and data storage. All the **Strong Motion Accelerographs (**SMAs**)** and **Seismograph** shall preferably be GPS enabled. Central Recording station will be the main instrumentation room of the dam. This control room should have facilities for communication (broadband or network connection), GPS, batteries, battery chargers with 24 x 7 uninterrupted power supply. Recorder room should be fully air conditioned which should be able to cater to high humidity. This room should have water and airtight sealed doors so that leakage water from galleries may not enter the room. There should be clean passage (i.e. water should not get stored and other hindrances should not be there) from lift to this room so that installation and maintenance of instrumentation can be carried out with ease. In case of emergency, the room should have arrangements for rescue through vertical shaft.
The seismic instrument needs to be operated continuously and maintained periodically.

Care should be taken while installing the Strong **Motion Accelerographs (**SMAs**)** and **Seismographs** to ensure that they are installed in a room having proper ventilation and low moisture conditions.

In case of free field, a ventilated room must be made as given in Figure 4 & Figure 5 below. The **Strong Motion Accelerographs (**SMAs**)** /Seismographs should be properly bolted to a concrete slab. Proper water proofing of roof and wall must be carried out to avoid moisture inside room. Provision of conduit pipe is to be kept for wiring, if any required.

In case of dam top a ventilated room must be made as given in Figure 6 & Figure 7 below. The **Strong Motion Accelerographs (**SMAs**)** should properly be bolted to a concrete slab. Proper water proofing of roof and wall must be carried out to avoid moisture inside room. Provision of conduit pipe is to be kept for wiring, if any required.

For installation of **Strong Motion Accelerographs (**SMAs**)** in foundation gallery, the SMAs should be placed in sealed environment so that they could be protected from humidity in gallery. The SMAs should be placed at such height so that they are protected from the flooding.

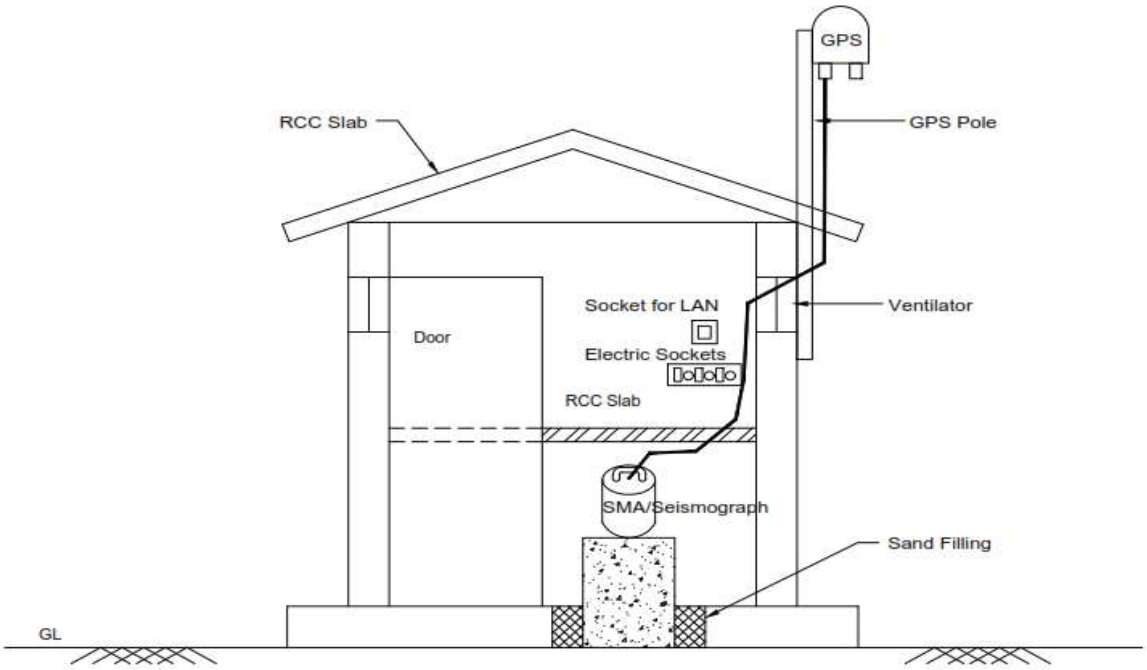


Figure 4
Sectional View
For Free Field Accelerograph/Seismograph Room

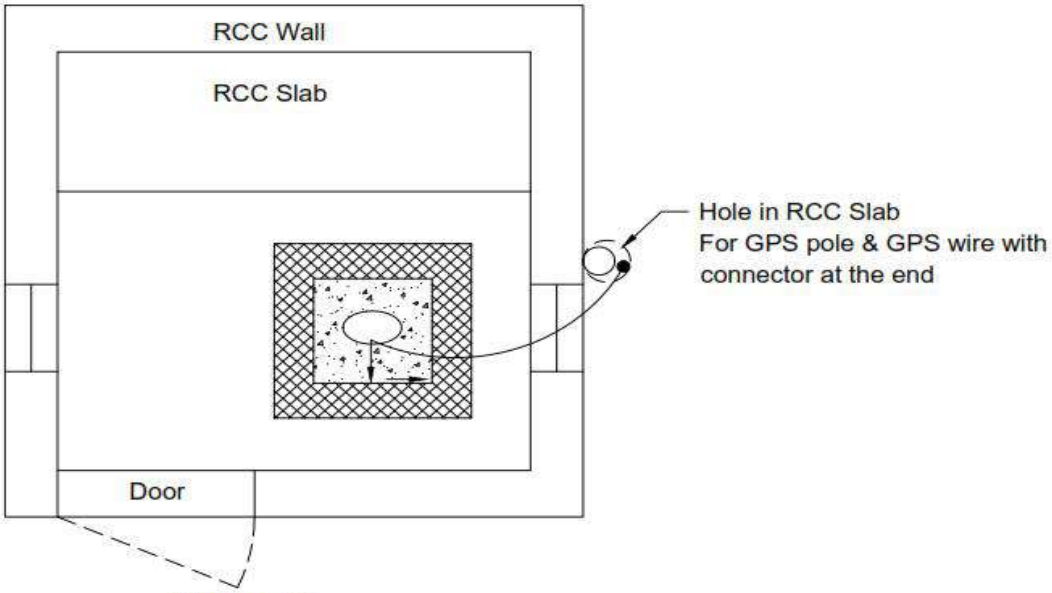


Figure 5
Plan View
For Free Field Accelerograph/Seismograph Room

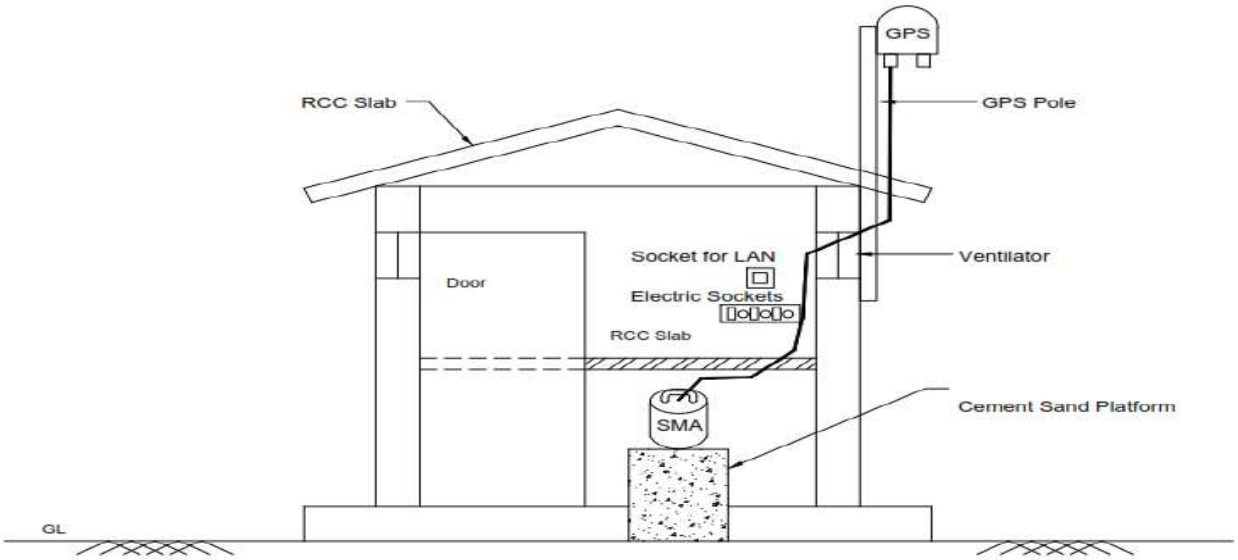


Figure 6
Sectional View
For Dam Top Accelerograph Room

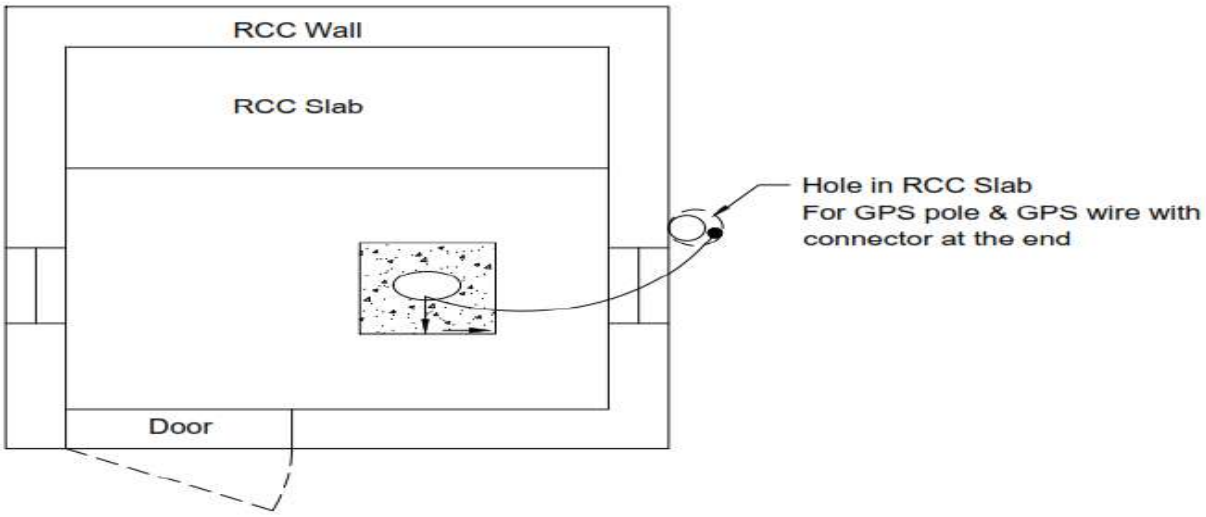


Figure 7
Plan View
For Dam Top Accelerograph Room

3 Data processing:

The raw data recorded by the **Strong Motion Accelerographs (**SMAs**)** and **Seismograph** needs to be corrected for the Scaling Error, Random Error in Time and Acceleration Records, Baseline Errors, and Band Passed Filtering. The raw data of acceleration, velocity time histories obtained from above instruments needs to be processed for getting final output respectively. Then, the displacement time history can be evaluated from the final output of acceleration &velocity time histories, if required.

Strong motion data as recorded should be analyzed to estimate the dynamic characteristics (natural frequency and damping ratio) of the dam and also used to scale up the observed response of a dam to possible strongest earthquake to assess the safety of the dam to actual earthquakes and a report shall be prepared.

4 Data Storage:

The **Strong Motion Accelerographs (**SMAs**)** and **Seismograph** should be operated in continuous data acquisition mode. The storage media size should be sufficient to store above data.

54 (2) (r) *The mandatory site specific seismic parameter studies of existing specified dams under clause (c) of sub-section (2) of section 38;*

Section 38 sub-section (2) (c) general assessment of seismic safety of specified dam with mandatory site specific seismic parameters study in certain cases as specified by the regulations;

General Assessment:

1. The specified dam shall be assessed for its structural performance i.e. it should have strength to resist seismic forces without damage; capability to absorb high seismic forces by inelastic deformations (opening of joints and cracks in concrete dams; movements of joints in the foundation rock; inelastic deformation characteristics of embankment materials) and stability against sliding and overturning stability.
2. There may be multiple types of dams forming a common reservoir. In such case, each such dam reach should be evaluated separately and safety assured. For dams of same type but spanning across separate abutments for a common reservoir, each dam will be assessed independently of each other for seismic safety.
3. Interfaces especially between rigid structures like masonry/ concrete and soils/ rocks are vulnerable to the separation and damage which may prove hazardous. It is necessary that integrity of such interfaces should also be evaluated for the seismic safety assessment of the dam(s).
4. A number of old dams have been provided with composite structures in which the masonry wall is deriving stability through a earth/ rockfill backing on downstream. Alternately a number of old dams have been strengthened through provision of buttresses/ backing of masonry or concrete. The safety of interface integrity in the event of a design seismic event should be ensured.
5. For the above purpose it is important to ensure following for its safety monitoring :
    a. strong motion instrumentation of dam and foundation
    b. visual observations and inspection after an earthquake
    c. data analysis and interpretation
    d. post-earthquake safety assessment
6. Further, it is important that the structure serves its intended purpose safely like following the Rule curves and various operational guidelines even after the earthquake. For this purpose it is important to place experienced and qualified dam maintenance staff.
7. In the event of an earthquake, the post earthquake management of reservoir may require depletion to handle reduced structural capacity of the dam. It is therefore, necessary that the hydro mechanical equipment and gates should be designed and tested for continued operability in a post earthquake scenario. This is especially critical in case of dams located in zones IV and V.
8. However, to deal with any untoward incident it is also important to be prepared from disaster perspective with robust Emergency Action Plan having water alarm, inundation mapping and evacuation plans. In case of any such eventuality it is also important to access the dam and reservoir safely after a strong earthquake and also the dam authority should be able to lower the reservoir minimizing the impact.

Mandatory site specific seismic studies:

The site specific seismic studies need to be carried out in respect of all such specified dams that are classified under '**Critical**' or '**Significant**' hazard potential categories as specified in Regulation "b" of section 54 of Dam Safety Act, 2021. Further, the seismic parameters should be reviewed if:

I. More frequent seismic activity observed in the region (substantially higher than the past seismic activity).
II. Any extreme seismic event having potential to affect/damage structure is observed (i.e., an event with magnitude of Peak Ground Acceleration (PGA) greater than the PGA corresponding to Design Basis Earthquake(DBE))
III. Major modification is proposed/ carried to the original structure or in design criteria.

IV. Major geological activity reported in the region.

54 (2) (a): *the guidelines, standards and other directions for achieving the satisfactory level of dam safety assurance under sub-section (1) of section 16;*

Section 16 (1): Every State Dam Safety Organisation shall, -

(a) keep perpetual surveillance;
(b) carry out inspections; and
(c) monitor the operation and maintenance,

of all specified dams falling under their jurisdiction to ensure continued safety of such specified dams and take such measures as may be necessary to address safety concerns that are noticed with a view to achieve satisfactory level of dam safety assurance as per such guidelines, standards and other directions on dam safety as may be specified by the regulations

(a) keep perpetual surveillance

Dam owners are primarily responsible for surveillance of Dams including the security and safety as per the operation and maintenance manual for the said dam.

(b) carry out inspections

The dam owner shall carry out the routine inspections, such as pre and post monsoon inspections, and also all the special inspections, viz.: inspections during and after every flood, earthquake or any such natural or man-made calamities, or if any sign of distress or any unusual behaviour is noticed in the dam body or any of its appurtenant structure.

Further, inspection shall also be carried out before initial filling of the reservoir to test the fitness of dam for filling.

(c) Monitoring the operation and maintenance

Operation and Maintenance of each specified dam shall be carried out as per the operation and maintenance manual of the said dam.

54 (2) (n): *The time interval of risk assessment studies to be carried out under sub-section (2) of section 35;*

Section 35 (2): Every owner of a specified dam, for each of its dam shall, carry out risk assessment studies at such interval as may be specified by the regulations and the first such study shall be made within five years from the date of commencement of this Act.

Risk assessment studies of each specified dam shall be carried out within 5 years from the date of commencement of the Dam Safety Act, 2021.

Thereafter, the risk assessment studies of each specified dam shall be carried out at every 10 years.

54 (2) (p): *The time interval for the comprehensive safety evaluation of specified dams under sub-section (1) of section 38;*

Section 38. (1) The owner of a specified dam shall make or cause to be made comprehensive dam safety evaluation of each specified dam through an independent panel of experts constituted as per regulations for the purpose of determining the conditions of the specified dam and its reservoir:

Provided that the first comprehensive dam safety evaluation for each existing specified dam shall be conducted within five years from the date of commencement of this Act, and thereafter the comprehensive dam safety evaluation of each such dam shall be carried out at regular intervals as may be specified by the regulations.

Comprehensive safety evaluation of each specified dam shall be carried out within 5 years from the date of commencement of the Dam Safety Act, 2021.

Thereafter, the Comprehensive safety evaluation of each specified dam shall be carried out at every 10 years.

*****

Annexure-III

Comments received on six draft regulations

Sr. No.	Regulation	Comments received				
		WRD Karnataka	**SDSO Uttarakhand**	**NDMA**	**IMD**	**Member (Regulations), NDSA**
54(2) i.	***The minimum number of set of instrumentations in the specified dams and the manner of their installation under sub-section (1) of section 32;*** ***Section 32. (1) Every owner of a specified dam shall have a minimum number of such instrumentations at each specified dam, and installed in such manner as may be specified by the regulations for monitoring the performance of such dam.***	Concurred in general, but note given under the section will be governing factor	➢ More no. of instruments should be added ➢ Time period of observation in respect of good functioning of the instruments should be added to Installation report.	No comments	No comments	➢ The regulation pertains to minimum nos. of instrumentation required to ensure monitoring the performance of specified dams. Therefore, the column specifying the *'visual observation'* is not relevant and superfluous. Further, the whole table apparently pertains to prescription of inspections for various parameters. Instead, the minimum number of instruments required to observe the said parameters should have been specified. ➢ Stress – Strain Measurement for Embankments may be included.
54(2)j.	***The form, manner and time interval for forwarding the analysis of readings to the State Dam Safety Organisation under sub-section (2) of section 32;*** ***Section 32. (2) Every owner of the specified dam shall maintain a record of readings of the instrumentations referred to in sub-section (1) and forward the analysis of such readings to the State Dam Safety Organisation, in the form, manner and at such interval as may be specified by the regulations.***	Concurred-Further a standard format may be issued for preparation of interpretation report for existing dams	➢ Automatic Data acquisition system should be real time-based telemetry system.	No comments	No comments	No comments

54(2) k.	***The data requirements of hydro-meteorological stations in the vicinity of specified dams under sub-section (1) of section 33;*** ***Section 33 (1) Every owner of a specified dam shall establish a hydro-meteorological station in the vicinity of each specified dam capable of recording such data as may be specified by the regulations.***	Concurred with provision made in the draft regulations	➢ For safe operation of any hydraulic structure following hydro-meteorological data are required: - Sediment Inflow & outflow data ➢ Frequency of carrying out Reservoir sedimentation has recommended as 05 years by Reservoir Sedimentation Committee of DoWR, RD & GR (earlier Ministry of Irrigation), GoI vide letter No. 57/4/76- P.II dated 27.11.1984 and also Clause 7.10 of IS 7323 'Operation of Reservoirs' states that "Capacity surveys should be done to compute the actual storage capacities at various levels at regular intervals depending on the rate of sedimentation. The higher the rate of sedimentation, the greater will be the frequency of survey. Capacity survey of reservoirs may be carried out once in 3 to 5 years or when the loss of capacity is 5 percent, whichever is earlier.	No comments	No comments	➢ SRRGs will require human intervention for collecting data as well changing graph papers. It is suggested that ARGs may be preferred. ➢ Some of the projects are in remotest area and therefore it may not possible to measure discharge by manual methods. Therefore, establishment of telemetry station may be considered. ➢ Bathymetric survey is altogether a different filed and therefore it shall not get covered under the proposed regulation.
54(2)l.	***The data requirements of seismological stations in the vicinity of specified dams under sub-section (1) of section 34;*** ***Section 34. (1): In the case of every specified dam, having a height of thirty metres or above or falling under such seismic zone, as may be specified by the regulations, the owner of the specified***	The number of Strong Motion Acceleration (SMA) and seismograph appears to be on higher side	Automatic Data Acquisition System should be added: 1. Automatic Water Level Recorder (AWLR) with velcimeter 2. Automatic Weather Station (AWS) equipped with facilities of observations of rainfall, real	No comments	No comments	The location SMAs at 1.1, 1.2 & 1.3 get covered in regulation (m). Therefore, it may be deleted from here.

	dam shall establish a seismological station in the vicinity of each such dam for recording micro and strong motion earthquakes and such other data as may be specified by the regulations.		time, minimum & maximum temperatures, evaporation, wind velocity & its direction, relative humidity, bright sunshine hours. 3. Instruments required as per Reports for Early Warning & Flood Forecasting and Emergency Action Plan requirements. 4. SCADA system at dam for safe operation			
54(2) m	***The suitable location and manner of collection, compliance, process and storage of data under sub-section (2) of section 34;*** ***Section 34 (2): Every owner of a specified dam shall collect, compile, process and store data referred to in sub-section (1) at such suitable location and in such manner as may be specified by the regulations.***	Concurred with provision made in the draft regulations	No comments	No comments	No comments	No comments
54(2) r	***The mandatory site-specific seismic parameter studies of existing specified dams under clause (c) of sub-section (2) of section 38;*** ***Section 38sub-section (2) (c)general assessment of seismic safety of specified dam with mandatory site-specific seismic parameters study in certain cases as specified by the regulations;***	Concurred with provision made in the draft regulations	No comments	No comments	No comments	No comments

Comments on 06 draft regulations received from Prof. CVR Murty

Broad Comments

The few lines being given as *Guidelines* are insufficient to aid the DSOs in implementing the said provisions of the Act. Detailed document should be prepared in the long run, which addresses earth dams, masonry dams and concrete dams of different structural configurations. Then, these *brief notes* (now being called *Guidelines*) should be replaced by the *detailed Guidelines*.

Section 54(2)(i)

The minimum number of set of instrumentations in the specified dams and the manner of their installation under sub-section (1) of section 32;

Section 32(1)

Every owner of a specified dam shall have a minimum number of such instrumentations at each specified dam, and installed in such manner as may be specified by the regulations for monitoring the performance of such dam.

1.1 Instrumentation of Dams

The criteria for minimum instrumentation in dams are:

(1) The DSOs should have an empowered *Technical Committee*, which advises the DSO on the details of *selection* (number, location and type) of instruments to be placed on the specified dams.

Vendors should not be entrusted with the responsibility of determining the specifications for selection of instruments. **This is conflict of interest, and a matter of audit and vigilance.**

(2) The minimum number, location and type of instruments required to be placed on the specified dams depends on the size of the dam and site conditions. This is because each dam is unique and determining the above requires engineering judgment. Here, the decision of the empowered *Technical Committee* shall be binding.

(3) The types of measurements and broad locations of instruments to be placed on specified dams are indicated in **Table 1**. Theses are the minimum requirements. The Technical Committee empowered by the DSO may specify more than those specified in Table 1 keeping in mind overall functional requirements and importance of dam.

1.2 Installation of Instruments

(1) The *Technical Committee* empowered by the DSOs shall advise on the details of *installation*, *calibration*, *recording* (especially frequency of sampling, data storage, data transfer and data processing), *maintenance* and *troubleshooting of instruments*. While placing instruments on an existing dam, sufficient care should be taken to *not damage* the dam.

Vendors should not be entrusted with the responsibility of determining the specifications for calibration and maintenance of instruments. **This is conflict of interest, and a matter of audit vigilance.**

(2) Engineers of the DSOs shall get their engineers (who are responsible for the upkeep of the instruments) trained in the correct use of instruments. Agreements shall be drawn up with manufacturers for providing the necessary training related to *installation*, *operation* and *maintenance* of the instruments to the engineers.

(3) Technical documentation related to the instruments shall detailed and include the *specifications*, and methods and requirements of *installing*, *calibrating* and *servicing* the instruments. Also:

(a) The *Specifications Document* shall include:

(1) …
(2) …
(3) …

(b) The *Installation Document* shall include:

(1) …
(2) …
(3) …

(c) The *Calibration Document* shall include:

(1) …
(2) …
(3) …

(d) The *Servicing Document* shall include:

(1) …
(2) …
(3) …

Table 1: Broad locations of instruments for monitoring specified dams

Type	*Feature*	*Movements*	*Uplift & Pore Pressure*	*Water Levels & Flow*	*Leakage Flow*	*Seepage Flow*	*Water Quality*	*Temperature*	*Cracks & Joint*	*Earthquake Shaking*	*Strains*
Embankment Dam Body	Upstream Slope Face	✓	✓	✓						✓	
	Downstream Slope Face	✓	✓		✓	✓	✓	✓	✓	✓	
	Abutments	✓	✓			✓	✓	✓		✓	
	Crest	✓	✓						✓	✓	
	Body of Dam *(Gallery for Internal Drainage, if any)*		✓		✓	✓	✓	✓		✓	
	Relief Drain		✓			✓	✓				
	Riprap and other Slope Protection										
Concrete & Masonry Dam Body	Upstream Slope Face	✓		✓				✓	✓	✓	✓
	Downstream Slope Face	✓	✓		✓			✓	✓	✓	✓
	Abutments	✓	✓			✓	✓			✓	✓
	Crest	✓	✓					✓	✓	✓	✓
	Body of Dam *(Gallery for Internal Drainage, if any)*	✓	✓		✓	✓			✓	✓	✓
	Relief Drain		✓			✓					
Spillway	Approach Channel	✓		✓							
	Inlet and Outlet Structures	✓	✓	✓		✓			✓	✓	
	Stilling Basin			✓					✓		
	Discharge Conduit or Channel		✓	✓							
	Gate Controls										
	Erosion Protection										
	Side Slopes	✓	✓			✓					
Outlet & Drain	Inlet and Outlet Structures	✓	✓	✓					✓	✓	
	Stilling Basin										
	Discharge Conduit or Channel	✓	✓	✓					✓		
	Trash Rack and Debris Controls										
	Emergency Systems										
General	Reservoir Surface						✓				
	Mechanical and Electrical Systems			✓							
	Shoreline						✓				
	Upstream Watershed						✓				
	Downstream Channel					✓	✓				
Barrages	Upstream Slope Face			✓							
	Downstream Slope Face			✓	✓						
	Representative Bays		✓								
	Concrete, Reinforcement and Foundation Soil										✓
	Joints between toes of abutments and between first & last barrage bay floors	✓									

Section 54(2)(j)

The form, manner and time interval for forwarding the analysis of readings to the State Dam Safety Organisation under sub-section (2) of section 32;

Section 32(2)

Every owner of the specified dam shall maintain a record of readings of the instrumentations referred to in sub-section (1) and forward the analysis of such readings to the State Dam Safety Organization, in the form, manner and at such interval as may be specified by the regulations.

2.1 Record of Readings of Instruments

Readings should be taken through automated methods, to the extent possible. When only manual reading is possible, the data from the same shall be entered into an automated documentation system. In particular:

(a) Manual System:

Readings collected from instruments or by standalone data loggers:

(1) Readings shall be noted on a field book with specially prepared field data sheets. Such pages should have provision to record clearly the project name, instrument type, date, time, observer, readout unit number, instrument number, readings, remarks, weather, temperature, construction activity, and details of other factors that may influence the readings.

(2) The latest readings shall be compared immediately with previous readings. If there is an unusual change, the reading should be verified and examined to eliminate errors caused by misreading or instrument malfunction.

(3) Raw data shall be copied, and the copied & original data should be stored in different safe places to guard against loss.

(4) Registers of records of all instruments (properly indexed, indicating page numbers) shall be maintained at safe location under the custody of a responsible person.

(5) All data recorded manually should be digitized for *storage*, *analysis* and *retrieval*.

(b) Automatic Data Acquisition System:

The frequency of data acquisition shall be set as per requirement of each data set. It may be reviewed to incorporate any abnormal or abrupt change in the concerned parameters.

2.2 Form and Manner of Readings and Data

After collection and digitization, the observed data shall be summarized in graphical form so that trends and real changes may be understood instantaneously.

Interval to Forward Analysis of such readings to State Dam Safety Organization

(a) Existing Dams

An interpretation report should be prepared by the *Dam Safety Unit (DSU)* containing the data graphs of all instruments of the dam indicating variations and possible causes thereof on a half yearly basis. But, in an emergent situation, when there are sudden changes or abnormalities in the observed data or otherwise, the SDSO should be informed immediately, and remedial measures initiated in consultation with the SDSO.

(b) Dams under Construction

The frequency of analysis may be according to monitoring schedule governed by the design & construction requirement and stage of the project. When there are sudden changes or abnormalities in the observed data or otherwise, which may require immediate attention, the frequency of observation shall be increased as per the field requirement, depending on the emergent situation.

Section 54(2)(k)

The data requirements of hydro-meteorological stations in the vicinity of specified dams under sub-section (1) of section 33;

Section 33(1)

Every owner of a specified dam shall establish a hydro-meteorological station in the vicinity of each specified dam capable of recording such data as may be specified by the regulations.

3.1 Hydro-Meteorological Stations

For safe operation of a dam, the following *hydro-meteorological inputs* are required:

10. Rainfall,
11. Water level,
12. Discharge,
13. Temperature,
14. Humidity,
15. Evaporation,
16. Wind velocity and direction,
17. Snowfall, as applicable, and
18. Reservoir sedimentation data through bathymetric survey at 10 to 15 years interval.

Accordingly, the following ***hydro-meteorological observation instruments*** shall be provided at the dams:

(1) *Ordinary Rain Gauge* at dam site and *Self Recording Rain Gauge* in the free catchment area of the dam,
(2) *Digital Water Level Recorder* or *Staff Gauge* for stage measurement at dam site,
(3) _____,
(4) *Minimum and Maximum Thermometer* at dam site,
(5) *Dry* and *Wet Bulb Thermometers* at dam site,
(6) *Evaporation Pan* at dam site
(7) *Anemometer* and *Wind-Vane* at dam site,
(8) *Snow Gauge* in the free catchment area of the dam, and
(9) _____.

Section 54(2)(l)

The data requirements of seismological stations in the vicinity of specified dams under sub-section (1) of section 34;

Section 34(1)

In the case of every specified dam, having a height of thirty meters or above or falling under such seismic zone, as may be specified by the regulations, the owner of the specified dam shall establish a seismological station in the vicinity of each such dam for recording micro and strong motion earthquakes and such other data as may be specified by the regulations.

4.1 Seismological Stations

Seismographs are required to be installed at each specified dam site for recording the local seismicity. The minimum requirements of instruments depending on the height of the dam are provided in **Table 2**. In addition:

(1) One *Strong Motion Accelerograph (SMA)* shall be co-located with each .,.

(2) If length of the dam is more than 500m, then additional instruments may be installed as described below:

(ii) For every 500m (or part thereof) increase in length of the dam, one *additional* SMA shall be installed in the incremental length at each of these locations:

(a) Crest of the dam, and

(b) Each of the galleries.

(3) When the dam layout comprises of independent dams of different types across multiple channels with intervening abutments, then each of them should be considered as independent dams for the applicability of provisions according to the criteria specified above.

Table 2: Requirements of Seismographs in dams of different heights

S.No.	*Seismic Zone (as per IS 1893 (Part 1) 2016)*	*Dam Height H (m)*	*Number of Seismic Stations*
1.	**Zone II** **Zone III**	*H < 15*	A single station in the vicinity of the dam (nearest possible location, if possible within 1 km from dam) If at least 10 events with magnitude above 1.0 are recorded within 50 km distance and within 1 year, a local network of at least 5 stations should be operated for at least 3 years. Observations shall be continued even after 3 years, if such seismic events with similar frequency observed within the 3 years.
		15 ≤ H < 60	
		60 ≤ H < 100	
		100 ≤ H	
2.	**Zone IV** **Zone V**	*H < 30*	A single station in the vicinity of the dam (nearest possible location, if possible within 1 km from dam) If at least 100 events with magnitude above 1.0 are recorded within 50 km distance and within 1 year, a local network of at least 5 stations should be operated for at least 3 years. Observations shall be continued even after 3 years, if such seismic events with similar frequency observed within the 3 years.
		30 ≤ H < 60	
		60 ≤ H	A single station in the vicinity of the dam (nearest possible location, if possible within 1 km from dam) If at least 100 events with magnitude above 1.0 are recorded within 50 km distance and within 1 year, a local network of at least 5 stations should be operated for at least 3 years. Observations shall be continued even after 3 years, if such seismic events with similar frequency observed within the 3 years. If the height *H* of the dam is 100m or more, or if the reservoir capacity is more than 1 billion m^3, a network of at least 5 seismographs shall be maintained. (a) In a project of construction of a new dam, network should be deployed for a period of at least one year during DPR stage, and observations continued even after commissioning, with relocation of seismographs, wherever required.

Section 54(2)(m)

The suitable location and manner of collection, compliance, process and storage of data under sub-section (2) of section 34;

Section 34(2)

Every owner of a specified dam shall collect, compile, process and store data referred to in sub-section (1) at such suitable location and in such manner as may be specified by the regulations.

5.1 Suitable Locations

In addition to the requirements of Seismographs given in **Regulation 4**, the requirements specified hereunder for *Strong-Motion Accelerographs (SMAs)* shall be applicable related to seismic instrumentation.

Strong-Motion Accelerographs (SMAs) are required to be installed at each specified dam to record the potentially destructive ground shaking and resulting dam vibrations. The minimum requirements of *Strong-Motion Accelerographs (SMAs)* depending on the height of the dam are provided in **Table 2**.

The number of SMAs to be provided on the downstream face of the dam shall be at least:

(1) *Nine* in *Arch Dams* at locations shown in **Figure 1**,
(2) *Ten* in *Gravity Dams* at locations shown in **Figure 2**, and
(3) *Nine* in *Embankment Dams* at locations shown in **Figure 3**.

In addition:

(1) If length of the dam is more than 500m, then additional instruments may be installed as described below:
   (iii) For every 500m (or part thereof) increase in length of the dam, one *additional* SMA shall be installed in the incremental length at each of these locations:
      (a) Crest of the dam, and
      (b) Each of the galleries.
(2) When the dam layout comprises of independent dams of different types across multiple channels with intervening abutments, then each of them should be considered as independent dams for the applicability of provisions according to the criteria specified above.

Table 3: Requirements of locations of SMAs in dams of different heights

S.No.	*Seismic Zone (as per IS 1893 (Part 1) 2016)*	*Dam Height H (m)*	*Number and Location of Strong Motion Accelerographs*
1.	**Zone II** **Zone III**	$H \leq 15$	At least *two* instrument, one each at locations mentioned below: (a) Foundation level (in the gallery or at the downstream toe of the dam, if the dam does not have a gallery at the foundation level)
		$15 < H < 60$	At least *five* instruments, *one each* at locations mentioned below: (a) Foundation level (in the gallery or at the downstream toe of the dam, if the dam does not have a gallery at the foundation level), (b) Crest of the dam, (c) Free-field at a distance 3H–4H away from dam body or base, preferably on the upstream side, and (c) Each abutment
		$60 \leq H < 100$	At least *six* instruments, at locations mentioned below: (a) *Three* in the highest section of the dam (namely at base, middle and crest of the dam), (b) *One* in the Free-field at a distance 3H–4H away from dam body or base, preferably on the upstream side, and (c) *One* at each abutment
		$H \geq 100$	*Comprehensive instrumentation* as per schemes indicated in **Figures 1, 2 and 3**, below for *arch*, *gravity* and *embankment* dams, respectively

2.	**Zone IV** **Zone V**	*H < 30*	At least *five* instruments, at locations as mentioned below: (a) *One* at the foundation gallery, (b) *One* at the top of the dam at the block/RD having maximum height from the deepest foundation, (c) *One* in the free-field at a distance 3H–4H away from dam body or base, preferably on the upstream side, and (d) *One* at each abutment
		30 ≤ H < 60	At least *six* instruments, at locations as mentioned below: (a) *Three* at the highest section of the dam (base, middle and crest), (b) *One* in the free-field at a distance 3H–4H away from dam body or base, preferably on the upstream side, and (c) *One* on each abutment.
		60 ≤ H	*Comprehensive instrumentation* as per schemes indicated in **Figures 1, 2 and 3**, below for *arch*, *gravity* and *embankment* dams, respectively Also, at least *one* instrument, at locations as mentioned below: (a) *S*pillway monolith of greatest height, and (b) *B*ase of the slope or at the foundation, if there are any special foundation conditions with concerns of sliding or slope instability

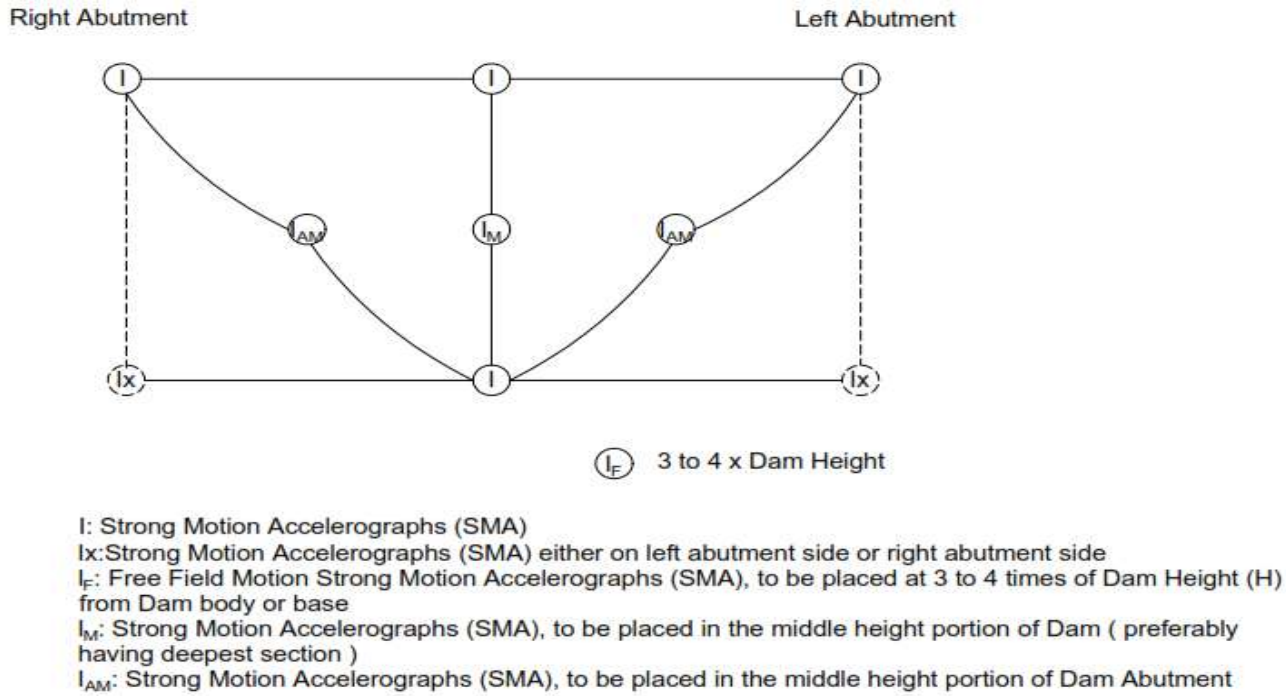
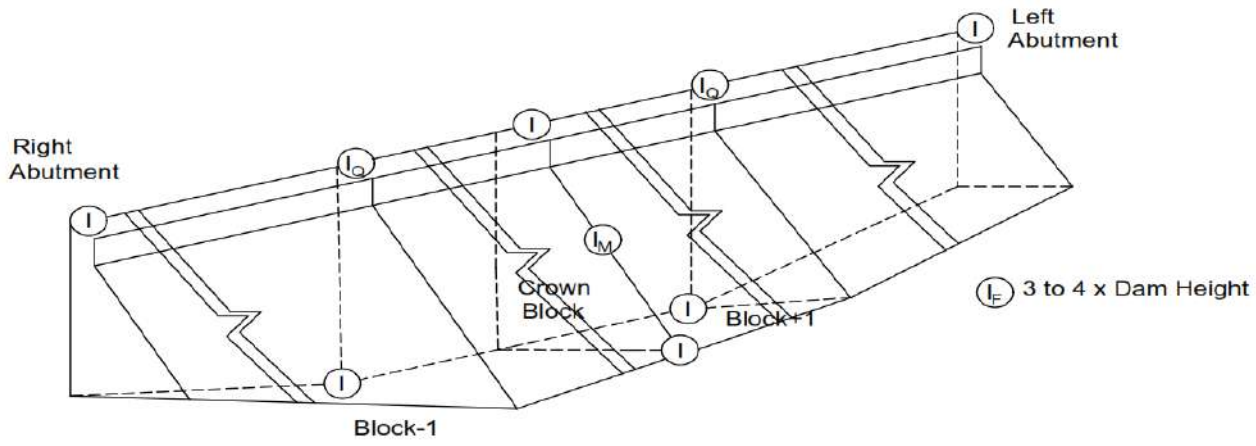


Figure 1: Location and number of SMAs to be provided in *Arch Dams*
Figure to be redrawn; some text is unclear



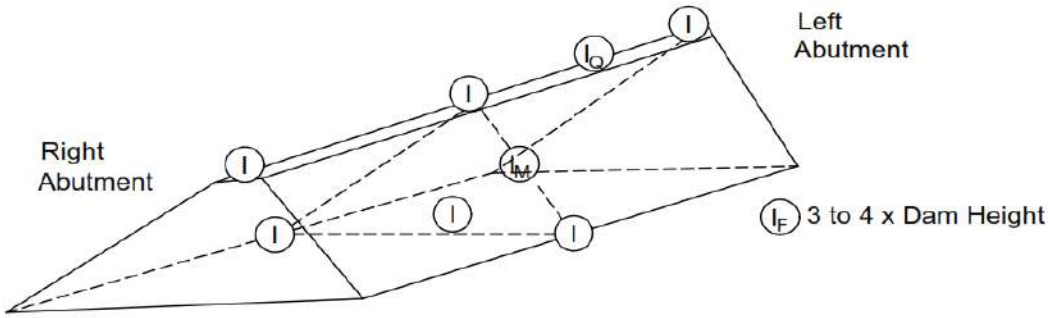
I: Strong Motion Accelerographs (SMA)

I_F: Free Field Motion Strong Motion Accelerographs (SMA), to be placed at 3 to 4 times of Dam Height (H) from Dam body or base

I_Q: Strong Motion Accelerographs (SMA), to be placed at quarter block (symmetrical to the central block)

I_M: Strong Motion Accelerographs (SMA), to be placed in the middle height portion of deepest block

Figure 2: Location and number of SMAs to be provided in *Gravity Dams*
Figure to be redrawn; some text is unclear



I: Strong Motion Accelerographs (SMA)

I_F: Free Field Motion Strong Motion Accelerographs (SMA), to be placed at 3 to 4 times of Dam Height (H) from Dam body or base

I_Q: Strong Motion Accelerographs (SMA), to be placed at quarter point either from Left Abutment or Right Abutment

I_M: Strong Motion Accelerographs (SMA), to be placed in the middle height portion of Dam (preferably having deepest section)

Figure 3: Location and number of SMAs to be provided in *Embankment Dams*
Figure to be redrawn; some text is unclear

5.2 Manner of Collection

All *Seismographs* and *Strong Motion Accelerographs (SMAs)* shall be connected to a *Central Recording Station (CRS)* of the dam for real-time monitoring and data storage. All the said instruments shall be enabled preferably with a GPS. This CRS shall:

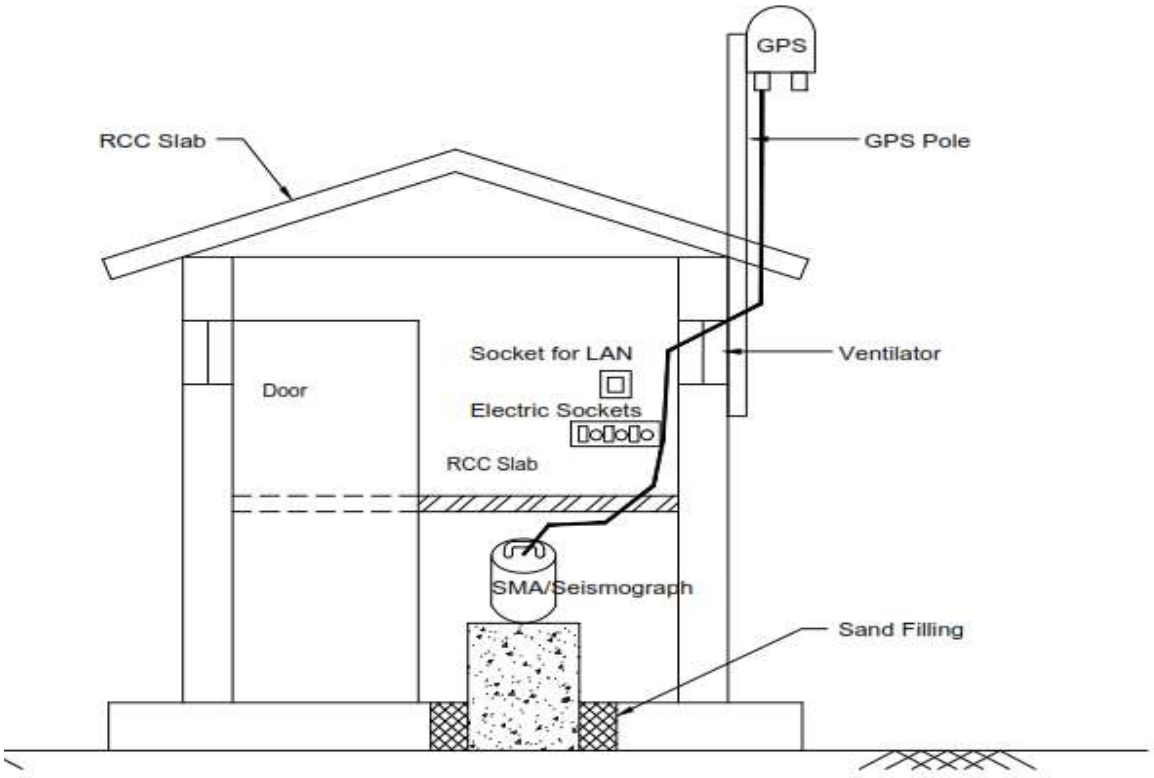
(1) Be located on independent ground at one of the abutments and at a height above the crest of the dam, away from local drainage paths of water, and not on the body of the dam.
(2) Be air-conditioned fully, to cater to control the humidity.
(3) Have facilities for communication (broadband or network connections), GPS, batteries, battery chargers with 24×7 uninterrupted power supply.
(4) Have easy egress in case of an emergency.

The seismic instrument needs to be operated continuously and maintained periodically.

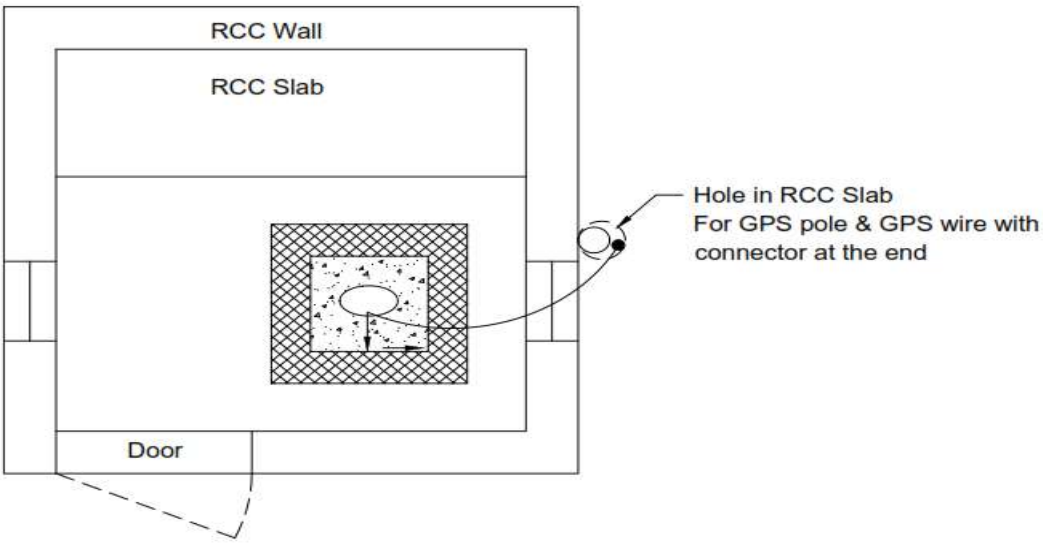
While installing *Seismographs* and *SMAs*,

(1) It shall be ensured that they are installed at locations with proper ventilation and low-moisture conditions. The design of the room shall be such that:
   (a) The room is dry to the extent possible; roof and walls shall be water-proofed; and
   (b) Electrical wiring shall be through conduit pipes.

(2) For instruments located at:
   (a) *Free-field locations*: The room shall be ventilated and made as per **Figure 4**. The instruments shall be bolted properly to a concrete mass.
   (b) *Crest of the dam*: The room shall be ventilated and made as per **Figure 5**. The instruments shall be bolted properly to a concrete mass.
   (c) *Foundation Gallery*: The room shall be water-tight and air-tight so that they are protected from humidity in gallery. The instruments shall be placed at such height that they are above the water level in case of flooding.



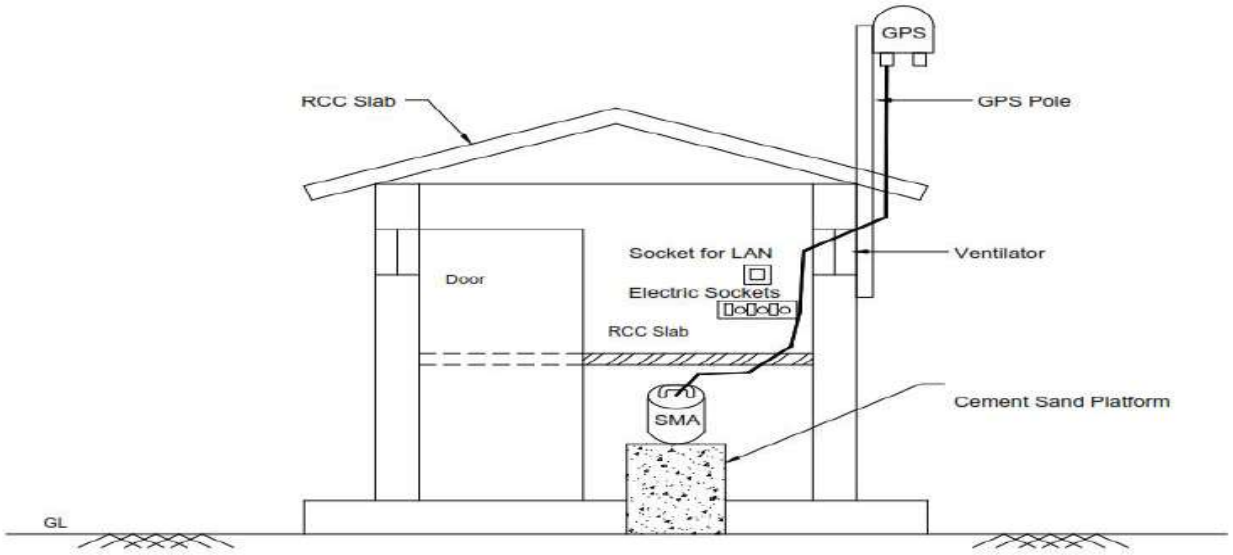
(a)



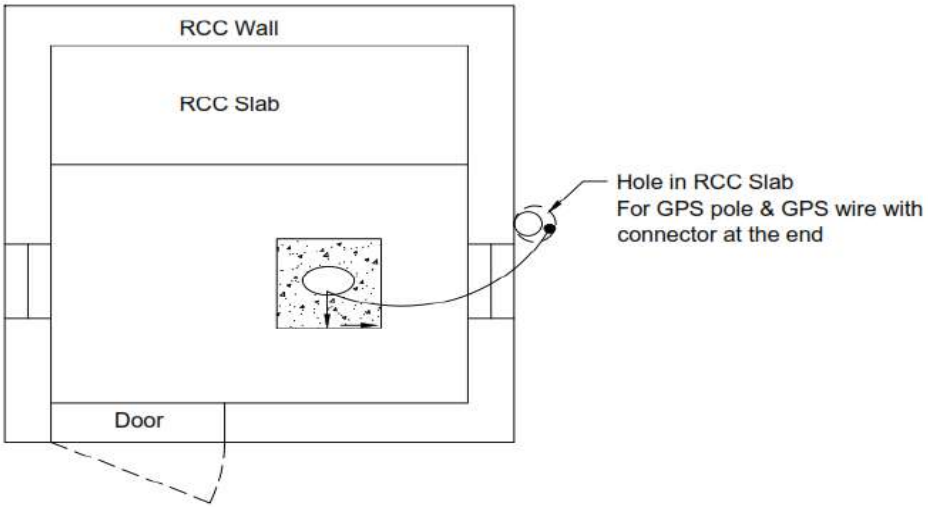
(b)

Figure 4: Room in free-field location housing instruments: (a) Sectional elevation view, and (b) Plan view

Figure to be redrawn; some text and details are unclear



(a)



(b)

Figure 5: Room at the crest of the dam housing instruments: (a) Sectional elevation view, and (b) Plan view

Figure to be redrawn; some text and details are unclear

5.3 Data Processing

The data recorded by the *Seismographs* and *SMAs* should be processed (corrected for the *Scaling Error*, *Random Error* in time and acceleration records, *Baseline Errors*, and *Band Passed Filtering*) to obtain the velocity and acceleration histories, respectively. And, the displacement history can be calculated from them, if required.

SMA data should be analyzed to estimate the *dynamic characteristics* (namely natural period, mode shape and damping ratio corresponding to each of the dominant modes) of the dam.

5.4 Data Storage

The *Seismographs* and *SMAs* should be should be operated in continuous data acquisition mode. The storage media size should be sufficient to store data so collected.

Section 54(2)(r)

The mandatory site-specific seismic parameter studies of existing specified dams under clause (c) of sub-section (2) of section 38;

Section 38(2)(c)

General Assessment of seismic safety of specified dam with *Mandatory Site-Specific Seismic Parameters Study* in certain cases, as specified by the regulations;

6.1 General Assessment

The *General Assessment* of a specified dam related to ensuring its *earthquake safety* includes the following:

(1) Under the expected *most-severe* earthquake ground shaking:
   (a) The structural capacity of the dam shall be such that:
      (i) It is safe against overturning and sliding;
      (ii) It does not sustain damage in the main body of the dam below the neck region, while some inelastic deformations may occur in the neck region. But, this shall not lead to toppling of the block above the neck.
   (b) The earthquake resistance of each dam shall be evaluated separately as per (1) above, when multiple dams are built on the rim of a common reservoir or when a single dam spans across separate abutments of the reservoir.
   (c) No separation or damage that is detrimental to the earthquake safety of dams shall occur at the interfaces especially between their *rigid parts* (made of *masonry* or *concrete*) and their *flexible parts* (made of *soil*).
   (d) Special attention shall be paid to the interfaces in existing *composite dams* (*e.g.*, the *masonry body* and the *earth or rockfill backing* on downstream side) and *dams strengthened with additional buttresses or backing* made of masonry or concrete.

(2) After the dam experiences an earthquake, the following activities shall be undertaken:
   (a) The dam shall be inspected visually and the major observations reported, which are likely to have impacted the safety of the dam.
   (b) The data recorded by the strong motion accelerographs and seismographs at the dam shall be analyzed and interpreted to understand the impact of the earthquake on the safety of the dam.
   (c) The safety of the dam shall be assessed as per (1) above, especially using the information from 2(a) and 2(b) above.
   (d) The strong motion accelerographs and seismographs at the dam shall be *serviced* to ensure snug fastening of anchor bolts of the instruments to the concrete blocks.
   (e) Examine the lateral resistance of the dam, and determine if reservoir level requires depletion to reflect the reduced structural capacity of the dam.
   (f) Review the efficacy of the *Emergency Action Plan* from disaster management perspective, and examine the sufficiency of:
      (i) Advance warning alarm for downstream population, inundation levels and evacuation plans.
      (ii) Maintenance of hydro-mechanical equipment and gates for continued operability, especially critical in dams located in earthquake zones IV and V.

6.2 Mandatory Assessment

A *mandatory* study of the *site-specific seismic parameters* shall be carried out of a specified dam:

(a) If it is classified as *Critical* or *Significant* in the *Regulation* corresponding to Section 54(b) of Dam Safety Act, 2021,
(b) When more frequent seismic activity is observed in the region (substantially higher than the past normal seismic activity),
(c) After an extreme seismic event having potential to affect/damage structure (i.e., an event with magnitude of Peak Ground Acceleration (PGA) greater than that used in design,
(d) Before major modification are made to the original structure,
(e) Before design criteria is revised upwards, and
(f) Major geological activity is reported in the region

Comments received on 3 draft regulations

Sr. No.	Regulation	Proposed	Comments received				
			IMD	KSEB	Member D&R, NDSA	Member (Regulation), NDSA	Prof. CVR Murty
54(2)a	***the guidelines, standards and other directions for achieving the satisfactory level of dam safety assurance under sub-section (1) of section 16*** ***Section 16 (1): Every State Dam Safety Organisation shall, -*** ***(a) keep perpetual surveillance;*** ***(b) carry out inspections; and*** ***(c) monitor the operation and maintenance,*** ***of all specified dams falling under their jurisdiction to ensure continued safety of such specified dams and take such measures as may be necessary to address safety concerns that are noticed with a view to achieve satisfactory level of dam safety assurance as per such guidelines, standards and other directions on dam safety as may be specified by the regulations***	**(a) keep perpetual surveillance** Dam owners are primarily responsible for surveillance of Dams including the security and safety as per the operation and maintenance manual for the said dam. **(b) carry out inspections** The dam owner shall carry out the routine inspections, such as pre and post monsoon inspections, and also all the special inspections, viz.: inspections during and after every flood, earthquake or any such natural or man-made calamities, or if any sign of distress or any unusual behaviour is noticed in the dam body or any of its appurtenant structure. Further, inspection shall also be carried out before initial filling of the reservoir to test the fitness of dam for filling. **(c) Monitoring the operation and maintenance** Operation and Maintenance of each specified dam shall be carried out as per the operation and maintenance	NIL		NIL	a) Dam owners are primarily responsible for surveillance of Dams including the security and safety as per the operation and maintenance manual for the said dam. SDSO through its own electronic reporting mechanism will keep itself abreast with any or all issues that are flagged by dam owners. b) The dam owner shall carry out the routine inspection including mandated pre and post monsoon inspections, and also all the special inspections, viz.: inspections during and after every flood, earthquake or any such natural or man-made calamities, or if any sign of distress or any unusual behaviour is noticed in the dam body or any of its appurtenant structure. SDSO will invariably carry out inspections of dams which fall in Category-I & II and generate its own report including recommended remedial measures to bring such dams under Category-III. Further, inspection shall also be carried out before initial filling of the reservoir to test the fitness of dam for filling. c) Operation and Maintenance of each specified dam shall be carried out as per the operation and maintenance manual of the said dam. SDSO through its own electronic reporting mechanism will keep itself updated of events which are deviation to the standard protocols as contained in the O&M manual.	**7.1 Perpetual Surveillance** The Dam Owners shall put in place systems and process to undertake perpetual surveillance of Dams, including the security and safety, as per the *Operation & Maintenance Manual* in force for the said dam. **7.2 Inspections** The Dam Owners shall carry out: (1) *Routine Inspections*, such as pre-monsoon and post-monsoon inspections, and (2) *Special Inspections*, such as inspections: (a) During and after every flood, (b) After every earthquake, (c) After any natural or man-made calamity, (d) When any sign of distress or any unusual behaviour is noticed in the dam body or any of its appurtenant structures during the *Routine Inspections*, and (e) Before initial filling of the reservoir to test the fitness of dam. **7.3 Operation and Maintenance** The Dam Owners shall carry out Operation and Maintenance of each specified dam as per the *Operation & Maintenance Manual* in force for the said

		manual of the said dam.					dam.
54(2)n	***The time interval of risk assessment studies to be carried out under sub-section (2) of section 35;*** ***Section 35 (2): Every owner of a specified dam, for each of its dam shall, carry out risk assessment studies at such interval as may be specified by the regulations and the first such study shall be made within five years from the date of commencement of this Act.***	Risk assessment studies of each specified dam shall be carried out within 5 years from the date of commencement of the Dam Safety Act, 2021. Thereafter, the risk assessment studies of each specified dam shall be carried out at every 10 years.	NIL		NIL	NIL	**8.1 Time Interval between Risk Assessment Studies** Risk assessment studies of each specified dam shall be carried out within 5 years from the date of commencement of the *Dam Safety Act, 2021*. Thereafter, the risk assessment studies of each specified dam shall be carried out at every 10 years.
54(2)p	***The time interval for the comprehensive safety evaluation of specified dams under sub-section (1) of section 38;*** ***Section 38. (1) The owner of a specified dam shall make or cause to be made comprehensive dam safety evaluation of each specified dam through an independent panel of experts constituted as per regulations for the purpose of determining the conditions of the specified dam and its reservoir:*** ***Provided that the first comprehensive dam safety evaluation for each existing specified dam shall be conducted within five years from the date of commencement of this Act, and thereafter the comprehensive dam safety evaluation of each such dam shall be carried out at regular intervals as may be specified by the regulations.***	Comprehensive safety evaluation of each specified dam shall be carried out within 5 years from the date of commencement of the Dam Safety Act, 2021. Thereafter, the Comprehensive safety evaluation of each specified dam shall be carried out at every 10 years.	NIL	KSEB proposed for Category III specified dams, the Comprehensive Safety Evaluation shall be carried out at intervals determined by the Comprehensive Safety Evaluation Committee, not exceeding 10 years	NIL	Member regulation proposed that Comprehensive safety evaluation of each specified dam shall be carried out at every 15 years considering the availability of expertise in the Country.	**9.1 Time Interval between Comprehensive Safety Evaluations** Comprehensive safety evaluation of each specified dam shall be carried out within 5 years from the date of commencement of the *Dam Safety Act, 2021*. Thereafter, the Comprehensive Safety Evaluation of each specified dam shall be carried out at least every 10 years, unless warranted to be undertaken before that from other considerations.

Number of Large (Specified) Dams as per NRLD 2023

S. No.	State/UT	Operational Dams	Under Construction	Total number of dams
1	Andaman & Nicobar (UT)	2	0	2
2	Andhra Pradesh	140	24	164
3	Arunachal Pradesh	1	3	4
4	Assam	3	2	5
5	Bihar	27	1	28
6	Chhattisgarh	339	7	346
7	Goa	5	0	5
8	Gujarat	487	4	491
9	Himachal Pradesh	23	6	29
10	Haryana	1	0	1
11	Jharkhand	55	24	79
12	Jammu & Kashmir (UT)	13	2	15
13	Karnataka	231	0	231
14	Kerala	61	0	61
15	Ladakh UT	2	0	2
16	Maharashtra	2333	41	2374
17	Meghalaya	8	1	9
18	Manipur	3	1	4
19	Madhya Pradesh	1354	0	1354
20	Mjzoram	1	0	1
21	Nagaland	1	0	1
22	Odisha	210	0	210
23	Punjab	18	1	19
24	Rajasthan	310	4	314
25	Sikkim	2	0	2
26	Telangana	161	13	174
27	Tamil Nadu	127	0	127
28	Tripura	1	0	1
29	Uttarakhand	32	5	37
30	Uttar Pradesh	151	4	155
31	West Bengal	36	0	36
	Total	**6138**	**143**	**6281**

Annexure-V

Mi/26/2023-NDSA-MOWR

I/86968/2023

भारत सरकार / Government of India
जल शक्ति मंत्रालय / Ministry of Jal Shakti
जल संसाधन नदी विकास एवं गंगा संरक्षण विभाग /
Department of Water Resources, RD & GR
राष्ट्रीय बाँध सुरक्षा प्राधिकरण / National Dam Safety Authority
कार्यालय सदस्य (तकनीकी) / Office of Member (Technical)

8th Floor (S), Sewa Bhawan
R.K.Puram, New Delhi-66
Tel. 011-29583600
Email : bcdnw-cwc@nic.in

09-08-2023

Sub: Empanelment of Technical Experts for Dam Safety under NDSA as per the Dam Safety Act, 2021

With reference to the above subject matter, the approved 'Empanelled List of Experts' is enclosed herewith for uploading the same on the CWC website under the 'Dam Safety Act' Tab so that it can be accessed by SDSOs/Dam Owners as and when required.

This is for kind information and further necessary action at your end please.

This issues with the approval of Member (Technical), NDSA.

Enclosed: As Above

Signed by Samir Kumar Shukla
Date: 09-08-2023 10:23:37
Reason: Approved

(Samir Kumar Shukla)
Director, BCD(N&W)

Director, SMD, CWC, Sewa Bhawan, New Delhi-66

Copy to: -

1. PPS to Chairman, NDSA & Member (D&R), CWC
2. Member (Technical), NDSA and Chief Engineer (N&W), CWC
3. Member (Policy & Research), NDSA and Chief Engineer, DSO, CWC
4. Member (Regulation), NDSA and Chief Engineer (East & North East), CWC
5. Member (Disaster & Resilience) and Chief Engineer (NW&S), CWC
6. Director, NDSA Secretariat, New Delhi

Copy for circulating the information in respective regions:

1. Sh. R. Thangmani, Director (Mon) CSRO & Regional Director, SR, NDSA, Neervalam, R-81, TNHB Colony, West Velacherry, Chennai. E-mail:

I/86968/2023

[dirmoncoimbatore-cwc@ nic.in]

2. Sh. R.P.S Verma, SE(C), IBO & Regional Director NR, NDSA, Block 4, 6th Floor, Kendriya Sadan, Sector 9A Chandigarh, e-mail: [secochandigarh-cwc@nic.in]
3. Sh. Sanjay Singh, Director (M&A), BBO & Regional Director, E&NE R, NDSA, CWC Complex, 2nd Floor, P.O.- Guwahati University, Guwahati. E-mail: [dirrnaguwahati-cwc@nic.in]
4. Sh. Umbarje Harish Girish, Director (M&A), MCO & Regional Director, WR, NDSA, NINA, Sinhagad Road, Khadakwasla, Pune. E-mail: [dirmapune-cwc@nic.in]

Annexure-VI

State-wise list of Emergency Action Plan prepared

STATE	NUMBER OF DAMS FOR WHICH PREPARED		NUMBER OF DAMS FOR WHICH UNDER PREPARATION	
	EMERGENCY ACTION PLAN	DISASTER MANAGEMENT PLAN	EMERGENCY ACTION PLAN	DISASTER MANAGEMENT PLAN
ARUNACHAL PRADESH*	-	-	-	-
ASSAM	1	NIL	NIL	NIL
BIHAR	NIL	NIL	1	NIL
CHHATTISGARH	NIL	NIL	NIL	NIL
JHARKHAND	NIL	NIL	NIL	NIL
MANIPUR*	-	-	-	-
MEGHALAYA	NIL	NIL	9	NIL
MIZORAM*	-	-	-	-
NAGALAND	NIL	NIL	NIL	NIL
ODISHA	26	NIL	NIL	NIL
SIKKIM*	-	-	-	-
TRIPURA	1	1	N.A	N.A
WEST BENGAL	4	NIL	NIL	NIL
HARYANA	NIL	NIL	NIL	NIL
HIMACHAL PRADESH	23	23	N.A	N.A
PUNJAB	14	14	N.A	N.A
UTTAR PRADESH	NIL	NIL	NIL	NIL
UTTARAKHAND	6	6	NIL	NIL
J & K (UT)	NIL	NIL	1	1
LADAKH (UT)*	-	-	-	-
ANDHRA PRADESH	1	NIL	NIL	NIL

STATE	NUMBER OF DAMS FOR WHICH PREPARED		NUMBER OF DAMS FOR WHICH UNDER PREPARATION	
	EMERGENCY ACTION PLAN	DISASTER MANAGEMENT PLAN	EMERGENCY ACTION PLAN	DISASTER MANAGEMENT PLAN
KARNATAKA	24	NIL	NIL	NIL
KERALA	49	NIL	4	NIL
TAMIL NADU	86	NIL	41	NIL
TELANGANA	NIL	NIL	NIL	NIL
ANDAMAN AND NICOBAR ISLAND (UT)*	-	-	-	-
GOA	NIL	NIL	NIL	NIL
GUJARAT	NIL	NIL	7	NIL
MADHYA PRADESH	52	NIL	1310	NIL
MAHARASHTRA	96	167	NIL	NIL
RAJASTHAN	1	NIL	6	NIL
SPECIFIED DAMS UNDER NDSA				
Northern Region				
NHPC	16	16	NIL	NIL
BBMB	4	NIL	NIL	NIL
THDCIL	2	NIL	NIL	NIL
SJVNL	1	NIL	NIL	NIL
NTPCL	1	1	NIL	NIL
SDSO UP Govt.	NIL	NIL	9	NIL
Eastern and Northern Region				
DVC	3	NIL	1	NIL
NEEPCO	NIL	NIL	8	8
NHPC	4	4	NIL	NIL

Western Region				
NHDC	02	02	NIL	NIL
SDSO UP Govt.	NIL	NIL	NIL	NIL
Southern Region				
KIOCL	NIL	NIL	NIL	NIL
SDSO Tamil Nadu Govt.	03	NIL	NIL	NIL
Tungbhadra Board	NIL	NIL	NIL	NIL
SDSO of Telangana & Andhra Pradesh	01	NIL	NIL	NIL
SDSO of Odisha & Andhra Pradesh	NIL	NIL	NIL	NIL

***** Information not submitted by State/Agency

Email **Dam Safety Design II**

Link for accessing the guidelines/manuals pertaining to dam safety-reg

From : Dam Safety Design II <dsd2dte-cwc@gov.in> Thu, Jun 08, 2023 09:37 PM

Subject : Link for accessing the guidelines/manuals pertaining to dam safety-reg

To : addlcec kohima <addlcec.kohima@gmail.com>, ankush gaunker <ankush.gaunker@gmail.com>, babbisharma803@gmail.com, bloomingwahlang@gmail.com, cedamsafety <ce-damsafety@ap.gov.in>, MANASH CHAKRABORTY <ce-dr@wbiwd.gov.in>, ce-ng-nwrws@gujarat.gov.in, ce cen deg rec <ce.cen.deg.rec@gmail.com>, ce ddn id <ce.ddn.id@gmail.com>, T. V. N. A. R. Kumar <ce_hydrology@ap.gov.in>, cecdo irr <cecdo.irr@gmail.com>, cedamsafety odisha <cedamsafety.odisha@gmail.com>, cedamsafety@gmail.com, cedamsafety@kseb.in, Vijay Shankar <cedesign-wrd-jhr@nic.in>, ALOK KUMAR JAIN <cednriduplu-up@nic.in>, cedsobengaluru@gmail.com, cehpswnasik@gmail.com, ceomwro@gmail.com, cepheifcladakh@gmail.com, cesdsopb@gmail.com, ceswrpd wr <ceswrpd.wr@rajasthan.gov.in>, ceswrpd10@rediffmail.com, dgkseb@kseb.in, djjayin@gmail.com, drip manipur <drip.manipur@gmail.com>, eedamsafety@gmail.com, Engineer-In-Chief, WRD <encwrbpl-mp@nic.in>, mahadev395@gmail.com, managing director <managing.director@tsecl.in>, pddrip wrd raj <pddrip.wrd.raj@gmail.com>, ppsphq@yahoo.in, rabi2006@gmail.com, samanronrang@gmail.com, sdso bhopal <sdso_bhopal@yahoo.co.in>, sdsobihar@gmail.com, sdsotelangana2022@gmail.com, AMIYA KUMAR BERA <se-damsc@wbiwd.gov.in>

Cc : Sanjay Kumar Sibal <memberdr-cwc@nic.in>, CEDSO <cedams@nic.in>

Sir(s),

As per the direction of NCDS, please refer to the link given below for accessing the guidelines/manuals pertaining to dam safety:

https://drive.google.com/drive/folders/1jNYmC4nXVMh3HC5qYMUkX2R_Fkm3mQv8?usp=sharing

Regards,
Ajit Kataria,
Dy. Director,
CWC

Annexure-VIII

State-wise status of Operation & Maintenance Manual

S.No.	Name of State/UT	Number of Dams
1.	Assam	01 Nos
2.	Bihar	Under progress
3.	Chhattisgarh	Nil
4.	Goa	6 Nos (All Dams)
5.	Gujarat	Nil
6.	Haryana	Maintained in all dams
7.	Himanchal Pradesh	23 specified dams
8.	Jammu & Kashmir	Maintained on dam
9.	Kerala	51 dams
10.	Jharkhand	Nil
11.	Karnataka State	67 specified dams
12.	Karnataka	48 Nos
13.	Madhya Pradesh	36 Nos
14.	Maharashtra	Under Progress
15.	Meghalaya	Under progress
16.	Odisha	26 Nos
17.	Punjab	Maintained
18.	Tamil Nadu	86 Nos
19.	Telangana	9 Nos
20.	Uttar Pradesh	93 Nos
21.	Uttarakhand	20 dams
22.	West Bengal	Nil

Annexure-IX

Status of State-wise constituted Dam Safety Units

S.NO.	STATES	NO. OF DSUS CONSTITUTED
1	ANDHRA PRADESH	156
2	ARUNACHAL PRADESH*	04
3	ASSAM	1
4	BIHAR	27
5	CHHATTISGARH	355
6	GOA	0
7	GUJARAT	0
8	HARYANA	0
9	HIMACHAL PRADESH	23
10	JHARKHAND	0
11	KARNATAKA	73
12	KERALA	18
13	MADHYA PRADESH	1
14	MAHARASHTRA	2529
15	MANIPUR	4
16	MEGHALAYA	0
17	MIZORAM*	1
18	NAGALAND	0
19	ODISHA	150
20	PUNJAB	14
21	RAJASTHAN	305
22	SIKKIM*	02
23	TAMIL NADU	128
24	TELANGANA	174
25	TRIPURA	1
26	UTTAR PRADESH	143
27	UTTARAKHAND	13
28	WEST BENGAL	34
29	ANDAMAN AND NICOBAR*	0
30	JAMMU AND KASHMIR	8
31	LADAKH	02
32	DAMS OWNED BY CENTRAL GOVT OR CENTRAL GOVT PSU	63
	TOTAL	4229

Annexure-X

State wise List of Status of Inspection of Large Dams (as on 23.11.2023)

Sl. No.	States/UT	Total N. of specified Dams Reported by the State (Constructed)	Inspection reported by States (Pre-Monsoon 2023)	Inspection reported by States (Post-Monsoon 2023)	Category of Dam as per Post Monsoon Inspection 2023		
					Cat-I	Cat-II	Cat-III
1	Andhra Pradesh	140	110	4	-	-	4
2	Arunachal Pradesh	1*	4	-	-	-	-
3	Assam	3	2	-	-	-	-
4	Bihar	27	27	5	-	1	4
5	Chhattisgarh	339*	347	-	-	-	-
6	Goa	5	6	6	-	2	4
7	Gujarat	487*	600	124	-	-	124
8	Haryana	1*	3	-	-	-	-
9	Himachal Pradesh	23	23	-	-	-	-
10	Jharkhand	55	33 (6DVC+27)	-	-	-	-
11	Karnataka	231	231	-	-	-	-
12	Kerala	61	60	-	-	-	-
13	Madhya Pradesh	1354*	1362	-	-	-	-
14	Maharashtra	2333*	2556	-	-	-	-
15	Manipur	3	-	-	-	-	-
16	Meghalaya	8	-	-	-	-	-
17	Mizoram	1	1	-	-	-	-
18	Nagaland	1	1	-	-	-	-
19	Odisha	210	209	41	-	1	40
20	Punjab	18	17	-	-	-	
21	Rajasthan	310	304	147	-	-	147
22	Sikkim	2	2	-	-	-	
23	Tamil Nadu	127	127	77	-	-	77
24	Telangana	161*	176	34	-	1	33
25	Tripura	1	1	1	-	-	1
26	Uttar Pradesh	151	143	-	-	-	-
27	Uttarakhand	32	25	21	-	2	19
28	West Bengal	36	34	-	-	-	-
29	A and N Island (UT)	2	-	-	-	-	-
30	J & K (UT)	13	8	-	-	-	-
31	Ladakh (UT)	2	2	-	-	-	-
	Total	**6138**	**6414**	**460**		**7**	**453**

* State Govts. are in the process of providing the updated list of specified dams

Annexure-XI

State-wise list of Category-I and II dams

S.N.	State	No. of Cat-I Dams	No. of Cat-II Dams	No. Cat-II dam under DRIP-II & III (as per EFC list)
1	Bihar	-	1	-
2	Chhattisgarh	-	4	1
3	Haryana	-	1	-
4	Jharkhand	-	9	9
5	Madhya Pradesh	-	41	8
6	Odisha	-	9	8
7	Punjab	-	3	2
8	Rajasthan	-	2	2
9	Tamil Nadu	-	19	12
10	Telangana	-	15	8
11	Uttar Pradesh	2	16	12
12	Uttarakhand	-	4	2
13	West Bengal	-	5	-
14	Kerala	-	18	17
15	Goa	-	2	2
16	Andhra Pradesh	-	2	2
17	Maharashtra	-	32	9
Total		2	183	94

List of Category–I Dams of Uttar Pradesh

S. No.	Name of Dam	Year of Completion	Type	Reasons	Present Status
1	Lower Khajuri	1949	Composite	Seepage problem through the body due to which bulging of stone masonry has been observed etc.	UP State has approved the revised cost of the project. UP state is finalising the bid document.
2	Jirgo	1958	Earthen	Design flood has been reviewed and revised from 1994.33 cumecs to 3537 cumecs	Based on the report of tomography survey, project of the dam (cost 3.95 cr) approved by CEC on 13.09.2023. PST is awaited.

List of Category –II Dams of all States

STATE-UTTAR PRADESH			
S. No	**Name of Dam**	**Year of Construction/Completion**	**Age in Years**
1.	Adwa Dam	1985	38
2.	Sirsi Dam	1958	65
3.	Dhandhraul DAM	1917	106
4.	Upper Khajuri dam	1958	38
5.	Chandraprabha Dam	1956	67
6.	Rihand Dam	1962	61
7.	Parichha Weir	1886	137
8.	Dhukwan Weir	1909	114
9.	Pahuj Weir	1909	114
10.	Jamini Dam	1973	50
11.	Shahjad Dam	1992	31
12.	Gangau Weir	1915	108
13.	Maudaha Dam	2004	19
14.	Dhora Dam	1961	62
15.	Sharda Sagar Dam	1962	61
16.	Baigul Dam	1968	55
State- Odisha			
1	Parhel	1988	35
2	Randa	1986	37
3	Saipala	1977	46
4	Laigam	1971	52
5	Ghodahada	1974	49
6	Gunduriposi	1975	48
7	Upper suktel	1992	31
8	Kumbho	1975	48
9	Rukura	2016	7
State- Telangana			
1.	Sriram Sagar Project (SRSP)	1977	46
2.	Shanigaram	1977	46
3.	Gujjulavagu Project	1998	25
4.	Pothangal Project	1985	38
5.	Nizam Sagar	1931	92
6.	Koulasnala Sroject	1999	24
7.	Gundlavagu Project	Not mentioned	
8.	Pedda Vagu	1981	42
9.	Jurala Project (P.J.P.)	1996	27
10.	Relampadu	Not mentioned	
11.	Kaddem Project (K.N.R. Project)	1958	65
12.	Suddavagu (Gaddenavagu)	2006	17
13.	Musi Project	1963	60
14.	Sathnala Project	1986	37
15.	Tatikunta		
16.	Teegalavagu Project, Peddathundla (V)	1980	43
State-Bihar			
1.	Kharagpur Lake	1876	147

State- Haryana			
1.	Kaushalaya Dam	2011	12
State-Punjab			
1.	Mirzapur Dam	1996	27
2.	Perch Dam	1993	30
3.	Jayanti Dam	2001	22
State- Uttarakhand			
1.	Bhimtal Dam	Not mentioned	
2.	Gola Barrage	Not mentioned	
3.	Joshiyara Barrage	Not mentioned	
4.	Maneri Dam	1984	39
State- Jharkhand			
1.	Jaipur Reservoir	1985	38
2.	Katri Reservoir	Not mentioned	
3.	Ranital Reservoir	Not mentioned	
4.	Butanduba Reservoir	1985	38
5.	Malay Reservoir	1985	38
6.	Temrain Reservoir	1973	50
7.	Chandrapura Weir (CTPS) (DVC)	Not mentioned	
8.	Bokaro Barrage (BTPS) (DVC)	Not mentioned	
9.	Tilaiya Dam (DVC)	1953	70
State-Rajasthan			
1.	Jawaharsagar Dam	1972	51
2.	Bundika Gothra Dam	1957	66
State- Tamil Nadu			
1.	Uppar (Tirupur) Dam (TNWRD)	1986	37
2.	Amaravathi Dam (TNWRD)	1958	65
3.	Poondi (TNWRD)	1944	59
4.	Manimukthanadhi (TNWRD)	1970	53
5.	Willingdon (TNWRD)	1923	100
6.	Gomuki Nadhi (TNWRD)	1965	58
7.	Mirugandanadhi (TNWRD)	2005	18
8.	Kodaganar (TNWRD)	1993	30
9.	Naganjiyar (TNWRD)	2004	19
10.	Thunacadavu (TNWRD)	1965	58
11.	Mettur (TNWRD)	1934	89
12	Chembarambakkam	Pallava Period	More than 100 Years
13.	Redhills	British Period	More than 76 Years
14.	Anaikuttam	1989	34
15.	Siddhamalli	1988	35
16.	Lower Bhavani (Bhavani Sagar)	1955	68
17.	Sholayar	1971	52
18.	Kadamparai Dam (TANGEDCO)	1984	39
19.	Pillur Dam (TANGEDCO)	1967	56
State- West Bengal			
1.	Teesta Barrage	2013	10
2.	Bindu Barrage	2004	19
3.	Hanumata Dam	2004	19

4.	Dangra Dam	1982	41
5.	Sali Dam	1985	38
	STATE- CHHATISGARH		
1	MINIMATA (HASDEO) BANGO	1990	33
2	RAVISHANKAR SAGAR	1979	44
3	TAMATA TANK	2003	20
4	AAMGAON TANK	2017	6
	State- Madhya Pradesh		
1	Hathaikheda Dam	1960	63
2	Girwari Bandh	1986	37
3	Jakhoda	1982	41
4	Raipur Bandh	1877	146
5	Udaipur	1984	39
6	Nawapura Tank	1986	37
7	Bhagwant Sagar Sukta Dam	1984	39
8	Chirkhan Dam	1981	42
9	Ardla	2015	8
10	Chandia Nalla Upper Lower	2011	12
11	Junia Tank	2012	11
12	Nirendpur	2020	3
13	Mansurwari Dam	1978	45
14	Juda	2015	8
15	Pitamber Garh	2012	11
16	Kaduawan	2015	8
17	Nandanpur	2015	8
18	Tamra Pahad	2014	9
19	Chhidua Dam	1982	41
20	Panagar Dam	1912	111
21	Aoda Dam	1934	89
22	Birpur	1908	115
23	Nagda Gajora	1911	112
24	Dhapora Dam	1915	108
25	Chandapatha Dam	1918	105
26	Chakarbhata	2013	10
27	Hardua Memary	2014	9
28	Bansujara	2018	5
29	Danmadi	2009	14
30	Bagharru Tank	2013	10
31	Rehti Dam	2013	10
32	Shivgarth Bedli Dam	1958	65
33	Rupaniya Khal Dam	1998	25
34	Kukarra	2016	7
35	Ghoghari	2015	8
36	Bardha	2004	19
37	Beerpur Dam	1877	146
38	Depalpur Dam	1952	71
39	Sakalda	1980	43
40	Bansagar Major Multipurpose Dam	2006	17
41	Jamakheri Dam	1916	107
	State- Kerala		

1	Cheruthoni	1976	47
2	Poringalkuthu	1957	66
3	Neyyar	1958	65
4	Kallada	1986	37
5	Malankara	1994	29
6	Mangalam	1966	57
7	Meenkara	1964	59
8	Walayar	1956	67
9	Malampuzha	1966	57
10	Pothundy	1971	52
11	Chulliar	1970	53
12	Siruvani	1984	39
13	Peruvannamoozhi (Kuttiyadi) Dam	Not mentioned	
14	Karapuzha	2004	19
15	Kanjirapuzha	1983	40
16	Pamba Barrage (Maniyar)	1993	30
17	Periyar Valley Barrage (Bhoothathankettu)	1966	57
18	Kulur (Pazhassi) Barrage	1979	44
	State- Goa		
1	Salauli Irrigation Project,	2000	23
2	Anjunem Irrigation Project,	1989	34
	State- Andhra Pradesh		
1	Raiwada Reservoir	1982	41
	State- Maharashtra		
1	Bhatasa	2005	18
2	Khand	1973	50
3	Mohakhurd	1974	49
4	Bholawali	2001	22
5	Kondivali	1996	27
6	Amboli	2006	17
7	Shil	1996	27
8	Chorgewadi	1992	31
9	Wagh	2001	22
10	Tilari Main Dam Dhamane	1986	37
11	Chaskaman	1999	24
12	Kasarsai	1995	28
13	Pawana	1983	40
14	Wadiwarhe	1983	40
15	Warasgaon	1992	31
16	Temghar	2010	13
17	Dhom Balkawadi	2006	17
18	Dimbhe	1995	28
19	Manikdoh	1984	39
20	Sina Kolegaon	2007	16
21	Jadhavwadi	2001	22
22	Balgawade	1986	37
23	Bhima Ujjani Dam	1980	43
24	Koyana	1967	56
25	Sapan	2010	13

26	Pench	1977	46
27	Pench Hydroeletric Project (Totladoh Dam)	1989	34
28	Darana	1916	107
29	Nandur Madhmeshwar	1910	113
30	Gul	2009	14
31	Mudgal	2012	11
32	Pusali	Not Mentioned	
Total Dams	**183 No.**		

List of category-II dams proposed under DRIP-II & III

S. No.	Name of dam
	State: Jharkhand
1.	Bokaro Barrage (BTPS) (DVC)
2.	Butanduba Reservoir
3.	Chandrapura Weir (CTPS) (DVC)
4.	Jaipur Reservoir
5.	Katri Reservoir
6.	Malay Reservoir
7.	Ranital Reservoir
8.	Temrain Reservoir
9.	Tilaiya Dam (DVC)
	State: Odisha
10.	Upper Suktel
11.	Parhel
12.	Randa
13.	Saipala
14.	Laigam
15.	Ghodahada
16.	Kumbho
17.	Gunduriposi
	State: Rajasthan
18.	Jawahar Sagar Dam
19.	Bundika Gothra Dam
	State: Punjab (Not yet on-board DRIP Ph-II)
20.	Perch Dam
21.	Mirzapur Dam
	State: Telangana
22.	Jurala Project (P.J.P.)
23.	Kaddem Project (K.N.R. Project)
24.	Koulasnala Project
25.	Musi Project
26.	Nizam Sagar
27.	Sathnala Project
28.	Sriram Sagar Project (SRSP)
29.	Suddavagu (gaddenavagu)
	State: Uttar Pradesh
30.	Adwa Dam
31.	Sirsi Dam
32.	Dhandhraul Dam

33.	Upper Khajuri Dam
34.	Pahuj Weir
35.	Jamini Dam
36.	Shahjad Dam
37.	Maudaha Dam
38.	Sharda Sagar Dam
39.	Baigul Dam
40.	Rihand Dam
41.	Dhukwan Weir
	State: Uttarakhand
42.	Joshiyara Barrage
43.	Maneri Dam Stage-I
	State: Andhra Pradesh
44.	Rallapadu Project
45.	Raiwada Reservoir
	State: Goa
46.	Salauli Irrigation Project
47.	Anjunem Irrigation Project
	State: Madhya Pradesh
48.	Bhagwant Sagar Sukta Dam
49.	Birpur
50.	Chandia Nalla Upper Lower
51.	Depalpur Dam
52.	Hathaikheda Dam
53.	Mansurwari Dam
54.	Rupaniya Khal Dam
55.	Sakalda
	State: Tamil Nadu
56.	Anaikuttam
57.	Kadamparai Dam (TANGEDCO)
58.	Kodaganar (TNWRD)
59.	Lower Bhavani (Bhavani Sagar)
60.	Manimukthanadhi (TNWRD)
61.	Mettur (TNWRD)
62.	Mirugandanadhi (TNWRD)
63.	Naganjiyar (TNWRD)
64.	Pillur Dam (TANGEDCO)
65.	Sholayar
66.	Siddhamalli

67.	Thunacadavu (TNWRD)
	State: Chhattisgarh
68.	Ravi Shankar Sagar Project
	State: Kerala
69.	Chulliar
70.	Kallada
71.	Kanjirapuzha
72.	Karapuzha
73.	Kulur (Pazhassi) Barrage
74.	Malampuzha
75.	Malankara
76.	Mangalam
77.	Meenkara
78.	Neyyar
79.	Pamba Barrage (Maniyar)
80.	Periyar Valley Barrage (Bhoothathankettu)
81.	Peruvannamoozhi (Kuttiyadi) dam
82.	Poringalkuthu
83.	Pothundy
84.	Walayar
85.	Cheruthoni
	State: Maharashtra
86.	Bhatasa
87.	Chaskaman
88.	Pawana
89.	Dhom Balkawadi
90.	Dimbhe
91.	Bhima Ujjani
92.	Koyana
93.	Sapan
94.	Darana

Annexure-XII

State-wise status of Instrumentation installed at dams

S. no	Name of states	Hydrometeorological Station installed	Seismological Stations installed
1	Assam	Under progress	Under progress
2	Bihar	Nil	Nil
3	Goa	6	6
4	Chhattisgarh	34	Nil
5	Gujarat	163 Hydrometeorological Station installed	8 seismological instruments installed
6	Haryana	All dams	Nil
7	Himanchal Pradesh	16	14 dams installed
8	Jammu & Kashmir	Nil	Nil
9	Jharkhand	Nil	Nil
10	Karnataka	49 instruments installed	49 instruments installed
11	Kerala	Under progress	16 dams
12	Maharashtra	Under progress	2
13	Meghalaya	to be installed	to be installed
14	Punjab	Installed at Ranjit Sagar dam	Installed at Ranjit Sagar dam
15	Tamil Nadu	17 dams	2 dams
16	Telangana	Minimum instruments installed	Minimum instruments installed
17	Uttar Pradesh	under progress	under progress
18	Uttarakhand	1	Nil
19	West Bengal	Nil	Nil

TE-31/1/2023-NDSA-MOWR

भारत सरकार/ Government of India
जल शक्ति मंत्रालय/ Ministry of Jal Shakti
I/88990/2023 जल संसाधन नदी विकास एवं गंगा संरक्षण विभाग/ Dept. of Water Resources, RD&GR
राष्ट्रीय बाँध सुरक्षा प्राधिकरण/ National Dam Safety Authority
****

4th Floor, Sewa Bhawan,
New Delhi

OFFICE MEMORANDUM

Sub: Constitution of Sub-committee of National Committee on Dam Safety (NCDS) on "Structural Engineering & Earthquake Safety of Dams" and "Capacity Development" -reg.

Approval of competent authority is hereby conveyed for constitution of sub-committees of National Committee on Dam Safety on "*Structural Engineering & Earthquake Safety of Dams*" and "*Capacity Development*". The above stated sub-committee(s) are approved with following compositions and Terms of Reference (ToR): -

A. Structural Engineering & Earthquake Safety of Dams

i). **Composition:**

1.	Prof. C. V. R. Murty, Professor, Department of Civil Engineering, IIT Madras	Chairman
2.	Dr. I. D. Gupta, Former Director, CWPRS, Pune	Member (Non-Official)
3.	Prof. Yogendra Singh, Professor, Department of Earthquake Engineering, IIT Roorkee	Member
4.	Prof. D. Srinagesh, Professor of Practice, Department of Civil Engineering, IIT Madras	Member (Non-Official)
5.	Sh. Sankhdip Chaudhary, General Manager, NHPC Limited, Delhi	Member
6.	Sh. Sanjay Belsare, Director General, Maharashtra Engineering Research Institute, Nashik, WRD, Maharashtra	Member (Non-Official)
7.	Director, FE&SA, CWC, New Delhi	Member-Secretary

ii). **Terms of Reference:**

(a) Preparation of Guidelines/Manuals on:
  (1) Seismic Analysis of Dams (Concrete and Embankment) and assessment criteria
  (2) Assessment of Structural and Seismic Safety of Dams
  (3) Vulnerability Assessment of Dams
  (4) Dam Safety Evaluation including Seismic & Risk Assessment
  (5) Proposed Rehabilitation and Retrofitting of Dams
  (6) Any other aspect related to Structural Engineering and Earthquake Safety of Dams

(b) Preparation of Draft Regulations as per Section 54(2) of the Dam Safety Act-2021 on the following:
  (1) The vulnerability and hazard classification criteria of Specified Dams under Section 17
  (2) The data requirements of Seismological Stations in the vicinity of Specified Dams under sub-section (1) of Section 34
  (3) The time interval of Risk Assessment studies to be carried out under sub-section (2) of Section 35
  (4) The time interval for the Comprehensive Safety Evaluations of Specified Dams in respect of Structural and Seismic Safety under sub-section (1) of Section 38

(5) The mandatory site-specific seismic parameter studies of existing Specified Dams under clause (c) of sub-section (2) of Section 38.

I/88990/2023

(c) Render technical advice on any other related matter, as and when referred by NCDS.

B. Capacity Development

i). **Composition:**

1.	Sh. D. K. Sharma, Chairman, HP Electricity Regulatory Commission, Shimla	Chairman (Non-Official)
2.	Prof. Ananth Ramaswamy, Professor & Course Co-Ordinator M.Tech Program under DRIP, IISc Bengaluru	Member
3.	Prof. N. K. Goel, Professor & Course Co-Ordinator M.Tech Program under DRIP, IIT Roorkee	Member
4.	Sh. C. P. Singh, Chief Engineer, Bhakra Beas Management Board, Nangal, Punjab	Member
5.	Chief Engineer, National Water Academy, CWC, Pune	Member
6.	Director, Training, CWC, New Delhi	Member Secretary

ii). **Terms of Reference:**

a) Identify the areas, resource persons/institutes for capacity development in the field of Dam Safety

b) Prepare the course content for Short and Long-Term Courses on dam safety

c) Prepare a road map for capacity building of States in the area of dam safety

d) Any other aspect related to Capacity Development

e) Render technical advice on any other related matter as & when referred by NCDS.

2. The non-official members of these Committees will be paid sitting fee as per DoE OM dated 12.04.2017 and Travel Allowance/Daily Allowance as per DoE OM dated 14.09.2017.

3. The Sub-committee's initial tenure shall be one year from the date of the constitution, which can be extended by another year depending on the requirement with the prior concurrence of the Chairman, NCDS.

4. This has the concurrence of IFD vide IFD Dy. No.441/2023-24 dated 28.08.2023 and approval of Hon'ble Minister, Jal Shakti vide note dated 09.09.2023.

Signed by Rakesh Kumar Gautam
Date: 18-10-2023 17:41:03
Reason: Approved
(R K Gautam)
Director

To,

All members of sub-committee (as per list).

Copy for kind information:

1. PPS to Secretary DoWR, RD & GR, Ministry of Jal Shakti, New Delhi.
2. PPS to Chairman, NCDS & Chairman, CWC, New Delhi.
3. PPS to Chairman, NDSA & Member (D&R), CWC, New Delhi.
4. PPS to Joint Secretary (RD&PP), DoWR, RD & GR, Ministry of Jal Shakti, New Delhi.
5. PS to Member (A and F), NDSA, Shram Shakti Bhawan, New Delhi.
6. PS to CE (DSO), CWC, Sewa Bhawan, R. K. Puram, New Delhi.
7. PS to CE (HRM), CWC, Sewa Bhawan, R. K. Puram, New Delhi.

List
1/88990/2023

A. Structural Engineering and Earthquake Safety of Dams

1. Prof C. V. R. Murty, Professor, Department of Civil Engineering, IIT Madras. [Email: cvrm@iitm.ac.in]
2. Dr. I D Gupta, Former Director, CWPRS, Pune. [Email: idgrh4@gmail.com]
3. Prof Yogendra Singh, Professor, Department of Earthquake Engineering, IIT Roorkee. [Email:yogendra.singh@eq.iitr.ac.in; yogendra.eq@gmail.com]
4. Prof D Srinagesh, Professor of Practice, Department of Civil Engineering, IIT Madras. [Email: dsrinagesh@iitm.ac.in]
5. Shri Sankhdip Chaudhary, General Manager, NHPC Limited, Delhi. [Email: schowdhury@nhpc.nic.in; sankhadipchowdhury@gmail.com]
6. Sh. Sanjay Belsare, Director General, Maharashtra Engineering Research Institute, Nashik, WRD Maharashtra. [Email: belsare.sanjay@gmail.com]
7. Director, FE&SA, CWC, New Delhi. [Email: fesadte-cwc@nic.in]

B. Capacity Building

1. Sh. D. K. Sharma, Chairman, HP Electricity Regulatory Commission, Shimla. [Email: dks.shimla@gmail.com]
2. Prof Ananth Ramaswamy, Professor & Course Co-ordinator M.Tech Program under DRIP, IISc Bengaluru. [Email: ananth@iisc.ac.in; ananthr63@gmail.com]
3. Prof N K Goel, Professor & Course Co-ordinator M.Tech program under DRIP, IIT Roorkee. [Email: nkgoel@hy.iitr.ac.in; coordinator.dsr@iitr.ac.in]
4. Sh. C P Singh, Chief Engineer, Bhakra Beas Management Board, Nangal, Punjab. [Email: cpsngl@gmail.com; cebhd@bbmb.nic.in]
5. Chief Engineer, NWA CWC Pune. [Email: cenwa.mah@nic.in]
6. Director, Training, CWC, New Delhi. [Email: trngdte@cwc.delhi.nic.in]

Annexure-XIV

List of dams covered under Azadi Ka Amrit Mahotsav

S. No.	Name of Dam	Date of Event	Remarks
1	Tungabhadra Dam	23-03-2023 & 24-03-2023	Conducted **before 2nd** NCDS meeting
2	Sardar Sarovar Dam	25-03-2023	
3	Maithon Dam	28-03-2023	
4	Idduki Dam	29-03-2023 & 30-03-2023	
5	Sathanur Dam	12-07-2023 & 13-07-2023	Conducted **after 2nd** NCDS meeting
6	Durgavati Dam	12-07-2023	
7	Tehri Dam	14-07-2023	
8	Rihand Dam	19-07-2023	
9	Gosikurd Irrigation Project	25-07-2023	
10	Ravi Shankar Dam	25-07-2023	
11	Indira Sagar Dam	27-07-2023	
12	Farakka Barrage	28-07-2023	
13	Srisailam Dam	03-08-2023 & 04-08-2023	
14	Bisalpur Dam	04-08-2023	
15	Bhakra Dam	07-08-2023	
16	Salaulim Dam	14-08-2023 & 15-08-2023	
17	Ranjit Sagar Dam	17-08-2023	
18	Hirakud Dam	22-08-2023	
19	Baglihar Dam	24-08-2023	
20	Kalpong Dam	24-08-2023 & 25-08-2023	
21	Teesta-V Dam	24-08-2023	
22	Kameng Dam	24-08-2023	
23	Nimoo Bazgo Dam	28-08-2023	
24	Umiam Dam	29-08-2023	
25	Nagarjuna Sagar Dam	05-09-2023 & 06-09-2023	

Annexure-XV

Meetings conducted with States SDSOs after 2nd Meeting of NCDS

S.no.	Date	States
1.	12.06.2023	States having more than 100 specified dams
2.	27.07.2023	States having more than 100 specified dams
3.	30.10.2023	States having more than 100 specified dams
4.	31.10.2023	States having less than 100 specified dams

Deliberations/discussions on following agenda points were done during above cited meetings: -

- Review of Pre-Monsoon Inspections 2023-24.
- Updating List of Specified Dams for preparation of National Database and Updation of NRLD 2019.
- Budget Provision for SDSOs and O&M of Dams.
- Plan for remediation of Cat-II Dams.
- Status of establishment of Dam Safety Units of dams.
- Status of Maintenance of Log Books of all the dams.
- Status of O & M manual and whether O & M manual followed or not, regarding specific dams.
- Status of Annual reports.
- Status of Emergency action plans.
- State wise list of Category-I & II dams and actions taken on them for rehabilitation.
- Status of Preparations for Post Monsoon Inspections 2023-24.
- Status of hydro-meteorological and seismological instruments installed in all specified Dams and status of data collected.
- Risk assessment studies carried out till date and status of compliance of outcome of these studies.
- Status of Diversion arrangement being adopted and also proposed initial reservoir filling methodology specific to each specified dam under construction.
- Status of posting of regular staff in SDSO.
- Status of all technical documentation concerning hydrology, dam foundation, structural engineering of dam, watershed upstream of dam, and nature or use of land downstream of dam.
- Status of meetings of SCDS to be conducted twice in a year in accordance with provision under section 13 (1) of the Act

File No.TE-23/1/2023-NDSA-MOWR

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
राष्ट्रीय बाँध सुरक्षा प्राधिकरण

आज़ादी का अमृत महोत्सव

OFFICE ORDER

Sub: Constitution of committee to examine the effect of GLOF in Teesta River on the projects-reg.

The Glacial Lake Outburst Flood (GLOF) generated in the Teesta River due to the bursting of South Lhonak Lake caused severe damage to the water resources structures, life and property. NDSA had earlier constituted a fact-finding team to assess the damages. The team could not visit all the structures due to road connectivity breakdowns.

Now, with the restoration of road connectivity and project authorities having made a fair amount of assessment of the damages, NDSA, as per clause (8) of Schedule II of the Dam Safety Act, 2021 constitutes a committee with the following officers to examine the issues related to the Sikkim disaster due to GLOF: -

1.	Sh. R.K. Jain, Ex- Chairman, CWC	Chairman
2.	Dr. V.K. Sharma, Ex-DDG, GSI	Member
3.	Sh. N.N. Rai, Director, Hydrology (NE) Dte, CWC	Member
4.	Sh. S.K. Sharma, Director, BCD (E&NE) Dte, CWC	Member
5.	Sh. V.D. Roy, Director, Morphology & CC Dte, CWC	Member
6.	Sh. Sanjay Kumar Singh, Regional Director, E&NE, NDSA	Member
7.	Sh. Durga Kamla Rai, Chairman SDSO, Sikkim	Member
8.	Shri Ritwik Majumdar, Scientist/Engineer 'SF' Geosciences Group, NRSC, Hyderabad	Member
9.	Sh. Balwan Kumar, Director (HPP&I), Central Electricity Authority, New Delhi	Member
10.	Sh. Rahul Kumar Singh, Director, NDSA and Gates (NW&S), CWC	Member Secretary

2. The Terms of Reference (ToR) of the committee are as follows:

a. To examine the causes leading to the bursting of Glacial Lake and consequent failure of Teesta-III dam and damages to other downstream dams.

b. To interact with dam owning agencies/owners to examine and analyze the probable cause of failure of Teesta-III dams and damages to other downstream dams.

c. To examine the status of Early Warning System installed by dam owners in Teesta basin and its performance during the recent GLOF event.

d. To review the status of monitoring of Glacial Lake, including the frequency of monitoring and responsibility of the dam owner.

e. To review the action taken by the Sikkim state and dam owners following the issuance of CWC advisory on GLOF in 2015 to the Sikkim state.

f. To review the reservoir and gate operations carried out by the dam authorities during heavy discharge release.

कार्यालय राष्ट्रीय बाँध सुरक्षा प्राधिकरण, चौथा तल (द.), सेवा भवन, आर.के.पुरम, नई दिल्ली-110066

g. To recommend measures to prevent/minimize the recurrence of such events in future.

h. The committee may co-opt any other member as per requirement with the permission of Chairman, NDSA.

3. The sitting fee will be applicable to the non-official members at Sr. no. 1 and 2 only @ Rs. 6000/- per sitting subject to a maximum of 10 sittings per month, and TA/DA as per their eligibility at the time of retirement.

4. The committee may call any official from concerned dam-owning agencies/owners or any other department for interaction and seek any information required by the committee to discharge its duty. The committee will submit its report to the NDSA within two (2) months.

This issues with approval of the competent authority.

Signed by Rakesh Kumar Gautam
Date: 20-11-2023 11:50:49
Reason: Approved

(Rakesh Kumar Gautam)
Director
E-mail: dsd2dte-cwc@gov.in
Phone: 011-29583362

To,

1. Sh. R.K. Jain, Ex- Chairman, CWC [Email: rkjaincwc@yahoo.com, Mob: 9811581705]
2. Dr. V.K. Sharma, Ex-DDG, GSI [Email: vksharma_gsi@yahoo.co.in, Mob:8004915833]
3. Sh. N.N. Rai, Director, Hydrology (NE) Dte, CWC , New Delhi [Email: hydne@nic.in, Mob:9999085580]
4. Sh. S.K. Sharma, Director, BCD (E&NE) Dte, CWC, New Delhi [Email: bcdene-cwc@nic.in, Mob: 9210891320]
5. Sh. V.D. Roy, Director, Morphology & CC Dte, CWC, New Delhi [Email: dirmorpho-cwc@nic.in, Mob: 9650804451]
6. Sh. Sanjay Kumar Singh, Regional Director, E&NE, NDSA, Guwahati [Email: dirmaguwahati-cwc@nic.in, Mob: 9650072606]
7. Sh. Durga Kaml Rai, Chairman SDSO, Sikkim [Email: durgakamalrai@gmail.com, Mob: 7550901383]
8. Shri Ritwik Majumdar, Scientist/Engineer 'SF' Geosciences Group, NRSC, Hyderabad [Email: ritwik_m@nrsc.gov.in, Mob: 9441930070]
9. Sh. Balwan Kumar, Director (HPP&I), Central Electricity Authority, New Delhi [Email: balwan72@nic.in, Mob: 8920911682]
10. Sh. Rahul Kumar Singh, Director, NDSA and Gates (NW&S), CWC, New Delhi [Email: dirdr-ndsa@gov.in, Mob: 8005490440]

Copy for kind information:

1. PPS to Chairman, CWC, Sewa Bhawan, New Delhi.
2. PPS to Chairman, NDSA and Member (D&R), CWC, Sewa Bhawan, New Delhi.
3. PS to JS (RD & PP), D/o WR, RD and GR, Shram Shakti Bhawan, New Delhi.
4. Chief Engineer (DSO), CWC, Sewa Bhawan, New Delhi.
5. Chief Engineer (HSO), CWC, Sewa Bhawan, New Delhi.
6. Chief Engineer (P&D), CWC, Sewa Bhawan, New Delhi.
7. Chief Engineer (E&NE) and Member (R), NDSA, New Delhi.
8. Chief Engineer (NW&S), CWC and Member (D&R), NDSA, New Delhi.
9. Chief Engineer (BBO), Regional office CWC, Guwahati.

Appendix-A

By Email

Government of India
Ministry of Jal Shakti
Department of Water Resources, RD & GR
National Dam Safety Authority
Member (Disaster & Resilience)

Date: 04.10.2023

To,

Shri Uday Chaudhari

Private Secretary to Minister.

Ministry of Jal Shakti

Subject: Preliminary report on incident occurred on 04.10.2023 in Teesta Basin of Sikkim - reg

Sir,

As desired, please find attached a preliminary report on the effect on projects in Teesta basin due to sudden cloud burst occurred over Lhonak Lake in North Sikkim on 4th October, 2023 at around 1 AM, resulting in flash flood in the Teesta River in Lachen Valley.

भवदीय

4/10/23

(राहुल कुमार सिंह)
निदेशक
(आपदा और समुत्थान-शक्ति),
(राष्ट्रीय बांध सुरक्षा प्राधिकरण)

Copy for kind information to:

1. PPS to Secretary, DoWR RD & GR, New Delhi
2. PPS to Chairman, CWC, New Delhi
3. Chairman, NDSA, New Delhi.
4. JS (RD&PP), DoWR, RD & GR, New Delhi.
5. JS (Admin), DoWR, RD & GR, New Delhi.

Room No. 602 (S), Sewa Bhawan
R.K. Puram-1, New Delhi-110066
Tel: 011-29583490, E-mail: gdnwsdte@nic.in & dirdr-ndsa@nic.in

Preliminary Report on Incident occurred on 04.10.23 in Teesta Basin of Sikkim

1. Incident

The potential threat from Glacial Lake Outburst Foods (GLOFs) has evolved over time, particularly evident in the State of Sikkim, where numerous dangerous lakes have been identified. It had been reported that South Lhonak Glacial Lake in Sikkim is having very high probability of sudden outburst which may cause floods in downstream areas. The South Lhonak lake (27°54′43″ N and 88°12′7″ E) is located in the northern part of the Teesta Basin, in Sikkim, Central Himalaya. The lake has an elevation of 5200 m above mean sea level (amsl). It is a proglacial lake located at the snout of the South Lhonak glacier, formed due to its retreat. The South Lhonak Lake lies at about 67 Km distance from Chungthang Town on Teesta river.

On 4th October around 1 AM (night), a sudden cloud burst over Lhonak Lake in North Sikkim, resulting in a flash flood in the Teesta River in Lachen Valley, which was compounded by the release of water from Teesta-III Dam at Chungthang.

2. Projects wise summary: -

The following diagram shows the project location and Table 1 shows the reported damages to the project.

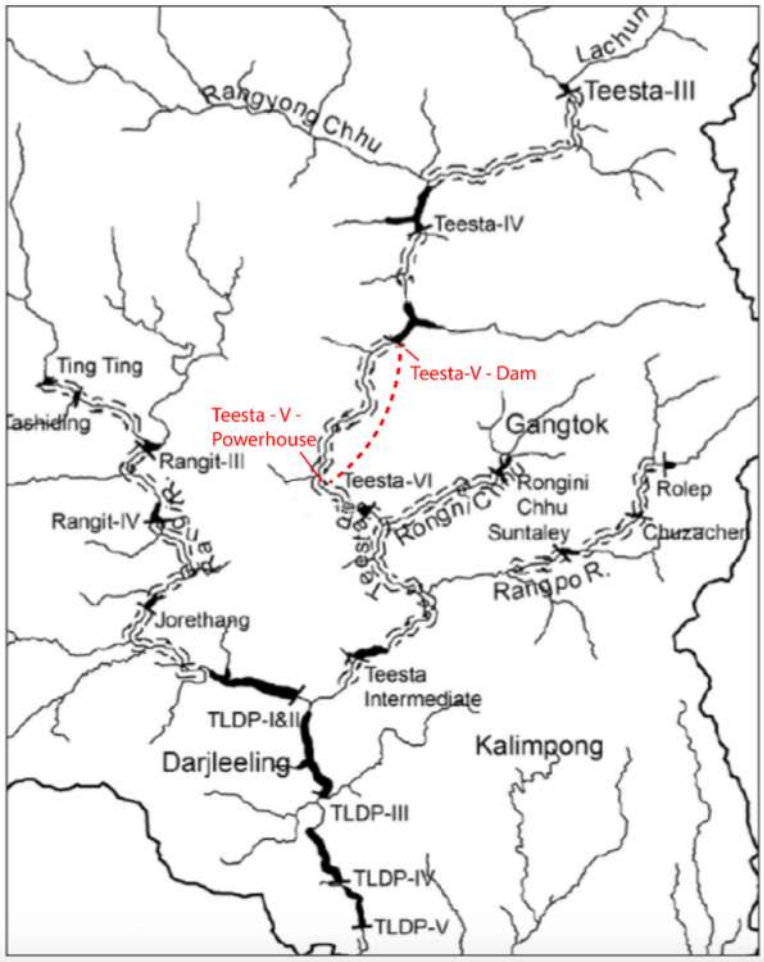


Table-1

Sl no	Project name	Reported Damages at the Dam sites	Reported Damages at Powerhouse site	Remarks
1	Teesta-III (60m High CFRD dam, 1200 MW-Installed capacity)	Part of CFRD washed out, and the spillway is intact	The powerhouse approach bridge washed out, and water ingress in the Main Access Tunnel (MAT) to the powerhouse.	Connectivity to the project is not available as of now.
2	Teesta-V (88.6 m high concrete gr dam, 510 MW Installed capacity (IC))	Concrete Dam was overtopped, damaging the superstructure and Gates.	Powerhouse is intact, and water ingress is reported	Connectivity to the project is not available as of now.
3	Teesta-VI (27 m High Barrage, 500 MW -IC	Under construction project. Coffer dams and machinery washed out and	Powerhouse construction camps are affected by water ingress.	Connectivity to the project is not available as of now.
4	TLDP-III (32 m High Barrage, 132 MW-IC)	Barrage was overtopped. No major damage	No damage has been reported to date.	Connectivity is partially restored
5	TLDP-IV (45 m high concrete dam, 160 MW -IC)	Concrete Dam was overtopped. No major damage	No damage has been reported to date.	Connectivity is partially restored

The Detailed preliminary report is enclosed as Annexure-1.

Major infrastructure has been damaged in the flash floods. The road to North Sikkim leading to Boundary with China has also been damaged. All the connecting bridges along the Teesta River (steel bridge at Singtam -Indreni bridge, L D Khazi Bridge, Phidang Bridge, 120-metre-cable suspension bridge) have also been damaged.

3. Further Actions

A team comprising of Member (Disaster and Resilience) of NDSA and senior officers from

CWC, NDSA and NHPC are going from Delhi to visit all possible project sites as per connectivity. They shall submit the report on its return. A letter to SDSO-Sikkim state and CMD NHPC has also been sent to submit the status report about the incident and emergency action plan in force.

Annexure-1

I. TEESTA-III PROJECT (1200 MW) – SIKKIM

As per available information, the Teesta-III dam (about 40 km u/s of Teesta-V dam) overtopped, and a substantial portion of CFRD washed out during the flash floods.

The water also entered the underground PH through MAT.

Due to a substantial part of the CFRD breach, there could be sudden release of water from the reservoir of Teesta-III which further abetted the flash flood conditions d/s of Teesta-III.

II. TEESTA-IV PROJECT (520 MW) – SIKKIM

Teesta-VI project is under the clearance stage, and no construction has been started yet.

III. TEESTA-V POWER STATION (510 MW) – SIKKIM

Teesta-V Power Station (3x170 MW) located in the State of Sikkim, is a run of the river with pondage scheme of 3-4 hrs. diurnal storage to harness the hydro power potential of river Teesta for peaking during the lean season. The Power Station was commissioned in the year 2008.

The project comprises of 88.6 m high Concrete Gravity Dam (located 2 Kms downstream of confluence of Teesta River with Dikchunala) with three penstocks of length 321 m and 17.2 Km long Head Race Tunnel housed on left bank.

The underground Power House near Sirwani with installed capacity of 510 MW houses 3 units of 170 MW capacity each designed to operate under the net rated head of 197 m and to generate 2573 MUs of energy in 90% dependable year with 95% machine availability.

Teesta-V Power Station was under normal operation and was operating at 507MW. It is learnt that South Lhonak Lake, which is 90 KM upstream from Teesta-V Dam has been suspected to get outburst resulting into flash flood in the region. The staff posted at Dam of Teesta-V Power Station tried to open all the radial gates to pass the river discharge but only two radial gates out of five were opened and others could not be opened due to sudden increase of huge inflow to save the human life. It is expected that more than 10000 Cumecs discharge was observed. As per telephonic conversation, it is known that water has been

over flowed from the top of the dam, gantry crane and radial gates are expected to be damaged/ washed out. Approach road to Dam is washed out. Control room at Dam for remote operation of gates (Power pack) and other electrical installations were washed out. One vehicle & one contract staff posted at dam is missing.

Considering the emergent situation at dam, the shutdown of all the 3 units was undertaken at Power House. Power House staff tried to lower the TRC gate but due to heavy discharge in the river the TRC gate could not be lowered. A suspension bridge near Power House connecting the Power House on the left bank and Residential complex on the right bank is washed out due to heavy discharge. 3 nos. of 400KV Transmission Towers near Power House collapsed and its associated electrical installations have been damaged. Two bridges, one upstream of Teesta-VI barrage and another at Singtham Bazar, have also been washed away.

All the drainage dewatering pumps were operated and the water entered into the power house has been dewatered. There is no damage in the Power House of Teesta-V. Later on TRC gates were also lowered successfully.

Due to heavy discharge near TRT area, level rose upto EL 378 M against the normal working level of TRT i.e. EL 361 m. Due to this some water entered back in bottom of Power House (drainage gallery & MIV floor) through air admission valve connected to draft tube and open in air at level EL 377 m.

River flow Near Power House

Dam of Teesta-V

Dam of Teesta-V

Bridge Connecting to Power House and Residential Complex

IV. TEESTA-VI PROJECT (500 MW) - SIKKIM

At around 1 am a message has been received from Teesta – III Power Station regarding breaching of Chungthang artificial lake. Immediate instructions were issued to the contractors working at site to evacuate all the men and Machinery from site and shift it to a safer place. Accordingly, contractor started evacuation process.

At about 2:20 am, again a message was received from Teesta-V Dam that a huge flood has hit the project and water started overtopping over Teesta-V Dam. At about 2:30 am, flood over topped the Coffer Dyke of Teesta-VI project and has reached EL 365 m at barrage area. The flood water has entered into Silt Flushing Tunnel (SFT), Power House and Transformer Gallery. Discharge in river was anticipated to be more than 15,000 cumecs.

During the flood, bridges at Balutar, (owned by NHPC) connecting left and right bank of under construction barrage, Balutar, Singtam, Samardung and Tarkhola (owned by NHPC) connecting left and right bank of Power House got completely washed out. Washing up of electrical cables has resulted into discontinuation of power supply to HRTs and accordingly works have been disrupted.

Evacuation of men and major equipment has been carried out promptly. No loss of life has been reported so far,

Discharge in the river is still very high and detailed assessment could be done only after water level recedes.

Barrage – Teesta-VI Project

V. TEESTA LOW DAM PROJECT - III (TLDP-III POWER STATION) - WEST BENGAL

All the units of TLDP-III were under normal operation. As TLDP-III Power Station is in downstream of Teesta-V Power Station. The message was communicated to TLDP-III and TLDP-IV Power Station. All the staff were on alert at TLDP-III Power Station. Accordingly, all the units of TLDP-III stopped between 02:47 hrs. to 2:50 hrs. and Intake gates were lowered. All the radial gates were opened to pass the heavy discharge. It is expected that more than 10000 Cumecs water passed in the river. Power House and Barrage are safe. Heavy discharge is being passed through radial gates.

TLDP-III Power House

VI. TEESTA LOW DAM PROJECT - IV (TLDP- IV POWER STATION) – WEST BENGAL

All the units of TLDP-IV were under normal operation. As TLDP-IV Power Station is in downstream of Teesta-V & TLDP-III Power Station. The message was communicated to TLDP-IV Power Station. All the staff were on alert at TLDP-IV Power Station. Accordingly, the Unit#1, Unit#2, Unit#3 and Unit#4 were stopped at 02:30 hrs., 02:35 hrs., 02:32 hrs., and 02:39 hrs. respectively. All the radial gates were opened to pass the water. It is expected that more than 15000 Cumecs discharge was observed. Power House and Dam are safe. Heavy water is being passed through radial gates.

Dam top of TLDP-IV

Dam top of TLDP-IV

VII. RANGIT-IV PROJECT – SIKKIM

Construction at project is going normally. As such, there is no impact of the incident on construction activities.

PRESENT SITUATION

Major infrastructure has been damaged in the flash floods. The road to North Sikkim leading to Boundary with China has also been damaged. All the connecting bridges along the Teesta River (steel bridge at Singtam -Indreni bridge , L D Khazi Bridge, Phidang Bridge, 120-metre-cable suspension bridge) have also been damaged.

Further, Executive Director (Siliguri Region), NHPC could not go beyond 29th Mile on NH-10 because of the road blockades/wash out at various locations.

The recent Road Situation Report issued by Sikkim Police is attached.

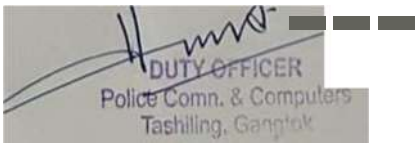
POLICE CONTROL ROOM,
CIRCULAR BUILDING, **NEW TASHIUNG SECRETARIAT,** GANGTOK

ROAD SI T UAT ION REPORT

DATED: 04.10.2023

DISTRICTS	STATUS
GANGTOK	I. DISTRICT COURT, GANGTOK VIA TAMANG GUMPA BLOCKED 2. SINGTAM TO 32 NO. ONE WAY CLEAR AT 14 MILE 3. SINGTAM TO RANGPO BLOCKED AT 19 MILE 4. SINGTAM TO DIKCHU BLOCKED 5. SINGTAMTO SANG CLEAR REST ALL ROADS CLEAR/JEEPABLE UNDER GANGTOK DISTRICT.
PAK.YONG	I. BARAPATHING TO CHOCI IEN ROAD BLOCK AT 4TH MILE 2. RANGPOTO RORATHANG ROAD CLEAR FOR LIGHT vrn IICLES ONLY. 3. PAKYONG TO RORATHANG ROAD BLOCKED AT BELOW AIRPORT.ALTERNATIVE ROUTE VIA NOP GAON - DUGHALAKHA REST ALL ROADS CLEAR/JEEPABLE UNDER PAK.YONG DISTRICT.
MANGAN	I. MANGAN TO DIKCHU BLOCKED NEAR PHIDANG BRIDGE. 2. MANGAN TO GANGTOK VIA PIIODONG ROAD CLEAR. 3. MANGAN TO CIIUNGTHANG ROAD BLOCKED ATTOONG BRIDGE (TOONG AND ABOVE ROAD COULDN'T BE UPDATEDBECAUSE OF LACK OF COMMUNICATION) REST ALL ROADS CLEAR/JEEPABLE UNDER MANGAN DISTRICT.
NAMCIll	I. RAVANGLA TO YANGANG BLOCKED ATGOGUNEY, 2. BERMIOK TONAMCHI VIA PHONGLA BLOCKED NEAR VEDGHARI. 3. JORETI IANG TO MELLI BLOCKED ATTIWLO GOLAl.MAZITAR & I0TH MILE, 4. NAMCIII TO RANGPO VIA NAMTIIANG-MAMRING BLOCKED AT NARAK-JHORA, 5. NAMCHI TO SINGTAM VIA DAMTHANG-TEMI BLOCKED AT GAMMON BRIDGE AND INDRENI BRIDGE, 6. RAVANG TO LEGSI IJP BLOCKED NEAR TREE IIOUSE. 7. NAMCHI TO JORETHANG VIA DI!NCI IUNG CLEAR. 8. NAMCI II TO MELLI VIA KITAM CLEAR. REST ALL ROADS CLEAR/JEEPABLE.
GYALSIIING	I. DENTAM TO PELUNG/ GYALSI IING ROAD BLOCKEDAT BB LALL BRIDGE, DENTAM. ALTERNAn v E ROAD VIA INTAKE. 2. UTTAREY TO SOPAKI IA ROAD BLOCKED. RI'.iST ALL ROADS ARI! CLhAR/ JEEPABLE UNDER GYALSIING DISTRICT.
SORENG	ALL ROADS ARE CLEAR/JEEPABLE UNDER SORI NG DISTRICT.
NH-10 SIL IGURI	I. 19"' MILi . NEAR SINGTAM. 2. MELLI, WI!ST BENGAL TO SILIOURI BLOCKED AT 29[111] MILE. 3. LIKIIAY BIIJR, NEAR TEESTA, WEST BENGAL. 4. MELLI, SIKKIM ·10 GANGTOK 13LOCKBDNEAR MELLI BAZAR, WB.

SPCR ROAD UPDATF.S



By Email

Government of India
Ministry of Jal Shakti
Department of Water Resources, RD & GR
National Dam Safety Authority
Member (Disaster & Resilience)

Date: 16.10.2023

सेवा में,

As per the list attached.

विषय: **Report on site visit to Teesta Basin Hydro Power Projects in Sikkim and West Bengal subsequent to flash flood incident occurred on 04.10.2023- reg**

महोदय,

As per the direction of Chairman, NDSA & member (D&R), CWC a team comprising of officers of NDSA, CWC and NHPC visited some of the Hydo-Power Projects in Teesta basin in India.

A brief report prepared based on the records, project visit and discussion with project authorities is enclosed herewith for information.

भवदीय

16/10/23

(राहुल कुमार सिंह)
निदेशक
(आपदा और समुत्थान-शक्ति),
(राष्ट्रीय बांध सुरक्षा प्राधिकरण)

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To:

1. PPS to PCE cum Secretary, Water Resources Department, Sikkim. (wrdgov23@gmail.com)
2. PPS to Principal Secretary, Water Resources Department, West Bengal. (iwd.prsecy@gmail.com)
3. PPS to PCE cum Secretary, Power Department, Sikkim. (secypower.sikkim@gmail.com, veeraganapati@gmail.com)
4. PPS to Secretary, Department of Power, West Bengal. (powersecy@wb.gov.in)
5. SDSO, Sikkim. (durgakamalrai@gmail.com)
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7. CMD, NHPC. (cmd@nhpc.nic.in)(cmd-mis@nhpc.nic.in)
8. MD, Sikkim Urja Limited. (dpb@sikkimurjalimited.in)
9. Regional Director(Eastern and North Eastern), NDSA

Copy to:

1. PPS to Hon'ble Minister of Jal Shakti, New Delhi.(minister-jalshakti@gov.in)
2. PPS to Hon'ble Minister of Power, New & Renewable Energy, New Delhi. (minister-power@gov.in)
3. PPS to Secretary, DoWR, RD & GR, New Delhi. (secy-mowr@nic.in)
4. PPS to Secretary, Power, New Delhi. (secy-power@nic.in)
5. PPS to Chairman, CWC, New Delhi.
6. PPS to Chairman, NDSA and Member (D&R), CWC, New Delhi.
7. PPS to JS (RD&PP), DoWR, RD & GR, New Delhi.
8. PPS to JS (Admin), DoWR, RD & GR, New Delhi.
9. NDSA Secretariat, New Delhi.

Site Visit Report on the Effect on the Projects in Teesta Basin Due to Glacial Lake Outburst Flood (GLOF) Lhonak Lake, North Sikkim on 04.10.2023

Prepared by:

Central Water Commission
&
National Dam Safety Authority

New Delhi **October-2023**

1 Teesta Basin and Projects

The Teesta river basin extends from Sikkim in India in the eastern Himalayas, through West Bengal (Darjeeling, Jalpaiguri, Cooch Behar, Uttar Dinajpur, Dakshin Dinajpur, and Malda districts), to the northern Rangpur division in Bangladesh (Lalmonirhat, Nilphamari, Rangpur, Kurigram, and Gaibandha districts), where the river joins the Brahmaputra before it flows into the Bay of Bengal after meeting with the Ganges and the Meghna (Figure 1). The river rises in the Teesta Khangse glacier in North Sikkim. It is then joined by several tributaries, including the Lachung Chu, Rangyong (Talung) Chu, Rangit, Rangphu, Mahananda, Balason, and Jaldhaka. It enters Bangladesh at Dimla in the Nilphamari district. The Buri-Teesta and Trimohini then join it before it flows into the Brahmaputra (Jamuna) at Chilmari upazila in Kurigram district (left bank) and Sundarganj upazila in Gaibandha district (right bank) at an elevation of 23 masl.

The river is 414 km long, with the more significant part in India (151 km in Sikkim, 19 km along the border between Sikkim and West Bengal, 29 km in West Bengal), 94 km along the Indo-Bangladesh border, and the final 121 km in Bangladesh. The total catchment area is 12,159 km^2 distributed between mountains and hills (8,051 km^2, with 6,930 km^2 in Sikkim and 1,121 km^2 in West Bengal) and plains (4,108 km^2, with 2,104 km^2 in West Bengal and 2,004 km^2 in Bangladesh).

There are four Glacial lakes in the Teesta basin. Glacial lakes (GLs) are common in the Himalayan region's high elevation of glacierised basins. Water Bodies (WBs) are formed by obstructions created in the drainage path due to landslides or artificial structures. GLs are formed when glacial ice or moraines impound water. There are varieties of such lakes, ranging from meltwater ponds on the glacier's surface to large lakes in side valleys dammed by a glacier in the central valley. These lakes normally drain their water through seepage in front of the retreating glacier. The moraine creates a topographic depression in which the meltwater generally accumulates, leading to glacial lake formation. When this lake is watertight, melt waters accumulate in the basin until seepage or overflow limits the lake level. The impoundment of the lake may be unstable, leading to the sudden release of large quantities of stored water. Flash floods caused by the outburst of GL/WBs, called Glacial Lake Outburst Flood (GLOF)/Lake Outburst Flood, are well known in the Himalayas. The shrinkage of Himalayan glaciers has resulted in the formation of more moraine-dammed lakes. The bursting of such lakes leads to flash floods, and these floods redistribute sediments and modify the landscape.

It was reported that South Lhonak Glacial Lake in Sikkim has a high probability of sudden outbursts, which may cause floods in downstream areas. The lake is 5,200 m (17,100 ft) above sea level. It formed due to the melting of the Lhonak glacier. The lake is growing abnormally rapidly due to the melting of the lake's associated South Lhonak glacier and additional meltwater from the adjacent North Lhonak

and main Lhonak glaciers. The lake coordinates 27°56'50.93"N 88°19'53.54"E. CWC conducted a Study up to about 175 km downstream of the lake using information from the inventory of GL/WBs, monitoring reports, and cross-section data @ 1 km interval extracted from CartoDEM ver.2, to analyse flood implications in the downstream villages namely Lachen, Chungthang, Dikchu, Singtam, Manipal, Rangpo & Bara Mungwa and hydropower projects on the river in Sikkim. A highly sophisticated mathematical model MIKE–11 was set for the study (CWC, March 2015, Annexure-1)

Fig. 1 below shows a Google Earth image of glacial lakes and locations of villages and hydropower projects (existing and planned) on the River Teesta. The schematic diagram showing locations and their drainage path is shown in Fig. 2.

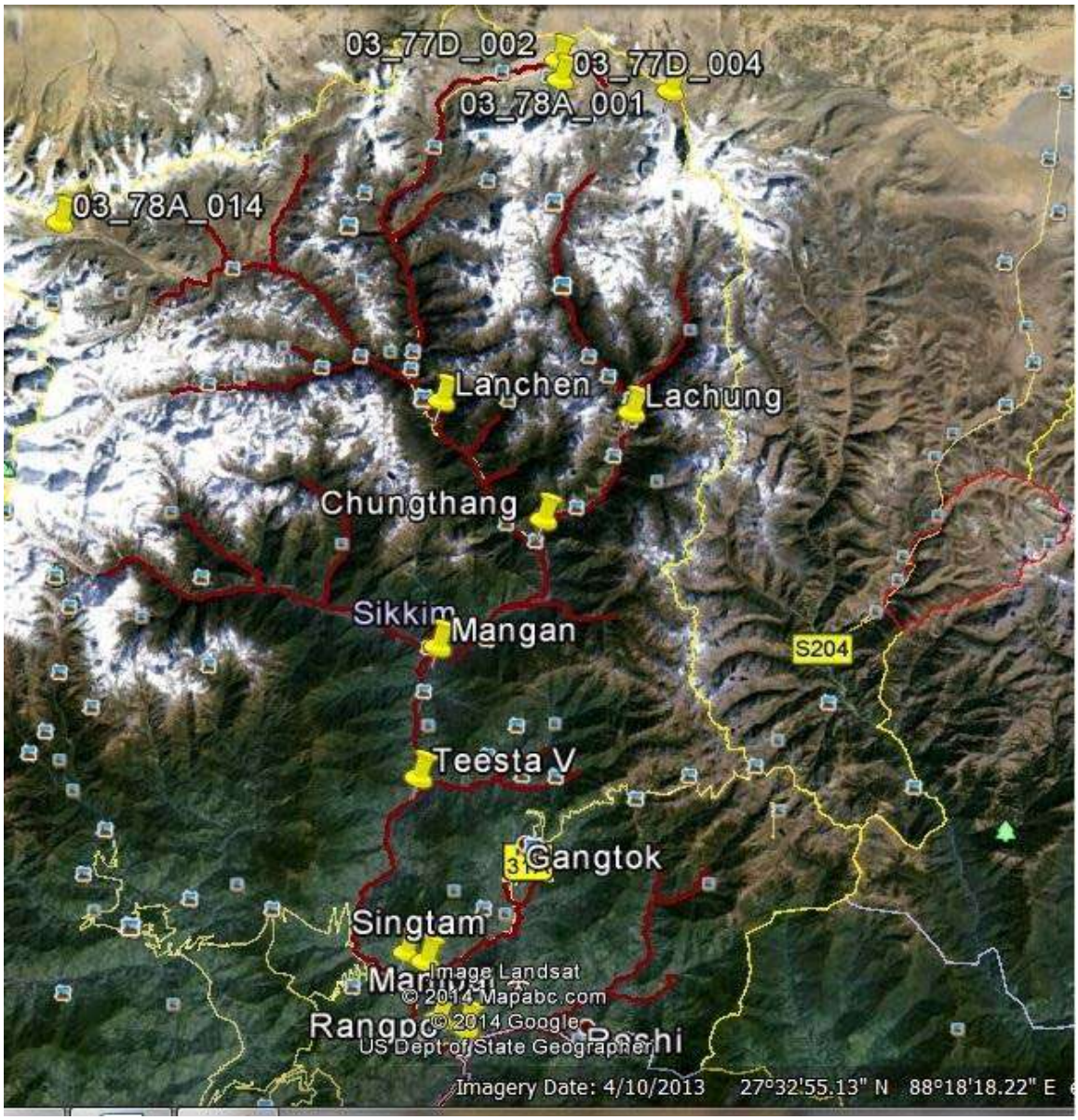


Fig. 1: Google Earth image of glacial lakes and locations of villages andhydropower projects (existing and planned) on the River Teesta

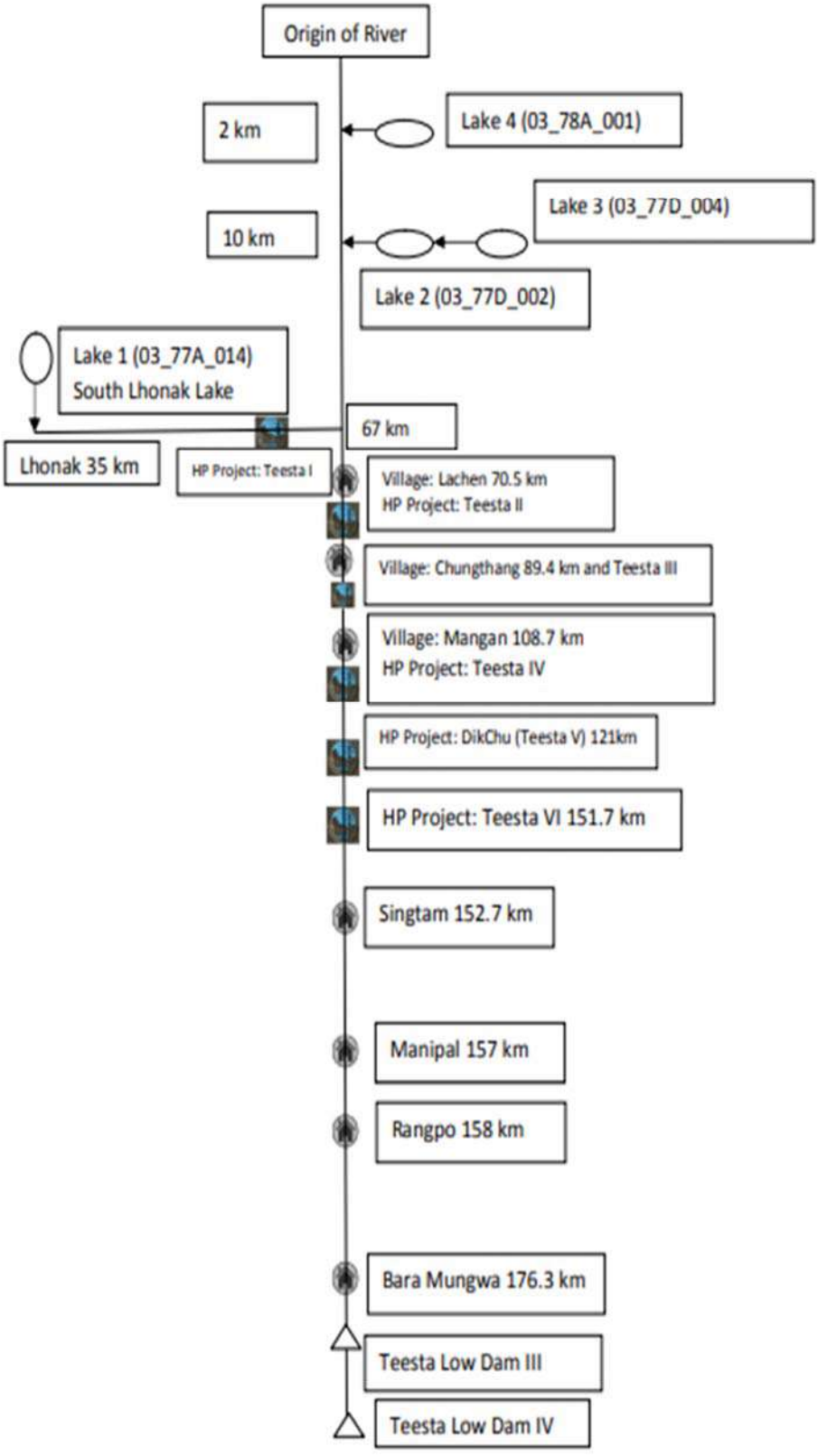


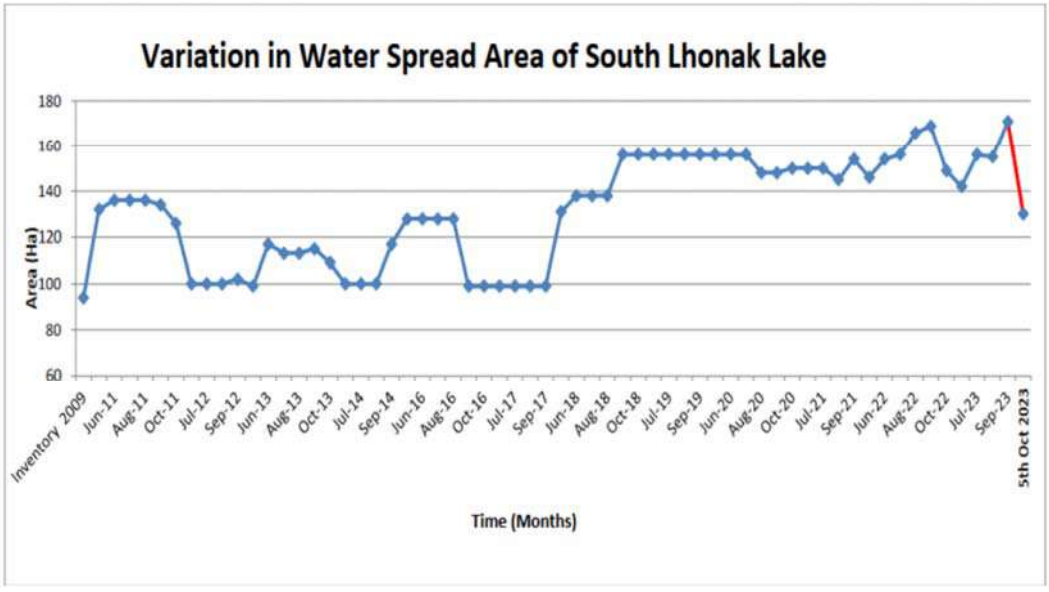
Fig. 2: Line diagram depicting glacial lakes, habitation and hydropowerprojects along River Teesta

2 The Incident of GLOF

The media quoted Mr Sunil Saraogi, Executive Chairman, Sikkim Urja Ltd, stating, "*The dam at Chungthang got washed away in ten minutes just after 12 midnight. We also saw that the 200-metre-long bridge connecting the powerhouse has been washed away. The entire powerhouse has been submerged underwater. At 11:58 p.m. on Tuesday, we got information from the Indo-Tibetan Border Police (ITBP). Immediately, our team went to the dam to open the gates. Before they could open, the flash flood hit them, and they ran away to save their lives. There were 12 to 13 people in the team, and they somehow got saved on the other side of the dam. Moreover, they would be evacuated by ITBP by 2 p.m. on Wednesday (Oct 4 2023). We are unable to reach the powerhouse. We do not know the extent of damage in the powerhouse at Mangan. No one could reach the powerhouse as the bridge connecting the dam had gone. Fortunately, as all have come out, no one is inside the powerhouse*".

According to the Preliminary Report of the Remote Sensing & GIS (RS&GIS) Centre of NHPC Ltd., the Satellite Data and analysis shared by NRSC, Hyderabad, the South Lhonak Lake was rapidly increasing its size. On 17 September 2023, the size of Glacial Lake was 162.7 ha, which increased to 167.4 ha on 28 September 2023. Thus, this increase was about 4.7 ha within the last 11 days. On 4 October 2023, the lake's size was reduced to only about 130 ha. suggesting a rupture in the lake. NRSC has not intimated the date and time of the outburst. However, about 37.4 ha. reduction in lake size is reported after comparing data from 4th October with that of 28th September 2023.

- Water Spread area of South Lhonak Lake varied from 100 ha to 160 ha during monthly monitoring period 2011-2023 during monsoon
- Maximum area was 169ha & 171 ha in Sept 2022 & Sept 2023 respectively



➢ The Water Spread area reduced to 130 ha on 5th Oct 2023 morning after lake outburst

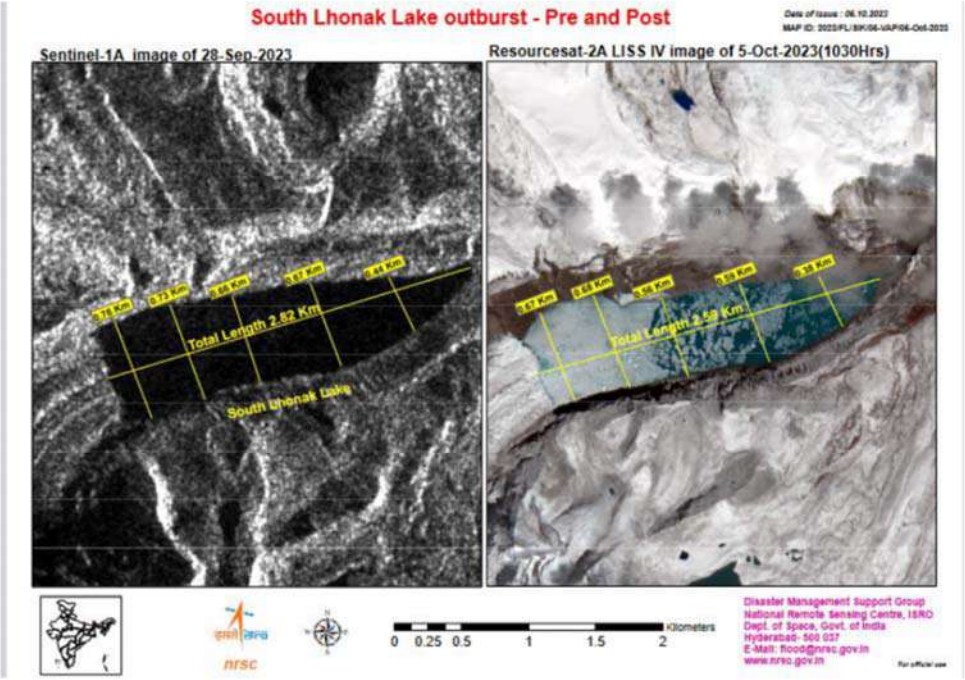


Fig. 3: The Images Shared by NRSC

In its Advisory of March 2015 report, CWC has reported following the spread of the south Lhonak Glacia lake.

Table-1

	Water Spread Area (ha)			
Lake ID *Month& Year*	*03_78A_014 (Lake1)*	*03_77D_002 (Lake 2)*	*03_77D_004 (Lake 3)*	*03_78A_001 (Lake4)*
Inventory (2009)	94	105	106	156
Jun-11	**136**	**119**	**123**	cloud
Jul-11	cloud	cloud	cloud	**180**
Aug-11	cloud	cloud	cloud	cloud
Sep-11	134	113	114	162
Oct-11	126	103	101	145
Jun-12	100	96	107	167
Jul-12	Cloud	cloud	118	cloud
Aug-12	Cloud	cloud	cloud	cloud
Sep-12	102	91	103	152
Oct-12	99	99	104	142
Jun-13	117	110	106	161
Jul-13	113	97	101	154
Aug-13	Cloud	Cloud	116	163

Sep-13	115	100	114	164
Oct-13	109	91	105	153
Jun-14	100	106	101	146
Jul-14	Cloud	106	112	Cloud
Aug-14	Cloud	Cloud	108	Cloud
Sep-14	117	Cloud	114	157
Oct-14	128	87	103	144

Lake 1 in the above table is South Lhonak River (See Fig. 2). The perusal of the table indicates that the South Lhonak spread area was 136 ha in Jube 2011, while it became 167.4 ha on 28 Sep. 2023.

In its report, CWC generated a scenario of the south Lhonak Glacial Lake outburst by considering a 136 hectares water spread area and 30 m average depth. The following table giver the discharge, water level and travel time of flood (GLOF) at different locations

Table 2: Scenario of South Lhonak Glacial Lake outburst

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time to reach at (minutes)*
Teesta I	4.43	6230	14.3	100
Lachen and Teesta II	4.31	6225	14.2	105
Chungthang and Teesta III	4.45	6210	12.45	120
Mangan and Teesta IV	4.71	6200	10.45	125
Dik-Chu (Teesta V)	7	6080	5.9	140
Singtam and Teesta VI	5.4	5846	5.4	192
Manipal	3.96	5788	4.3	210
Rangpo	3.65	5788	4.3	210
Bara Mungwa	2	5650	4	250

The above table shows the increase over and above the existing river water level due to a constant flow of 1000 m3/sec.

As it was the end of the Monsoon, it is expected that both the Teesta-III and Teesta -V reservoirs was between FRL and MDDL on the 4th Oct at 00.00 hrs.

The above table indicates that the lead time available for Teesta-III and Teesta-V projects is about 120 minutes and 140 minutes, respectively. However, Teesta-III, unaware of the lake burst, could not get time to operate the reservoir. Looking at the Teesta-V operation on the 4th of October night, they also got roughly 20 minutes to act, while TLDP-III and TLDP-IV got the necessary time to operate the reservoirs.

Due to the failure of the Teesta -III dam, gross storage of the Teesta-III dam (5.08 MCM) also got into the system along with GLOF volume. These waves, along with lots of boulders and slush from the failure of CFRD and Glacial Lake, reached Teesta-V in 20 to 30 minutes. During this period, dam authorities could open two radial gates and shut down the powerhouse. Due to the non-opening of sluice spillway radial gates, flood waves topped the dam along with floating boulders, tree trunks, vehicles, etc., which damaged the superstructure like the control room, power pack of radial gates, etc. All radial gates of the project washed away, and its reservoir volume (9.61 MCM) also got into the system.

Below the Teesta-V dam, CWC has its two H.O. sites, namely Khanitar and Melli. Fig. 3 and Fig. 4 show the water level observed at these sites on 4th Oct. 2023,

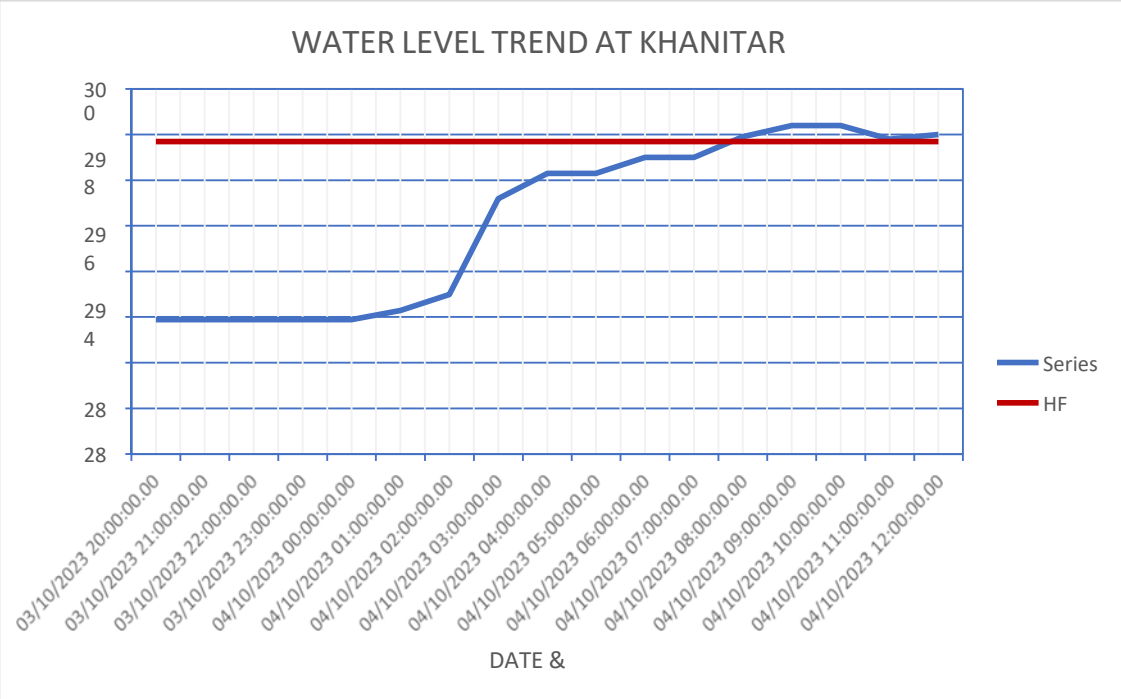


Fig.3: Water level at Khanital HO site on 3rd and 4th Oct. 2023

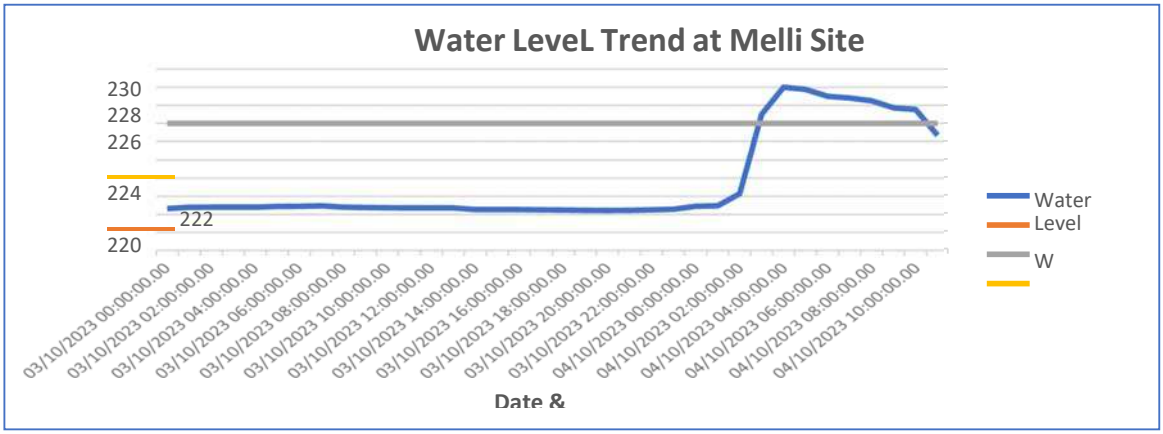


Fig.4: Water level at Melli HO site on 3rd and 4th Oct. 2023

Below the Melli Site are the Teesta Low Dam Project-3 (TLDP-3) and TLDP-4. Before the arrival of the flood waves, project authorities emptied the reservoirs and shut down powerhouses.

3 Ground situation of the Projects

Following officers from NDSA, CWC, and NHPC visited the projects in Teesta Basin 0n the 5th and 6th of October:-

NDSA/CWC

1. Shri Anil Jain, Member (Disaster and Resilience), NDSA
2. Shri Rahul Kumar Singh, Director (Gates), CWC/NDSA
3. Shri Vibhor Baghel, Asstt Director, NDSA

NHPC

1) Sh. R K Chaudhary, Director Technical
2) Sh. L K Tripathi, ED, Regional Office, Siliguri
3) Sh. Sanjay Darbari, ED, Planning Corporate Office
4) Sh. Om Prakash, Group General Manager (HoP), TLDP III&IV
5) Sh. Ashutosh Kumar. Jha, DGM (M), TLD-IV PS
6) Sh. Kundan Kumar, DM (C), TLD-IV PS
7) Sh. Rajesh Kumar Gupta, AM (M), TLD-IV PS
8) Sh. Lalit Bhusan Roy, AM (M), TLD-IV PS
9) Sh. S. Das, GM(E), TLD-III PS
10) Sh. Ashutosh Kumar, DGM (E), TLD-III PS
11) Sh. R.R. Mallick, GSM (E), TLD-III PS
12) Sh. Manoj Sah, GSM (C), TLD-III PS
13) Sh. Himanshu Shekhar, SM(C), TLD-III PS
14) Sh. Piyush Bhaskar, DM(Safety), TLD-III PS

15) Sh. U. K. Singh, SM (Research), RO Siliguri
16) Sh. Ajeet Kumar, SM (C), D&E Division, CO.
17) Sh. Ankur Vishwakarma, SM (C), D&E Division, CO.

Site Visit of TLDP-IV

Site Visit of TLDP-III

(a) Site Visit of TLDP-IV

The project is owned and operated by NHPC. The project's salient features are placed in Annexure 2. All the units of TLDP-IV were under normal operation as TLDP-IV Power Station is downstream of Teesta-V & TLDP-III Power Station. The message was communicated to TLDP-IV Power Station. All the staff were on alert at TLDP-III Power Station. Accordingly, the Unit#1, Unit#2, Unit#3 and Unit#4 were stopped at 02:30 Hrs., 02:35 Hrs., 02:32 Hrs. and 02:39 Hrs. respectively. All the radial gates were opened to pass the water. Heavy water was being passed through radial gates. The Power House and Dam are safe. On the day of the visit, 5th September 2023, the Reservoir level was 163.0 m, and the corresponding discharge was 1759 cubic meters at 15:00 hours. All the radial gates were open to pass the water.

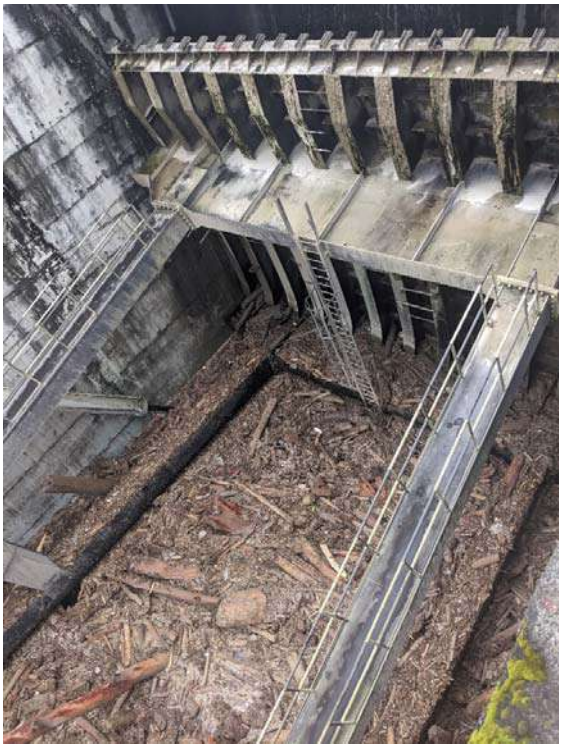
Fig 5: TLDP-IV heavy slush and bushes on Dam top

(b) Site Visit of TLDP-III

The project is owned and operated by NHPC. The project's salient features are placed in Annexure 3. All the units of TLDP-III were under normal operation as TLDP-III Power Station is downstream of Teesta-V Power Station. The message was communicated to TLDP-III and TLP-IV Power Station. All the staff were on alert at TLDP-III Power Station. Accordingly, all the units of TLDP-III stopped between 02:47 Hrs. to 02:50 Hrs. Intake gates were lowered. All the radial gates were opened to pass the heavy discharge. Power House and Barrage are safe.

During the visit, it was observed that the Tail race channel of the powerhouse was filled with silt, which had to be removed before starting the powerhouse. A monorail crane for operating the stoplogs downstream of the radial gate is reportedly washed away.

Fig.-6 TLDP-III D/s view of power House. Silt and slush deposit on TRC




INTAKE GATE 01

Photos of TLDP-III

(c) Information Gathered on Teesta-VI

NHPC, a central PSU, owns the under-construction Teesta-VI barrage. The project's salient features are placed in Annexure 4. At around 1 a.m., a message was received from Teesta – III Power Station regarding the breaching of Chungthang Dam (Teesta-III) lake. Immediate instructions were issued to the contractors working at the site to evacuate all the men and machinery from the site and shift them to a safer place. Accordingly, the contractor started the evacuation process.

At about 2.20 a.m., a message was received from Teesta-V Dam that a massive flood had hit the project and water started overtopping over Teesta-V Dam. At about 2.30 am, the flood overtopped the Coffer Dyke of the Teesta-VI project and reached EL 365 m at the barrage area. The flood water has entered the Silt Flushing Tunnel (SFT), Power House and Transformer Gallery.

During the flood, bridges at Balutar (owned by NHPC) connecting the left and right banks of the construction barrage, Balutar, Singtam, Samardung and Tarkhola (owned by NHPC) connecting the left and right banks of Power House got completely washed out. The washing up of electrical cables has resulted in the discontinuation of power supply to HRTs, and accordingly, works have been disrupted.

The evacuation of men and significant equipment was carried out promptly. No loss of life has been reported so far.

Fig.-7 Teesta VI: Under Construction Barrage

(d) Information Gathered on Teesta-V

Teesta-V Power Station (3x170 MW), located in the State of Sikkim, is a run-of-the-river scheme with pondage of 3-4 hrs. diurnal storage to harness the hydropower potential of river Teesta for peaking during the lean season. The Power Station was commissioned in the year 2008. The project is owned and operated by NHPC, a central PSU. The project's salient features are placed in Annexure 5.

The project comprises an 88.6 m high Concrete Gravity Dam (located 2 Kms downstream of the confluence of Teesta River with Dikchunala) with three penstocks of length 321 m and a 17.2 Km long Head Race Tunnel housed on the left bank.

The underground Power House near Sirwani, with an installed capacity of 510 MW, houses three units of 170 MW, each designed to operate under the net rated head of 197 m and generate 2573 MUs of energy in a 90% dependable year with 95% machine availability.

Teesta-V Power Station was under normal operation and was operating at 507MW. It is learnt that South Lhonak Lake, which is 90 KM upstream from Teesta-V Dam, has been suspected of getting outbursts resulting in a flash flood in the region. The Dam of Teesta-V Power Station staff tried to open all the radial gates to pass the river discharge. However, only two radial gates out of five were opened, and others could not be opened due to the sudden increase of massive inflow to save human life. As per our telephone conversation, it is known that water has overflowed from the top of the dam, and the gantry crane and radial gates are expected to be damaged/washed out. The approach road to the Dam is washed out. The control room at the Dam for remote operation of gates (Power pack) and other electrical installations was washed out.

Considering the emergent situation at the dam, the shutdown of all three units was undertaken at Powerhouse. The Powerhouse staff tried to lower the TRC gate. However, due to heavy discharge in the river, the TRC gate could not be lowered. A suspension bridge near the Powerhouse connecting the Powerhouse on the left bank and the Residential complex on the right bank is washed out due to heavy discharge. Three nos. of 400KV Transmission Towers near Powerhouse collapsed, and its associated electrical installations have been damaged. Two bridges were washed away, one upstream of Teesta-VI barrage and another at Singtam Bazar.

Fig.8: Teesta-V: Dam Downstream View

Fig.9 Teesta V Powerhouse Bridge collapse

Photos of TLDP-V

(e) Information Gathered on Teesta-III

The 60 m high, 1200 MW projected was owned and operated by Sikkim Urja Ltd., a State Govt PSU. The old and current condition of the dam is shown in the following figure.

As per available information, the Teesta-III dam (about 40 km u/s of Teesta-V dam) overtopped, and a substantial portion of CFRD washed out during the flash floods. The water also entered the underground Powerhouse through MAT.

4 Conclusion

Based on the site visit, information gathered, and data available post-GLOF event, the following points are noted: -

i. The presence of an Early Warning System (EWS) at the Glacial Lake could have a crucial lead time of 120 minutes for the preparation of the safe operations at Teesta-III, Teesta -V and Teesta-VI dam Authorities.

ii. CWC issued a report titled, “Advisory sheet Glacial Lake Outburst Flood-South Lhonak System in Teesta Basin” in March 2015 (See Annexure-1) where in possible Scenario in case of GLOF due to South Lhonak was discussed and all project Authorities and the State Governments were advised to take mitigation measures.

iii. NDSA issued an advisory to all State Dam Safety Organisations (SDSO) for installing EWS, Flood Forecasting network and preparing Emergency Action Plans (EAP) for the specified dams in their jurisdictions. (see Annexure-6).

iv. A significant portion of Concrete Faced Rockfill Dams (CFRD) from the Junction of the Concrete Spillway has been washed away from the Teesta-III project. The Powerhouse Main Access Tunnel (MAT) has been flooded, and inspection of the powerhouse is not possible. The bridge connecting the powerhouse has also been washed away. The project requires a complete rehabilitation programme.

v. Most of the spillway piers of Teesta Dam -V got damaged at different locations, probably by hitting the floating boulders, tree trunks and other objects. The rest of the concrete dam portion of the Teesta -V project appears to be in good condition, but its detailed inspection is not possible due to the washing away of the dam top connecting road. All five radial gates, including their hydraulic cylinders and power packs, have been washed away in the GLOF. The gantry cranes appeared to be damaged.

vi. A suspension bridge near the Powerhouse connecting the Powerhouse on the left bank and the Residential complex on the right bank is washed out due to heavy discharge. Three nos. of 400KV Transmission Towers near Powerhouse collapsed, and its associated electrical installations have been damaged. Two bridges, one upstream of Teesta-VI barrage and another at Singtham Bazar, have also been washed away.

vii. The Teesta-V Powerhouse is reportedly in good condition and requires deep cleaning, including TRC. However, to restart, many significant works for Hydro-mechanical (HM works) and electro-mechanical (EM works) are required. NHPC is to assess the work needed for restarting the project.

viii. The GLOF overtopped the Coffer Dyke of the Teesta-VI project and has reached EL 365 m at the barrage area. The flood water has entered the Silt Flushing Tunnel (SFT), Powerhouse and Transformer Gallery. During the flood, bridges at Balutar (owned by NHPC) connecting the left and right banks of the construction barrage, Balutar, Singtam, Samardung and Tarkhola (owned by NHPC) connecting the left and right banks of Powerhouse got completely washed out. The washing up of electrical cables has resulted in the discontinuation of power supply to HRTs, and accordingly, works have been disrupted.

ix. The Powerhouse and Barrage of TLDP-III are safe. However, about 29 m deep silt and slush have been deposited over TRC. The downstream walkway and Monorail for operating d/s stoplog gates have been washed away. Minor damage to the Trash Rack of the powerhouse is noticed. The project can restart with some deep cleaning and restoring some hydro-mechanical works.

x. The Powerhouse and Dam of TLDP-IV are safe. The dam top requires some deep cleaning. The powerhouse can be restarted once silt concentration in the Teesta River reaches the permissible limits. On the day of inspection, it was about 15000 PPM at TLDP-IV.

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सत्यमेव जयते

Central Water Commission

Ministry of Water Resources,

River Development & Ganga Rejuvenation

Advisory Sheet

Glacial Lake Outburst Flood –South Lhonak System in Teesta River Basin

Planning and Development Organisation

March 2015

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ABBREVIATIONS:

DEM – Digital Elevation Model
GL – Glacial Lake
GLOF – Glacial Lake Outburst Flood
WB – Water Body

EXECUTIVE SUMMARY

Glacial lakes (GLs) are common in the higher elevation of glacierised basins in Himalayan region and Water Bodies (WBs) are being formed by obstructions created in the drainage path generally due to massive landslides. GLs are formed when glacial ice or moraines impound water. Incidents of outburst of Glacial Lakes/Water bodies in Himalayan region are increasing which have potential of flooding in downstream areas. Flash floods caused by the outburst of GL/WBs are called as Glacial Lake Outburst Flood (GLOF)/Lake Outburst Flood.

CWC has prepared an inventory of GL/WBs (area > 10 ha.) in the Himalayan Region through NRSC, Hyderabad in June 2011. The GL/WBs are being monitored (area > 50 ha) on monthly basis during monsoon season. The monitoring reports are shared with the related field offices of CWC for considering the information in flood management, as deemed fit.

A study was taken up by CWC to identity habitation or important structures in the downstream of GL/WBs which are vulnerable from flood hazard aspects in the event of GLOF. The size & location of GL/WBs; human habitation; water resources project in the downstream areas were considered for prioritising GL/WBs for taking up the outburst or breach studies, in order to advise the concerned States and stakeholders.

It was reported that South Lhonak Glacial Lake in Sikkim is having very high probability of sudden outburst which may cause floods in downstream areas. CWC conducted a Study up to about 175 km downstream of the lake using information from inventory of GL/WBs, monitoring reports, cross section data @ 1 km interval extracted from CartoDEM ver.2 to analyse flood implications in the downstream villages namely Lachen, Chungthang, Dikchu, Singtam, Manipal, Rangpo & Bara Mungwa and hydropower projects on the river in Sikkim. A highly sophisticated mathematical model MIKE–11 was setup for the study.

It has been observed that four glacial lakes at different locations are discharging in the initial reach of the river. Total Five probable scenarios were analysed for the worst possible situation including a scenario where all four glacial lakes burst at same time but the possibility of that event is very low. The outcome of the study is in the form of likely rise in water level over and above the existing water level in the river due to constant flow of 1000 m^3/s. The rise in water level is varying from 2.0 to 15.24m at various identified locations and is expected to reach in a span of 1.5 hr hr to 6 hr from the time of bursting of the lake(s). The State authorities are advised to inform the local bodies and the Project Authorities of likely consequences of GLOF and to incorporate the information in land use planning, project planning and operation suitably.

1. INTRODUCTION

Glacial lakes (GLs) are common in the high elevation of glacierised basins in Himalayan region and Water Bodies (WBs) are being formed by obstructions created in the drainage path due to landslides or manmade structures. GLs are formed when glacial ice or moraines impound water. There are varieties of such lakes, ranging from melt water ponds on the surface of glacier to large lakes in side valleys dammed by a glacier in the main valley. These lakes normally drain their water through seepage in front of the retreating glacier. The moraine creates topographic depression in which the melt water is generally accumulated leading to formation of glacial lake. When this lake is watertight, melt waters will accumulate in the basin until seepage or overflow limits the lake level. The impoundment of the lake may be unstable, leading to sudden release of large quantities of stored water. Flash floods caused by the outburst of GL/WBs, called as Glacial Lake Outburst Flood (GLOF)/Lake Outburst Flood, are well known in Himalaya. The shrinkage of Himalayan glaciers has resulted in the formation of more moraine-dammed lakes. Bursting of such lakes lead to flash floods and these floods redistribute sediments and modify the landscape.

The study has been taken up to analyse the impact of GLOF at vulnerable locations including villages, water resources projects etc. in the downstream areas. The analysis has been carried out by developing mathematical model of the system using MIKE-11 software.

2. OBJECTIVE

The objectives of the study are as following:

1. To develop mathematical model for glacial lake outburst study for Teesta River.
2. To study impact of outburst flood at identified vulnerable locations along the river in downstream.

3. STUDY AREA AND DATA

3.1. Study Area

Main study area is upper reaches of the Teesta River which is one of the major tributaries of River Brahmaputra. The river reach, considered for the study starts from origin of critical lake(s) to village Bara Mungwa [Lat: 27° 3'56.13"N Long: 88°25'27.69"E]. There are four lakes whose outburst may cause serious flash flood situation in the downstream areas.

3.2. Data

Water spread area and lake-IDs of the four glacial lakes have been taken from the report "Inventory of Glacial Lakes/Water Bodies in Himalayan Region of Indian River Basin" and monthly monitoring reports. Cross sections of the river reach @ 1 km internal have been extracted using CartoDEM ver.2. In the absence of bed profile of the lakes, due to inaccessibility, the average depth of lakes has been taken as 30 m and also an existing constant flow of 1000 m^3/s has been assumed in the river for the purpose of study.

Fig. 1 below shows Google earth image of glacial lakes and locations of villages and hydro power projects (existing and planned) on the River Teesta and the schematic diagram showing locations and their drainage path are shown in Fig. 2.

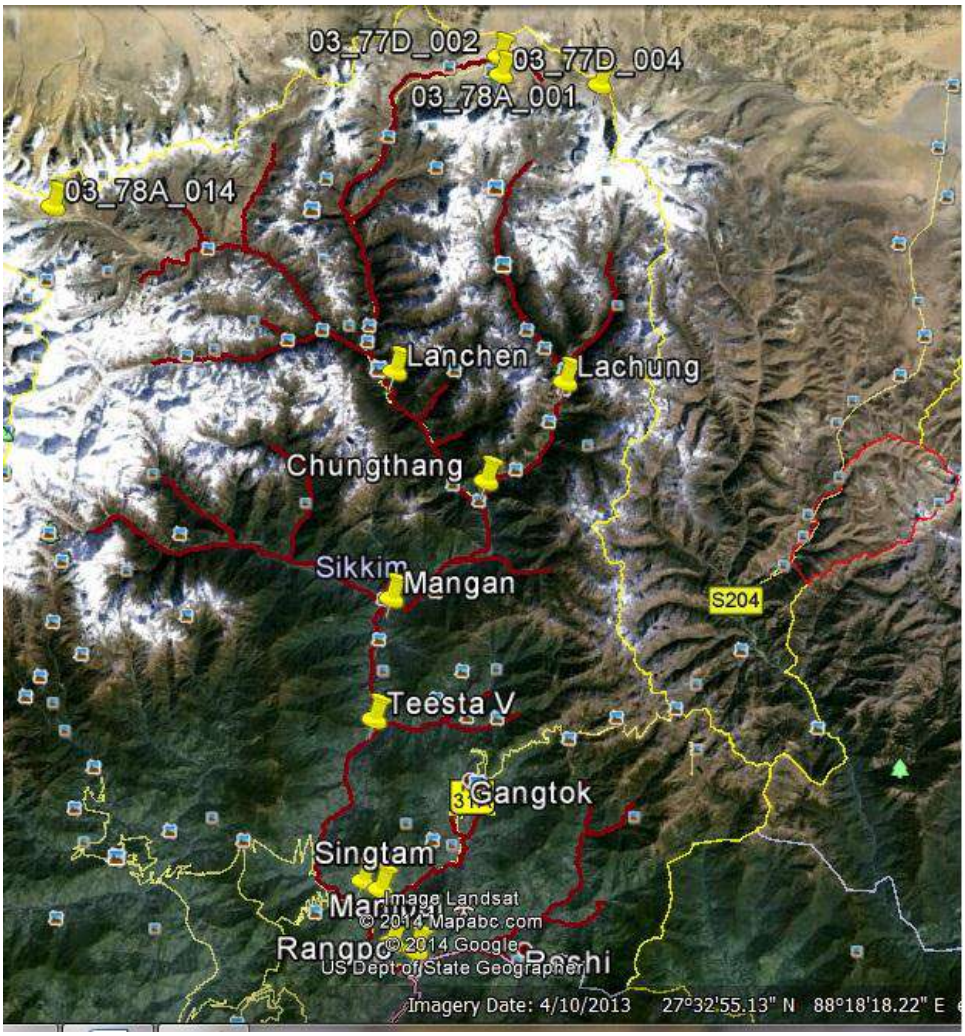

Fig. 1: Google earth image of glacial lakes and locations of villages and hydro power projects (existing and planned) on the River Teesta

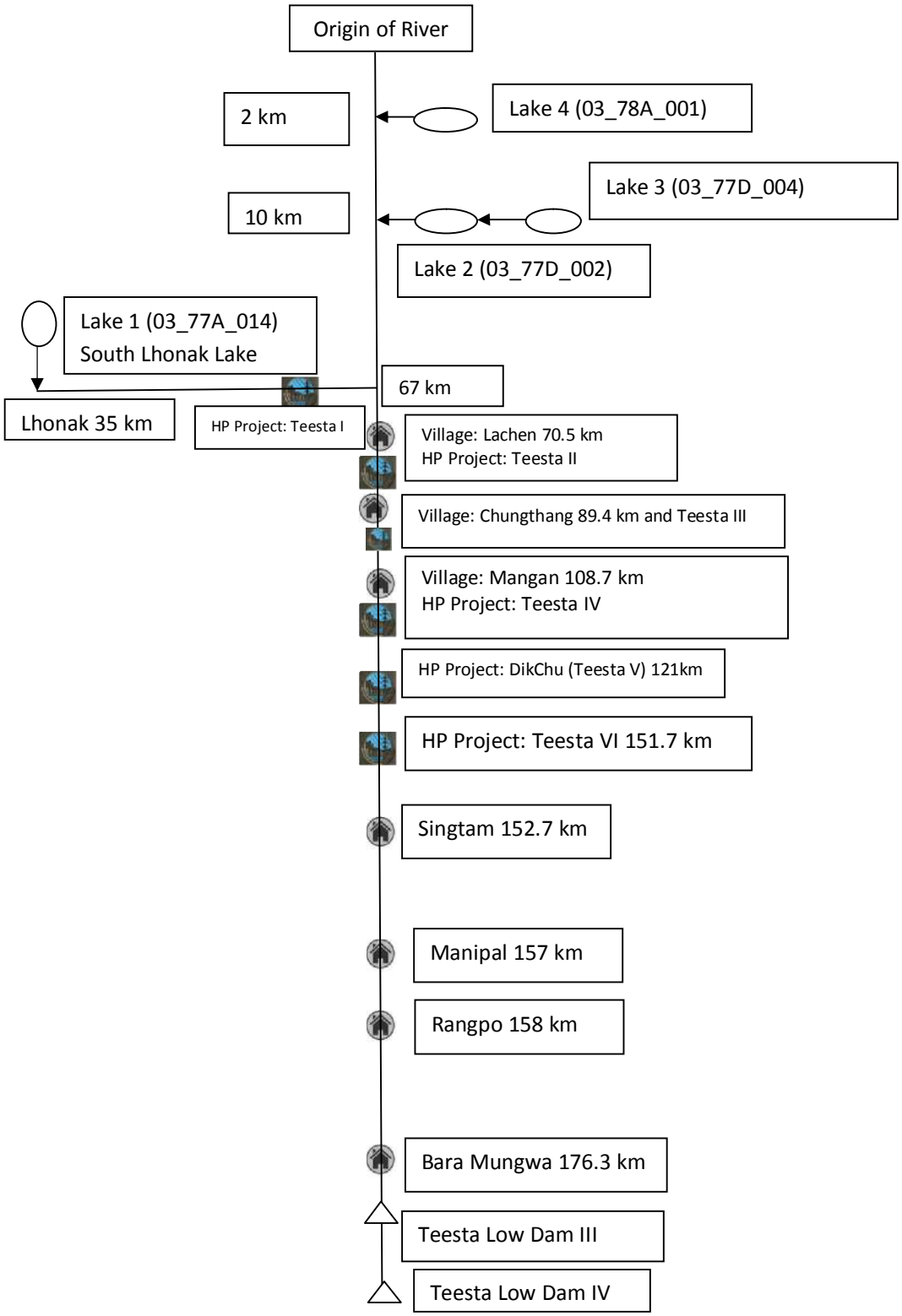

Fig. 2: Line diagram depicting glacial lakes, habitation and hydropower projects along River Teesta

4. VULNERABLE LOCATIONS

Details of the vulnerable locations along Teesta river downstream of the glacial lakes taken for the study as identified in the "Vulnerability Study of

Glacial Lakes in Himalayan Region within Indian Boundary" prepared by Central Water Commission are given below in Table 1:

Table 1: Details of vulnerable locations downstream of glacial lakes

Name of Human Habitation/ Hydropower Project	*Latitude*	*Longitude*	*Population/Power generation*
Teesta I	27°46'31.68"N	88°30'24.35"E	Hydro Power Project
Lanchen and Teesta II	27°42'58.99"N	88°33'33.85"E	1000 & Hydro Power Project
Chungthang and Teesta III	27°36'12.47"N	88°38'49.46"E	2800
Mangan and Teesta IV	27°30'1.32"N	88°31'58.37"E	1250 (2001 census) & Hydro Power Project
Teesta V (DikChu)	27°23'14.22"N	88°30'12.50"E	Hydro Power Project
Teesta VI	27°14'32.20"N	88°28'39.58"E	Hydro Power Project
Singtam	27°13'53.61"N	88°29'39.35"E	210
Manipal	27°10'58.06"N	88°30'4.42"E	Educational Hub
Rangpo	27°10'26.41"N	88°31'30.20"E	3724
Bara Mungwa	27° 3'56.13"N	88°25'27.69"E	1297

5. BEHAVIOUR OF GLACIAL LAKES

The water spread area of the identified four glacial lakes as per monthly monitoring reports is given in Table 2 below. It may be noted that the water spread area of the lakes is fluctuating on month-to-month basis but it was the highest in the month of Jun/Jul 2011 during the monitoring period of four years.

Table 2: Water spread area of glacial lakes

	Water Spread Area (ha)			
Lake ID / *Month& Year*	*03_78A_014 (Lake1)*	*03_77D_002 (Lake 2)*	*03_77D_004 (Lake 3)*	*03_78A_001 (Lake4)*
Inventory (2009)	94	105	106	156
Jun-11	**136**	**119**	**123**	cloud
Jul-11	cloud	cloud	cloud	**180**
Aug-11	cloud	cloud	cloud	cloud
Sep-11	134	113	114	162
Oct-11	126	103	101	145
Jun-12	100	96	107	167
Jul-12	Cloud	cloud	118	cloud
Aug-12	Cloud	cloud	cloud	cloud
Sep-12	102	91	103	152
Oct-12	99	99	104	142
Jun-13	117	110	106	161
Jul-13	113	97	101	154
Aug-13	Cloud	Cloud	116	163
Sep-13	115	100	114	164
Oct-13	109	91	105	153
Jun-14	100	106	101	146
Jul-14	Cloud	106	112	Cloud
Aug-14	Cloud	Cloud	108	Cloud
Sep-14	117	Cloud	114	157
Oct-14	128	87	103	144

The variation in water spread area of the identified glacial lakes is shown in graphical form in Fig. 3 below:

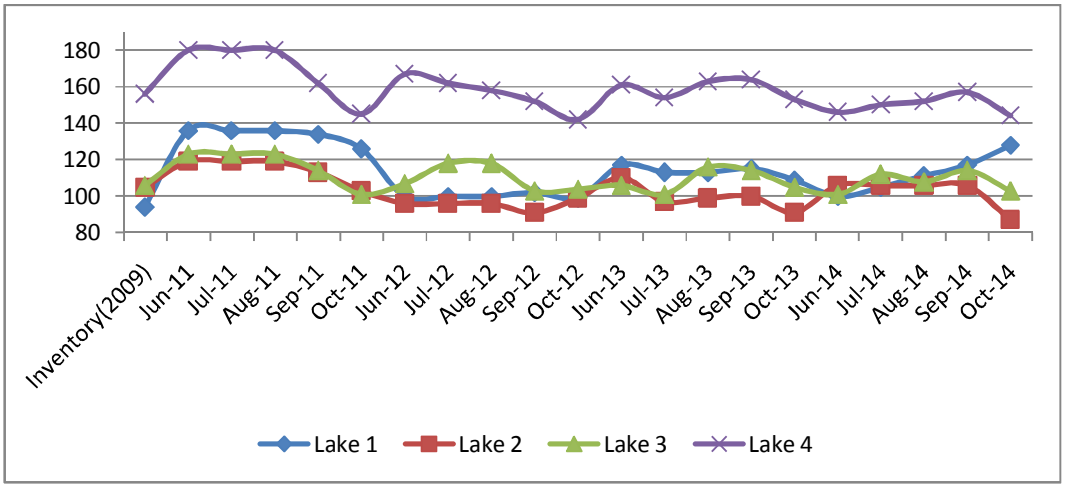

Fig. 3: Graph showing variation in water spread area of four lakes

6. POSSIBLE SCENARIOS FOR STUDY

It may be seen from the Fig. 2 that lake 1 and lake 4 are independent and probability of outburst happening at the same time is very less, whereas lake 2 and lake 3 are interconnected. Lake 3 drains its water into Lake 2 so there can be two possibilities. A worst possible scenario of all lakes getting burst at same time is also considered, but probability of that event happening is really low.

A. Lake 2 alone bursts
B. Lake 3 bursts and consecutively Lake 2 also bursts.

Therefore, Five possible scenarios as given below are likely to occur for which simulation studies have been carried out.

Scenario a. Only lake 1 outbursts
Scenario b. Only lake 2 outbursts
Scenario c. Lake 2 and lake 3 outburst at almost same time
Scenario d. Only lake 4 outbursts
Scenario e. All lakes outburst at same time.

7. METHODOLOGY

7.1. Volume of Glacial Lakes

The volume of water contained in the glacial lakes is a key input for the study as tabulated below in Table 3.

Table 3: Maximum water spread area and volume of glacial lakes

Lake	*Maximum Area (ha)*	*Average depth (m)*	*Volume (m^3)*
Lake 1	136	30	40.8×10^6
Lake 2	119	30	35.7×10^6
Lake 3	123	30	36.9×10^6
Lake 4	180	30	54.0×10^6

7.2. Scheme of the River Network

River network scheme has been digitized using the MIKE-11 GIS application. The river network along with glacial lakes has been schematized and exported as MIKE-11 Network file.

7.3. Cross sections

Extracted cross-sections, at an interval of 1 km, were exported as MIKE-11 cross section files. The cross sections were examined and incompatible cross-sections (which did not follow the profile) were removed. Generated longitudinal profile of the river is shown in Fig. 4.

7.4. Mathematical Model setup

Glacial lakes were represented as separate branch using dummy cross sections and volume of the glacial lakes has been assigned as storage volume of respective cross sections. These branches were hydraulically connected to the main river at the appropriate location.

Cross-sections extracted using DEM were incorporated in the model. Model was run for identified five scenarios as detailed under para 6 above.

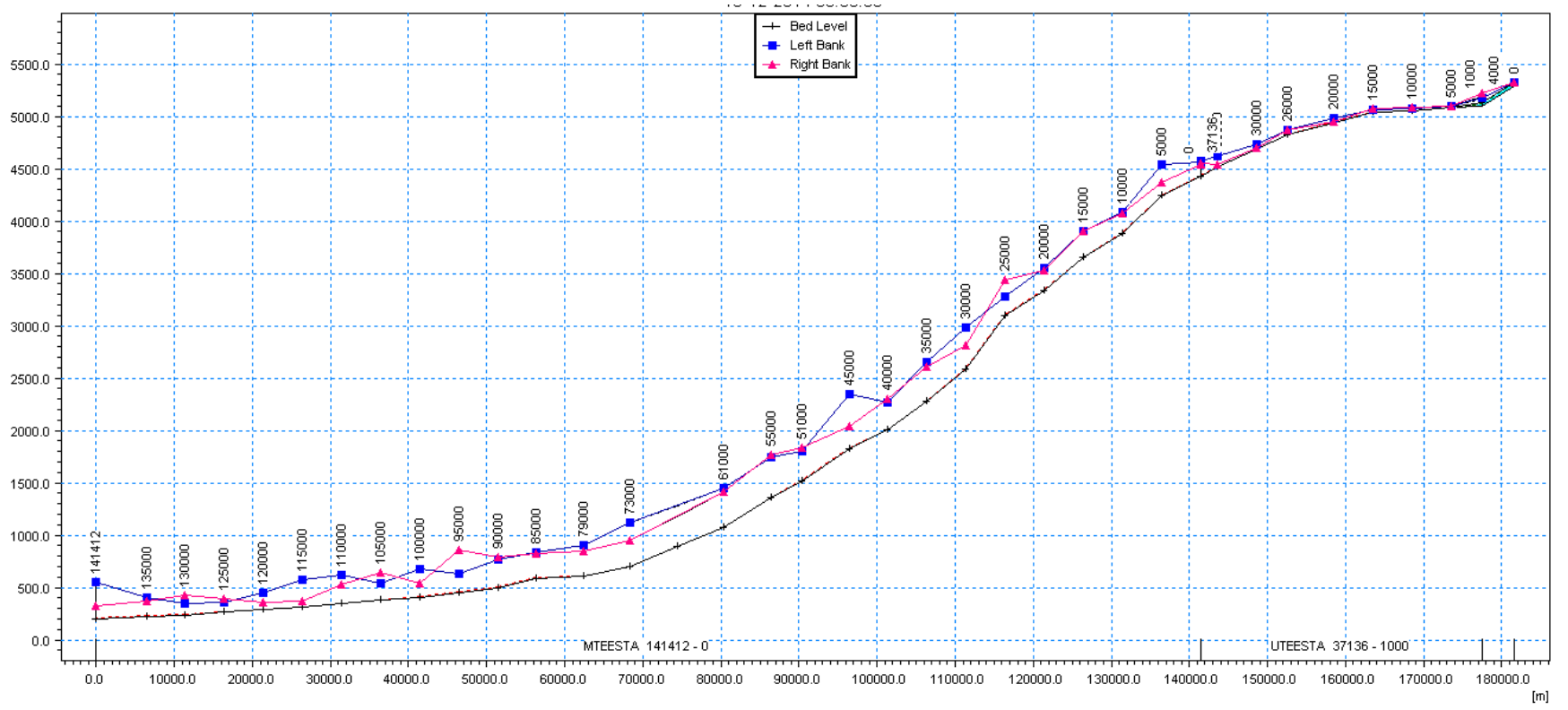

Fig. 4: Longitudinal profile of River Teesta

7.5. Assumptions and Limitations

The following assumptions and limitations have been considered in the study:

- It has been considered that flow is not being modified at hydro power projects.
- A scenario with constant flows of 1000 m^3/s have been considered as existing conditions in the river, though the real case may be different.
- Depth of the glacial lakes is assumed as 30 m as per guidance available in the related literature.
- The cross sections considered are not actual but derived from CartoDEM ver.2 digital elevation model.

8. RESULTS

Increase in water levels and discharges, maximum velocities and time for the peak flood wave to reach at the site due to GLOF at all locations under study were worked out as given below in the tables 4a to 4e for five scenarios. The increase is over and above of existing water level in the river due to a constant flow of 1000 m^3/sec as already explained above. The site of proposed Teesta I project would be affected only in scenario a.

Table 4a: Scenario a

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time to reach at (minutes)*
Teesta I	4.43	6230	14.3	100
Lachen and Teesta II	4.31	6225	14.2	105
Chungthang and Teesta III	4.45	6210	12.45	120
Mangan and Teesta IV	4.71	6200	10.45	125
Dik-Chu (Teesta V)	7	6080	5.9	140
Singtam and Teesta VI	5.4	5846	5.4	192
Manipal	3.96	5788	4.3	210
Rangpo	3.65	5788	4.3	210
Bara Mungwa	2	5650	4	250

Table 4b: Scenario b

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time (minutes)*
Lachen and Teesta II	4.08	5520	13.5	120
Chungthang and Teesta III	3.6	5500	12	140
Mangan and Teesta IV	4.04	5460	9.2	140
Dik-Chu (Teesta V)	5.43	5180	6.3	160
Singtam and Teesta VI	4.84	4935	5.7	220

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time (minutes)*
Manipal	3.38	4800	4.5	260
Rangpo	3.28	4770	4.1	260
Bara Mungwa	2.37	4640	3.5	280

Table 4c: Scenario c

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time (minutes)*
Lachen and Teesta II	7.51	11810	18.3	120
Chungthang and Teesta III	7.03	11600	16.5	120
Mangan and Teesta IV	7.64	11500	12.2	140
Dik-Chu (Teesta V)	8.87	10800	8.2	160
Singtam and Teesta VI	8.29	10250	7.35	200
Manipal	6.15	9900	5.4	220
Rangpo	5.81	9820	5.2	220
Bara Mungwa	4.21	9080	4.5	260

Table 4d: Scenario d

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time (minutes)*
Lachen and Teesta II	4.4	6090	14.1	180
Chungthang and Teesta III	4.11	6070	12.8	190
Mangan and Teesta IV	4.49	6050	9.5	190
Dik-Chu (Teesta V)	6.04	5900	6.6	220
Singtam and Teesta VI	5.55	5690	6	270
Manipal	3.85	5630	4.4	290
Rangpo	3.78	5600	4.1	290
Bara Mungwa	2.87	5490	3.5	330

Table 4e: Scenario e

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Time to reach at (minutes)*
Teesta I	**4.43**	**6230**	**14.3**	100
Lachen and Teesta II	**12.65**	**30520**	**29.64**	115
Chungthang and Teesta III	**12.78**	**30430**	**25.96**	125
Mangan and Teesta IV	**13.25**	**30400**	**21.52**	130
Dik-Chu (Teesta V)	**15.24**	**30110**	**16.20**	135
Singtam and Teesta VI	**13.51**	**28900**	**11.241**	165
Manipal	**13.48**	**28215**	**8.98**	172
Rangpo	**13.45**	**28180**	**8.25**	176
Bara Mungwa	**12.71**	**26149**	**7.2**	195

Graphs in Fig. 5a to 5e show the discharge and time to reach peak flood wave after the lake the outburst. It may be seen that the maximum levels, discharges and velocities are likely to occur in scenario when lake 2 and lake 3 outburst almost at the same time.

Since the locations Teesta IV and Singtam are close they are represented by a single hydrograph and same is the case with Mangan-Teesta IV and Lachen-Teesta II and Chungthang-Teesta III. The zero hour in simulation is 1200 hrs and the dates are tentative.

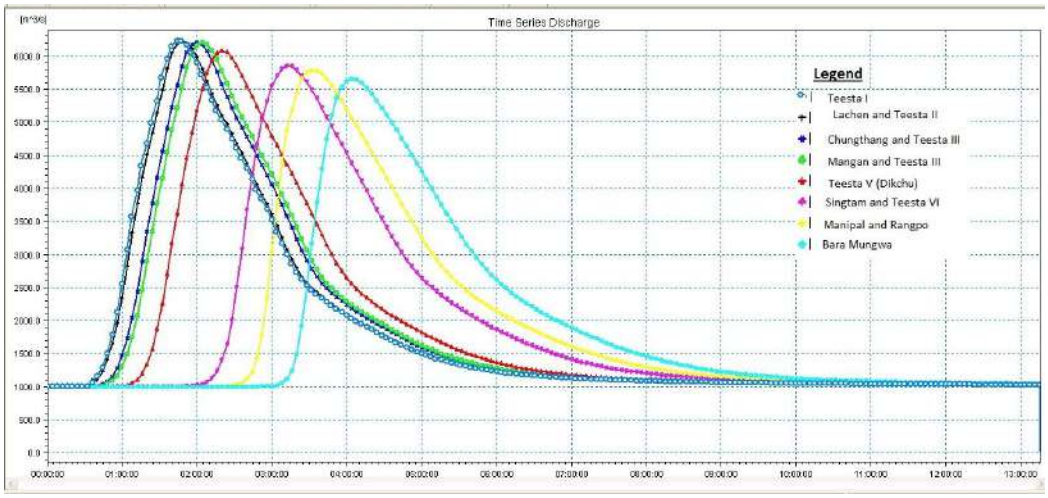

Fig. 5a: Hydrograph at various locations with time lag for scenario a

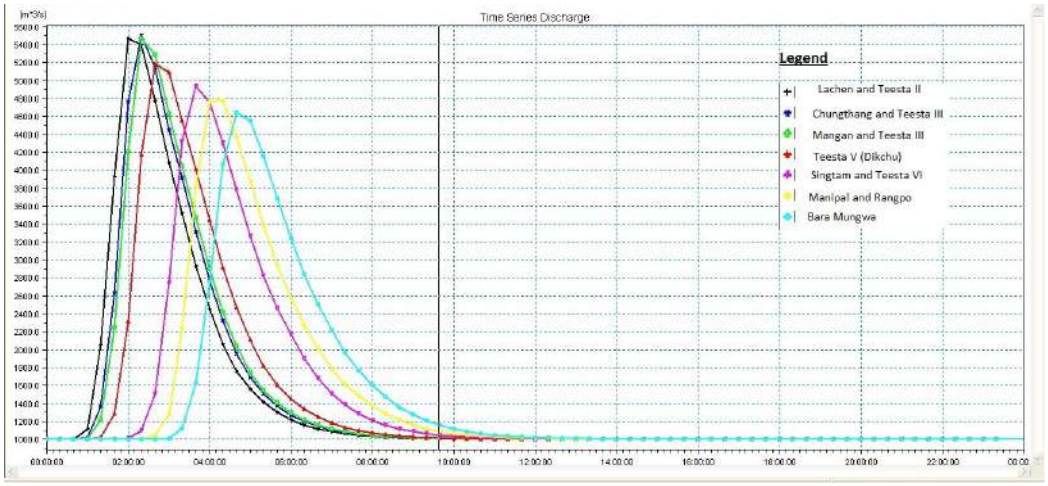

Fig. 5b: Hydrograph at various locations with time lag for scenario b

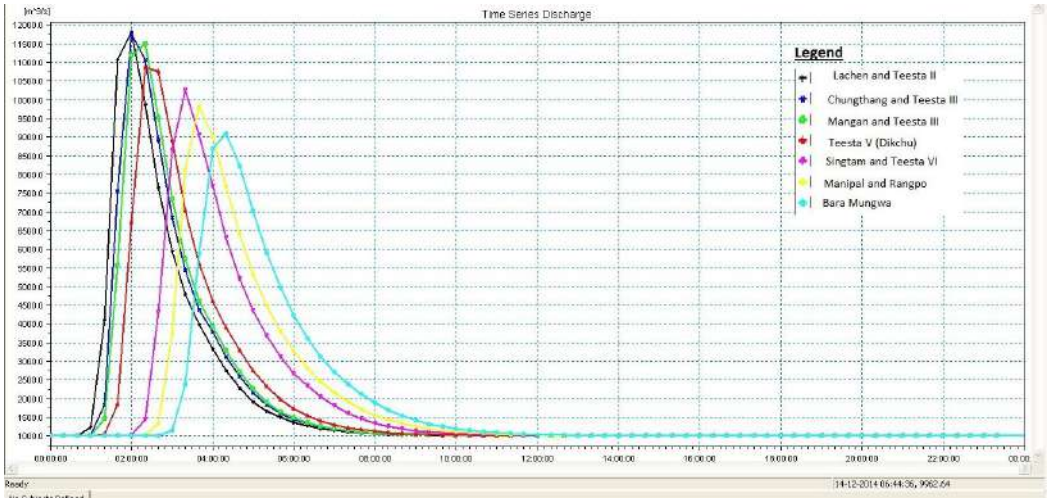

Fig. 5c: Hydrograph at various locations with time lag for scenario c

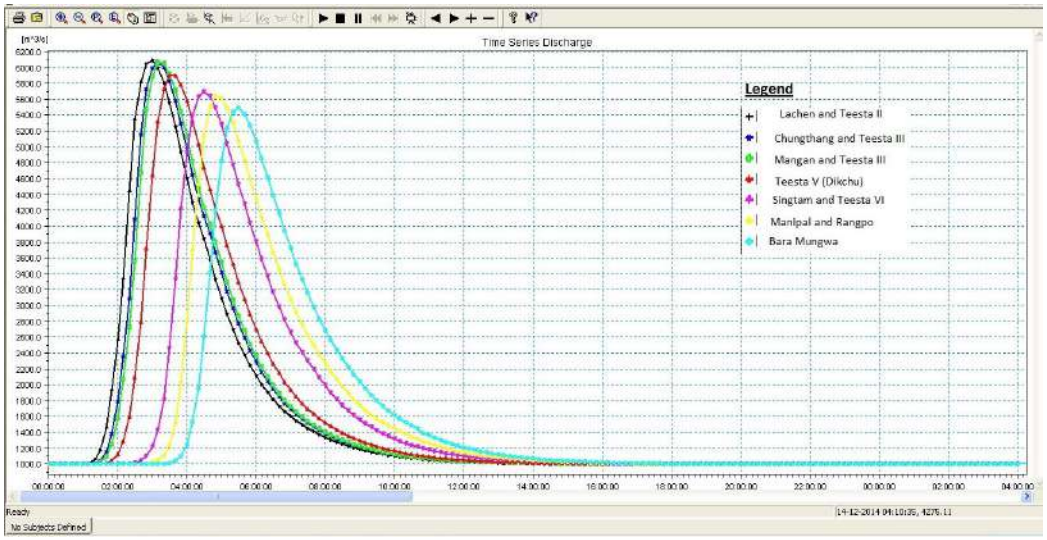

Fig. 5d: Hydrograph at various locations with time lag for scenario d

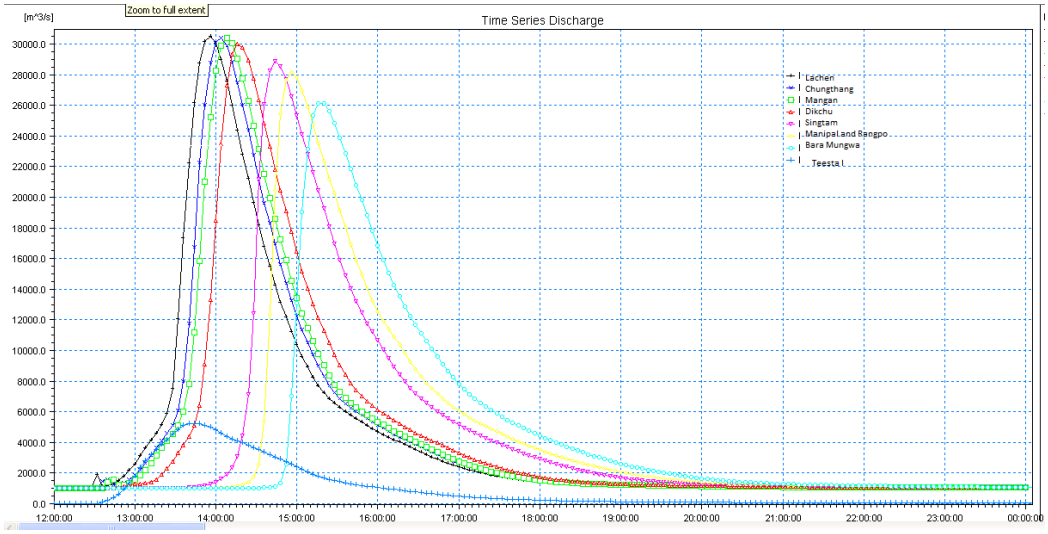

Fig. 5e: Hydrograph at various locations with time lag for scenario e

9. ADVISORY

Based on the study conducted, the State Authorities are being made aware of the situation, which may arise, in case of outburst of Glacial Lake(s) situated in the upstream of Teesta river. The villages in the downstream are likely to experience a rise in water level to the tune of 2.0 m to 15.24 m varying from place to place, over and above the water level generally attained during flood season at those locations.

The Hydropower project authorities are also advised to consider the findings and develop mechanism for close monitoring of the lakes in order to get very timely warning about abnormal rise-fall in the water level in the lakes and its geological health. Standard Operating Procedures may also be developed to mitigate adverse situations.

The maximum likely water level rise, discharge and velocities at various locations which will be happening in case of breach of all lakes at same time are given in Table 5. However the probability of this event occurring is very low.

Table 5: Water levels, discharge and maximum velocities at various locations (all lakes burst at same time)

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*
Teesta I	**4.43**	**6230**	**14.30**
Lachen and Teesta II	**12.65**	**30520**	**29.64**
Chungthang and Teesta III	**12.78**	**30430**	**25.96**
Mangan and Teesta IV	**13.25**	**30400**	**21.52**
Dik-Chu (Teesta V)	**15.24**	**30110**	**16.20**
Singtam and Teesta VI	**13.51**	**28900**	**11.241**
Manipal	**13.48**	**28215**	**8.98**
Rangpo	**13.45**	**28180**	**8.25**
Bara Mungwa	**12.71**	**26149**	**7.20**

Independent and interconnected glacial lakes outburst events have more probability than the above case (i.e. all glacial lakes outburst at same time.). The maximum likely water level rise, discharge and velocities at various locations which will be happening in such case are given in Table 6.

Table 6: Water levels, discharge and maximum velocities at various locations

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Remark*
Teesta I	**4.43**	**6230**	**14.30**	**Scenario a**
Lachen and Teesta II	**7.51**	**11810**	**18.30**	**Scenario c**
Chungthang and Teesta III	**7.03**	**11600**	**16.50**	**Scenario c**
Mangan and Teesta IV	**7.64**	**11500**	**12.20**	**Scenario c**

Location	*Increase in water level (m)*	*Discharge (m^3/s)*	*Maximum velocity (m/s)*	*Remark*
Dik-Chu (Teesta V)	**8.90**	**10800**	**8.20**	**Scenario c**
Singtam and Teesta VI	**8.29**	**10250**	**7.35**	**Scenario c**
Manipal	**6.15**	**9900**	**5.40**	**Scenario c**
Rangpo	**5.81**	**9820**	**5.20**	**Scenario c**
Bara Mungwa	**4.21**	**9080**	**4.50**	**Scenario c**

Important: In no case, the advisory suggest that the lake(s) are geologically weak or that they are like to breach any time soon. However, appropriate precautions must be taken to ward of any untoward situation.

10. SUCGESTIONS FOR FURTHER WORK

Suggestions for further Improvisations which may be made in the study are listed below; however these improvisations would require additional specific data sets.

1. With the specific warning for heavy rainfall in the catchment, the model can give advance warning regarding the rise in water levels and discharges at all the locations in the river valley.
2. The model can be run incorporating 100 year return period flood as the existing flow in the river, in place of assumed constant flows of 1000 m^3/s.
3. Inundation extent may be analysed.
4. Development of mechanism for installation of sensor based river gauges and high decibel warning in affected area.

11. Acknowledgement

Shri Manoj Kumar, Assistant Director, CWC and Shri Vasanthakumar V, Assistant Director, CWC have carried out this pioneering work including data collection, input preparation, model setup, run and preparation of the Report.

Contributions of Shri Sanjiv Aggarwal, CE, PMO; Shri M.P Singh, CE, P&DO; Shri Ashok Kumar Kharya, CE, IBO; Shri Bhopal Singh, Director, Hyd(S); Shri. G.L. Bansal, Director, Hyd(N); Shri N N Rai, Director, Hyd(NE); Dr. B.R.K Pillai, Director (FE&SA), (DSR); Shri Ram Jeet Verma, Director (P&D) and Shri O P Gupta, Director (FE&SA) for giving the ideas, guiding the work and shaping the advisory sheet in its current form are gratefully acknowledged.

12. Reference

(i) Inventory of Glacial Lakes/Water Bodies in the Himalayan region of Indian River Basin by CWC in association with NRSC, Hyderabad.

(ii) Monthly Monitoring reports of the Glacial Lakes/Water Bodies in the Himalayan region of Indian River Basin by CWC in association with NRSC, Hyderabad.

(iii) Report on the Prioritization of Glacial Lakes/Water Bodies in the Himalayan region of Indian River Basin prepared by CWC.

(iv) ICIMOD guidelines on depth of glacial lakes in Nepal and Bhutan.

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TLDP-IV: Salient Features

Location		
State	:	West Bengal
District	:	Darjeeling
River	:	Teesta
Dam Site	:	18.3 km d/s of Teesta bridge on nh31a
Power House	:	50 m d/s of dam axis on the left bank
Hydrology		
CATCHMENT AREA	:	8021 SQ.KM
Reservoir		
Full Reservoir Level (FRL)	:	EL. 182.25 m
Minimum Draw Down Level (MDDL)	:	EL. 179.0 m
Gross storage at FRL	:	36.63 M cum
Live Storage	:	7.91 MCM
Area under submergence at FRL	:	257.26 HA
Dam		
Type	:	Concrete Gravity / RCC
Length at the Top	:	530 m
Top elevation	:	EL 185.00 M
Height of Dam Above River Bed Level	:	± 30 M
Height of Dam Above Deepest Foundation Level	:	± 45 M
Spillway		
Design Flood for Spillway	:	15400 cumec
Type	:	Sluice type with Breast Wall
Crest elevation	:	El.157.0 m
Number and Size of Spillway Opening	:	7Nos., 11 m X 17 m (w x h)
Diversion Arrangement		
Length of Diversion channel	:	±700 m
Height of U/S Cofferdam	:	13 m
Height of D/S Cofferdam	:	12.5 m
Intake		
Invert Level	:	El.165.50 m
Number & Size of Gate Opening	:	4 Nos., 7.0 m x 7.0 m
Penstock		
Number	:	4
Shape	:	Circular, steel lined
Size	:	7.0 m dia
Length	:	45m each
Power House		
Type	:	Surface: Left Bank
Design Discharge	:	716.0 cumec
Installed capacity	:	4X40 MW
Power House size	:	134mX24.5mX63.0 m
Number of units	:	4 Nos
Type of turbine	:	Kaplan

Turbine axis elevation	:	El.180.0 m
Maximum gross head	:	25.76 m
Rated net head	:	25.05 m
Tail Race channel		
Shape	:	Trapezoidal
Base width	:	Varying From 100 m To 104 m
Length	:	98 m
Weir Level	:	El.152.12 m
Switchyard		
Size and Location	:	200 m X 95 m on left bank at EL. ± 215.00 m
Power Generation		
Annual energy generation in 90% dependable year	:	720 MU

TLDP_III: Salient Features

Location		
State	:	West Bengal
District	:	Darjeeling
River	:	Teesta
Barrage site	:	7.2 KM. D/S OF TEESTA BRIDGE
Latitude	:	27°00'00" N
Longitude	:	88°27'30" E
Nearest rail head	:	New Jalpaiguri
Nearest airport	:	Bagdogra
Hydrology & Climatology		
Catchment area	:	7755 sq.km
Location of catchment	:	Latitude 27°0' N to 28°07' N Longitude 88°0' E to 88°53' E
Average Annual rainfall	:	2218mm
Maximum temperature	:	37°C
Minimum temperature	:	8°C
Reservoir		
Full Reservoir Level (FRL)	:	EL. 208.0 m
Minimum Draw Down Level (MDDL)	:	EL. 203.0 m
Gross storage at FRL	:	18.36 M cum
Area under submergence at FRL	:	156.49 HA
Capacity at MDDL	:	11.57 M cum
Live Storage	:	6.79 M cum
Barrage		
Type	:	RCC Raft with piers
Top elevation	:	210.0 m
Crest elevation	:	El.183.0 m
Downstream Floor Level	:	El.178.0 m
Length of Floor	:	190.0 m
Upstream Floor Level	:	El.182.0 m
Upstream Floor Thickness	:	1.5m
Length at the Top	:	144.50 m
Thickness of Pier	:	3.5m
Height of Barrage	:	32m
Spillway		
Design Flood for Spillway	:	10430 cumec
Type	:	Gated Weir with Breast Wall
Crest elevation	:	El.183.0 m
Number and Size of Spillway Opening	:	7Nos., 14 m X 14 m
Type of Gate	:	Radial Gate
Design discharge for Energy Dissipation	:	5850 cumec
Energy Dissipation	:	Stilling Basin with End Sill
Diversion Arrangement		
Type	:	Diversion Channel and Dykes
Diversion Capacity	:	4700 cumec
Height of Concrete Coffer Wall (From deepest level)	:	21.6m (maximum)
Height of Dykes	:	15.76m

Intake		
Overt Level	:	El.198.25 m
Invert Level	:	El.189.20 m
Number & Size of Gate Opening	:	4 Nos., 7.0 m x 7.0 m
Stoplogs Openings	:	4 Sets., 7.0 m x 7.0 m
Penstock		
Number	:	4
Shape	:	Circular, steel lined
Size	:	7.0 m dia
Length	:	44m each
Design Discharge	:	173.4 cumec (each unit)
Power House		
Type	:	Surface
Design Discharge	:	693.6 cumec
Installed capacity	:	4X33 MW
Power House size	:	125mX23.5mX56.9 m
Number of units	:	4 Nos
Type of turbine	:	Kaplan
Turbine axis elevation	:	El.180.0 m
Maximum gross head	:	22.09 m
Rated net head	:	21.34 m
Draft tube gate	:	8 Nos, 5.95 m X 7.40m
Minimum TWL (for one machine)	:	El.182.73 m
Normal TWL (4 units running)	:	El.184.24 m
Maximum Flood Level for 10430 cumec	:	El.194.75 m
Tail channel		
Shape	:	Trapezoidal
Base width	:	88m
Length	:	100m
Weir Level	:	El.180.0 m
Power Generation		
Annual energy generation in 90% dependable year	:	594.07 MU
Project Cost		
Total Cost Including IDC	:	Rs. 768.92 crore (Including IDC & FC of Rs.

Teesta-VI: Salient Features

LOCATION		
Country	:	India
State	:	Sikkim
District	:	South Sikkim
Constituency	:	Rateypani/ West Pendan
River	:	Teesta
Type of Scheme	:	Run of the River
Power House Site	:	Subin Khor (Right Bank of River Teesta at Tarkhola, upstream of Seti Khola, about 1200m downstream)
Barrage Site	:	100 m downstream of L.D.Kazi Bridge on River Teesta at Sirwani
HYDROLOGY		
Catchment Area	:	4500 Sq.km
Maximum Design Flood	:	11600 Cumec
RESERVOIR		
Full Reservoir Level (FRL)	:	EL.360 m
Minimum Draw Down Level (MDDL).	:	EL.354 m
Live Storage	:	1.73 M cum
Area under submergence at FRL	:	36 Ha
BARRAGE & APPURTENANT WORKS		
Top Elevation	:	369m
Length	:	105m
Crest Elevation	:	342.5 m
Height from River Bed	:	26.5 m
Type of Gates	:	Radial, 3 Nos. 15m (W) X 17.50m (H) Crest type Radial gates without flap 2 Nos. 15m (W) X 17.50m (H) Crest type Radial gates with flap
Energy Dissipation Arrangement	:	Stilling Basin
Barrage Stoplogs	:	1 set, 15.0m (W) x 17.Sm (H) U Is stoplog comprising of 4 units 1 set, 15.0m (W) x 17.Sm (H) D/s stoplog comprising of 4 units
Gantry Crane & Lifting Beam fo1 Barrage Stoplog	:	2 numbers. (Separate Gantry Crane and lifting beam for u/ s and d/ s stoplog)
Compensation/Ecological water pipes and Knife edge gate valves - 800mm dia	:	2 Sets of pipe & Knife edge gate valves of 800mm dia
DESILTING CHAMBER & DESILTING BASIN		
Type	:	Surface
No. of chambers	:	2 Nos, Desilting Chamber with 2 Cunette each
Size	:	250m(L)x28m(W)(Top)x25.57m (H) with 2 cunette each
Desilting Basin Intake Trash racks	:	4 nos., 20.lm (W) x 14.493m (Inclined height)

TRCM cum gantry crane	:	TRCM cum Gantry
Desilting Basin Intake Gates	:	4 Nos., 9.09m (W) x 11.5m (H)
Hoist for Desilting Basin Intake Gate	:	4 Nos., Rope Drum Hoist
Desilting Intake Stoplogs	:	1 Set of stoplog 9.09m (W) x 11.5m (H)
Hoist for Desilting Intake Stoplogs	:	TRCM cum Gantry crane
Flushing Tunnel Gates	:	4 nos., 3.0m (W) X 3.0m (H) each (12 Nos. Service & 2 Nos. Emergency)
Hoists for Flushing Tunnel Gates	:	4 Nos. Hydraulic Hoist
INTAKE		
No., Type and size	:	Two/ Bell Mouth Rectangular/ 8.0 m x 9.8 m
Intake Tunnel	:	-
HEAD RACE TUNNELS		
Design Discharge	:	531 Cumecs
Number	:	2 (Two)
Shape	:	Modified Horse Shoe
Length	:	13.76 km each (approx.)
Size	:	9.8 m Diameter (finished)
HRT Intake Gates	:	2 nos., 8m (W) X 9.8m (H)
Hoist for HRT Intake Gates	:	2 nos., Rope Drum Hoists
HRT Intake stop log	:	Intake stoplog has been deleted and Desilting Intake Stoplog has been introduced.
Hoist for HRT Intake stop log	:	
ADIT INSPECTION GATE		
	:	2 nos., 2.5m (W) x 2.5m (H)
SURGE SHAFTS		
Type	:	Restricted Orifice type
Number	:	2 (Two)
Size	:	16.0 m Dia (along with 850.0m long, 9.8m dia. Modified horse shoe shaped Surge Gallery connected at EL.320.0m with surge shaft)
Height	:	89.30 m
Surge Shaft Gates	:	4 nos., 4.3m (W) x 5.4m (H)
Hoists for Surge Shaft Gates	:	4 nos., Rope Drum Hoists
PENSTOCKS		
Steel Liners (Penstocks) - 5.4m inner dia	:	4 nos., 5.4m dia.
DRAFT TUBE		
Draft Tubes Gates	:	8 Nos., 3.25m (W) x 7.5m (H), two numbers for each Draft Tube
Hoist for Draft Tubes Gates	:	Power House EOT crane
PRESSURE SHAFT		
Type	:	Vertical
Numbers	:	4 (Four)
Size	:	5.40 m Dia I 4.5 Dia

Length	:	151m for 5.4m dia & 30.5m for 4.5m dia (Average length - 180m)
TAIL RACE TUNNELS		
Number	:	4 (Four)
Type	:	D shaped
Size	:	8.5 m (W) x 7.5 m (H)
Average Length	:	247 m (approx)
Maximum Tail Water Level	:	242.4m
Minimum Tail Water Level	:	240m
Tailrace Tunnel Outlet Gate	:	4 no., 8.5m (W) x 7.5m (H)
Hoist for Tailrace Tunnel Outlet Gate	:	4 nos., Rope Drum Hoists
POWERHOUSE		
Type	:	Underground
Type of Turbine	:	Francis (Vertical Shaft)
Installed Capacity	:	500 MW (4 X 125 MW)
Size of Cavern	:	142.75m(L)X18.5m(W)X52.44m(H)
Gross head (max.)	:	116m
Net design Head	:	105.38 m
Head loss	:	10.22
Annual Energy Generation (90% dependable year 1994-95)	:	2400 Gwh
Generation Voltage	:	11 kV
Rated speed of Turbine	:	166.67 rpm
Combined Turbo-generator efficiency	:	93.1%
XLPECABLE	:	220KV
MIV CHAMBER & BUTTER FLY VALVE		
Type	:	Underground
Size of Cavern	:	90.5 m(L) X 8 m(W) X 20.5 m(H) (approx.)
Butterfly Valve Dia	:	4.5m
TRANSFORMER CAVERN		
Type	:	Underground
Size of Transformer Cavern	:	128 m(L) X 14.5 m(W) X 21 m(H) l(approx.)
Generator Transformer (4 nos.)	:	11/220 kV, 153 MVA (51MVA, 1Transformer bank) , Oil Directed Water Forced Type
GIS	:	245 kV, Accommodated in this Cavern
GIS	:	245 kV
Voltage rating of Bus duct including LAVT & NG cubicles	:	11 kV
Voltage rating of UAT HV winding	:	11 kV
POTHEAD YARD		
Type	:	Surface
Length x Width	:	30m (W) x l00m (L)
Potyard Equipment	:	220 kV
EVACUATION SYSTEM	:	220 kV D/c (Twin Moose Conductor), Transmission Line-15 Km from project switchyard to pooling Station at Rangpo.

Teesta-V: Salient Features

LOCATION		
State	:	Sikkim
District	:	East Sikkim
HYDROLOGY		
Catchment area	:	4307 sq.km
Design flood	:	14596 m^3/s (PMF)
River diversion design flood	:	3251 m^3/s
RESERVOIR (Post 2014 Survey)		
Maximum reservoir level	:	EL 580.72 m
Full reservoir level	:	EL 579.00 m
Minimum draw down level	:	EL 568.00 m
Gross & Live storage	:	9.61 million m^3 & 5.44 million m^3
Length along the river	:	5.1 km (approx)
CONCRETE DAM		
Max. height above river bed level	:	52.20 m
Max. height from deepest level	:	88.60 m
Dam top elevation	:	EL 583.20 m
Length at dam top	:	176.50 m
SPILLWAY		
Energy Dissipation Device	:	Low level ogee shaped spillways with radial gates and flip bucket
Design flood	:	9500 m^3/s
Crest of spillway	:	EL 540.00 m
Number and size of sluices	:	Five (Each 9.0m wide, 12.0m high)
Max Tail pool Level (at PMF)	:	EL. 550.00
DIVERSION TUNNELS		
Number & Shape	:	Two nos., Horse –shoe shaped
Diameter (finished)	:	12.2m
Length	:	473 m & 610 m
INTAKE STRUCTURE		
Number & size of inlets	:	Three nos. of 6.5m x 6.5 m
Design discharge	:	350.84 m^3/s
Invert level	:	EL 554.00/556.50 m
DESILITING CHAMBER		
Type	:	Dufour shaped
Length	:	250 m
Number and size	:	Three; 19.7m x 24.5 m
Minimum particle size to be Removed	:	90 % of 0.2 mm or above
HEAD RACE TUNNEL		

Shape	:	Horse-shoe
Diameter (finished)	:	9.5 m
Length	:	17.1 Km
Design discharge	:	292.37 m^3/s
No. of adits/gated adit	:	5 Nos./ 4 Nos.
SURGE SHAFT		
Type		Semi underground (restricted Orifice)
Height & Internal diameter	:	92.5 m & 30.0 m
Area of orifice (gate groove)	:	24.95 Sq. m
Thickness of RCC lining	:	1.0 m
Maximum upsurge	:	EL 625.80 m
Maximum down surge	:	EL 542.00 m
PRESSURE SHAFTS		
Number and type	:	Three nos., steel lined
Diameter (internal)	:	4.7 m
Height	:	174.0m
UNDERGROUND POWER HOUSE		
Installed capacity	:	510 MW (3 units of 170 MW each)
Dimensions of machine hall	:	118.5m (L) x 23m (W) x 47.5 m (H)
Dimensions of transformer cavern	:	100.5m (L) x 14.5m (W) x 10.7 m (H)
Switchyard type	:	Indoor GIS with roof top pothead yard of size 100m x 30m
Type of turbine	:	Francis, vertical axis
Spacing of unit axis	:	22.5m
Peaking Capacity	:	4.30 hrs
Max. Tail water level	:	EL 360.00 m (with 3 units)
Min./Extreme min. tail water level	:	EL 359.00 m / EL 358.50 m
Gross head/Rated net head	:	215 m (approx.)/ 196.15 m
Rated discharge	:	97.46 cumecs per unit
TAILRACE TUNNELS		
Tunnel shape	:	D-shaped, 3 nos
Diameter (finished)	:	6.0 m
Length	:	165 m, 175 m, 185 m
POWER GENERATION FIGURES		
Installed capacity	:	510 MW
Annual energy (in 90%dependable year)	:	2573 GWh

Annexure-6
By Email

Government of India
Ministry of Jal Shakti
Department of Water Resources, RD & GR
National Dam Safety Authority
O/O of Member (Disaster & Resilience)
Gates (NW&S) (Nodal)

Date: 06.04.2023

To,

All SDSO & SCDS as per list I & II,

विषय: Establishment of an early warning relate to operation of reservoirs-reg.

Sir,

Early warning is a major element of disaster risk reduction. It prevents loss of life and reduces the economic and material impact of disasters.

As per section 26, functions of National Dam safety Authority, “Early warning systems need to incorporate appropriate framework for the exchange of real time hydrological and meteorological data and information related to operation of reservoirs by the owner of a dam”.

In view of the above, it is requested to incorporate appropriate framework for the exchange of real time hydrological and meteorological data and information related to operation of reservoirs at the earliest under intimation to this office.

This issues with the approval of Member, Disaster and Resilience, NDSA.

भवदीय
Signed by Rahul Kumar Singh
Date: 10-04-2023 10:14:55
Reason: Approved
(Rahul Kumar Singh)
Director (Gates Design NW&S)

Copy for kind information to:

1. Chairman, NDSA, New Delhi.
2. NDSA Secretariat, New Delhi.
3. Regional Director (E&NE, Northern, Southern and Western), NDSA.

Room No. 602 (S), Sewa Bhawan
R.K. Puram-1, New Delhi-110066
Tel: 011-29583490, E-mail: dirdr-ndsa@gov.in & gdnwsdte@nic.in

Government of India
Ministry of Jal Shakti
National Dam Safety Authority
Disaster and Resilience Wing
* * * * * * *

602 (S), 6th Floor, SewaBhawan,
R.K. Puram, New Delhi-110066
Tel: 011-29583490,
E-mail: gdnwsdte@nic.in

To,

All SDSO & SCDS as per list I & II

विषय: Preparation of Emergency Action Plan and Annual report – reg

संदर्भ: DoWR, RD & GR OM No. N-52011/2/2021-BM/PR dated 25.04.2014

The Parliament of India has enacted the Dam Safety Act, 2021, which has come into force with effect from 30th December, 2021. The Act provides for surveillance, inspection, operation and maintenance of the specified dam for prevention of dam failure related disasters and to provide for institutional mechanism to ensure their safe functioning and for matters connected therewith or incidental thereto.

Various activities are to be undertaken under the Dam Safety Act, 2021 by the State/UT Governments/dam owners for safety of dams falling under their jurisdiction. At this juncture, kind attention of all SDSO and SDSC is invited on following two very important activities are to be taken by all SDSO and SDSC:-

1 ANNUAL REPORT:-

All the SDSO's shall prepare and submit the annual report containing the documentation of activities in relation to Dam Safety as per relevant sections of the Act which is to be laid by the State Government in the house of State Legislature. A copy of the same shall be forwarded to the Member (Disaster & Resilience) as well as to NDSA Secretariat, New Delhi. NDSA shall be preparing a Consolidated Annual

Report for the entire country.

2 EMERGENCY ACTION PLAN (EAP):-

All the SDSO's shall prepare an Emergency Action Plan (EAP) of all the specified dams under their jurisdiction as per section 36 (1) of the Dam Safety Act, 2021 and the same shall be updated at the regular intervals as per the provisions of the act.

In view of the above, all the SDSOs and dam owners are directed to take the necessary steps to fulfill the above statutory provisions of Dam Safety Act, 2021 to ensure overall safety of the existing and under construction/new dams and send all the necessary documents to NDSA with in time for record and further necessary action.

This issues with the approval of Member-Disaster & Resilience, NDSA.

Signed by Saket Kumar
Date: 30-10-2022 17:35:28
Reason: Approved

(साकेत कुमार)
उप निदेशक

To,

1. **List-I, State committee on Dam Safety**
2. **List-II, State Dam Safety Organisation**

Copy for Information to,

1. **Chairman, NDSA, New Delhi.**
2. **NDSA Secretariat, New Delhi.**

TE-16015/3/2023-NDSA-MOWR

By Email

I/83298/2023

Government of India
Ministry of Jal Shakti
Department of Water Resources, RD & GR
National Dam Safety Authority
Member (Disaster & Resilience)

Date: 28.04.2023

To,

All SDSO & SCDS as per list I & II,

विषय: Prevention of Dam Failure/ incidents during the upcoming monsoon-reg.

Sir,

Dam Safety Act 2021 vide Chapter VII, Safety, Inspection and Data Collection has given the responsibility to every Dam owner of specified dams to undertake pre-monsoon and post-monsoon inspection to check any unusual behaviour or sign of distress.

As monsoon is approaching and during the season, dam's stability and safety becomes more critical. In view of this Dam owners are requested to ensure the safety of all the dams under their jurisdiction specially category I & II dams, if any. In case of dams under catergory-I/II, it is mandatory to take necessary corrective actions, at the earliest, so that any dam failure or dam incident could be avoided.

This issues with the approval of Member, Disaster and Resilience, NDSA

Signed by Rahul Kumar Singh भवदीय
Date: 28-04-2023 17:18:10
Reason: Approved
(राहुल कुमार सिंह)
Director (Gates Design NW&S)

Copy for kind information to:

1. Principal Secretary, All States.
2. Chairman, NDSA, New Delhi.
3. JS (RD&PP), DoWR, RD & GR, New Delhi.
4. Member (Technical), NDSA, New Delhi.

Room No. 602 (S), Sewa Bhawan
R.K. Puram-1, New Delhi-110066
Tel: 011-29583490, E-mail: gdnwsdte@nic.in & dirdr-ndsa@nic.in

I/83298/2023

5. Member (P&R), NDSA, New Delhi.
6. Member (Regulation), NDSA, New Delhi.
7. NDSA Secretariat, New Delhi.
8. Regional Director (E&NE, Northern, Southern and Western), NDSA.

Appendix-B

संजय कुमार सिब्बल
SANJAY KUMAR SIBAL

सदस्य (अभिकल्प एवं अनुसंधान), केन्द्रीय जल आयोग
एवं पदेन अपर सचिव, भारत सरकार
जल संसाधन नदी विकास एवं गंगा संरक्षण विभाग
जल शक्ति मंत्रालय, भारत सरकार एवं
अध्यक्ष (अतिरिक्त प्रभार), राष्ट्रीय बांध सुरक्षा प्राधिकरण
409,चतुर्थ तल (द), सेवा भवन, आर.के. पुरम, नई दिल्ली-110066

Member (Design & Research), Central Water Commission
& Ex-officio Addl. Secretary to the Govt. of India
Department of Water Resources, River Development and
Ganga Rejuvenation, Ministry of Jal Shakti, Govt. of India &
Chairman (Additional Charge), National Dam Safety Authority (NDSA)
409, 4th Floor (S), Sewa Bhawan, R.K. Puram, New Delhi

DO No. TE-16/3/2023-NDSA-MOWR

1st November, 2023

Dear Dr. Rajat,

A six-member Committee led by Member (Disaster & Resilience), National Dam Safety Authority, was deputed from 23rd to 25th October 2023 to examine the reasons for the sinking of the piers of the Medigadda Barrage. The NDSA Committee held discussions with EnC (General), I& CAD Dept., Telangana on 23rdat Hyderabad, carried out an inspection of the Medigadda Barrage on 24th and held the final round of discussions with various stakeholders viz. I & CAD Dept., L&T Infra Ltd., SDSO, etc., on the 25th of October at Hyderabad.

The Committee, based on the barrage site inspection, discussions held with the stakeholders and after examination of the documents made available by I & CAD Dept., has submitted its report to the Chairman, NDSA. The broad findings of the Committee are as follows:

i) The Committee has sought a list of 20 data/inputs to examine the matter. Of these, data/inputs about only 11 items in the list have been submitted. In line with NDSA communication dated 27.10.2023, it is construed that the I & CAD Dept. has nothing to submit about instrumentation data, pre-monsoon & post monsoon inspection reports, completion reports, quality control reports, condition of gates and many other inputs sought in the list therein. Per the Dam Safety Act 2021, the I & CAD Dept [dam owner] cannot deny the inputs sought by NDSA, if available, with them.

ii) As per the Committee findings, piers had sunk due to a combination of issues involving planning, design, quality control and Operation and maintenance (O&M).

iii) As per the Committee, the primary reason for the failure is the settlement of the barrage raft. The piers, being monolith with it, have also settled, moved and cracked. This could occur due to several possible reasons, viz. piping, wherein transportation of foundation material has occurred; inadequate bearing capacity of foundation material [sand]; failure of upstream secant piles due to barrage load; etc.

iv) There appears to be construction deficiency due to a lack of stringent quality control during the construction of sub-surface contiguous secant piles and plinth connection between the raft and cut-offs. Gaps might have been created in the secant pile formation, making the barrier permeable, leading to piping and subsequent progressive failure.

v) There are deficiencies in the project planning & design as well. The Barrage has been designed as a floating structure but constructed as a rigid structure. The contiguous secant pile type cut-offs adopted by the project authorities were taken up to rock both at upstream and downstream of the barrage. This has changed the structure behaviour from the designed. Taking the downstream cut-off up to the impermeable strata alters the uplift pressure due to blocking the sub-surface flow. The construction methodology adopted for transverse cut-offs has imposed different conditions than what was assumed in the design. The alignment of the flared-out wall provided upstream of the barrage makes the barrage hydraulic deficient.

vi) The dam owner is supposed to undertake sounding and probing in the apron area every year immediately after the monsoon to assess the scours and launching of aprons in the vicinity of structures. The non-launching portion should also be carefully examined, particularly downstream, to ensure the effectiveness of the inverted filter. The upstream floor should be inspected every year early in the fair-weather season by probing and using underwater lamps. A careful inspection of joints is also to be carried out. The dam owners have not inspected or maintained the cement concrete blocks or launching aprons since the commissioning of the barrage in 2019-20. In this regard, this maintenance deficiency of the dam owners has progressively weakened the barrage, leading to its failure. This is a significant lapse on the operation and maintenance front.

vii) NDSA has regularly asked the Telangana State Dam Safety Organisation to get done the pre and post-monsoon inspections to check for any unusual behaviour or signs of distress. But it appears that this has not been complied with. This is a significant omission, thus attracting provisions of section 41 (b) of chapter X of the Dam Safety Act 2021. There appear to be many areas where compliance with DSA 2021 provisions was found missing. This is a serious matter as the Barrage has a high-risk potential for life and the economy.

viii) The distress condition developed in one block of the Medigadda barrage is adversely affecting the functionality of the barrage. The barrage under the present condition is rendered useless until fully rehabilitated.

ix) The damaged block may have to be structurally restored to make it functional. Considering the commonalities, the likelihood of the failure of other blocks resulting in a similar mode exists. This would warrant rehabilitating the whole barrage.

x) Filling the reservoir in the present condition would worsen the barrage's health and should not be resorted to.

xi) The two barrages constructed upstream of Medigadda under the Kaleshwaram Project, viz; Annaram and Sundilla barrages, have similar designs and construction methodologies, making them prone to similar failure modes. Signs of boiling already exist downstream of Annaram Barrage, a precursor to failure. These barrages also should be examined urgently for signs of piping/ distress.

The Telangana state may look into the issues raised in the Committee report and undertake measures to remedy the barrage. A detailed investigation may be carried out to determine the failure's causes. NDSA may be informed of the outcome of such an investigation and the proposed rehabilitation process. Similar action may also be taken for the other two upstream barrages.

Regards,

Yours sincerely,

01/11/2023

(Sanjay Kumar Sibal)

Encl. As Above

Dr Rajat Kumar,
Special Chief Secretary,
Irrigation & CAD,
Telangana.

Copy to:

1. The Secretary, DOWR
2. The Chairman, CWC.

Copy for information to

1. PS to the Hon’ble Minister of Jal Shakti

File No. TE-16/3/2023-NDSA-MOWR
Government of India
Ministry of Jal Shakti Department of Water Resources, RD & GR
National Dam Safety Authority
Member (Disaster & Resilience)

Date: 01.11.2023

To,

Chairman,
National Dam safety Authority (NDSA), New Delhi.

विषय : Submission of Report of the Committee constituted by NDSA to examine the reasons for the sinking of the piers of Medigadda (Lakshmi) Barrage - reg.

महोदय,

A six member committee was constituted vide Office Order of NDSA, DoWR, MoJS, GoI No. MI/35/2023-NDSA-MOWR Dated 22/10/2023 to examine the reasons for the sinking of the piers of Medigadda (Lakshmi) Barrage, Telangana under the chairmanship of Shri Anil Jain, CE (NW&S) CWC & Member (D&R), NDSA. The committee was mandated to submit its report on the matter after interacting with all the stakeholders including officers of Telangana, SCDS and SDSO, Telangana, the Agency involved in the construction of the Barrage, etc.

After a thorough examination of the matter and discussions with all the stakeholders during the site visit of the team from 23rd to 26th October 2023, a report has been prepared and submitted for information and further action.

This issues with the approval of Member, Disaster and Resilience, NDSA.

भवदीय

Encl : As above

1/11/23
(राहुल कुमार सिंह)
Director (Gates Design NW&S)

Room No. 602 (S), Sewa Bhawan
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Report of the Committee constituted by NDSA
to examine the reasons for the sinking of the piers of
Medigadda (Lakshmi) Barrage

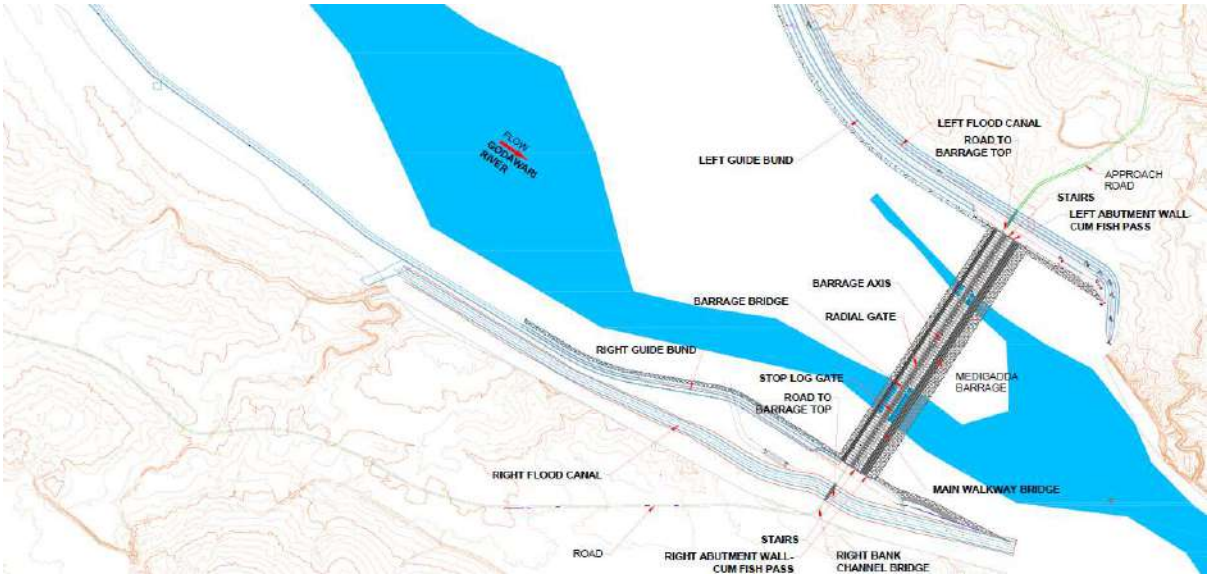
A committee was constituted vide Office Order of NDSA, DoWR, MoJS, GoI No. MI/35/2023-NDSA-MOWR Dated 22/10/2023 (enclosed as **Annexure –I**) to examine the reasons for the sinking of the piers of Medigadda (Lakshmi) Barrage, Telangana with the following composition:

1. Shri Anil Jain, CE (NW&S) CWC & Member (D&R), NDSA – Chairman
2. Shri S. K. Sharma, Director BCD (E&NE), CWC
3. Shri R. Thangamani, Director NDSA, SR, Chennai
4. Shri Rahul K Singh, Director Gates (NW&S), CWC & Director NDSA
5. Shri Devender Rao, SE, Godavari Circle, CWC
6. Shri Praveen Annepu DD, KGBO, CWC

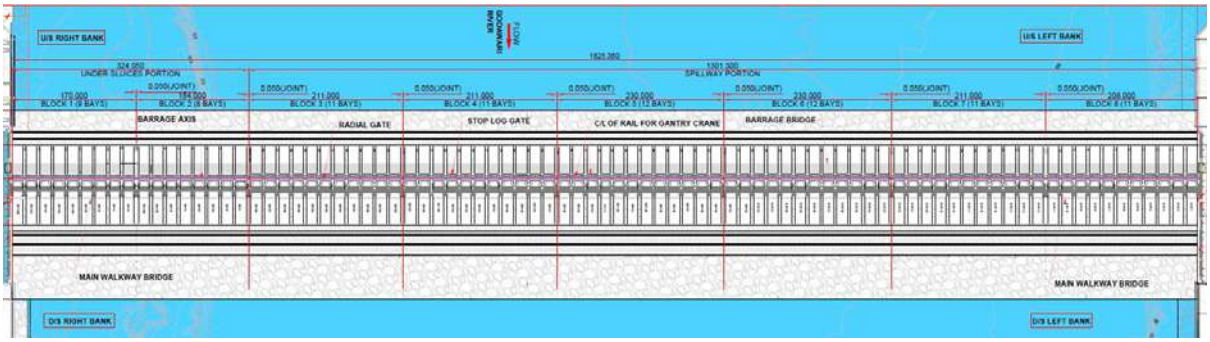
The committee was mandated to interact with all the stakeholders (including officers of Telangana, SCDS and SDSO, Telangana, the Agency involved in the construction of the Barrage, etc.) and, after a thorough examination of the matter, to submit its report.

2.0 Brief Description of Project

Medigadda Barrage, Telangana, is an integral part of the Kaleshwaram Project. The layout drawing of the Kaleshwaram Project is enclosed as **Annexure II**. Medigadda Barrage (Lakshmi Barrage) was commissioned in 2019-20. The barrage is situated on River Godavari at 22 km downstream of the confluence of Pranahita River with Godavari Main. It comprises 85 bays (left to right, 68 spillway bays of size 15 m X 11 m + 17 river sluices of size 15 m X 12 m). The crest level of spillway bays is at EL+89 m, and that of River sluice bays is at EL+88 m. The pond level of the barrage is EL+100 m. The salient features of the Barrage are enclosed as **Annexure – III.**



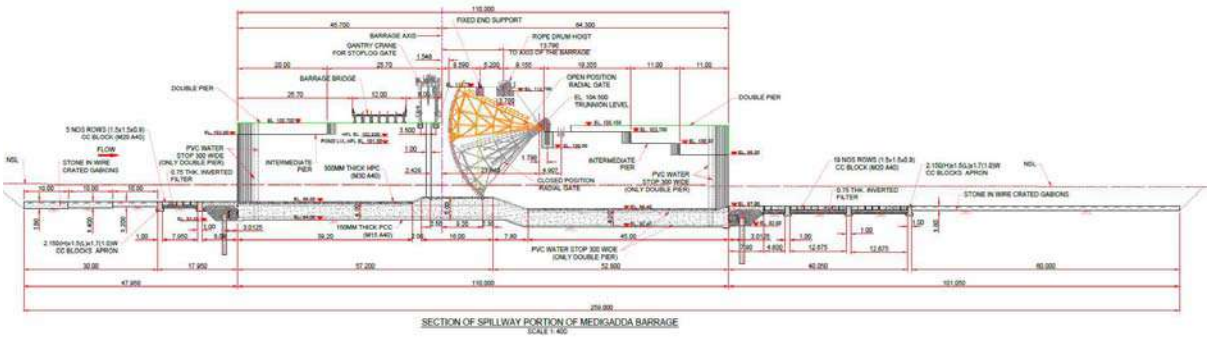
Project Layout



Block 1 **to** **Block 8**

Top Plan of Barrage

Barrage length	**1625 M**
Barrage Width (Concrete Raft)	**110 M**
Barrage Width (with Aprons)	**259 M**
No. of Vents (Gates)	**85 Nos (in 8 blocks)**
Storage Capacity	**16.17 TMC**



Typical Section of Barrage

3.0 Incident Details

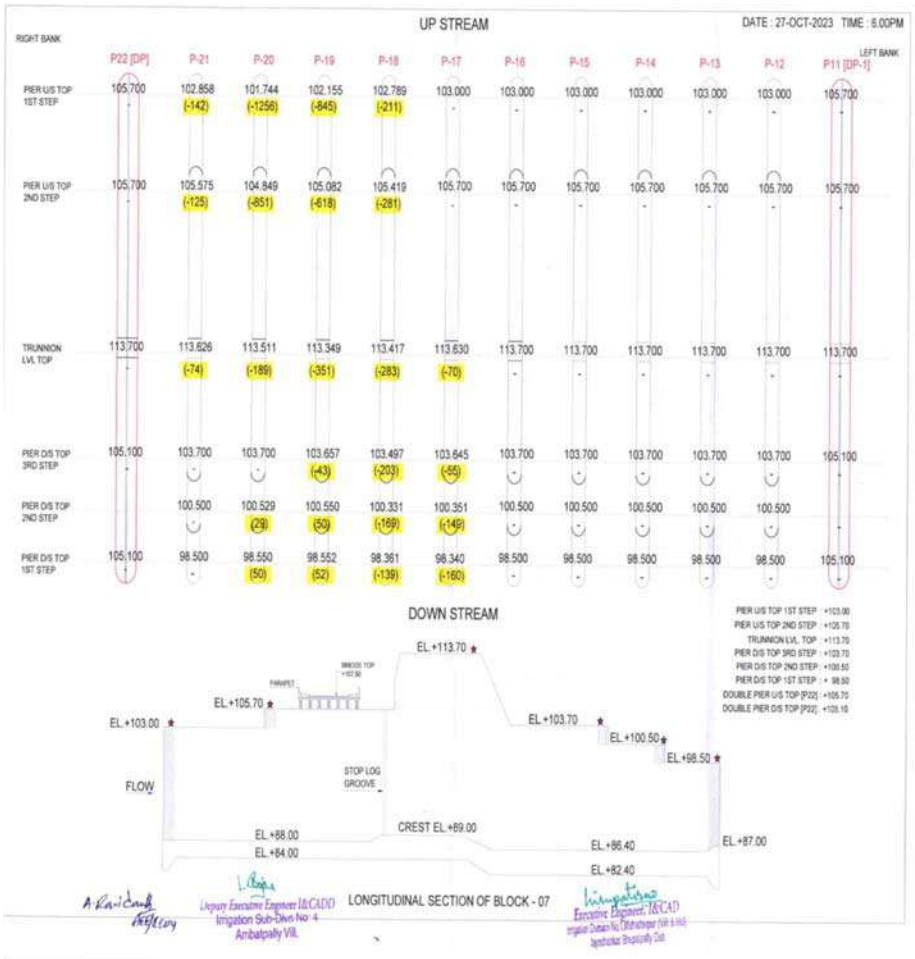
A dam incident of settlement of some piers of Medigadda (Lakshmi) Barrage was reported on 21-10-2023 at approx. 6:30 pm. The water level in the Pond at 6 pm on that day was EL+98.00 m with corresponding storage of 10.33 TMC out of 16.17 TMC gross, inflow 14980 cusec and out flow 13100 cusec with open gates 8Nos of 85. Noticing the settlement incident, the barrage authorities started releasing water through the gates. The corresponding values represent the various parameters at that time were as follows:

Date: 21-10-2023@09:00 PM Level: +97.80 /100.00 M Capacity: 9.870/16.17 TMC Total inflows: 14,980 Cusecs Instant Outflows through Laxmi PH: NIL Cusecs **Barrage Gates: 68,060 Cusecs** Total: 68,060 Cusecs No of gates open: **46**/85	Date: 22-10-2023@12:00 AM Level: +96.40 /100.00 M Capacity: 6.878/16.17 TMC Total inflows: 14,980 Cusecs Instant Outflows through Laxmi PH: NIL Cusecs **Barrage Gates: 2,74,770 Cusecs** Total: 2,74,770 Cusecs No of gates open: **65**/85	Date: 22-10-2023@03:00 AM Level: +94.60 /100.00 M Capacity: 4.048/16.17 TMC Total inflows: 14,980 Cusecs Instant Outflows through Laxmi PH: NIL Cusecs **Barrage Gates: 1,99,280 Cusecs** Total: 1,99,280 Cusecs No of gates open: **60**/85
Date: 22-10-2023@06:00 AM Level: +92.80 /100.00 M Capacity: 2.154/16.17 TMC Total inflows: 14,980 Cusecs Instant Outflows through Laxmi PH: NIL Cusecs Barrage Gates: Nil Cusecs Total: Nil Cusecs No of gates open: 0/85	Date: 22-10-2023@09:00 AM Level: +93.50 /100.00 M Capacity: 2.815/16.17 TMC Total inflows: 17,310 Cusecs Instant Outflows through Laxmi PH: NIL Cusecs Barrage Gates: Nil Cusecs Total: Nil Cusecs No of gates open: 0/85	Date: 22-10-2023@12:00 PM Level: +93.80 /100.00 M Capacity: 3.112/16.17 TMC Total inflows: 17,310 Cusecs Instant Outflows through Laxmi PH: NIL Cusecs Barrage Gates: 4,380 Cusecs Total: 4,380 Cusecs No of gates open: 5/85

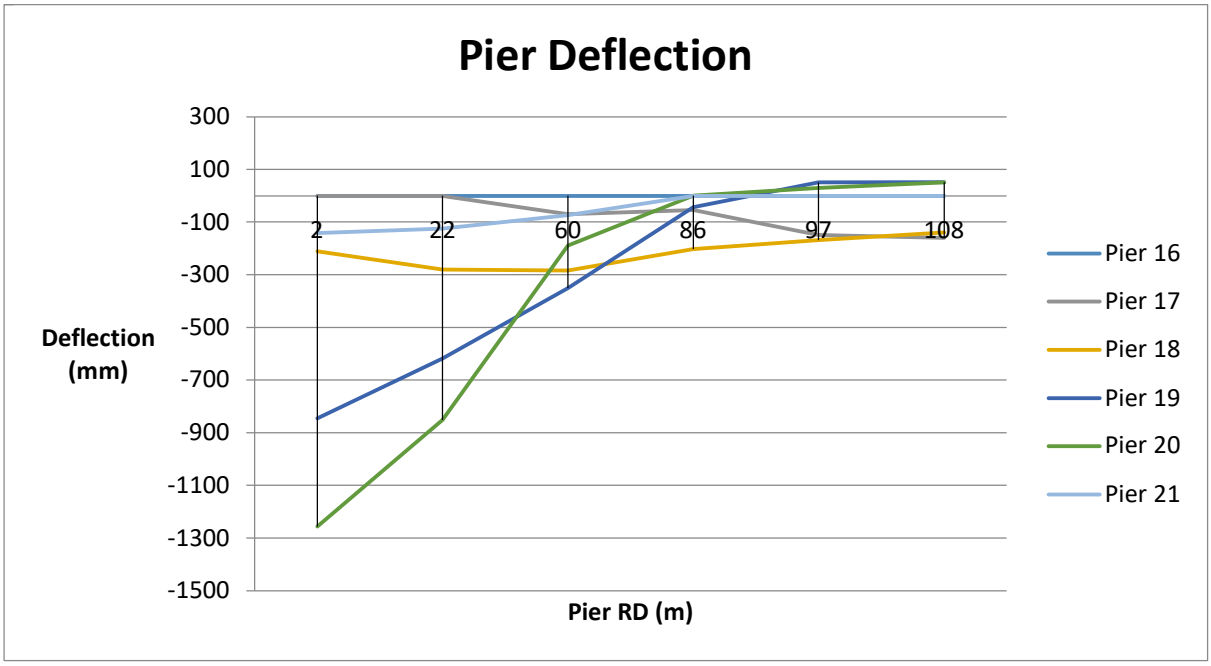
Due to the incident at Lakshmi Barrage, the outflow reached **2,74,770 cusecs** at 00:00 hrs on 22.10.2023. Consequently, the outflow from Tupakulagudem (PVN Rao Kanthanapally) reached **1,40,103 cusecs** at 06:00 hrs on 22.10.2023 and stayed constant till noon. The Water Level at the Perur HO Site of CWC rose from EL+70.95m at 06:00 hrs to EL+75.14m at noon (corresponding discharge 4528 cumecs or 1.60 lakh cusec). Tracking of peak travel from the Barrage out flows and Water Levels at the various downstream HO stations /Projects, along with a line diagram of Godavari River, are given in **Annexure –IV.**

Deck Slab Deflection at Pier 20 of 7th Block

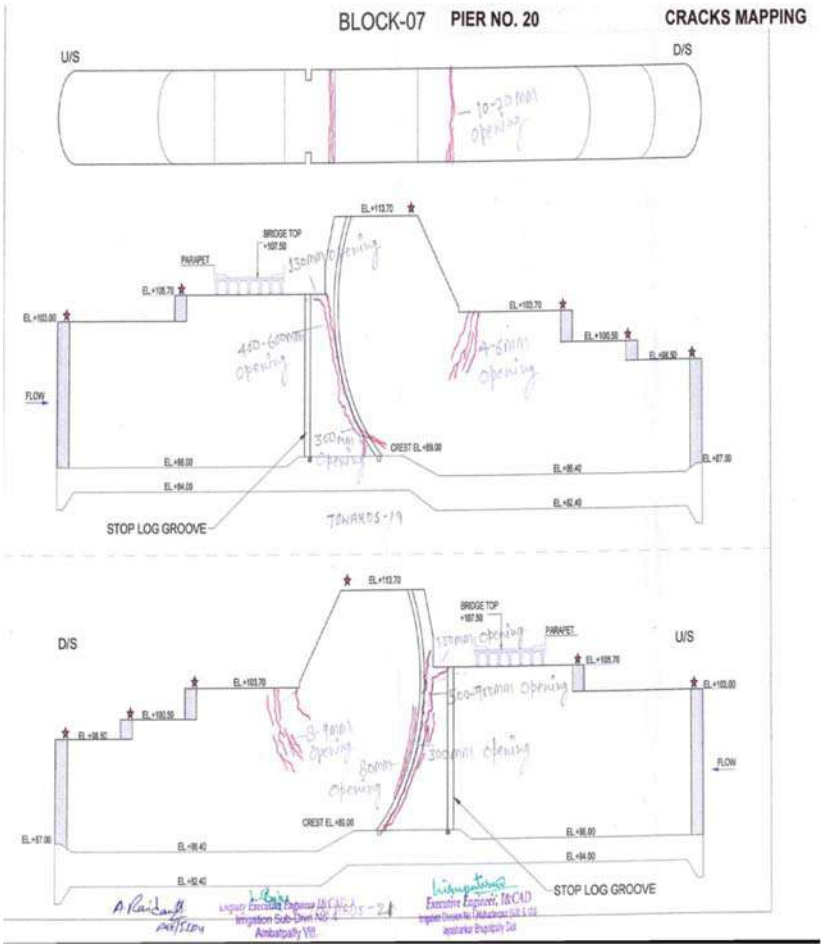
Crack in Pier No. 20 of 7th Block.



Top Elevation of Piers in 7th Block showing Settlement as of 27th October 2023



The plot of settlement of Piers of 7th Block as of 27th October 2023



The cracks were also mapped on the sectional elevation of piers (Pier no. 16 to 20) of Block 7

The mapping of cracks in the piers mentioned above is enclosed as **Annexure V**

4.0 Site Visits and Meetings held by Committee

The committee left Delhi on 23rd October 2023 at 10:25 AM, reached Hyderabad at 12:30 noon and held a meeting with EnC (General), Irrigation & CAD Department, Telangana, at Hyderabad. The committee left Hyderabad by afternoon, reached Warangal on the same day, visited the Medigadda Barrage on 24 October 2023, and returned to Hyderabad on the same day. A meeting with various stakeholders, e.g., L & T Infra Ltd, SDSO, I and CAD Dept., Telangana, etc., was held the next day on 25th October 2023. The list of participants for the visit and meetings is given in **Annexure –VI**.

5.0 Data and Inputs Requested by the Committee

To examine the issue, the Committee requested the following data and inputs from Project authorities:

S. No.	Data / Input	Status
1	Geological and geotechnical details of foundation strata, especially where settlement has taken place - Borehole log details, SPT results, Plate load test results (if any), etc.	Provided
2	Instrumentation data of barrage:- Piezometer, stress cells, etc. to date	Provided (only two points in time scale)
3	Details of all distress conditions observed in the barrage to date.	Provided only for the present issue
4	Relevant Drawings of Barrage.	Provided
5	Relevant Sectional drawings of the structure showing settlement.	Provided
6	Relevant Sectional drawings of the structure showing geological profile	**Not Provided**
7	Since the barrage has been added as a specified Dam, NDSA-related information may be supplied, such as pre and post-monsoon inspection reports, EAP, etc.	**Not Provided**
8	Design calculations of barrage. Hydraulic (surface and subsurface) and stability. e.g. Safe exit gradient calculation, Max and Mimi stress under raft for various design conditions, etc.	Provided (under examination)
9	Foundation improvement works, if any.	Not carried out in block 7
10	Quality Control Reports.	**Not Provided**
11	Third-party monitoring Reports, if any.	**Not Provided**
12	Physical Model Study Report	Provided
13	Pre-monsoon and post-monsoon cross-sections/soundings on u/s and d/s since the commissioning of the barrage, along with actual retrogression.	**Not Provided**
14	Relevant clauses of contract agreement regarding defects liability period.	Provided

15	Completion Reports of each Block consisting of all components.	**Not Provided**
16	Photographs of bearings condition both upstream and downstream.	Provided
17	Mapping of all cracks in all settled piers.	Provided for Block 7. Remaining Blocks Not Provided
18	Drawing showing transverse secant pile cut-off under the double pier and detailing of joining top of Piles with pier.	Provided
19	Condition of all gates in block No 7.	Provided
20	Condition of stop log grooves in block No. 7	Provided

The Committee had sought a list of 20 data/inputs to examine the matter. Data/inputs of only 11 items in the list have been submitted. The instrumentation data provided is grossly inadequate. In line with NDSA communication dated 27.10.2023, it is construed that the I & CAD Dept. has nothing to submit of instrumentation data, pre-monsoon & post monsoon inspection reports, completion reports, quality control reports, and many other important inputs sought in the list therein. It has already informed to the State that if the dam owner denies the inputs sought by NDSA, despite being available with the I & CAD Dept., the matter would have to be dealt with under the relevant provisions of the Dam Safety Act, 2021.

6.0 Observation & Conclusions

With the data and inputs received, the following observations and conclusions are made by the committee:

6.1 Reasons for settlement of Piers

i. Since the Barrage is Raft type, the Piers are integral with Raft. (The Layout Drawings and other relevant project drawings are enclosed as **Annexure VII)**. If Piers have undergone settlement, the raft is expected to have also undergone settlement.

ii. Under present circumstances, the Raft can undergo settlement due to one or a combination of the following reasons:
   a. Liquefaction
   b. Clay consolidation
   c. Piping
   d. Compaction of Sandy strata

iii. In the absence of any immediate seismic event, Liquefaction is not likely the cause.

iv. As per foundation material data collected before construction by Project authorities (Geological and Geotechnical details of the Barrage are enclosed as **Annexure VIII**), clay is not present. Hence, settlement due to the consolidation of clay is also not likely.

v. Therefore, the upstream-to-downstream movement of the foundation material (sand) through piping or compaction of sandy strata appears to be the reason for the settlement of Raft.

vi. The committee from the bridge noticed a flow phenomenon resembling oozing out of the water from below the raft, downstream of the end sill beam, between Bay 16-17 and Bay 17-18, indicating a possible piping phenomenon. The committee also noticed the visible cracks on the piers and sagged bridge deck due to the settlement of the piers.

vii. However, at the time of the visit (24th October 2023), the water level at the barrage was at EL 89.4 m (approx.). Since the upstream Raft and apron are at EL 88.0 m, the downstream stilling basin is at EL 86.4 m, and the downstream apron is at EL 87.0 m. Therefore, all these components were underwater (under 3.0 m to 1.4 m depth of water). Further, no access or arrangements had been made by the Project authorities for the committee to inspect these components. Therefore, the committee could not examine these underwater components to ascertain the extent of damage to the raft.

viii. Contiguous Secant piles have been provided by the Project authorities to act as cut-offs on upstream & downstream longitudinal cut-offs (perpendicular to flow). (Refer to **Annexure VII** for relevant Drawings.)

The Contiguous Secant piles are subsurface construction and need stringent quality control on verticality of piles, density of bentonite slurry, concrete properties, etc. As indicated in the communication of the committee with the state dated 27/10/2023, it is deemed that the dam owner does not have the quality control reports, which leads to the conclusion that the deviation from the specifications and poor-quality control developed gaps/failure of cut-off walls making it unable to provide an impenetrable barrier leading to piping and subsequent progressive failure.

Since transverse cut-offs (i.e., cut-offs along flow direction provided beneath double piers) are provided as sheet pile cut-offs, it is not understood why they were not adopted for upstream and downstream. This is a planning issue as it might have saved time and money and simplified the design.

ix. The plinth connection/parametric joint between the raft and cut-offs also requires high-quality control during construction and impeccable maintenance during operation. The lack of quality control led to gaps in the plinth connection, which could be one reason for piping and subsequent progressive failure. This is a planning & design issue and also involves quality issues.

6.2 Issues Related to Design of Barrage

The following design issues were examined in the project designs:

a. From the drawings and geological survey details provided by project authorities (vide annexures VII & VIII), it is evident that Contiguous Secant pile type cut-offs adopted by the Project authorities were taken into rock upstream and downstream (i.e., impermeable strata). Usually, the Barrage is designed as a floating structure to reduce bearing capacity requirements and avoid locking up uplift pressures, as is evident from the following provisions.

i. As per cl 17.1.1 of IS 6966 Hydraulic Design of Barrages & Weirs – Guidelines," "in case impermeable strata is encountered, the depth of cut-off wall should be such that it avoids the build-up of uplift".

ii. Also, as per Cl 4.1.3.7 of the CBIP Manual on Barrages and Weirs, it is mentioned that "If impermeable layers are encountered…… on downstream such embedment should be avoided so that pressures are not locked up".

b. Drainage arrangements in the stilling basin area have not been provided. These are generally provided to reduce uplift on the stilling basin raft.

Therefore, it is concluded that the barrage design was not done as per relevant BIS codes and the CBIP manual. However, in the instant case, the barrage design needs to be seen to decide on the appropriateness of the cut-off design.

6.3 Other related issues with the Layout of Barrage, Conceptualization of design and Construction Quality

i. The alignment of the right bank flared-out wall upstream of the barrage is such that it affects the flow through the barrage; it obstructs the flow and may generate crossflows. This configuration is different from the DPR proposal. Such alignment of the flared-out wall is hydraulically inefficient for the barrage. This is a planning issue.

Image showing Upstream and Downstream Right bank Flared out Walls of Medigadda Barrage.

ii. The quality-related issues may require further investigations—for example, testing bentonite slurry, the verticality of Secant foundation improvement, etc.

6.4 Non-compliance of the provisions of the Dam Safety Act, 2021

The Medigadda Barrage (commissioned in 2019-20) comes under the ambit of the Dam Safety Act 2021; however, relevant provisions of the Dam Safety Act were not followed by the Project authorities:

i. The directions from NDSA to the Telangana State Dam Safety Organisation dated 28/4/2023 for carrying out pre and post-monsoon inspections to check for any unusual behaviour or signs of distress have not been complied with. As conveyed by Project authorities in a meeting dated 25 October 2023, Pre-Monsoon Inspections have not been carried out. The post-monsoon inspection has not been carried out / provided by Project Authorities. This is a major omission by the dam owner, thus attracting section 41 (b) of Chapter X of the Dam Safety Act 2021.

ii. As indicated in the communication of the committee with the state dated 27/10/2023, it is deemed that the sought inputs, namely EAP, O & M Manual, Logbook, etc., are not maintained by the dam owner. The non-compliance of the provisions of the Act, leading to public safety concerns, is a serious matter on the part of the dam owner.

iii. Project authorities vide letter dated 29 Oct 2023 have replied that the inspection was not carried out as the Project Identification Code (PIC) was awaited from CWC; this is not tenable as it is not required to obtain PIC before conducting Pre and post-monsoon inspection of a structure identified as specified dam under provisions of Dam Safety Act 2021.

6.5 Deficiencies in the Operation and Maintenance of Barrage

i. As per IS 7349:2012 [Barrages and Weirs — Operation and Maintenance — Guidelines] Cl. 5.3.1 & 5.3.2, sounding and probing in the apron area should be undertaken every year immediately after the monsoon to assess the scours and launching of aprons in the vicinity of structures. The non-launching portion should also be carefully examined, particularly downstream, to ensure the effectiveness of the inverted filter.

ii. Project authorities have not inspected or maintained the CC blocks or launching aprons since the commissioning of the barrage in 2019-20. This is a significant maintenance issue.

iii. There could be a possibility that CC blocks may have been dislodged and also damaged the parametric joint of the plinth slab, making the barrage sceptical to piping and subsequent progressive failure. It implies that the negligence of the dam owners in this regard has made the barrage susceptible to piping and subsequent progressive failure. This is a significant Operation and Maintenance issue.

6.6 Concerns about other barrages of the Kaleshwaram project

The two barrages constructed upstream of Medigadda under the Kaleshwaram Project, viz. Annaram and Sundilla Barrages have similar designs and construction methodologies, making them prone to similar casualties. These barrages also should be examined for signs of piping/ distress.

7.0 Way Forward

i. The project designs and drawings (as designed and built) need to be examined along with the results of geotechnical and geological investigations.

ii. Considering the commonalities, the likelihood of the piping failure of other blocks resulting in a similar failure is very much possible. Therefore, all piers and rafts of the Barrage must be surveyed, especially in block seven and blocks 6 and 8 (adjoining blocks), immediately to see if there is any piping/settlement. The observations should be made continuously to observe whether it is continuing.

iii. Inspection of apron/plinth connection downstream and upstream should be inspected urgently to know the gravity of the damage and plan for subsequent repair / remedial measures. Cracks should be monitored through standard methods (e.g., affixing glass strips with making across cracks, etc.).

iv. Before the remedial measures can be formulated, the extent of settlement and damage to the raft needs to be ascertained by project authorities and balance input/data provided to the committee.

v. Piping in a hydraulic structure is a sign of progressive failure. Therefore, its possibility needs to be ruled out in all structures of the Kaleshwaram project through investigations.

vi. The distress condition developed in one block of the Medigadda barrage is adversely affecting the functionality of the barrage. The barrage under the present condition cannot be functional until rehabilitation. To avoid further aggravation of the situation until it is fully rehabilitated, the following measures should be taken:

   a. Hydraulic head should not be created by ponding as it may worsen piping.

   b. Gantry crane should not be operated.

   c. Gates in block number 7 should not be operated.

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Annexure-I

National Dam Safety Authority
Department of Water Resources
Ministry of Jal Shakti

No: Mi/35/2023-NDSA-MOWR **Dated 22.10.2023**

Office Order

The pillars numbering 15 to 20 of the sixth to eighth blocks of the "Medigadda (Laxmi) barrage" of the Kaleswaram project had reportedly sunken down on the night of 21.10.2023. Accordingly, per para 8 of Schedule -II of the Dam Safety Act 2021, a committee is constituted with the following members to examine the reasons for the sinking of the piers of Madigadda (Lakshmi) Barrage:

1. Shri Anil Jain, CE (NW&S) CWC & Member (D&R), NDSA - Chairman
2. Shri S. K. Sharma, Director BCD (E&NE), CWC & Director NDSA
3. Shri R. Thangamani, Director NDSA, SR, Chennai
4. Shri Rahul K Singh, Director Gates (NW&S), CWC & Director NDSA
5. Shri Devender Rao, SE, Godavari Circle, CWC
6. DD, KGBO (To be nominated by CE KGBO, Hyderabad)

The team shall interact with all the stakeholders, including officers of WRD Telangana, SCDS and SDSO, Telangana, the Agency involved in the construction of the Barrage, etc. and after a thorough examination of the matter shall submit the detailed report duly indicating reasons for the incident. The team shall start its visit on 23rd Oct. 2023 and submit a report on its return.

This issues with the approval of the competent authority.

(Rakesh Kumar Gautam)
Director, NDSA Secretariat

To

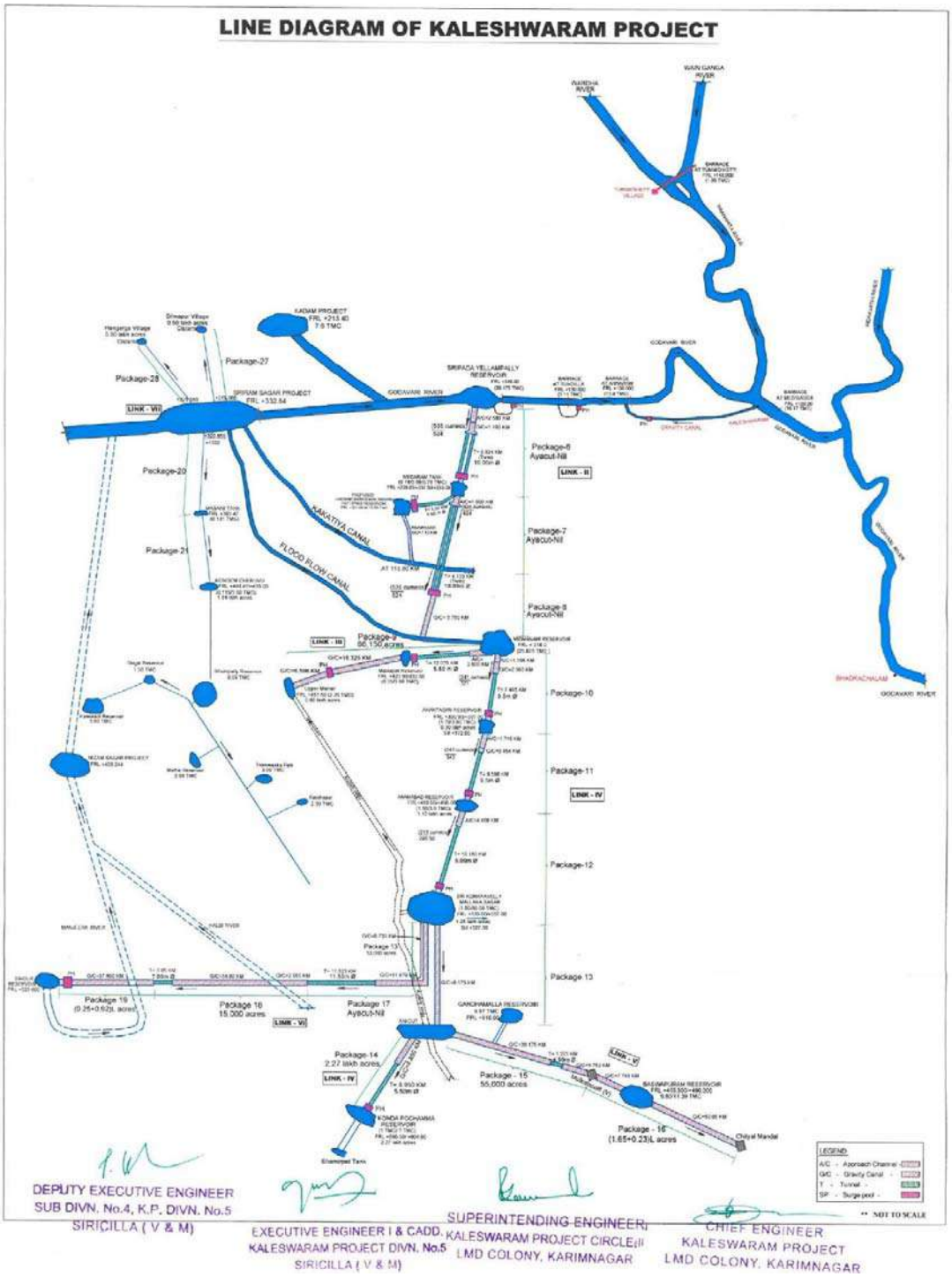
1. PPS to Hon'ble Minister of Jal Shakti.
2. PPS to Secretary, DOWR
3. PPS to Chairman, CWC
4. PPS to Spl Chief Secretary, Irrigation & CAD
5. PPS to Member (D&R), CWC & Chairman, NDSA
6. JS (RD&PP), DoWR, RD & GR, New Delhi.
7. CE, KGBO, Hyderabad, CWC

Annexure –I

…contd….

8. Member (Disaster & Resilience), NDSA, New Delhi.
9. Member (Technical), NDSA, New Delhi.
10. Member (P&R), NDSA, New Delhi.
11. Member (Regulation), NDSA, New Delhi.
12. NDSA Secretariat, New Delhi.
13. SCDS & SDSO, Telangana (with the request to arrange the logistics for the visit)
14. All members of the Central team.

Annexure - II



DEPUTY EXECUTIVE ENGINEER
SUB DIVN. No.4, K.P. DIVN. No.5
SIRICILLA (V & M)

EXECUTIVE ENGINEER I & CADD.
KALESWARAM PROJECT DIVN. No.5
SIRICILLA (V & M)

SUPERINTENDING ENGINEER
KALESWARAM PROJECT CIRCLE
LMD COLONY, KARIMNAGAR

CHIEF ENGINEER
KALESWARAM PROJECT
LMD COLONY, KARIMNAGAR

Annexure – III

KALESHWARAM PROJECT
LAKSHMI (MEDIGADDA) BARRAGE
SALIENT FEATURES

S.No.	Items	Description
1	Location	Medigadda Revenue Village, Ambatpally Grama Panchayath, Mahadevpur Mandal, JS Bhupalpally Dist., Telangana state.
2	Latitude	18º 42' 48'' North
3	Longitude	80º 04' 37'' East
4	Catchment Area	2,25,652 Sq. Km (87,125 Sq. Miles)
5	Design Flood	80,000 Cumecs (28.25 Lakh Cusecs)
6	High Flood Lcvcl (HFL)	+102.60 M
7	F.R.L	+100.00 M
8	T.B.L	+105.70 M
9	Avg. River Bed Level	+88.00 M
10	Crest Level - Barrage Bays - Under Sluice Bays	+89.00 M +88.00 M
11	Length of Barrage	1,632.00 M
12	Width of Barrage	110.00 M
13	Live Storage	16.17 TMC
14	No of Gates - Main Barrage Bays - Under Sluice Bays	68 Nos 17 Nos Total : 85 Nos
15	Size of Gates - Main Barrage Bays - Under Sluice Bays	15.00 x 12.30 M 15.00 x 13.30 M

Annexure – IV

Water Level (WL) and Discharge due to the incident at Lakshmi Barrage

Due to the incident at Lakshmi Barrage, the outflow reached **2,74,770 cusec** at 00:00 hrs on 22.10.2023. Consequently, the outflow from Tupakulagudem (PVN Rao Kanthanapally) reached **1,40,103 cusec** at 06:00 hrs on 22.10.2023 and stayed constant till 12:00 hrs.

1. The Water Level at **Perur** rose from 70.95m at 06:00 hrs and peaked at **75.14m** at 12:00 hrs (corresponding discharge 4920 cumec or 1.74 lakh cusec). The travel time from Perur to Eturnagaram is 6-8 hours.
2. WL at **Eturnagaram** rose by 0.71 m from 10:00 to 19:00 and peaked at **68.22 m** at 19:00 hrs.
3. WL at **Dummugudem** rose by 2.06m from 44.75m at 12:00 to **46.81m** at 05:00 hrs on 23.10.2023.
4. WL at **Bhadrachalam** rose by 2.39 m from 35.34m at 18:00 hrs on 22.10.2023 to **37.73m** at 10:00 hrs on 23.10.2023 with observed discharge of 3189 cumec (1.12 lakh cusec). (At 13:00 hrs on 22.10.2023, it was predicted that the WL at Bhadrachalam could peak at 37.83 m with the corresponding discharge of 3485 cumec (1.23 lakh cusec))
5. WL at **Polavaram** rose by 0.24 m from 14.817m at 06:00 hrs on 23.10.2023 to **15.057m** at 04:00 hrs on 24.10.2023 with corresponding discharge of 906 cumec (32,000 cusec).
6. On Sabari, WL rose from 32.33 m at 05:00 on 23.10.2023 at Konta to peak at 32.57m at 15:00 hrs on the same day. Consequently, the WL at Chinturu peaked at 30.45m at 18:00 hrs on the same day. It was observed that the WL at Kunavaram (confluence of Sabari with Godavari) kept rising and peaked at 29.30m at 05:00 hrs on 25.10.2023. This resulted in another rise at Polavaram, where the WL peaked at 15.077m at 22:00 on 25.10.2023

The WL rise at Perur was attenuated by the time it reached Bhadrachalam and further attenuated by the time the peak reached Polavaram (PRR-BCM 18+ hrs, BCM-POL 12+ hrs).

The Barrage outflows and Water Levels at the various downstream HO stations are shown in the table below:

Date / Time	Lakshmi Barrage (06:00)				Tupakulagudem (PVNRao Kanthapally)			
	WL	Cap.	I/F	O/F	WL	Cap.	I/F	O/F
	Metres	TMC	Cusecs	Cusecs	Metres	TMC	Cusecs	Cusecs
21-10-2023 18:00	98.000	10.330	14,980	13,100				
21-10-2023 19:00								
21-10-2023 20:00								
21-10-2023 21:00	97.800	9.870	14,980	68,060	80.000	4.180	22,100	45,000
21-10-2023 22:00								
21-10-2023 23:00								
22-10-2023 00:00	96.400	6.878	14,980	2,74,770	80.000	4.180	22,100	45,000
22-10-2023 01:00								
22-10-2023 02:00								
22-10-2023 03:00	94.600	4.048	14,980	1,99,280	80.000	4.180	1,48,770	92,000
22-10-2023 04:00								
22-10-2023 05:00								
22-10-2023 06:00	92.800	2.154	14,980	0	80.000	4.180	2,09,870	1,40,103
22-10-2023 07:00								
22-10-2023 08:00								
22-10-2023 09:00	93.500	2.815	17,310	0	80.000	4.180	2,09,870	1,40,103
22-10-2023 10:00								
22-10-2023 11:00								
22-10-2023 12:00	93.800	3.112	17,310	4,380	80.000	4.180	2,09,870	1,40,103
22-10-2023 13:00								
22-10-2023 14:00								
22-10-2023 15:00	93.900	3.112	19,870	17,810	79.500	3.810	17,520	23,733
22-10-2023 16:00								
22-10-2023 17:00								
22-10-2023 18:00	93.600	2.914	0	31,000	79.500	3.810	17,520	23,733
22-10-2023 19:00								
22-10-2023 20:00								

Date / Time	Lakshmi Barrage (06:00)				Tupakulagudem (PVNRao Kanthapally)			
	WL	Cap.	I/F	O/F	WL	Cap.	I/F	O/F
	Metres	TMC	Cusecs	Cusecs	Metres	TMC	Cusecs	Cusecs
22-10-2023 21:00	90.400	0.754	19,870	1,12,080	79.500	3.810	31,810	31,810
22-10-2023 22:00								
22-10-2023 23:00								
23-10-2023 00:00								
23-10-2023 01:00								
23-10-2023 02:00								
23-10-2023 03:00								
23-10-2023 04:00								
23-10-2023 05:00								
23-10-2023 06:00	89.700	0.632	12,240	45,260	79.700	3.960	80,450	63,383
23-10-2023 07:00								
23-10-2023 08:00								
23-10-2023 09:00	89.600	0.626	12,240	38,500	79.800	4.030	72,980	62,725
23-10-2023 10:00								
23-10-2023 11:00								
23-10-2023 12:00	89.400	0.614	22,500	22,500	80.000	4.180	55,400	55,440
23-10-2023 13:00								
23-10-2023 14:00								
23-10-2023 15:00	89.400	0.614	22,500	22,500	80.000	4.180	48,740	48,740
23-10-2023 16:00								
23-10-2023 17:00								
23-10-2023 18:00	89.400	0.614	22,500	22,500	80.000	4.180	32,750	32,750
23-10-2023 19:00								
23-10-2023 20:00								
23-10-2023 21:00	89.400	0.614	22,500	22,500	80.000	4.180	32,750	32,750
23-10-2023 22:00								

Date / Time	Lakshmi Barrage (06:00)				Tupakulagudem (PVNRao Kanthapally)			
	WL	Cap.	I/F	O/F	WL	Cap.	I/F	O/F
	Metres	TMC	Cusecs	Cusecs	Metres	TMC	Cusecs	Cusecs
23-10-2023 23:00								
24-10-2023 00:00								
24-10-2023 01:00								
24-10-2023 02:00								
24-10-2023 03:00								
24-10-2023 04:00								
24-10-2023 05:00								
24-10-2023 06:00	89.400	0.614	22,500	22,500				
24-10-2023 07:00								
24-10-2023 08:00								
24-10-2023 09:00					80.000	4.18	30,400	30,400
24-10-2023 10:00								
24-10-2023 11:00								
24-10-2023 12:00	89.400	0.614	22,500	22,500	80.000	4.18	30,400	30,400
24-10-2023 13:00								
24-10-2023 14:00								
24-10-2023 15:00	89.400	0.614	22,500	22,500	80.000	4.18	30,400	30,400
24-10-2023 16:00								
24-10-2023 17:00								
24-10-2023 18:00	89.400	0.614	22,500	22,500	80.000	4.18	30,400	30,400
24-10-2023 19:00								
24-10-2023 20:00								
24-10-2023 21:00					80.000	4.18	30,000	30,000

Date / Time	Lakshmi Barrage (06:00)				Tupakulagudem (PVNRao Kanthapally)			
	WL	Cap.	I/F	O/F	WL	Cap.	I/F	O/F
	Metres	TMC	Cusecs	Cusecs	Metres	TMC	Cusecs	Cusecs
24-10-2023 22:00								
24-10-2023 23:00								
25-10-2023 00:00								
25-10-2023 01:00								
25-10-2023 02:00								
25-10-2023 03:00								
25-10-2023 04:00								
25-10-2023 05:00								
25-10-2023 06:00	89.830		20,900	20,900				
25-10-2023 07:00								
25-10-2023 08:00								
25-10-2023 09:00	89.300		20,900	20,900	80.000	4.18	30,000	30,000
25-10-2023 10:00								
25-10-2023 11:00								
25-10-2023 12:00	89.300		20,900	20,900	80.000	4.18	30,000	30,000
25-10-2023 13:00								
25-10-2023 14:00								
25-10-2023 15:00	89.300		20,900	20,900	80.000	4.18	28,900	28,900
25-10-2023 16:00								
25-10-2023 17:00								
25-10-2023 18:00	89.300		20,900	20,900	80.000	4.18	28,900	28,900
25-10-2023 19:00								
25-10-2023 20:00								

Date / Time	Lakshmi Barrage (06:00)				Tupakulagudem (PVNRao Kanthapally)			
	WL	Cap.	I/F	O/F	WL	Cap.	I/F	O/F
	Metres	TMC	Cusecs	Cusecs	Metres	TMC	Cusecs	Cusecs
25-10-2023 21:00	89.300		20,900	20,900	80.000	4.18	28,900	28,900
25-10-2023 22:00								
25-10-2023 23:00								
26-10-2023 00:00	89.300		20,900	20,900	80.000	4.18	28,900	28,900
26-10-2023 01:00								
26-10-2023 02:00								
26-10-2023 03:00	89.300		20,900	20,900	80.000	4.18	28,900	28,900
26-10-2023 04:00								
26-10-2023 05:00								
26-10-2023 06:00	89.300		20,900	20,900	80.000	4.18	28,900	28,900
26-10-2023 07:00								
26-10-2023 08:00								
26-10-2023 09:00	89.300		20,900	20,900	80.000	4.18	28,900	28,900

Date/Time	Perur	Eturunagaram	Dummugudem	Bhadrachalam	Konta	Chinturu	Kunavaram	Polavaram	GodavariRlyBridge (Rajahmundry)	Dowlaiswaram	Atreyapuram
ZOG	**65.000**	**58.500**	**40.000**	**26.610**	**29.000**	**27.000**	**20.000**	**10.897**	**HHS**	**10.670**	**1.500**
Warning Level (gauge metre)	**13.100**	**14.830**	**13.000**	**19.110**	**11.300**	**13.500**	**16.740**		**17.680**	**3.580**	**12.000**
Danger Level (gauge metre)	**16.15**	**17.33**	**15.00**	**22.16**	**14.30**	**15.00**	**18.24**		**19.51**	**5.41**	**13.50**
21-10-2023 18:00	5.52	9.01	4.74	8.73	3.50	3.40	7.04	3.870	14.100	3.320	2.23
21-10-2023 19:00	5.53	9.01	4.74	8.73	3.47	3.40	7.04	3.870	14.100	3.320	2.24
21-10-2023 20:00	5.53	9.01	4.74	8.73	3.44	3.40	7.03	3.870	14.100	3.320	2.26
21-10-2023 21:00	5.53	9.01	4.74	8.73	3.44	3.37	7.03	3.870	14.100	3.320	2.26
21-10-2023 22:00	5.55	9.01	4.74	8.73	3.42	3.36	7.02	3.870	14.100	3.320	2.26
21-10-2023 23:00	5.57	9.01	4.74	8.73	3.40	3.33	7.02	3.870	14.100	3.320	2.26
22-10-2023 00:00	5.59	9.01	4.74	8.73	3.38	3.30	7.01	3.870	14.100	3.320	2.26
22-10-2023 01:00	5.61	9.01	4.74	8.73	3.37	3.28	7.01	3.870	14.100	3.320	2.25
22-10-2023 02:00	5.64	9.01	4.74	8.73	3.37	3.28	7.01	3.870	14.100	3.320	2.24
22-10-2023 03:00	5.68	9.01	4.74	8.72	3.37	3.28	7.01	3.870	14.100	3.320	2.23
22-10-2023 04:00	5.73	9.01	4.74	8.72	3.37	3.28	7.02	3.910	14.100	3.320	2.22
22-10-2023 05:00	5.78	9.01	4.74	8.72	3.37	3.28	7.03	3.910	14.100	3.320	2.21
22-10-2023 06:00	5.95	9.01	4.74	8.72	3.37	3.28	7.04	3.910	14.100	3.320	2.21
22-10-2023 07:00	6.60	9.01	4.75	8.72	3.37	3.26	7.05	3.910	14.100	3.320	2.20
22-10-2023 08:00	7.50	9.01	4.75	8.72	3.37	3.25	7.05	3.910	14.100	3.320	2.19
22-10-2023 09:00	8.61	9.01	4.75	8.72	3.37	3.25	7.05	3.910	14.100	3.320	2.19
22-10-2023 10:00	9.23	9.01	4.75	8.72	3.35	3.25	7.05	3.910	14.100	3.320	2.19

Date/Time	Perur	Eturunagaram	Dummugudem	Bhadrachalam	Konta	Chinturu	Kunavaram	Polavaram	GodavariRlyBridge (Rajahmundry)	Dowlaiswaram	Atreyapuram
ZOG	**65.000**	**58.500**	**40.000**	**26.610**	**29.000**	**27.000**	**20.000**	**10.897**	**HHS**	**10.670**	**1.500**
Warning Level (gauge metre)	**13.100**	**14.830**	**13.000**	**19.110**	**11.300**	**13.500**	**16.740**		**17.680**	**3.580**	**12.000**
Danger Level (gauge metre)	**16.15**	**17.33**	**15.00**	**22.16**	**14.30**	**15.00**	**18.24**		**19.51**	**5.41**	**13.50**
22-10-2023 11:00	9.78	9.02	4.75	8.72	3.35	3.25	7.04	3.910	14.100	3.320	2.19
22-10-2023 12:00	10.14	9.03	4.75	8.72	3.35	3.25	7.04	3.910	14.100	3.320	2.19
22-10-2023 13:00	10.06	9.13	4.76	8.72	3.39	3.26	7.03	3.910	14.100	3.320	2.19
22-10-2023 14:00	9.72	9.30	4.77	8.73	3.38	3.27	7.03	3.910	14.100	3.320	2.19
22-10-2023 15:00	9.11	9.46	4.78	8.73	3.36	3.26	7.02	3.910	14.100	3.320	2.22
22-10-2023 16:00	8.02	9.56	4.79	8.73	3.35	3.25	7.02	3.910	14.100	3.320	2.26
22-10-2023 17:00	6.93	9.65	4.83	8.73	3.34	3.25	7.02	3.910	14.100	3.320	2.28
22-10-2023 18:00	6.52	9.70	4.88	8.73	3.34	3.25	7.02	3.910	14.100	3.320	2.30
22-10-2023 19:00	6.41	9.72	4.91	8.74	3.34	3.25	7.02	3.920	14.100	3.320	2.32
22-10-2023 20:00	6.35	9.64	4.95	8.76	3.36	3.24	7.02	3.920	14.100	3.320	2.34
22-10-2023 21:00	6.30	9.59	5.00	8.79	3.37	3.23	7.02	3.920	14.100	3.320	2.36
22-10-2023 22:00	6.25	9.55	5.11	8.86	3.38	3.21	7.02	3.920	14.100	3.320	2.38
22-10-2023 23:00	6.22	9.51	5.25	8.96	3.38	3.22	7.02	3.920	14.100	3.320	2.38
23-10-2023 00:00	6.22	9.47	5.38	9.12	3.38	3.24	7.02	3.920	14.100	3.320	2.38
23-10-2023 01:00	6.22	9.44	5.51	9.38	3.37	3.25	7.03	3.920	14.100	3.320	2.37
23-10-2023 02:00	6.24	9.41	5.64	9.67	3.36	3.25	7.03	3.920	14.100	3.320	2.36
23-10-2023 03:00	6.26	9.39	5.82	9.98	3.35	3.25	7.04	3.920	14.100	3.320	2.35

Date/Time	Perur	Eturunagaram	Dummugudem	Bhadrachalam	Konta	Chinturu	Kunavaram	Polavaram	GodavariRlyBridge (Rajahmundry)	Dowlaiswaram	Atreyapuram
ZOG	65.000	58.500	40.000	26.610	29.000	27.000	20.000	10.897	HHS	10.670	1.500
Warning Level (gauge metre)	13.100	14.830	13.000	19.110	11.300	13.500	16.740		17.680	3.580	12.000
Danger Level (gauge metre)	16.15	17.33	15.00	22.16	14.30	15.00	18.24		19.51	5.41	13.50
23-10-2023 04:00	6.28	9.37	6.00	10.29	3.34	3.25	7.05	3.920	14.100	3.320	2.34
23-10-2023 05:00	6.32	9.36	6.81	10.56	3.33	3.24	7.06	3.920	14.100	3.320	2.34
23-10-2023 06:00	6.35	9.36	6.32	10.78	3.33	3.23	7.08	3.920	14.100	3.320	2.34
23-10-2023 07:00	6.38	9.36	6.36	10.86	3.35	3.24	7.11	3.930	14.100	3.320	2.34
23-10-2023 08:00	6.41	9.33	6.37	11.05	3.40	3.25	7.15	3.930	14.100	3.320	2.34
23-10-2023 09:00	6.46	9.32	6.37	11.10	3.47	3.27	7.20	3.940	14.100	3.320	2.34
23-10-2023 10:00	6.48	9.32	6.37	11.12	3.50	3.30	7.26	3.940	14.100	3.320	2.34
23-10-2023 11:00	6.48	9.32	6.34	11.12	3.54	3.34	7.38	3.950	14.100	3.320	2.34
23-10-2023 12:00	6.48	9.32	6.29	11.08	3.54	3.38	7.53	3.950	14.100	3.320	2.34
23-10-2023 13:00	6.48	9.32	6.21	10.98	3.54	3.40	7.66	3.960	14.100	3.320	2.34
23-10-2023 14:00	6.48	9.32	6.11	10.88	3.55	3.41	7.76	3.960	14.100	3.320	2.34
23-10-2023 15:00	6.46	9.32	6.01	10.78	3.57	3.42	7.85	3.970	14.100	3.320	2.34
23-10-2023 16:00	6.43	9.32	5.91	10.67	3.57	3.43	7.93	3.970	14.100	3.320	2.34
23-10-2023 17:00	6.40	9.32	5.81	10.56	3.57	3.44	8.01	3.990	14.100	3.320	2.34
23-10-2023 18:00	6.36	9.30	5.71	10.45	3.56	3.45	8.09	4.000	14.100	3.320	2.34
23-10-2023 19:00	6.32	9.28	5.61	10.35	3.52	3.45	8.15	4.010	14.100	3.320	2.34

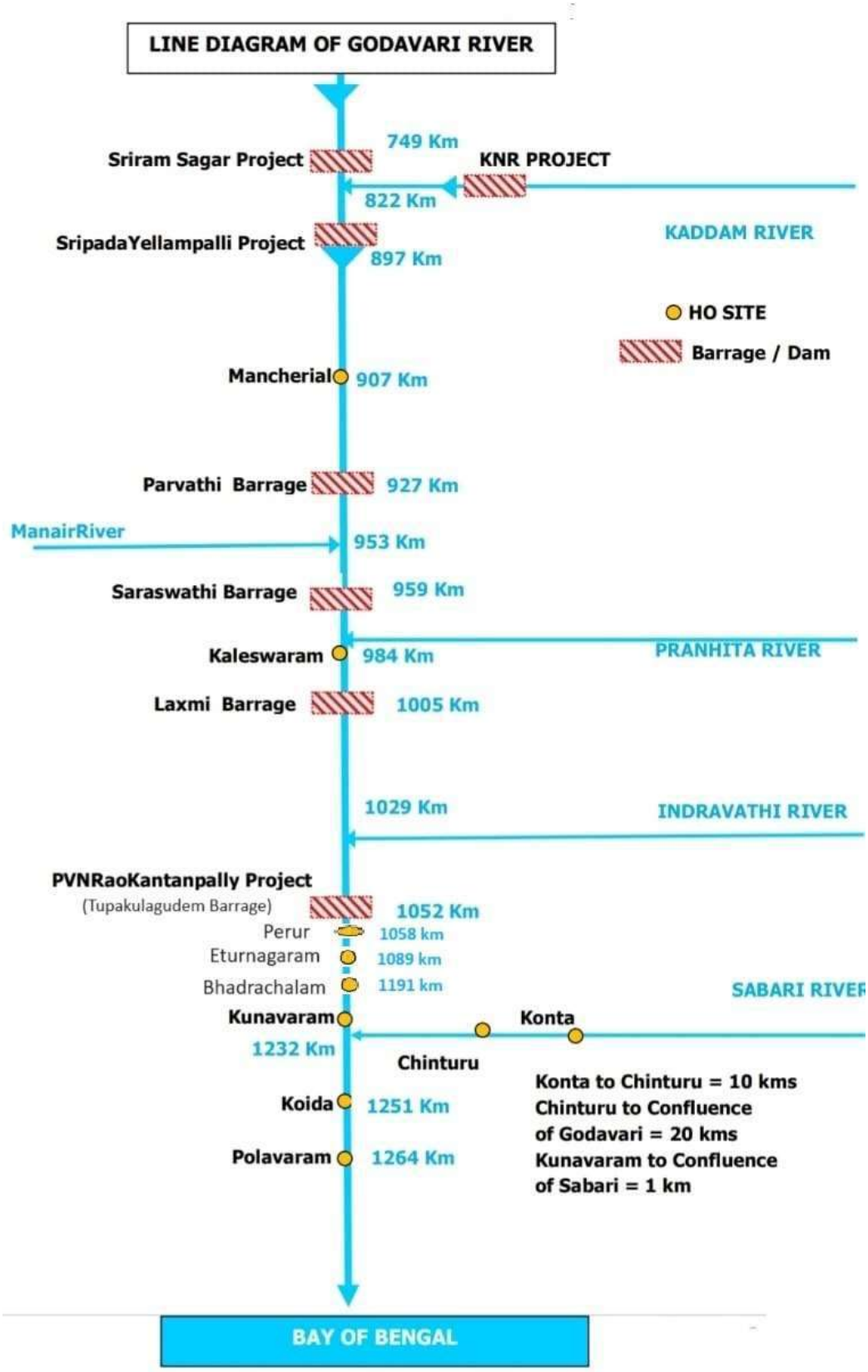
Date/Time	Perur	Eturunagaram	Dummugudem	Bhadrachalam	Konta	Chinturu	Kunavaram	Polavaram	GodavariRlyBridge (Rajahmundry)	Dowlaiswaram	Atreyapuram
ZOG	65.000	58.500	40.000	26.610	29.000	27.000	20.000	10.897	HHS	10.670	1.500
Warning Level (gauge metre)	13.100	14.830	13.000	19.110	11.300	13.500	16.740		17.680	3.580	12.000
Danger Level (gauge metre)	16.15	17.33	15.00	22.16	14.30	15.00	18.24		19.51	5.41	13.50
23-10-2023 20:00	6.28	9.27	5.51	10.28	3.49	3.45	8.21	4.020	14.100	3.320	2.34
23-10-2023 21:00	6.24	9.26	5.45	10.16	3.45	3.42	8.25	4.030	14.100	3.320	2.34
23-10-2023 22:00	6.18	9.25	5.40	10.06	3.45	3.38	8.29	4.040	14.100	3.320	2.34
23-10-2023 23:00	6.10	9.25	5.35	9.93	3.45	3.35	8.32	4.060	14.120	3.320	2.34
24-10-2023 00:00	6.02	9.24	5.31	9.85	3.45	3.32	8.35	4.080	14.140	3.320	2.34
24-10-2023 01:00	5.92	9.24	5.25	9.80	3.44	3.30	8.4	4.100	14.140	3.320	2.34
24-10-2023 02:00	5.81	9.23	5.20	9.74	3.40	3.28	8.45	4.120	14.140	3.320	2.34
24-10-2023 03:00	5.71	9.23	5.15	9.70	3.36	3.26	8.5	4.140	14.140	3.320	2.38
24-10-2023 04:00	5.60	9.23	5.10	9.66	3.32	3.24	8.55	4.160	14.140	3.320	2.42
24-10-2023 05:00	5.50	9.23	5.08	9.63	3.30	3.22	8.60	4.160	14.140	3.320	2.46
24-10-2023 06:00	5.40	9.22	5.07	9.61	3.30	3.20	8.65	4.160	14.140	3.320	2.5
24-10-2023 07:00	5.30	9.22	5.06	9.59	3.30	3.20	8.69	4.130	14.140	3.320	2.52
24-10-2023 08:00	5.20	9.21	5.05	9.58	3.31	3.20	8.74	4.100	14.140	3.320	2.54
24-10-2023 09:00	5.15	9.21	5.04	9.56	3.33	3.20	8.78	4.070	14.140	3.320	2.55
24-10-2023 10:00	5.10	9.20	5.02	9.54	3.31	3.20	8.83	4.040	14.140	3.320	2.56

Date/Time	Perur	Eturunagaram	Dummugudem	Bhadrachalam	Konta	Chinturu	Kunavaram	Polavaram	GodavariRlyBridge (Rajahmundry)	Dowlaiswaram	Atreyapuram
ZOG	**65.000**	**58.500**	**40.000**	**26.610**	**29.000**	**27.000**	**20.000**	**10.897**	**HHS**	**10.670**	**1.500**
Warning Level (gauge metre)	**13.100**	**14.830**	**13.000**	**19.110**	**11.300**	**13.500**	**16.740**		**17.680**	**3.580**	**12.000**
Danger Level (gauge metre)	**16.15**	**17.33**	**15.00**	**22.16**	**14.30**	**15.00**	**18.24**		**19.51**	**5.41**	**13.50**
24-10-2023 11:00	5.06	9.20	4.99	9.50	3.30	3.20	8.87	4.020	14.130	3.320	2.56
24-10-2023 12:00	5.03	9.20	4.96	9.47	3.30	3.20	8.92	4.000	14.120	3.320	2.56
24-10-2023 13:00	5.00	9.19	4.93	9.44	3.25	3.19	8.96	3.980	14.120	3.320	2.56
24-10-2023 14:00	4.98	9.19	4.90	9.39	3.23	3.18	9.00	3.960	14.120	3.320	2.56
24-10-2023 15:00	4.96	9.19	4.87	9.35	3.21	3.17	9.03	3.940	14.100	3.320	2.54
24-10-2023 16:00	4.94	9.19	4.84	9.30	3.20	3.16	9.06	3.920	14.100	3.320	2.53
24-10-2023 17:00	4.94	9.18	4.81	9.25	3.24	3.15	9.09	3.900	14.100	3.320	2.52
24-10-2023 18:00	4.95	9.18	4.95	9.20	3.27	3.14	9.11	3.880	14.100	3.320	2.51
24-10-2023 19:00	4.97	9.18	4.75	9.15	3.27	3.14	9.13	3.870	14.100	3.320	2.5
24-10-2023 20:00	5.00	9.18	4.72	9.10	3.27	3.14	9.16	3.860	14.100	3.320	2.49
24-10-2023 21:00	5.03	9.18	4.69	9.10	3.27	3.15	9.18	3.850	14.100	3.320	2.48
24-10-2023 22:00	5.06	9.18	4.66	9.05	3.25	3.16	9.21	3.850	14.100	3.320	2.47
24-10-2023 23:00	5.09	9.18	4.62	9.00	3.24	3.16	9.23	3.850	14.100	3.320	2.45
25-10-2023 00:00	5.13	9.18	4.63	8.96	3.24	3.16	9.26	3.850	14.100	3.320	2.43
25-10-2023 01:00	5.16	9.18	4.58	8.92	3.22	3.16	9.27	3.850	14.100	3.320	2.4

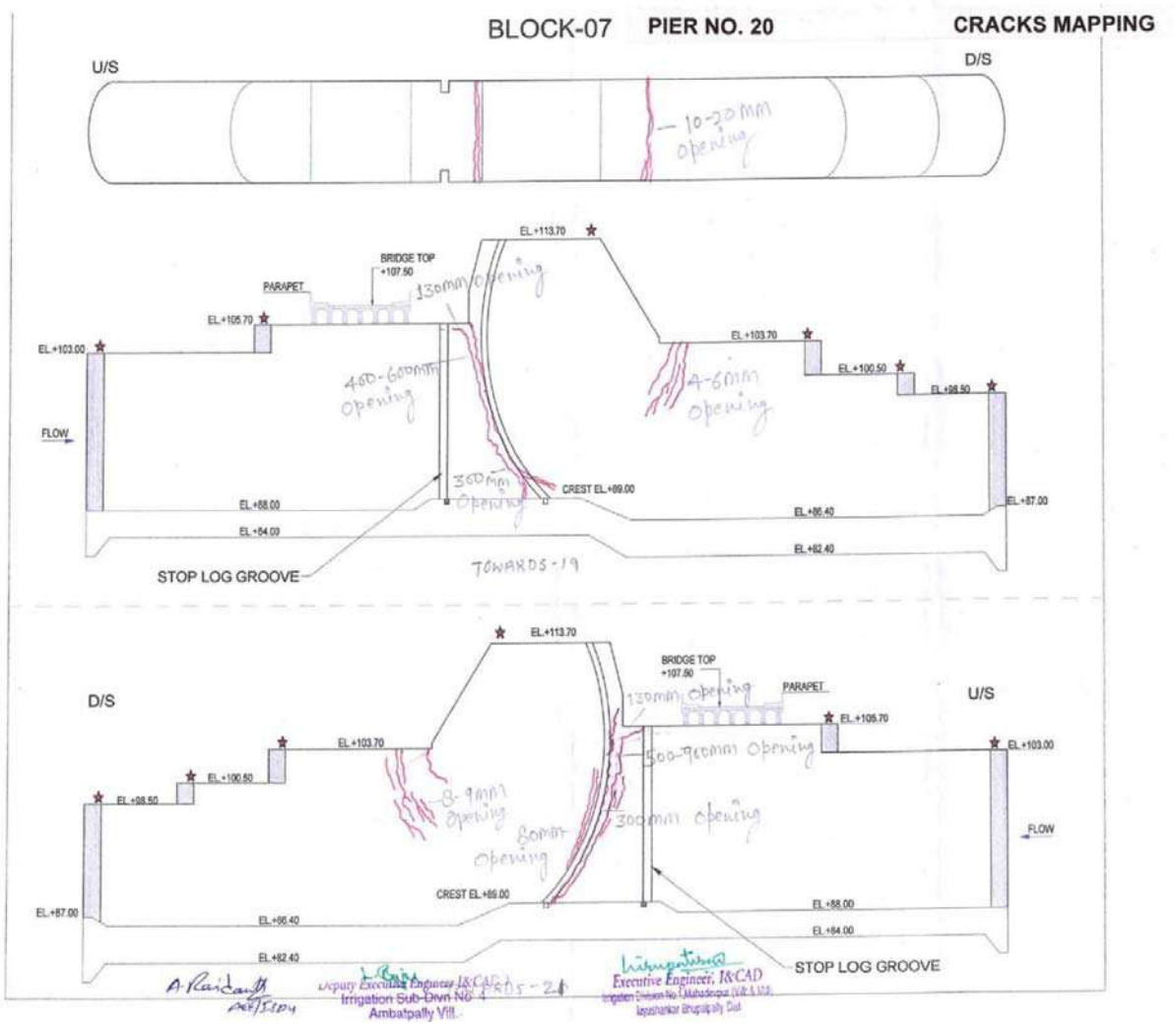
Date/Time	Perur	Eturunagaram	Dummugudem	Bhadrachalam	Konta	Chinturu	Kunavaram	Polavaram	GodavariRlyBridge (Rajahmundry)	Dowlaiswaram	Atreyapuram
ZOG	**65.000**	**58.500**	**40.000**	**26.610**	**29.000**	**27.000**	**20.000**	**10.897**	**HHS**	**10.670**	**1.500**
Warning Level (gauge metre)	**13.100**	**14.830**	**13.000**	**19.110**	**11.300**	**13.500**	**16.740**		**17.680**	**3.580**	**12.000**
Danger Level (gauge metre)	**16.15**	**17.33**	**15.00**	**22.16**	**14.30**	**15.00**	**18.24**		**19.51**	**5.41**	**13.50**
25-10-2023 02:00	5.19	9.18	4.57	8.89	3.20	3.16	9.28	3.850	14.100	3.320	2.35
25-10-2023 03:00	5.22	9.18	4.55	8.85	3.18	3.14	9.29	3.850	14.100	3.320	2.3
25-10-2023 04:00	5.25	9.18	4.51	8.81	3.16	3.12	9.29	3.850	14.100	3.320	2.25
25-10-2023 05:00	5.27	9.18	4.48	8.79	3.14	3.10	9.3	3.860	14.100	3.320	2.25
25-10-2023 06:00	5.29	9.18	4.44	8.77	3.12	3.08	9.3	3.880	14.100	3.320	2.25
25-10-2023 07:00	5.31	9.18	4.42	8.70	3.12	3.07	9.3	3.900	14.100	3.320	2.23
25-10-2023 08:00	5.34	9.17	4.41	8.67	3.18	3.06	9.3	3.920	14.100	3.320	2.19
25-10-2023 09:00	5.37	9.17	4.40	8.65	3.27	3.06	9.3	3.940	14.100	3.320	2.19
25-10-2023 10:00	5.42	9.17	4.40	8.64	3.30	3.06	9.3	3.960	14.100	3.320	2.19
25-10-2023 11:00	5.49	9.17	4.40	8.63	3.35	3.1	9.29	3.97	14.100	3.320	2.19
25-10-2023 12:00	5.56	9.17	4.40	8.62	3.4	3.15	9.29	3.98	14.100	3.320	2.19
25-10-2023 13:00	5.61	9.17	4.40	8.61	3.44	3.18	9.28	3.98	14.100	3.320	2.2
25-10-2023 14:00	5.65	9.17	4.41	8.60	3.44	3.22	9.26	3.99	14.100	3.320	2.2
25-10-2023 15:00	5.69	9.17	4.41	8.59	3.44	3.26	9.24	4.01	14.120	3.320	2.21
25-10-2023 16:00	5.72	9.17	4.42	8.58	3.46	3.3	9.22	4.03	14.140	3.320	2.21

Date/Time	Perur	Eturunagaram	Dummugudem	Bhadrachalam	Konta	Chinturu	Kunavaram	Polavaram	GodavariRlyBridge (Rajahmundry)	Dowlaiswaram	Atreyapuram
ZOG	65.000	58.500	40.000	26.610	29.000	27.000	20.000	10.897	HHS	10.670	1.500
Warning Level (gauge metre)	13.100	14.830	13.000	19.110	11.300	13.500	16.740		17.680	3.580	12.000
Danger Level (gauge metre)	16.15	17.33	15.00	22.16	14.30	15.00	18.24		19.51	5.41	13.50
25-10-2023 17:00	5.75	9.17	4.43	8.57	3.44	3.33	9.2	4.06	14.160	3.320	2.23
25-10-2023 18:00	5.77	9.17	4.44	8.57	3.42	3.36	9.17	4.09	14.180	3.320	2.26
25-10-2023 19:00	5.79	9.17	4.45	8.40	3.4	3.36	9.15	4.12	14.180	3.320	2.27
25-10-2023 20:00	5.8	9.17	4.46	8.40	3.4	3.36	9.14	4.15	14.180	3.320	2.28
25-10-2023 21:00	5.81	9.17	4.47	8.40	3.4	3.36	9.12	4.17	14.180	3.320	2.32
25-10-2023 22:00	5.83	9.17	4.48	8.40	3.39	3.36	9.11	4.180	14.180	3.320	2.36
25-10-2023 23:00	5.85	9.17	4.49	8.50	3.38	3.36	9.09	4.18	14.180	3.320	2.4
26-10-2023 00:00	5.87	9.17	4.5	8.60	3.3	3.36	9.08	4.18	14.180	3.320	2.4
26-10-2023 01:00	5.89	9.16	4.51	8.70	3.34	3.33	9.08	4.17	14.180	3.320	2.47
26-10-2023 02:00	5.91	9.16	4.52	8.70	3.3	3.33	9.08	4.15	14.18	3.320	2.51
26-10-2023 03:00	5.93	9.16	4.52	8.70	3.28	3.28	9.08	4.13	14.18	3.320	2.54
26-10-2023 04:00	5.95	9.16	4.52	8.80	3.26	3.25	9.08	4.1	14.18	3.320	2.58
26-10-2023 05:00	5.97	9.16	4.54	8.80	3.25	3.22	9.08	4.08	14.17	3.320	2.58
26-10-2023 06:00	5.99	9.16	4.56	8.90	3.25	3.22	9.08	4.06	14.16	3.320	2.59
26-10-2023 07:00	6.04	9.16	4.58	9.00	3.25	3.2	9.09	4.05	14.14	3.32	2.59

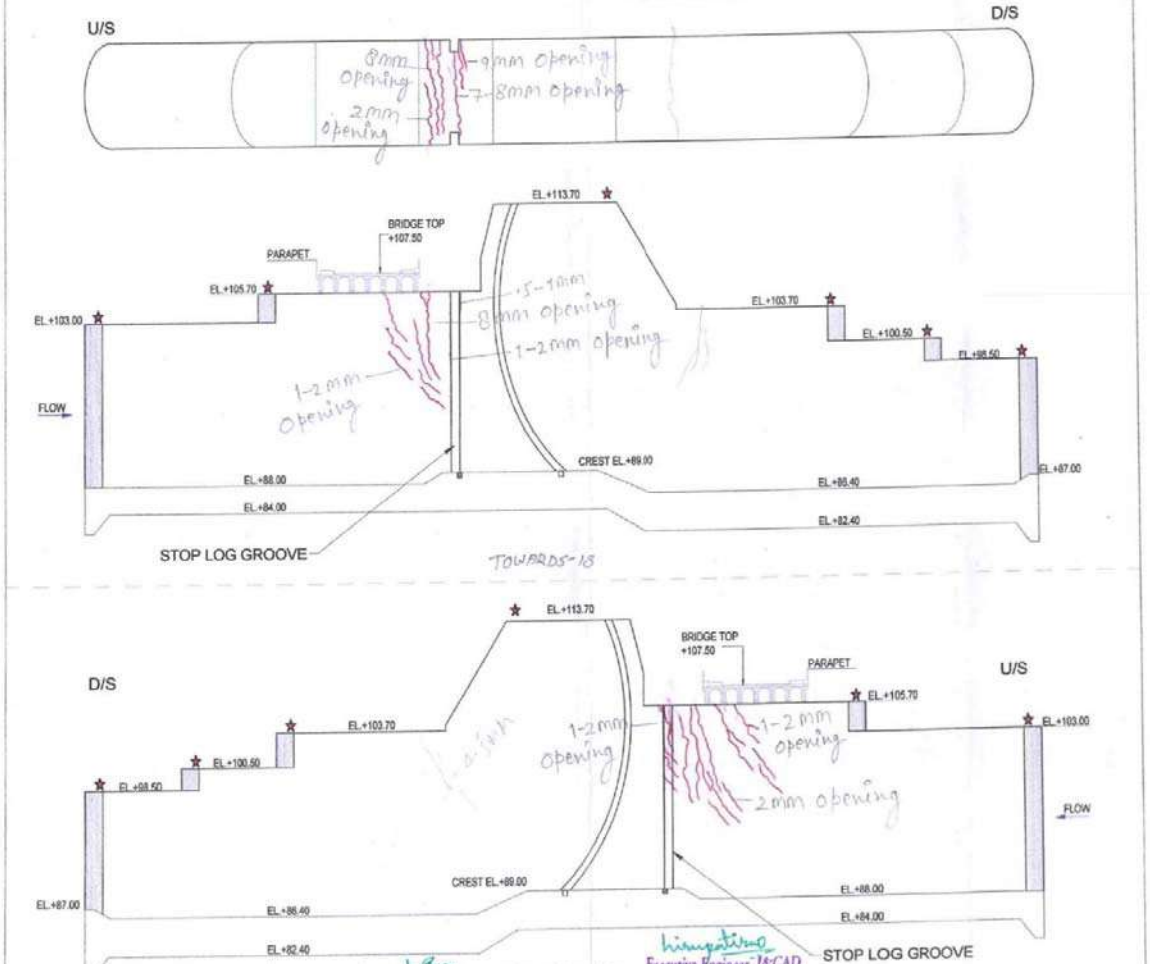
Date/Time	Perur	Eturunagaram	Dummugudem	Bhadrachalam	Konta	Chinturu	Kunavaram	Polavaram	GodavariRlyBridge (Rajahmundry)	Dowlaiswaram	Atreyapuram
ZOG	**65.000**	**58.500**	**40.000**	**26.610**	**29.000**	**27.000**	**20.000**	**10.897**	**HHS**	**10.670**	**1.500**
Warning Level (gauge metre)	**13.100**	**14.830**	**13.000**	**19.110**	**11.300**	**13.500**	**16.740**		**17.680**	**3.580**	**12.000**
Danger Level (gauge metre)	**16.15**	**17.33**	**15.00**	**22.16**	**14.30**	**15.00**	**18.24**		**19.51**	**5.41**	**13.50**
26-10-2023 08:00	6.01	9.16	4.61	9.00	3.25	3.18	9.09	4.01	14.14	3.32	2.59


LINE DIAGRAM OF GODAVARI RIVER
749 Km
Sriram Sagar Project
KNR PROJECT
822 Km
KADDAM RIVER
SripadaYellampalli Project
897 Km
HO SITE
Barrage / Dam
Mancherial
907 Km
Parvathi Barrage
927 Km
ManairRiver
953 Km
Saraswathi Barrage
959 Km
Kaleswaram
984 Km
PRANHITA RIVER
Laxmi Barrage
1005 Km
1029 Km
INDRAVATHI RIVER
PVNRaoKantanpally Project
(Tupakulagudem Barrage)
1052 Km
Perur
1058 km
Eturnagaram
1089 km
Bhadrachalam
1191 km
SABARI RIVER
Kunavaram
Konta
1232 Km
Chinturu
Konta to Chinturu = 10 kms
Chinturu to Confluence
of Godavari = 20 kms
Kunavaram to Confluence
of Sabari = 1 km
Koida
1251 Km
Polavaram
1264 Km
BAY OF BENGAL

Annexure – V


BLOCK-07
PIER NO. 20
CRACKS MAPPING
U/S
D/S
10-20MM opening
EL +113.70
BRIDGE TOP +107.50
PARAPET
130mm opening
EL +105.70
EL +103.00
FLOW
460-600MM opening
EL +103.70
EL +100.50
EL +98.50
4-6MM opening
350MM opening
CREST EL +89.00
EL +88.00
EL +84.00
EL +86.40
EL +87.00
EL +82.40
STOP LOG GROOVE
TOWARDS-19
D/S
U/S
EL +113.70
BRIDGE TOP +107.50
130mm opening
PARAPET
EL +105.70
EL +103.70
EL +103.00
EL +100.50
EL +98.50
500-900MM opening
8-9MM opening
80MM opening
300MM opening
FLOW
CREST EL +89.00
EL +87.00
EL +88.00
EL +86.40
EL +84.00
EL +82.40
STOP LOG GROOVE
Deputy Executive Engineer I&CAD
Irrigation Sub-Divn No 4
Ambatpally Vill.
Executive Engineer, I&CAD
TOWARDS-20

BLOCK-07 **PIER NO. 19** **CRACKS MAPPING**

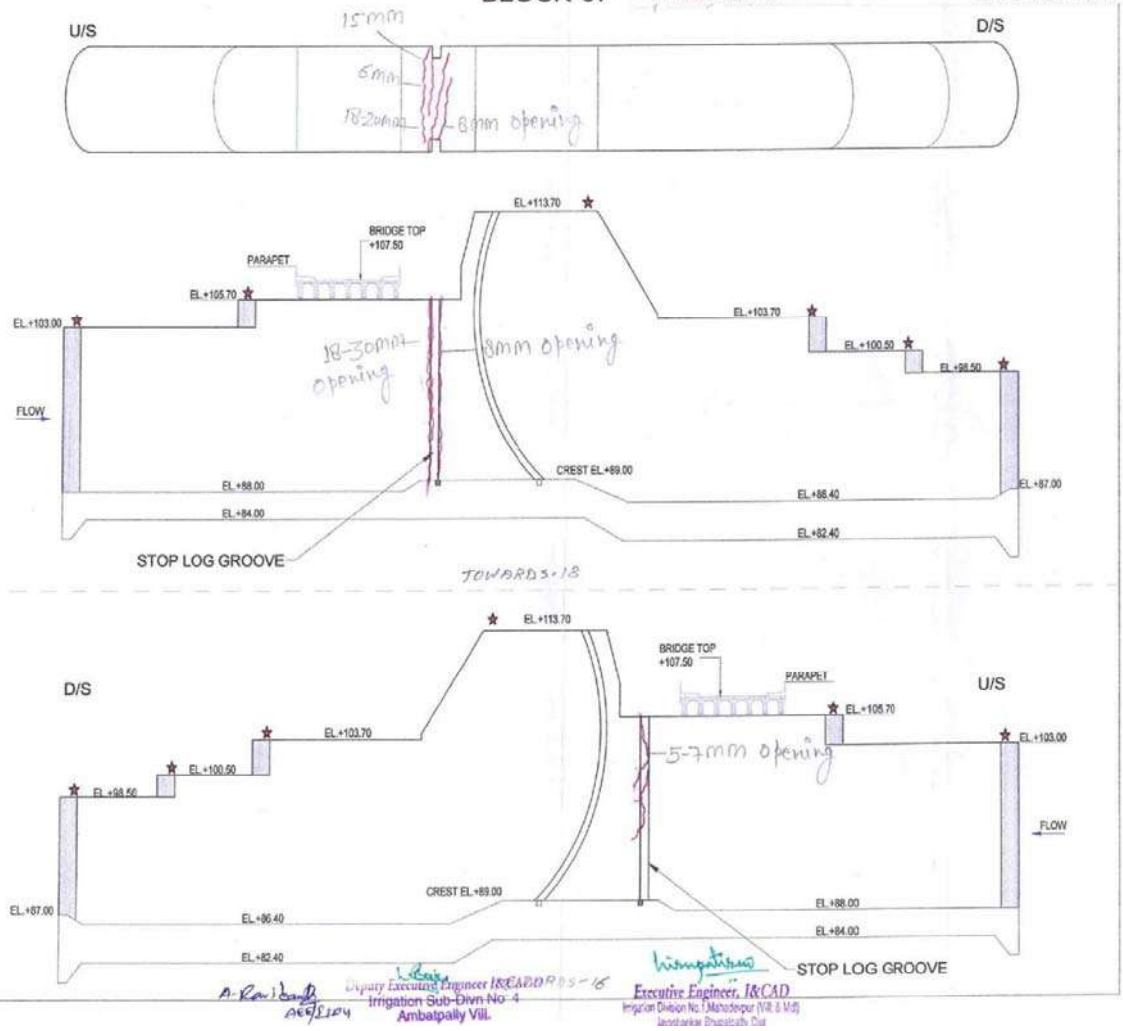


A. Ravibaull AEE/8504

Deputy Executive Engineer I&CAD 20
Irrigation Sub-Divn No 4
Ambatpally Vill.

Executive Engineer, I&CAD
Irrigation Division No.1 Mahadevpur
Jayashankar Bhupalpally Dist

BLOCK-07 **PIER NO. 17** **CRACKS MAPPING**



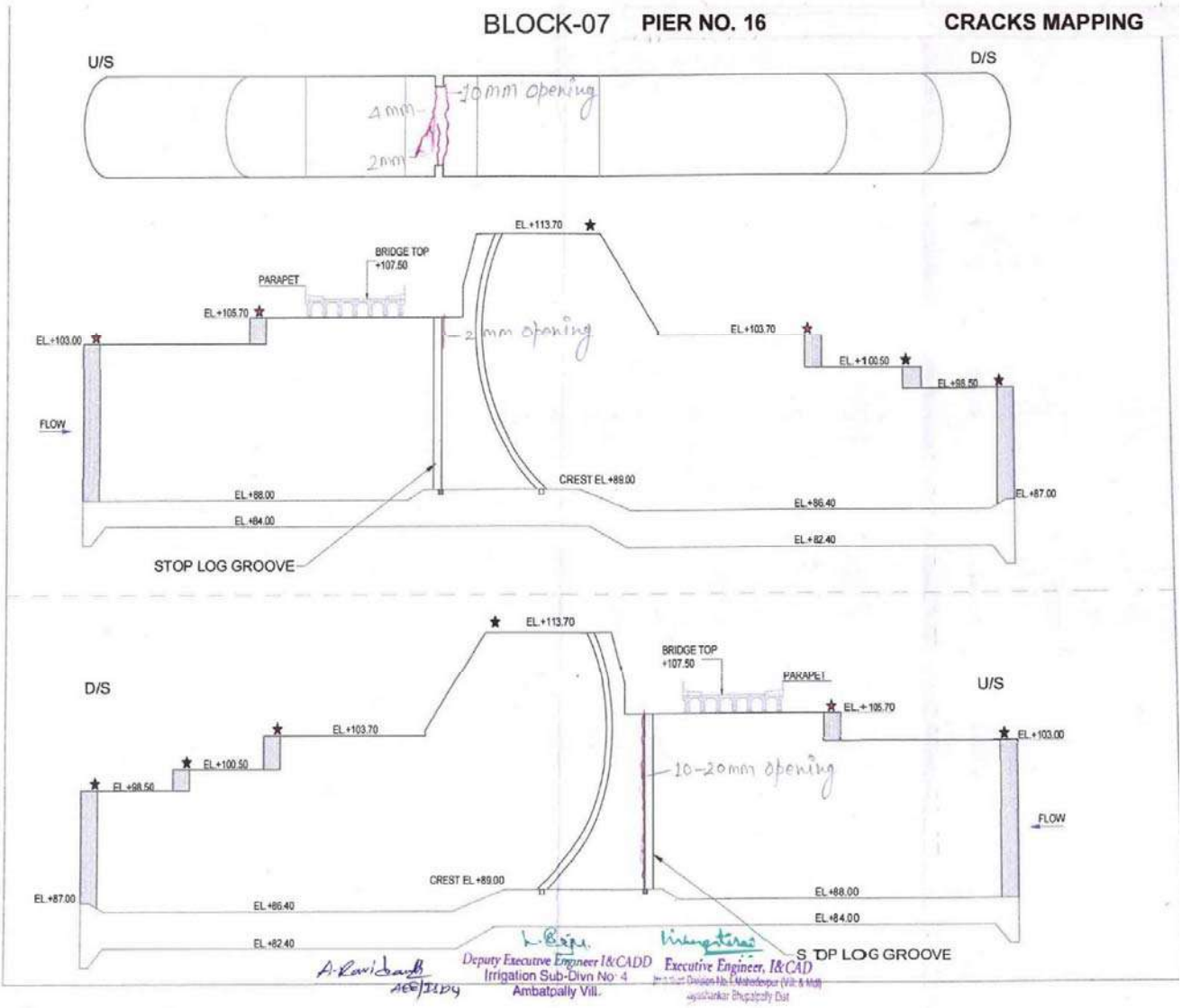
A. Ravi Kanth
AEE/2104

Deputy Executive Engineer I&CAD
Irrigation Sub-Divn No. 4
Ambatpally Vill.

TOWARDS-16

Executive Engineer, I&CAD
Irrigation Division No. I Mahadevpur (Vill. & Mdl)
Jayashankar Bhupalapally Dist

BLOCK-07 PIER NO. 16 CRACKS MAPPING



Deputy Executive Engineer I&CADD
Irrigation Sub-Divn No: 4
Ambatpally Vill.

Executive Engineer, I&CAD

Annexure- VI

Introductory Meeting by NDSA committee with officers of WRD Telangana, SCDS and SDSO, Telangana, held on 23.10.2023

LIST OF PARTICIPANTS

A. CWC, DoWR, RD & GR, Ministry of Jal Shakti

1. Shri Anil Jain, CE (NW&S) CWC & Member (D&R), NDSA - Chairman
2. Shri S. K. Sharma, Director BCD (E&NE), CWC & Director NDSA
3. Shri R. Thangamani, Director NDSA, SR, Chennai
4. Shri Rahul K Singh, Director Gates (NW&S), CWC & Director NDSA
5. Shri Devender Rao, SE, Godavari Circle, CWC, KGBO, Hyderabad
6. Shri Annepu Praveen, Dy. Director, M&A(AP), CWC, KGBO, Hyderabad

B. Irrigation & CAD Dept., GoTS

1. Shri Muralidhar Rao, E-in-C(General), WRD
2. Shri Nagendra Rao, E-in-C(O&M),WRD
3. Smt Pramela Tadi, Chief Engineer (SDSO), WRD
4. Sh Mohan Kumar, CE(CDO), WRD
5. Shri Murali Krishna, SE (SDSO), WRD

Inspection visit by NDSA team with officers of I&CAD Dept.Telangana, SCDS and SDSO, Telangana dated 24.10.2023

LIST OF PARTICIPANTS

B. CWC, DoWR, RD & GR, Ministry of Jal Shakti

1. Shri Anil Jain, CE (NW&S) CWC & Member (D&R), NDSA - Chairman
2. Shri S. K. Sharma, Director BCD (E&NE), CWC & Director NDSA
3. Shri R. Thangamani, Director NDSA, SR, Chennai
4. Shri Rahul K Singh, Director Gates (NW&S), CWC & Director NDSA
5. Shri Devender Rao, SE, Godavari Circle, CWC, KGBO, Hyderabad
6. Shri Annepu Praveen, Dy. Director, M&A(AP), CWC, KGBO, Hyderabad

B. Irrigation & CAD Dept., GoTS

1. Shri Nagendra Rao, E-in-C(O&M), QC & SDSO
2. Shri Venakateswarulu, E-in-C(Irrigation)
3. Shri Murali Krishna, SE (SDSO)
4. Shri M. Karunakar, SE (IC), Ramagundam.
5. Shri Ch. Tirupathi Rao, EE, ID-I, Mahderpur
6. Shri P. Sateesh Kuma, EE, ID-I, Mahderpur
7. Shri L Bheema Raju, DEE, SD-IV, Ambatipalli
8. Shri A Suresh Ky, DEE, SD-V, Ambatipalli
9. Shri Mohammed Ghouse, AEE, SDSO, Hyderabad

Interaction with Stakeholders by NDSA team consisting of officers of I&CAD Dept. Telangana, SCDS and SDSO, Telangana dated 25.10.2023

LIST OF PARTICIPANTS

C. CWC, DoWR, RD & GR, Ministry of Jal Shakti

1. Shri Anil Jain, CE (NW&S) CWC & Member (D&R), NDSA – Chairman
2. Shri. D.Ranga Reddy, Chief Engineer, KGBO, Hyderabad
3. Shri S. K. Sharma, Director BCD (E&NE), CWC & Director NDSA
4. Shri R. Thangamani, Director NDSA, SR, Chennai
5. Shri Rahul K Singh, Director Gates (NW&S), CWC & Director NDSA
6. Shri Devender Rao, SE, Godavari Circle, CWC, KGBO, Hyderabad
7. Shri Annepu Praveen, Dy. Director, M&A(AP), CWC, KGBO, Hyderabad

B. Irrigation & CAD Dept., GoTS

1. Shri C. Muralidhar Rao, E-in-C(General)
2. Shri Nagendra Rao, E-in-C(O&M), QC & SDSO
3. Shri Venakateswarulu, E-in-C(Irrigation)
4. Shri Sridhar Rao Dongal, OSD to EM, CMO
5. Smt T.Pramila, Chief Engineer (SDSO)
6. Shri S.Bala Kumar, CE(CDO)
7. Shri K.Sudhakar Reddy, CE, Jagital
8. Shri B.V.Ramana Reddy, CE, MNBR
9. Shri P.A Venkatakrishna, CE, QC, Hyderabad
10. Shri C.Srinivas, CE, CDO
11. Shri D.V.Mohan Kumar, CE, CDO
12. Shri K Srinivas, SE, P&M, E-in-C(General)
13. Shri MM Sajid, SE, P&M, Secretariat
14. Shri Murali Krishna, SE (SDSO)
15. Shri M. Karunakar, SE (IC), Ramagundam.
16. Shri K.Devender Reddy, SE, QC&I Circle, Warangal
17. Shri H.Baswaraj, SE, Irrigation circle Siddipet
18. Shri M.Rama Subha Reddy, EE (CDO)
19. Shri Ch. Tirupathi Rao, EE, ID-I, Mahderpur
20. Smt S.Vijaya Lakshmi, EE, SDSO
21. Smt G.Naglakshmi, DCE, SDSO
22. Shri P. Sateesh Kuma, EE, ID-I, Mahderpur
23. Shri M.Raghu Rao, EE, O/o QC&I Division no.1, Ramagundam
24. Shri CH.Tirupathi Rao, EE, IRRDiv.Nal, Mahaderpur
25. Smt T.Hemalatha, DEE, O/o CE/CDO
26. Shri L Bheema Raju, DEE, SD-IV, Ambatipalli
27. Shri A Suresh Ky, DEE, SD-V, Ambatipalli
28. Shri B.Kiran Kumar, DEE, O/o QC&I Division no.1, Ramagundam
29. Shri P.Sathish Kumar, DEE, O/o Chief Engineer, SDSO
30. Shri Mohammed Ghouse, AEE, SDSO, Hyderabad

C. Executing Agency

1. Shri S.Suresh Kumar, GM-HCAS, L&T
2. Shri Chouhan, L&T

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