एनएचपीसी लिमिटेड
NHPC LIMITED
(भारत सरकार का उद्यम)
(A Govt. of India Enterprise)
तीस्ता V पावर स्टेशन
Teesta V Power Station
सिंगताम, पूर्वी सिक्किम - 737134
Singtam, East Sikkim- 737134

A Navratna Company

Great Place To Work Certified

IS/ISO 9001 IS/ISO 14001 IS 18001
आई एम एस प्रमाणित पावर स्टेशन
IMS certified Power Station
दूरभाष/Ph: 03592-247349
फ़ैक्स/Fax: 03592-247227/349

Ref No. NH/TSV/Cont/EC-158/NIT-1019/2025-26/104 **Dated: 03-07-2025**

Consolidated Reply of Pre-Bid Queries

Please refer to Tender invited vide NIT No.: **NH/TSV/CONT/EC-158/NIT-1019/2025-26/74 Dated: 29/05/2025 (GeM Bid No.: GEM/2025/B/6288791)** for the work of "**Insurance Coverage for the GIS equipment under EAR, third party liability and terrorism risk for the work "Supply, Erection, Testing & Commissioning of 420 KV GIS, 400 KV Outdoor Pothead Yard, 400 KV XLPE Cables and associated accessories for Teesta V Power Station"**, the final consolidated Reply of employer (NHPC Ltd.) on Techno-Commercial queries (from the prospective bidders (received through representation at GEM Portal)) has been attached herewith as Annexure-A (Reply of Techno-Commercial quarries).

All the terms & conditions of Tender Documents shall remain unchanged.

For & On behalf of NHPC Limited.

03/07/25

Dy. General Manager (Civil)
Contract Division
Teesta – V Power Station

उप महाप्रबंधक (सि.) / Dy General Manager (Civil)
सं० व सं० विभाग / P&C Division
तीस्ता पावर स्टेशन / Teesta-V Power Station
बलुटार सिक्किम/ Balutar Sikkim

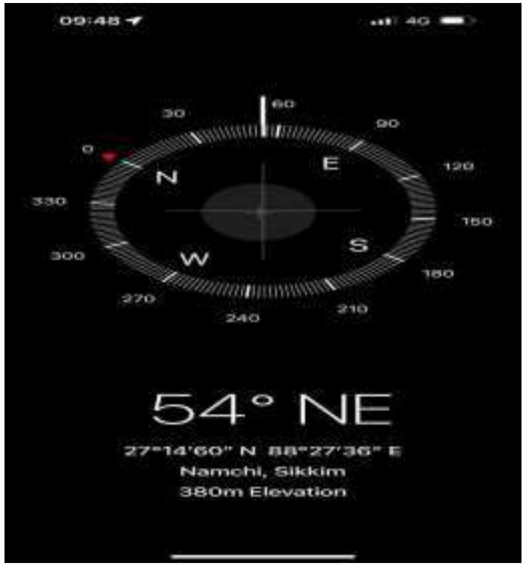
Annexure-A

Final consolidated Reply of Employer (NHPC Ltd.) on Techno-Commercial queries (from the prospective bidder though representation at GEM Portal)

N.O.W.: Insurance Coverage for the GIS equipment under EAR, third party liability and terrorism risk for the work "Supply, Erection, Testing & Commissioning of 420 KV GIS, 400 KV Outdoor Pothead Yard, 400 KV XLPE Cables and associated accessories for Teesta V Power Station.

GEM Bid No.: GEM/2025/B/6288791 Dated: 29.05.2025.

SL. N.	Tender Reference	Tender Description/Existing clause as per Bid Documents	Pre-Bid query (Techno-Commercial) received	Reply of NHPC Ltd.
1	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	Brief description of the project	Please provide clarity on the following point: Location coordinates or kmz File where the substation is being constructed.	Exact location coordinate is as below:-

				27°14′60″ N 88°27′36″ E  The GIS building is being constructed **in front of the main access of the Power House**, within close proximity and **inside the project area**.

SL. N.	Tender Reference	Tender Description/Existing clause as per Bid Documents	Pre-Bid query (Techno-Commercial) received	Reply of NHPC Ltd.
2	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	-	Please provide clarity on the following point: Capacity of Transformer (in MVA).	Not in the scope of supply of the subject work.
3	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	Annexure-I of SCC (Section-III) of Bid documents	Please provide clarity on the following point: Details of works outside substation premises along with their values if involved (Eg overhead T&d lines, u/g cables, Approach roads etc)	All works are confined within the substation premises; no external works are planned.
4	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	Annexure-I of SCC (Section-III) of Bid documents	Please provide clarity on the following point: storage location address/coordinates, maximum individual location storage exposure at any time and type of storage (open/closed)	Storage will be within the project area near the specified coordinates and housed in a single temporary shed.

SL. N.	Tender Reference	Tender Description/Existing clause as per Bid Documents	Pre-Bid query (Techno-Commercial) received	Reply of NHPC Ltd.
5	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	-	Please provide clarity on the following point: Flood return period considered in design and flood loss prevention plan.	Flood return period is 100 years; Emergency Action Plan has been attached as '**Annexure-I**) and DAM break analysis has been attached as '**Annexure-II**' herewith.
6.	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	Annexure-I of SCC (Section-III) of Bid documents	Please provide clarity on the following point: MR wet risk endorsement is applicable as per tender. Please share details of wet risk being covered in the scope of works along with its value	Wet risk including but not limited to flooding or water damage of the work of Rs. 1,093,700,700/- needs to be covered in MR Wet risk.
7	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	Section-V of Bid documents	Please provide clarity on the following point: Contractor details	Andritz Hydro Private Limited, D-17, Mpakvn, Industrial Area, Mandideep, Raisen, Bhopal, Madhya Pradesh-462046.

SL. N.	Tender Reference	Tender Description/Existing clause as per Bid Documents	Pre-Bid query (Techno-Commercial) received	Reply of NHPC Ltd.
8	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	Section-V of Bid documents	Please provide clarity on the following point: Project Schedule.	Project Schedule has been attached herewith as '**Annexure-III**'
9	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	Section-V of Bid documents	Please provide clarity on the following point: Overall layout plan	Overall layout plan has been attached herewith as '**Annexure-IV**'
10	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	Section-V of Bid documents of Bid documents & Section-III (SCC) of Bid Documents	Please provide clarity on the following point: Completion Period	12 months from the date of issue of LOA i.e 09/01/2026 **Insurance Coverage Period**: **During Construction Period**- Period of insurance shall be equivalent to the period of contract, commencing from the date of unloading of the first batch of material at site of construction and expiry on the date of handing over of the contract work to the NHPC Limited. **During Defect Liability Period**- The insurer shall also cover the defect liability period i.e. thirty- six (36)months from the date of issue of Completion Certificate of the respective unit bay or twenty-four(24) months from the date of issue of Taking-Over Certificate of the respective unit bay whichever happens earlier.

SL. N.	Tender Reference	Tender Description/Existing clause as per Bid Documents	Pre-Bid query (Techno-Commercial) received	Reply of NHPC Ltd.
11	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	Section-III (SCC) of Bid Documents	Please provide clarity on the following point: Sum Insured details for EAR & Terrorism	Rs.1,093,700,700/-
12	GeM Bid Details (Custom Bid Documents dated 29.05.2025).	Section-III (SCC) of Bid Documents	Please provide clarity on the following point: Limit of Liability for TPL	The TPL limit will be Rs. 10 Cr.

ANNEXURE-I
(Emergency Action Plan)

EMERGENCY ACTION PLAN

TEESTA-V POWER STATION

Balutar, East Sikkim

Approved By

1-2-19

(SAHADEV KHATUA)
General Manager (I/C),
Teesta-V Power Station

Issued By

01-02-2019

(SANJEEV KUMAR)
Sr.Manager (Elect.),
Teesta-V Power Station

Prepared By

01/02/2019

(JITENDRA KUMAR)
Asst.Manager (Civil),
Teesta-V Power Station

REVISION STATUS

Rev No	Date	Revision Description
0	05-01-2017	Original
1	01-02-2019	Annex & Contact no. revised
2		

DISTRIBUTION

Sl.	Copy Holders	Copy No.
01	Head of power Station	01
02	HOD-Medical services	02
03	GM(C)	03
04	GM(E)	04
05	HOD – IT&C	05
06	HOD – Central Store	06
07	HOD-Human Resources	07
08	HOD-Procurement	08
09	HOD-Finance	09
10	Power House (Mechanical Maintenance)	10
11	Power House (Operation & Electrical Maintenance)	11
12	Power House (Civil)	12
13	Incharge –(Environment)	13
14	Incharge –(Infra)	14
15	Incharge –Electrical Maintenance	15
16	Incharge – Dam (Civil)	16
17	Incharge – HM	17
18	Incharge – Contract	18
19	Incharge – Mech. Workshop	19
20	Incharge – Fire & Safety	20
21	Incharge – Library	21
22	O&M Division, NHPC Ltd., Corporate Office, Faridabad	22
23	Auditor's Copy	23
24	District Authority	24
25	Management Appointee (MA)	25

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i.

1. INTRODUCTION

Teesta-V Hydro Electric Project, now referred as Teesta -V Power Station, is situated in East Sikkim District of Sikkim (India) and was commissioned in March 2008. The installed capacity of the Power Station is 510 MW (3 x 170 MW) which has been designed to generate 2573 MU in a year. It comprises of 88.6m high (from the deepest foundation level), 176.5m long (at top) concrete gravity Dam, 17.20 Km long, 9.5 M dia horse-shoe type Head Race Tunnel and an underground Power House along with three D-shaped Tail Race Tunnels of 6m dia. As per post monsoon reservoir survey in 2014 for Teesta-V dam, the gross and live (above FRL) storage capacity of reservoir is 9.61 Mm^3 and 5.44 Mm^3 respectively. Index (Location) map and salient feature of the Project are placed at **Annexure – A** and **Appendix-1** respectively.

As per National Register of Large Dams (updated July 2014), the Teesta-V dam is part of 4858 large dams constructed throughout country. It is located at $27^0$23’13” N latitude and $88^0$30’13”E longitude and falls in seismic zone-IV. The Project Identification Code (PIC) is ***SK30HH0002***.

1.1 Purpose of an EAP

Emergency Action Plan (EAP) is a formal document defining the unusual & unlikely conditions that may endanger Teesta-V dam and is intended to help emergency officials, save lives, minimize damages to property, structures and inhabitations and also to minimize environmental impacts in the event of flooding caused by heavy water releases from the dam, dam failure or in other such events.

The National Water Policy 2012 framed by Ministry of Water Resource, Govt. of India stresses on preparation of EAP for all large dams. For Management of Flood & Drought, the policy stipulates that ***“To increase preparedness for sudden and unexpected flood related disasters, dam/embankment break studies, as also preparation and periodic updating of emergency action plans / disaster management plans should be evolved after involving affected communities”.***

The EAP document will help in emergency preparedness and response capability of the agency involved with the safety of the dam. The document encompasses the surveillance and emergency concept of the dam safety and will serve following purposes:

i) Preplan the coordination of necessary actions by Teesta-V Project Authority and the responsible Local & State officials to provide for timely notification, warning, and evacuation in the event of an emergency.

ii) Reduce the risk of loss of life and property damage, particularly in downstream areas, resulting from an emergency situation.

1.2 Scope

This document defines the functions and responsibilities of all concerned, managerial, operational & supporting services, medical services, fire and Security service and other emergency management authorities, viz. Civil Administration, Armed forces, Paramilitary forces, Project Authorities and other Central/ State Agencies for effective management of the on-site-emergency situations.

This document has been prepared on the basis of "***Guidelines for Development and Implementation of Emergency Action Plan (EAP) for Dams***" published by CWC in May, 2006. In order to have conformity regarding roles and responsibilities, etc., reference has been drawn from **Disaster Management Plan (DMP) of Teesta-V Power Station.** Following elements have been covered under the scope of Emergency Action Plan of Teesta-V Dam:

1. Notification flow Charts with Contact information/ communication no.
2. Responsibilities /Response process
3. Emergency Procedure –Action Plan/Notification procedure
4. Preventive Action- Surveillance , Access, Resource and Power
5. Inundation Map
6. Appendices/ additional Information

1.3 Notification Flow Chart

A notification flow chart mentioning the personnel responsible for notifying to each owner's representative and/or public official(s) on priority has been enclosed at **Annexure – H** (Chart-1, page no.62) & (Chart-2, page no.63) in case of the following emergency conditions arises at dam.

- ***Failure is imminent or has occurred.***
- ***Potential emergency situation has developed or is developing.***
- ***Flooding is occurring or is expected to occur.***

2. RESPONSIBILITIES

Responsibilities of Main Controller, Site Controller and Incident Controller-I, Incident Controller-II & other officials in Emergency Preparedness Plan of Teesta Power Station-V are outlined here under. They have also been summed up in **Annexure - G, page no.62**.

2.1 Owner's Responsibility

As dam owner, the HOP of Teesta-V Power Station is responsible for maintaining a safe dam, which includes management of operations, maintenance, repair & rehabilitation functions. The responsibilities and duties of owner or his representative are described as below:

Main Controller **(Chief General Manager/ General Manager -Incharge)**	1. Determine and identify the condition(s) or triggering event(s) that initiate or require emergency actions. 2. Assess the magnitude of the situation. 3. Decide regarding declaration of emergency. 4. Provide instructions to Site Controller for the operation of the power station during the anticipated emergency.
Site Controller **(General Manager / Dy. General Manager)**	1. Co-ordinate with the Main Controller, Incident Controller and with Security personnel for relief and rescue operation. 2. Take specific actions at the dam in accordance with the established procedures for reservoir operation after the notification procedures have been implemented.
Incident Controller – I **(Dy. General Manager**	1. Inform the Main Controller & Site Controller of the latest situation

/ Sr.Manager)	2. Direct all operations within the affected areas.
Incident Controller – II **(Sr. Manager / Manager)** (In-charge of the Dam and appurtenant structures)	1. Co-ordinate with Main Controller, Site Controller, Incident Controller – I 2. Liaison with outside and Govt. Agencies, Civil Administration including local Emergency Management Authority for relief and rescue operations. 3. Direct all operation/ regulation of gates & hoist gates 4. Be available at the dam site, as required. 5. Assist & encourage local officials to develop a plan to safeguard life and property from flooding due to dam fail or passing unusually large flows through Spillways. 6. Co-ordinate training, seminar, drilling & revision related activities.
Duty Officer (DM/ AM/Engineer/Safety Officer)	1. Report to Incident Controller-II and be assigned the duty over Control room at dam 2. Detect/ confirm incident at dam 3. Determine emergency level & inform to Incident Controller -II. 4. Support onsite operator on emergency level 5. Provide regular status reports to senior management 6. Coordinate with upstream and downstream dam owners on operations During the monsoon season (1st May - 31st October), the Duty Officer shall be available on dam 24 hrs in shifts.

The contact numbers of key officials and Important Numbers of other departments are given in **Annexure-I**.

Incident Controller-II will liaison with out-side agencies i.e. nearby industries, Police, Civil Administration, Govt of Sikkim & West Bengal etc. for timely exchange of information / required help / aid during emergency as per list in 'Annexure-J'.

Further, Incident Controller-II will co-ordinate EAP related activities including (but not limited to) preparing revisions to the EAP, establishing training, seminars, coordinating EAP mock drills, etc. The duty officer is expected to be aware of relevant acts and legislations on Fire Safety, Disaster Management, safety manual etc.

The India Meteorological Department (IMD), Central Water Commission (CWC) and / or other State and Central agencies have the general responsibility for issuing flood warnings. It will, therefore, be desirable to notify the IMD, CWC or other appropriate agency of any pending or actual dam break flooding, so that its facilities can enhance warnings being issued.

For handling natural disaster, National Disaster Response Force and Civil Defence has been set up under Ministry of Home Affairs, Govt. of India. The department of Land Revenue and Disaster Management, Govt. of Sikkim is responsible for disaster prevention, mitigation and preparedness and acts as a nodal agency for implementing various Disaster Management Programs. The state of West Bengal has a separate department of Disaster Management. The information/warning/help on natural calamities can be coordinated with the National/ State Disaster Management Authority or State head of Civil Defence on the following address/ contact Nos.

NDMA Control Room	Sikkim	West Bengal
NDMA Control Room, NDMA Bhawan, # A-1 Safdarjung Enclave, New Delhi -110029 Tel No. 011-26701/700/728/ 730, 011-26701729/16 (Fax), Helpline No. 011-1078 Mobile: 9868891801, 9868101885 E-Mail: controlroom@ndma.gov.in , ndmacontrolroom@gmail.com	Chief Secretary and Chairperson, State Steering Committee, Sikkim Disaster Management Authority Tel. - 03592- 202315, 202323 (Off), 204323 (Fax), 203750 (Res.), E-mail: cs-skm@hub.nic.in	Chief Secretary and Chairperson, State Steering Committee, West Bengal Disaster Management Authority Tel.- 033- 22145858, 22144328 (Fax) , 24480450 (Residence) E-mail: cs-westbengal@nic.in
	Commandant General, Home Guards & Director Civil Defence Home Guards HQrs., Kazi Road, Gangtok-737101 Tel. 03592-205314(O), 202432(O)	Shri R.J.S.Nalwa, IPS Director Civil Defence, Civil Defence Building, 81/2/2, Phears Lane, Kolkata-700 012. Tel. 033- 22252179(O)

Disaster Management Cell, Ministry of Home Affairs, Govt. of India and regional Battalion of NDRF can be approached at following address:

Disaster Management Division NDCC-II, MHA Control Room; New Delhi Tel. No. 23092923, 23093054, 23092885, 23093571/897 Fax - 23093750, 23092763, Toll Free No. 011-1078, Website: http://www.ndmindia.nic.in/	2nd BN NDRF, Haringhata, Mohanpur, Nadia, (West Bengal) Pin-741246 Tel. No. 033- 25875032, 25875032 (Fax), Mobile- 09474061104/09474116775 E-mail: wb02-ndrf@nic.in

2.2 Responsibility for Evacuation, Rescue & Relief

Responsibility: Sikkim State Government / Deputy Commissioner

Scope: To undertake rescue, relief and rehabilitation measures in the event of a disaster.

In constitutional set up of India, the basic responsibility for undertaking rescue, relief and rehabilitation measures in the event of a disaster is that of State Government concerned. At the State level, response relief and rehabilitation are handled by Department of Relief and Rehabilitation.

The district level is key level for disaster management and relief activities. The Deputy Commissioner being the chief administrator is responsible for the preparation of district plans and in directing, supervising and monitoring calamities for relief.

The Deputy Commissioner is required to maintain close liaison with various departments of State Governments as well as the nearest units of Armed Forces/ Central police organisations and other relevant Central/State Government Organisations like Ministries of Communications, Water Resources, Health, Drinking water, Surface Transport, who could supplement the efforts of the district administration in the rescue and relief operations.

The efforts of the Govt. and NGO's for response and relief are co-ordinated by the Deputy Commissioner. The Deputy Commissioner and the coordination committee under him reviews preparedness measures prior to an impending hazard and coordinate response when the hazard strikes. As all the Departments of the State Government at the district level report to the Deputy Commissioner, there is an effective coordination mechanism ensuring holistic response.

2.3 Summary of EAP Responsibility

Entity	Responsibilities
Dam owner/ Operator	1. Verify and assess emergency conditions. 2. Notify other participating emergency management agencies. 3. Take corrective action at facility. 4. Declare termination of emergency at facility. 5. Update EAP on at least on annual basis. 6. Respond to emergencies at the facility. 7. Receive condition status reports.
Govt. Agencies, Civil Administration including Local Emergency Management Authority	1. Receive condition status reports from dam owner. 2. Notify Public in the downstream areas. 3. Conduct evacuation from inundation areas, if required. 4. Render assistance (rescue, relief and emergency services) to affected d/s areas, as necessary. 5. Render assistance to dam owner, as necessary.

3. EMERGENCY PROCEDURES

3.1 Emergency Identification, Evaluation & Classification

Teesta River, on which the dam is located, is a perennial and snow fed river, originating from Cho Lamho glacier in the Himalayas. This river is prone to floods due to rains in monsoon season generally commencing from early May to end of October. Some situations in dam operation are potential emergency conditions. Situations of flood emergencies/ unusual events can be caused due to

a) Overtopping of a dam due to insufficient spillway capacity/ constraints in utilizing full capacity during large inflows to the reservoir,

b) Earthquake damages,

c) Landslides generated waves within reservoir.

Hydraulics, hydrodynamics, hydrology, sediment transport mechanics and geo-technical aspects are all involved in breach formation and eventual dam failure. The prominent causes can be listed as follows:

1) Heavy rains/ extreme storm,
2) Cloud burst,

3) Massive landslides,
4) Equipment malfunctions,
5) Earthquake,
6) Overtopping,
7) Structural damages/ failure,
8) Sabotage.

The above unusual situation(s) occurring solely or in combination may lead to flooding due to large releases in downstream of dams without breach of dam or partial breach or full breach of dam.

The potential emergency conditions can be identified with the help of gauge data, already installed monitoring instrumentation data, surveillance, pre and post monsoon inspections of dam, information collection system, monitoring arrangements, etc.

Emergency levels or events or Situations

- High flow: Flooding is occurring on the river system, but there is no apparent threat to the integrity of the dam.
- Non-failure: A problem is developing, however the dam is not in danger of failing but flooding is expected in the downstream areas.
- Potential failure: A situation is developing that could cause the dam to fail.
- Imminent failure: A dam failure is occuring that may result in flooding and threatening life and property.

Determining Emergency Level

Event	Situation	Emergency Level
Large Spillway Release	Reservoir water surface elevation at spillway crest level is flowing with no active erosion	Non-Failure
	Spillway flowing with gully erosion on glacis	Potential failure
	Spillway flow that could result in flooding at downstream in habitat area if the reservoir level continues to rise	Potential failure
	Spillway flowing with an advancing head cut that is threatening the control section	Imminent failure
Overtopping	Water level rising above MWL	Potential Failure
Seepage	New seepage area in or near dam	Non-Failure
	New seepage areas with cloudy discharge or increasing flow rate in the abutments or d/s areas	Potential failure
Instruments	Instrumentation readings beyond predetermined values	Non-Failure
Gallery Seepage	Increase in the normal rate of gallery seepage	Non-Failure
Earthquake	Measurable earthquake felt or reported	Non-Failure
	Earthquake resulted in visible damage to the dam or appurtenances	Potential failure
	Earthquake resulted in uncontrolled release of water from the dam	Imminent failure
Massive Landslide	Massive landslide in the reservoir area causing high waves/ afflux	Potential Failure
	Massive land slide on abutments	Potential Failure
	Massive land slide in plunge pool areas	Potential Failure
Security Threat	Verified bomb threat that, if carried out, could result in damage to the dam	Potential failure
	Detonated bomb that has resulted in damage to the dam or appurtenances	Imminent failure
Sabotage/ Vandalism	Damage that could adversely impact the functioning of the dam	Non-Failure
	Damage that has resulted in seepage flow	Potential failure
	Damage that has resulted in uncontrolled water release	Imminent failure

Emergency Level – Potential Failure

Condition	Description of Condition	Action to be taken
High Water Level/ Large Spillway Release	Reservoir level reaches at FRL and in rising trend.	1. Check for signs of erosion from spillway sill, glacis and bucket. 2. Assess cause of increased reservoir stage, especially during fair weather conditions. 3. Perform additional tasks as required. 4. Make notifications if condition worsens such that downstream flooding is imminent.
Seepage	Localized new seepage observed in downstream area with muddy discharge with increasing trend but situation under control.	1. Measure and record feature dimensions, approximate flow rate and relative location to existing surface features. Take photos. Document location on a site plan and in inspection report. 2. Inspect the dam and collect piezometer water level and seepage flow data daily. Carefully observe dam for signs of seepage, cracking or movement. 3. Contact Corporate Office and provide all data collected. 4. Maintain continuous monitoring of feature. Record measured flow rate and any changes of condition, including presence or absence of muddy discharge and review. 5. Make notifications if condition worsens such that failure is imminent.
Massive Landslide	Large stresses developed & cracks visible propagating in abutments. Mass movement of soil or rock from slopes in the reservoir/ abutments/ plunge pool area.	1. Assess extent of landslide occurred and visually inspect entire reservoir area for afflux and other damages. Based on inspection results, confirm if extent of damage warrants revised emergency level and additional notifications. 2. If necessary to lower reservoir level, open gate(s). 3. Perform additional tasks as directed by the Corporate Office. 4. Make notifications if conditions worsen.

Sabotage and Miscellaneous Other Issues	Criminal action with significant damage to dam or structures where significant repairs are required and the integrity of the facility is compromised – condition appears stable with time	1. Contact local administration and restrict all access (except emergency responders) to dam. Restrict traffic on dam crest to essential emergency operations only. 2. Assess extent of damage and visually inspect entire dam for additional less obvious damage. Based on inspection results, confirm if extent of damage to various components of the dam warrants revised emergency level and additional notifications. 3. If necessary to lower reservoir level, open gate(s). 4. Perform additional tasks as directed by the Corporate Office. 5. Make notifications if conditions worsen.
Gate Malfunction or Failure	Dam gates damaged structurally (sabotage, debris etc.) with uncontrolled release of water at a constant volume. Condition appears stable.	1. Close any other gates, if open. 2. Install stoplog or use any other methods to stop or slow down the flow of water. 3. Consult Corporate Office for evaluation and recommendations. Consult HM contractor for evaluation and recommendations. 4. Repair/ replace gate as necessary. 5. Make notifications if conditions worsen such that further structural failure is imminent.
Damages to the concrete structures	Sliding, rotation or settlement of part of dam or entire dam. Movement or cracking of structural concrete.	1. Assess extent of damage and visually inspect entire dam for additional less obvious damage. Based on inspection results, confirm if extent of damage to various components of the dam warrants revised emergency level and additional notifications. Check instruments. 2. If necessary to lower reservoir level, open gate(s). 3. Perform additional tasks as directed by the Corporate Office. 4. Make notifications if conditions worsen.

Alert Level and Warnings

To take care of the incidents at dam due to reasons such as landslides into reservoir, earthquake, adverse meteorological conditions etc., alert and warning system with colour codes **(Blue, Yellow, Orange and Red)** subject to the gravity of the situations has been established and mentioned below at Table 1. The alert level Blue colour is the lowest level & corresponds to a routine or normal situation, whereas the alert level Red colour corresponds to a serious or catastrophic situation.

Table 1: Alert Levels for Dam Break Planning

Type of alert	Alert level	Situation	Response system	Engineer in charge Actions
	Blue	No immediate off-site impact anticipated or detection of anomalies in the dam or other events that neither compromise the structural dam safety nor its operational elements and do not make unviable the dam observation system. Situation is stable or developing very slowly. The gravity of existing problems must let belief that no consequences are expected in the valley downstream of the dam.	Direct Command System	1. Measures to solve problem. 2. Give internal alert signal of blue level. 3. Make notification in chart No.1. Inform to Dam Owner (CGM/ GM-Incharge)

INTERNAL ALERT	Yellow	Existence of anomalies or events that might compromise up to some degree. The structure and/ or operational dam safety or the dam observation system, assuming that eventual small consequences downstream the dam can happen: 1. Existence of meteorological adverse conditions; 2. Detection of anomalies in: - Dam structural elements, or; - Dam operational elements, or - Dam observation system. 3. Existence of foundation problems 4. Situation is developing slowly 5. Instrument showing large variation in measurements.	Direct Command System	1. Measures to solve problem 2. Give internal alert signal of yellow level 3. Make notifications in chart No.1 4. Inform to - Dam Owner (CGM/GM-Incharge) - Director/ CMD - Deputy Commissioner (if necessary)
	Orange	Situation with high probability of dam failure, belief that it might not be possible to control the situation, and might cause serious consequences downstream of the dam: 1. Detection of severe anomalies in - Dam structural elements, or - Dam operational elements 2. Existence of severe foundation problems 3. Occurrence of floods with high recurrence interval. 4. Dam owner / operator need assistance from outside agencies or jurisdiction. 5. Situation is progressing rapidly. 6. "Some amount of time" is available for analysis, decisions and mitigation to be made before off-site impact may occur.	Incident Command System	1. Measure to solve problem. 2. Give external alert signal of orange level. 3. Implement Incident Command System. 4. Make notification in chart No.2 5. Inform to - Deputy Commissioner - CGM/GM-Incharge - Director/ CMD - State Flood Control Cell 6. Warning – Population downstream of the dam to be ready for evacuation.

EXTERNAL ALERT	**Red**	Situation of inevitable catastrophe 1. Imminence of dam failure 2. Dam failure 3. "Little or no time is available" for analysis, decisions & mitigation to be made before downstream of dam impacts occur. 4. Situation is worsened and a breach is apprehended. 5. "Little or no time is available" for analysis, decisions and mitigation to be made before off-site impact occur.	Incident Command System	1. Give external alert signal of red level. 2. Make notification in chart No.2. 3. Informs to: - Authority - Dam owner (CGM/ GM- Incharge) - Director/ CMD - Civil Authority (DC/SP), - Commissioner - State Flood Control Cell - Warning: Population downstream of the dam to evacuate quickly.
ACTION		Dam is failing or failed		1. Call and coordinate with - Civil Protection (DC & SP) 2. Inform Commissioner 3. Ensure official notifications are made.

3.1.1 FLOODS

3.1.1.1 Discharge Measurement

- Average inflow of last 24 Hrs is calculated on the basis of Power House Generation from TPS-V and change in reservoir level plus spillage.
- In addition, information regarding Teesta River discharge is also being monitored regularly from G&D sites at Lachen, Lachung, Chungthang, Sanklang, Dikchu (Dam Axis I and 14th mile), Sirwani.
- Information regarding any sudden change in discharge is also being collected from Teesta IV and Teesta –III H.E. Project.

3.1.1.2 Preventive Measures

- **Silt content in water at intake during floods is to be checked regularly. In case of continuous flood, if silt content exceed permissible limit (5000 PPM), the machines are to be stopped.**
- **It is necessary that all spillway gates and mechanical equipments for operating the gates be thoroughly inspected every year before the start of monsoon.**
- **Inflow data should be strictly monitored.**

3.1.1.3 Flooding due to Heavy Rainfall /Storm in the Catchments

Teesta River on which the dam is located is a perennial and snow fed river, originating from Cho Lamo glacier in the Himalayas. This river is prone to floods in the monsoon season commencing from start of May to end of October, due to various reasons viz. heavy rains, occasional cloud burst, landslides, etc.

Teesta - V Dam has been designed for a probable maximum flood of 9500 cumec. The Dam gates are designed for passing a continuous flow of 9500 cumecs. However, it is pertinent to mention here that CWC has revised the design flood of Teesta-V Power Station to 14596 cumec in year 2011 vide letter no. 7/Sikkim2/2005/-teestaIII/Hyd(NE)/106 dated 11/04/2011.

As and when the river discharge crosses the limit of 500 cumecs and sustains for a considerable period with rising trends, the river shall be considered under flood. Further river discharge more than 1500 cumecs shall be considered as high Flood. The reservoir levels should be checked every 15 minutes and gates should be operated till the water reaches to EL 577m. After that if the reservoir level still rises, the gate operation should be done more cautiously.

3.1.1.4 Role and Responsibility – Flooding at Dam

Roles & responsibility have already been defined at para no. 2.1 (Owner's responsibility). In addition to normal shift staffs at Dam, following staffs may be included during monsoon:

Staff(s)	a) Gate Operator – 2 nos. (1 for Dam top + 1 for Sluice Gallery. b) Messenger/ Helper – 2 nos. (1 for Dam top + 1 for Sluice Gallery. c) Gauge Reader – 1 no. (For dam top). d) Electrician – 1 no. (For dam top). e) Telephone Operator- 1 no.

3.1.1.4 Action plan during flood situation at dam

Permissible limit for Reservoir level as per Regulation Rules

Period		Reservoir Water Level as per Reservoir operation manual
From	To	
1st May	15th May	EL 579 m (FRL)
16th May	10th October	EL 572.5 m (if discharge is less than 350 cumecs)
		EL 568.5 m (if discharge is greater than 350 cumecs)
11th October	30th April	EL 579 m (FRL)

Action Plan at various discharges

River Discharge is more than 500 cumec but below 1500 cumec	• Red signal at dam top must be **ON** and siren be blown. • The officer (AM/ DM) of the gate operation should be available at control room to supervise the regulation of the gate and watch its functions during the high discharge and/or out flow of heavy concentration of trash or sediment. • During the night or odd hours, there should be an arrangement for contacting the Incident Controller-II, in case of emergency.

	• Records of gauge in river, nos. and size of gate openings should be maintained in the Control Room and duly signed by the Duty Officer.
River Discharge is more than 1500 cumec	• Incident Controller-II shall take over the control over the dam and shall guide all activities during this period till the flood discharge comes below 4500 cumecs. • Information in all the above three cases shall be sent to HOP. • The information of high floods released from the Dam shall also be sent to concerned District Officers for downstream population.

Role of IRB	• All entries & exists from the Dam area be closely monitored and entry of unauthorized vehicles and persons be prohibited in case of emergency as well as normal routine.

A list of competent contractors/ agencies has to be kept ready who can be assigned for restoration activities of damaged components of the structures.

3.1.2 Earthquake

Teesta Power Station-V lies in seismic zone – IV of Sikkim Himalaya of Northeast India and is prone to earthquake. Emergency Action Plan aims at minimizing the damage and restoration of the normal life at the earliest. However, over some natural calamities like earthquake, mankind has no control on the occurrence of this natural phenomenon. These happen so suddenly that there is no time of any preparedness' or even for gasping. It is well known that damages due to earthquake at a location depend not only on the earthquake size and distance of the earthquake source, but also on the local site conditions.

Bureau of Indian Standards [IS:1893 (part – I)- 2002], based on various scientific inputs from a number of agencies including earthquake data supplied by IMD, has grouped the country into four seismic zones viz., Zone-II, III, IV and V. Of these, zone V is rated as the most seismically active region, while zone II is the least. The Modified Mercalli (MM) Intensity, which measures the impact of the earthquakes on the surface of the earth, broadly associated with various zones is as follows:

Seismic Zone		Intensity on MM scale
II	(Low intensity zone)	VI (or less)
III	(Moderate intensity zone)	VII
IV	(Severe intensity zone)	VIII
V	(Very severe intensity zone)	IX (and above)

Provisions have been made in BIS: 1893 for earthquake resistant design of various structures including structures for power station. Teesta-V Power Station has been designed based on the above code and no major damages due to earthquake have been reported in regard to operating power stations.

Site specific seismic studies of the power station areas are normally carried out by establishing seismological observatories for observing and recording micro earthquake as well as major earthquake events in the power station area. Based on data collected from these observatories on micro earthquake activities in the power station area as well as seismic data of past earthquakes in and adjoining the power station area, design seismic parameters are adopted for the design of structures for hydroelectric power projects.

3.1.2.1 History of Earthquake Occurrence in Project Area:

Teesta-V Dam site lies in an active seismic zone and surrounding area had been rocked by earthquake in the past at frequent intervals. A few of earthquakes resulting in great damages have occurred in the region, in the past. Lately, an earthquake of magnitude 6.8 has been recorded on 18th September 2011 (16:10 IST) with its epicenter located about 68km NW of Gangtok (27° 20’N : 80° 37’E) having depth of focus at 19.7 km. Shocks of this earthquake were felt in neighboring Nepal, Bhutan, Bangladesh besides Eastern India, Bihar and West Bengal.

3.1.2.2 History of Major Earth quakes (Over Magnitude 5) in Near by Regions

Teesta Power Station-V Latitude: 32' 36" 19"N, Longitude: 75' 54" 23" E

DATE	TIME			LAT.	LONG.	MAGNITUDE
	HH	MM	SEC			
22-03-1973	1	6	57.4	28.14	86.99	5.2
24-03-1974	14	16	3.1	27.73	86.11	5.7
24-04-1975	1	35	51.2	27.24	86.9	5.1
24-06-1975	15	38	28.1	27.47	87.29	5.2
26-11-1975	15	2	31.1	28.34	87.64	5.1
23-10-1976	16	9	19.8	28.68	86.23	5.1
04-10-1978	13	53	52	27.83	85.96	5.2
19-06-1979	16	29	8.4	26.74	87.51	5.1
19-11-1980	19	00	44.5	27.39	88.75	6.1
09-02-1981	15	49	21.6	27.04	89.75	5.1
05-04-1982	2	19	41.1	27.42	88.86	5.1
06-07-1982	6	13	35.5	25.91	90.32	5.1
07-01-1986	20	20	0.4	26.93	88.32	5
10-01-1986	3	46	30.9	28.65	86.53	5.4
20-04-1988	6	40	25.8	27.04	86.69	5.4
20-08-1988	23	9	10.1	26.75	86.62	6.8
27-09-1988	19	10	1	27.17	88.29	5
29-10-1988	9	10	52.5	27.87	85.65	5.4
20-12-1988	9	45	43.6	27.62	91.15	5
09-04-1989	23	13	6.1	29.18	90.08	5.2
22-05-1989	19	24	31	27.24	87.89	5
09-01-1990	2	29	21.8	28.23	88.16	5.5
22-02-1990	13	33	13.3	29.22	90.09	5
07-08-1991	11	36	29.1	25.1	88.79	5
20-03-1993	21	26	39.4	29.08	87.33	6.2
31-03-1993	13	44	10.1	29.09	87.35	5.1
26-04-1996	16	31	3	27.83	87.82	5
03-07-1996	10	10	33.8	29.92	88.19	5
25-09-1996	17	41	17.2	27.43	88.55	5
30-12-1996	15	16	29.5	27.43	86.64	5
30-10-1997	2	2	52	29.55	89.7	5.3
27-11-1997	16	11	57	27.62	87.35	5.1
08-12-1997	2	3	55.8	27.48	87.18	5
08-07-1998	3	44	59.3	27.33	91.03	5.2
18-08-1998	4	10	20.6	27.56	90.98	5.2
03-09-1998	18	15	56.5	27.85	86.94	5.6
26-11-1998	10	14	27.6	27.75	87.89	5.1
01-08-1999	8	24	46.1	28.44	86.73	5.2
28-04-2001	10	37	56.5	28.87	87.16	5.2

02-12-2001	22	41	13.7	27.15	88.17	5.1
31-08-2002	12	40	35.3	29.87	87.88	5
16-01-2003	11	36	49.1	29.8	88.01	5.1
25-03-2003	18	51	26.3	27.26	89.33	5.5
14-02-2006	5	5	25	27.38	88.39	5.3
11-08-2007	14	35	54.8	27.34	87.74	5
02-12-2008	5	11	42	27.37	88.05	5.2
18-09-2011	12	40	47	27.7	88.2	6.8
18-09-2011	13	11	59	27.6	88.5	5.0
27-03-2012	23	40	12.6	26.08	87.77	5
05-04-2016	07	42	24	25.76	90.54	5
22-05-2016	01	48	48	28.45	87.53	5.4
22-05-2016	02	05	54	28.56	87.48	5.1
27-11-2016	23	35	21	27.80	86.53	5.4
12-09-2018	04	50	46	26.37	90.16	5.3

Courtesy: USGS website:
http://earthquake.usgs.gov/earthquakes/eqarchives/epic/epic_global.php

3.1.2.3 Seismic Design Parameters for Concrete Dam:

The site lies between two major thrusts, the Main Central Thrust (MCT) and Main Boundary Fault (MBF). During past, a number of earthquakes of variable intensities have been recorded in and around area of the site.

The seismic design parameters for Teesta-V power station have been adopted after detailed study of information on the tectonic models of the Himalayas and past history of earthquakes in the power stations area by Department of Earthquake Engineering, University of Roorkee, Roorkee, which is now known as IIT, Roorkee.

Based on the data of earthquake occurrence and geological and tectonic set up of the area, the seismic risk at Teesta –V Dam area in terms of peak ground acceleration form deterministic magnitude distance- acceleration relation has been evaluated. Accordingly, the Maximum Credible Earthquake (MCE) of 0.32g and Design Basis Earthquake (DBE) of 0.16g were adopted.

Indian standard criteria for Earthquake Resistant Design of Structure and soil foundation factor were used as per IS: 1894-1984 as suggested by Department of Earthquake Engineering, IIT Roorkee.

3.1.2.4 Preparedness

3 nos. Accelerograph has been installed at Teesta-V Dam for monitoring of seismic activities. Connection of these Accelerographs has also been carried out through NHPC LAN for online data monitoring/ downloading from Corporate Office. The data is analyzed by Project Investigation Division after occurrence of seismic events. Severity of earthquake is decided based on data analysis and communicated to the power station for further necessary action.

3.1.2.5 Action Plan

Followings are the action plan in case of occurrence of earthquake at Dam area:

- Incident Controller – II shall immediately contact Engineer Incharge at dam as well as in Power House
- If intensity of earthquake is more than 5.0 as discerned through TV news or as per information at http:\usgs.com, he shall order immediate visual inspection at dam by the staff present there.
- Care shall be taken to dispatch personnel to the site, particularly at night as the hill roads are prone to slides during earthquakes.
- He would notify the danger/ emergency level as per colour code.

3.1.3 Security against Sabotage/ Violent Agitation/ Bomb Threats/ Terrorist Threats

3.1.3.1 Indian Reserve Battalion - Teesta Power Station-V

Background of Security

In the power station area, IRB has been allocated the security of Power House, Switch Yard, Dam, Administrative Building. Security of town ship is under home guards. Local law & order is being maintained by Police Station, Singtam, Makha (outpost) and Temi, which is situated in the power station vicinity. As this power station is situated in the nearby areas of international border with China, it is considered to be a sensitive power station.

3.1.3.2 IRB Security

Highest Official –Inspector

Sl No	Name of Check Post	Location	In charge	Contact Number
1	Dam Check post -1	Dam		9800003543
2	Control Room IRB	Balutar		247286, 470
3	Quarter Guard/Barack	Balutar		461

Home Guard Security

The security responsibility of Administrative Building, Town Ship etc. is being looked by Sikkim home guards. The deployment is given as under that consists of mainly Ex-servicemen and the headquarters is in the district of East Sikkim:

Sl No	Location	Check post (Yes or No)	Contact Number
1	Dam Office & Store	Yes	9800003543

3.1.3.3 Purpose

Looking forward to the security conditions of the National interest, there is a constant threat to the electricity producing installations by the anti-national elements. Hence, there is a necessity to have an Emergency Plan. The main aim to have this plan is to prepare the installation to counter the possible danger, so that different agencies within the power station function in full co-ordination. Below mentioned emergency conditions are possible in the installation:

1. **Bomb blast or finding out bomb or explosives.**
2. **Terrorist attack or attack on the security personnel.**
3. **Fire incidences.**
4. **Destruction due to any reason and subsequent hindrance in the power supply.**
5. **Strike by the employees or violent agitation.**
6. **Natural disasters like earthquake or flood.**
7. **Local law and order problem.**
8. **The problem of power breakdown.**

9. Electrical Grid failure.
10. Landslide causing excessive wave and downstream damage
11. Flood beyond design capacity/ Dam break.
12. Air Strike during war

3.1.3.4 Emergency Plan against Hindrance in Power Supply due to Destruction or any Reasons:

Havoc is created due to destruction and hindrance in the power supply. In this regard, the following actions have to be taken:

1. To identify important places and keep a constant vigil.
2. To instate static duty and cover at important places and keep a regular check by patrolling.
3. To identify suspect people and to keep them under vigilance.
4. To alert the nearby police/ security post.
5. If necessary, call extra security personnel and initiate a combing operation in the area.
6. To detain suspected people for inquiry and to inform the higher officials and to hand them over.
7. To be alert at the incident site so that due to the crowd around, anyone does not try to steal or enters the area un-authorized.
8. Do not allow anyone to touch anything at the incident area, may be by the time investigation committee arrives, the evidence is destroyed.
9. Important institution will be given electricity supply by the generator and the concerned departments are to be informed.
10. Information system has to keep a vigilant eye on the condition and have to watch out the movements of non-satisfied employees and to analyze the same.

3.1.3.5 Emergency Plan in case of Strike or Violent Agitation:

As per IRB Act, the property and employees security of the installation is the responsibility of the IRB. According to it, when the employees of the installation are

indulged with outside people in a violent agitation, only then IRB has to come into action. The following actions will be taken:

- **I. To give minute to minute information to the NHPC Management.**
- **II. To control the activities of violent mob with the help of local police and administration.**
- **III. To control the violent mob by deploying extra security personnel and if necessary, to act according to mob dispersal drill.**
- **IV. Try to engage the violent mob in talks rather than taking up reflective action, so that they can put forward their views to the management.**
- **V. The information system has to keep a vigilant eye and keep vigilance on the activities of non satisfied employees and to analyze them.**
- **VI. To deploy extra security at the peaceful post. The security personnel at these posts will try to prevent the non-satisfied employees from diluting the friendly atmosphere around.**
- **VII. To provide full protection to the loyal employees, if necessary, provide them security while coming and going from the duty.**
- **VIII. To update the security personnel by regular briefing & debriefing and keep them informed about the latest situation.**
- **IX. To inform the local administration and police about latest incidents.**
- **X. To regularly inform the IRB Headquarters, Regional Headquarters and Information Department about the latest incidents.**
- **XI. To keep an eye on the agitators during and after the agitation.**
- **XII. After the agitation, inform the Management about the shortfalls and the problems faced, so that preventive steps are taken in the future and such incidents are prevented.**
- **XIII. In these situations, the security personnel have to maintain their patience and even in high tempered situations, they have to keep their cool.**
- **XIV. IRB in its action has to be impartial and has to work according to and within rules & regulations.**

3.1.3.6 Emergency Plan against Bomb Threat/ Terrorist Threat/ War like Situation:

Immediate Action in case Bomb Explosion or Finding out Explosives:

Whosoever gets the First Information

1. **To alert everyone.**
2. **To vacate the area.**
3. **To prohibit people from going in the area.**
4. **Not to touch any unidentified object.**
5. **To take the help of the nearest security personnel and/or Army Unit.**

Action by the Control Room.

1. **To inform the security personnel in the unit line to get ready.**
2. **To send extra security personnel to cordon the area.**
3. **To inform the fire station.**
4. **To call the ambulance and send it to the said area.**
5. **To inform the local Police and if necessary, ask for bomb detection squad.**
6. **To inform the higher officials and the concerned officials of the installation.**
7. **To control the traffic, if necessary.**
8. **To act according to the plan after getting the extra help.**

Action by Unit Line

In any emergency conditions, even off duty security personnel will assemble in front of security control room. The senior most official will act as the operation in-charge. He will work as under:

1. **To inform all the security personnel about the incident and get them ready.**
2. **To issue arms as per necessity.**
3. **To depart for the incident site.**
4. **During their journey to incident site, the in-charge will distribute the action plan to different groups. So that they immediately after getting to the site, come into action.**

Check-list for Bomb and Explosives

As soon as the control room In-charge gets the information about the Bomb; he has to ask from the informant the following questions:

1. **Where is the Bomb installed?**
2. **By what time the Bomb is going to explode?**
3. **Why is the Bomb planted?**
4. **How does the Bomb look?**
5. **Where are you speaking from?**
6. **Have you kept / seen the Bomb?**
7. **What is your name and address?**

After getting the above mentioned information, the In-charge will take up the action as following:

1. **By what time is the Bomb going to explode?**
2. **Is that a populated area?**
3. **Is any criminal involved in it?**
4. **Is this a mischief by someone or is it not a kidding by a child?**
5. **Isn't it act of misleading or of disturbance?**
6. **Do you suspect someone?**

On getting above mentioned threat or danger, the following actions have to be taken:

1. **To vacate and cordon the area.**
2. **Not to allow anybody into the area.**
3. **To inform for extra help.**
4. **To find out the suspect object as per the plan.**
5. **After getting the suspect object not to touch it.**
6. **To call trained or Bomb Disposal Squad for help.**
7. **To arrange sand bags around the suspect object.**

<u>Other Important Actions</u>:

1. **To inform police and Bomb Disposal Squad.**
2. **To inform the higher authorities.**
3. **To inform the Fire Station.**
4. **To inform the nearby offices.**
5. **To investigate as per plan.**
6. **Get ready the Ambulance.**

7. **To keep the phone free for incoming calls.**

As per the directives of IRB Headquarters, to maintain the similarity in the incidental report and investigation analysis, the Control Room of Home Ministry and National Security Guard, New Delhi has to be informed on the following phone numbers by Incident Controller - II.

Home Ministry	:	Phone: 23092161, 23092011,23092923 & 23092885
		Fax: 23093750 & 23092763
N.S.G.	:	Phone: 25663100, Fax: 25671535

Explosion site is to be cordoned, any object is to be left un-touched and the evidence as well as the suspect is to be handed over for investigation.

3.1.3.7 Emergency Plan against Terrorist Attack:

Action by the person having first information:

1. **To alert everyone.**
2. **To prepare and position oneself for the counter attack.**
3. **To inform the Control Room.**

Action by Control Room:

1. **To prepare the security personnel in the unit line and to depart for the incident site.**
2. **To send the security personnel available in that area to cordon the area.**
3. **The armed security personnel to take their position.**
4. **To inform the higher officials and officers concerned in the installation.**
5. **To act according to the plan after getting extra help in the unit line.**
6. **To ready the Ambulance.**

Action by Unit Line**:**

The senior most official will act as the operation in-charge. He will work as under:

1. **To inform all the security personnel about the incident and get them ready.**
2. **To issue arms as per necessity.**

3. **To depart for the incident site.**
4. **During their journey to incident site, the in-charge will distribute the action plan to different groups. So that they immediately after getting to the site come into action.**

Action Plan after reaching the Incident Site:

1. **Try to find out the situation and position of the attacker and his arms.**
2. **The theory of Bullet for Bullet has to be followed.**
3. **The Arms & Ammunition have to be used in such a way that scarcity of it is not felt.**
4. **The Advance Party will attack the attacker and will physically overpower him.**
5. **The Second Support Party will give the cover fire and help to the Advance Party.**
6. **After overpowering and arresting the attacker, action has to be taken as per rules.**
7. **The muscle power is to be implemented just to overpower the attacker.**
8. **Injured person is to be immediately taken to the Hospital for first-aid.**
9. **The party that arrives for help is to be identified properly.**

Contingency Plan to Counter Sudden Attack by Terrorist/ Anti Social Elements for Sabotage Purposes:.

Preventive Measures

The Dam complex is also guarded by IRB staff round the clock and few identified public vehicular traffic of nearby village is allowed over the Dam. The entry of unauthorized persons is strictly prohibited.

Precautionary Measures

- Regular updation of the security arrangements in close coordination with IRB and HR Department
- Adequate numbers of Walkie Talkie/Wireless with adequate back-up are provided to the security staff for communication.
- All entries into the power station area are closely monitored and entry of unauthorized vehicles and persons is strictly prohibited.
- Emergency list telephone Nos. is available at Dam complex entrance gate.
- A close liaison is to be kept with state department and security & police department.

However, the detailed contingency plan for encountering any terrorist attack/bomb blast/intruders with sabotage intentions has been prepared by the project unit of IRB, duly vetted by the Distt. Authorities /DIG (Police).

3.1.3.8 Emergency Plan in case of Bomb Threat:

Bomb may be planted at the dam complex for fulfilling any of the following aims by terrorist group.

a) To disrupt functioning of plant/ power station.
b) To increase panic among employees.
c) To kill an important senior officer of the plant/ power station.
d) To gain publicity by killing large number of innocent people and then claiming responsibility and to demoralize the security forces.

Targets for Bomb Threat

The following vital installation can be selected as targets for achieving their aims:

1. Vital installation of the power station
   - i. Dam control room
   - ii. Dam Intake structure
   - iii. DG set building

iv. Dam Store & Workshop

Possible Places where Bomb can be Planted:

In general, areas where bombs can easily be placed / planted are identified as under:

a) Dam galleries
b) Gates and other HM installations
c) Dam control room
d) Dam bridge
e) Areas which are not commonly visited

Probable Sources of Entry of Bomb:

The Bomb can gain entry to the plant through any of the following resources:

a) Visitors, Contractors and their laborers.
b) Packed material boxes
c) Disgruntled employees
d) General supply material
e) Govt. and private vehicles

Preventive Measures

The following preventive measures must be adopted by IRB and management of the Teesta -V Power Station as well as other agencies to prevent entry/ planting of Bomb inside the Dam complex and other installations:

a) IRB Staff deployed at various Posts/ Barriers must remain alert and vigilant for men and materials.
b) Thorough searching of all visitors, contractors, their laborers, suppliers, employees and their belonging such as suit cases, bags, parcels and Tiffin carriers even with the help of metal detector.

c) Entry and exits at the Dam complex gate should be properly supervised by the officer deputed.

d) Visitors pass must be checked properly.

e) The personnel deployed at dam complex should be kept on special watch particularly attendants and other laborers.

f) HR Department must ensure that character and antecedents of all employees and trainees and contract labours working are verified through police.

g) Company commander must ensure that all vehicles at the barriers must be thoroughly checked under the supervision of officers.

h) The management should issue instructions to all drivers not to park vehicle everywhere and they should carry out anti sabotage check for all the vehicles.

i) Vital installation should be guarded by IRB and frequently checked by guard.

j) All the employees & visitors must display their ID cards to make it visible at all entrances.

k) All sections must identify the disgruntled employees who may support the terrorists.

l) The intelligence wing personnel of IRB should keep a watch on vital installations, which are not frequently visited by the employees of IRB duty personnel.

m) All the office must be locked/ sealed after office hours and keys deposited at the security posts.

n) All the heads in their respective sections must ensure that proper housekeeping is being maintained in such a way that any unidentified object could be seen easily and is not mixed up in unattended manner.

Bomb Threat Action Plan:

I. Bomb Threat at Dam Complex:

If there is bomb in the plant premises, it can be communicated in two ways.

a) It can be telephonically communicated by a Bomb planter when objective is to destroy a facility rather than to kill people.

or

b) A telephone call just to create a panic in the power station premises.

II. Response to Telephone Bomb Threat:

In case of receipt of any telephonic message about planting of Bomb/ Explosive, the receiving person will try to ascertain the following from caller:

a) What is the exact location of the bomb?
b) What does the bomb looks like?
c) Who is calling?
d) Where is he calling from?
e) What organization does he belong to?
f) Why is he doing this?
g) Whether male or female voice?

The receiver must bear in mind that he or she would be in a position to furnish accurate and detailed information about the caller to the IRB & Management and therefore not only should he or she be calm and cool but also able to obtain maximum possible information from the caller in that brief encounter.

Two essential points on which information must be obtained are:

1) The expected time when the bomb would go off.
2) The location of the bomb.

<u>Tips for the calls receiver</u>:

a) Attempt to keep the caller on the line as long as possible to gather more information and to ascertain, if the threat is genuine. This can be done by gently encouraging the conversation and while trying to obtain the exact location of the bomb mentioning places or land marks which do not exist at all. If the caller accepts this, the threat is likely to be bogus/ hoax.

b) Record in writing or if feasible, tape record exact words of the caller regarding location of the bomb, expected time of explosion, its size, type, what it looks like.

c) Attempt to establish the approximate age, education status and the attitude of the caller, more particularly his reason for placing the bomb.

d) Note any particular of speech especially his accent and favorite words etc. which may help to establish his identity.

e) Do not upset or panic the caller by asking too many questions.

f) If the person who has received the call is not IRB Control Room Officer, he should immediately inform the IRB Control Room Duty officer with full details.

Keeping in view the above, a check list has been prepared. During conversation, the check list should be completed and handed over to IRB officers for further action.

III. Duties of IRB Control Room:

1. Inform the Head of Power station, Inspector, IRB and other members of the bomb threat co-ordination Committee.
2. The IRB Control Room in-charge will direct the IRB personnel to seal all entry and exit points of the affected area.
3. The IRB Control Room in-charge will alert all IRB duty personnel with available communication. He will receive OK or otherwise reports from other duty personnel on regular intervals of time and will keep himself fully informed. He will also direct the duty personnel to give OK or otherwise report to designated bomb threat co-ordination control room and will provide them such telephone numbers.
4. He will immediately inform Inspector, IRB, Quarter Guard etc. regarding the threat by quickest means of available communication.
5. He will not leave the telephone unattended. If the threat call has been received by some other IRB personnel or any employees of the Power Station, he will ensure that the same telephone is not left un-attended. If possible, he will also arrange for recording of the telephone call.
6. He will immediately inform to the following:

- Shift I/C Control room Dam Complex
- Fire Station
- Chief Medical Officer for ambulance and first aid
- Bomb Disposal squad
- Police Station
- Local intelligence officials

7. If the receiver of the call is duty officer of the IRB Control Room, he will complete the Bomb Threat Check List attached at Annexure-“O”.
8. In case the explosion of the Bomb appears immediately, he will arrange to blanket the area with sand bags around the suspected object/bomb.

IV. Duties of Cordon Group :

a) The Cordon Group In-charge will ensure by posting his group at reasonable distance for cordoning the affected area, building. While doing so, he will ensure that armed personnel are placed in the cordon at all positions.

b) He will instruct his men to challenge any intruder/suspected trying to run away

c) He will ensure that no outsider enter the cordon area. If it is building, which is being cordoned, the area between building and Cordon Group is cordoning area.

d) He will ensure that after proper cordoning has been completed, it is reported to Inspector for his further action.

V. Returning to Normal:

a) The coordinator in consultation with members of Bomb Threat Assessment Committee will call off the emergency on receiving clearance from the bomb disposal squad, which they will give either when they are satisfied or when they have defused the bomb.

b) Then the Commandant/IRB will announce over Public Address system “AREA CLEAR, EMERGENCY CALLED OFF”.

3.1.4 Land Slides

The Teesta- V Power Station lies in the so-called lesser Himalayas, consisting of pre-tertiary, poorly fossiliferous rocks, which have been highly folded, shattered in an extremely complex structure. Barren bedrock is common everywhere, especially along the steeper slopes. Overburden consists of fluvial and co-alluvial material scattered along the higher slopes and alluvial sands and gravels along the riverbeds.

As the area is prone to heavy rain falls, especially during the monsoons, the occurrence of landslides at different locations is a common phenomenon. The various roads viz. the Power House to Dam site and Power House to Surge Shaft are prone to damages often leading to road blockades and thereby cutting off essential supplies.

3.1.4.1 Preventing Measures:

Proper drainage along the roadside are maintained. Further treatment can be provided as per requirement.

3.1.4.2 Roles and responsibilities

Responsibility: Incident Controller-II.

Overall Responsibility: Site Controller.

Resources: Heavy earthmoving equipments are ensured to be in working condition well before the onset of monsoon season to remove landslide, if any immediately. Sufficient Nos. of Dumpers, Dozers and Cranes etc. are available in mechanical workshops in ready/working condition to clear landslides. Road communication between dam and power house & colony are essentially kept in order.

Adequate provision of POL and spares and team of dedicated mechanics are kept in readiness.

3.2 Notification Procedures

Individuals or agencies to be notified in emergency situations are as below:

(i) Residents and property owners located immediately d/s of dam within the area of potential inundation, where available warning time is limited.

(ii) Owner personnel: **Annexure – I & K.**

(iii) Law enforcement officials: **Annexure – J.**

(iv) Operators of u/s and d/s dams or water retention facilities: **Annexure – J.**

(v) Appropriate State and Local agencies: **Annexure – J.**

(vi) Others, as appropriate – News media including radio, television and newspapers.

Format for information which should be used during notification by incident commander or designee:

(i) This is ____NHPC Ltd____ monitoring ____Teesta-V____ dam.

(ii) The date is _____________ and the time is ____________.

(iii) The condition at the dam are (describe situation and include damages, outflows, reservoir elevation, potential or actual failure and non-hydrological hazard, etc.)

(iv) We will notify you if the conditions at the dam change. We will give you the next briefing at ____________ hours or sooner.

(v) For further information, contact __________________ at __________________.

(vi) This message will be sent to you in the text form (fax or other).

Event Reports

Following event report forms shall be used while recording various emergency situations and unusual occurrences for documentation.

(i) Emergency Event/ unusual occurrence report (Form 1) (Annexure – M)

(ii) Earthquake Damage Report (Form 2) (Annexure – N)

(iii) Bomb threat report (Form 3) (Annexure – O)

In addition to the above, it is desirable that all officials receiving reports from dam operating personnel shall maintain diary, tape recorded messages, photos and video graphs for complete documentation.

4. PREVENTIVE ACTIONS

Preventive actions are required both prior to and following the development of emergency conditions. Preventive actions involve the installation of equipment or the establishment of procedures for one or more of the following purposes:

- ❖ Preventing emergency conditions from developing, if possible, or warning of the development of emergency situations.
- ❖ Facilitating the operation of the dam in an emergency situation.
- ❖ Minimizing the extent of damage resulting from any emergency situations that do develop.

An important factor in the effectiveness of EAP is the prompt detection and evaluation of information obtained from instrumentation and/or physical inspection procedures. There are several types of preventive actions that should be considered. These actions include:

4.1 Surveillance

Surveillance of a dam shall be done by way of the following manners:

- ➢ Instrumentation reading to be sent monthly to Design office outlining changes.
- ➢ Shift staff including G&D observer should be available at Dam control room. They should take reservoir water level measurement as prescribed in Reservoir Operation manual. Shift staff at dam control room should remain vigilant and promptly notify responsible officials of dam of emergency conditions at dam.
- ➢ Installation of a remote surveillance system that includes instrumentation and tele-metering facilities at the dam site, to provide a continuous reading of headwater and tail water levels at a dam control/ PH control room that is manned 24 hours a day. The system should include a computer at the operation centre to monitor the data and to activate an audible alarm whenever the rate of change of the headwater or tail water over a given period of time exceeds prescribed limits. The alarm also should be activated if the headwater or tail water elevations exceed prescribed maximum or minimum levels during dam operation, floods, maintenance, etc.

- Operation of the alarms should be checked on a monthly basis during non-monsoon period & on a weekly basis during monsoon. Proper functioning of alarms should be confirmed by testing.
- Pre and post monsoon dam safety inspections.

The following procedure shall also be adopted:

- **Attendance**: The dam should be properly manned all the year round. There should be a full time duty officer. Further, arrangement should be made for alternate personnel who will attend to the dam duties in his absence.
- **Daily reports**: Daily reports about stage of the reservoir and condition and behavior of the dam must be submitted by the Engineer responsible for continuous vigilance of the dam to his immediate superior.
- **Operation of storage reservoir**: This should be followed as per the Standard Dam regulation guidelines made for the dam with the objective to limit the flood stages in the river downstream and with maximum feasible utilization of the flood capacity of the river channel downstream of reservoir, consistent with the safety of the dam. Schedule for the dam as per Operation & Maintenance Manual should be strictly adhered. The Duty Officer should inform immediately to the Dam Owner i.e., General Manager for the releases from the reservoir. Further action to be taken as per stages of emergency.
- **External Inspection:** As per “Dam Safety Procedures”, comprehensive safety review of large dams is being carried out once in 10 years by an independent panel of Experts. Comprehensive safety inspection of Teesta-V dam was done in December 2016.

4.2 Access to the site

Map showing connectivity to Teesta -V dam to nearby rail head and airports are enclosed at **Annexure – B**. Some of the routes connecting Teesta-V dam are as below:

- Nearest rail head at New Jalapiguri – 120 Kms connected by road (NH-31A), Travel time – 3 hrs.
- Nearest airport at Bagdogra, Siliguri – 125 Kms connected by NH-31A and NH-31, Travel time – 3.5 hrs.

❖ Nearest Airport at Pakyong, Gangtok- 40 Kms connected by NH-10, Travel time 1.5 Hrs.

Helipad (Location & Coordinate): A Helipad is located at Project headquarter at Balutar on the right bank of river near power house. The cordinates are $27^0 14' 56.5''$N (latitude) and $88^0 27' 25''$E (longitude).

4.4 Response during periods of power failure/ Alternate source of power

Responsibility : Manager/DM (Elect)
Overall Responsibility : DGM/Sr. Manager (Elect)
Overall Monitoring : General Manager
Scope : Electrical Works departments will be responsible for restoration/ extension of power supply during emergency situation within Power Station.

We have two 400 kV feeders Teesta Circuit no-I and Teesta Circuit no-II. In case of failure of one circuit, load of one circuit can be shifted to another circuit automatically.

We have one 66/11 KV S/s and two 11 kV lines along the left bank of the Teesta river to feed power to the residential colonies. Both the lines are kept charged. There is two more 11 kV lines from Teesta power station to Surge Shaft area and Dam site respectively along the left bank of the river for supply of power from power house to Surge Shaft, Dungdung area and Dam complex.

All these sub-stations are charged from 66/11 KV substation. During the failure of one feeder, the supply can be fed from another feeder. We have well trained staff to meet day-to-day exigencies. The following are the sub-stations in Dam area.

Sr. No.	Capacity	Location	Feeding Areas
1.	2x 500 KVA	Dam Site, Dikchu	Dam

4.5 Alternative systems of communication

Responsibility : DM (IT&C)

Overall Responsibility : Sr. Manager (E), IT&C Division

Overall Monitoring : General Manager

Purpose: To provide communication facility between all sites/offices or amongst the employees.

Scope : To establish communication system to all sites /offices during emergency.

For communication we have various backup arrangements.

Type of Communication	Specification/ Technical Detail
• **Local EPABX Exchange System** • **PH AREA** • **DAM AREA**	connected with the P&T exchange 500 lines exchange 50 lines exchange
• **BSNL Landline/ Fax/ Broadband Connection**	46 Landline, 3Fax, 4 Mbps shared Broadband
• **VSAT Connection (3 nos.)**	- Ku band up to 1Mbps Communication System - VSAT Phone at Admin block Power house and Dam site - Connected with Corporate office and other power station of the NHPC & ERLDC
• **Mobile (CUG Airtel)**	- CUG facility within Sikkim/ WB. - Includes Rangit PS, Teesta IV, TLDP-III and TLDP-IV HEPs.
• **MPLS VPN -PGCIL**	4 Mbps
• **MPLS VPN-BSNL**	2 Mbps
• **Data Card via SSL VPN-3G speed**	-Facility within Power Station

• **Internet lease line**	- 4 Mbps speed
• **INMARSAT**	Nil
• **PLCC telephone circuits**	2 nos. for 400 KV substation at Binaguri
• **OPGW Network**	For communication with beneficiaries and ERLDC.(One IP Phone & one Analogue Phone)
• **Video Conferencing**	Connected with Corporate office and other power station of the NHPC

4.5 Stockpiling materials and equipments

Details regarding following are enclosed at **Annexure - L**:

a) Materials needed for emergency repair, their location, source and intended use. Materials should be as close as possible to the dam site. (Annex. – L1)

b) List of supplies and suppliers along with address and contact nos. (Annex. – L2).

c) List of equipments, its location. (Annex. – L3)

d) List of local and outside contractor along with address & contact nos. (Annex. – L4)

4.6 Coordinating information on flows

There is a need for coordination of information on flows based on weather and runoff forecasts and action required in case of any failure or other emergency condition. The coordination with various organizations/ departments to be made is as follows:

❖ Coordination with the India Meteorological Department (IMD) or other appropriate agency like CWC, etc to monitor storms, river stages and flood waves resulting from a dam break. These agencies might also be able to supplement the warnings being issued by using their own communication system.

❖ Coordination with dam officials and project people for necessary actions to be taken to lower the reservoir water level elevation as per dam operation manual/ guidelines.

❖ Coordination with officials of u/s dams (Teesta-III) for actions to be taken to reduce inflows to the reservoir of Teesta-V dam.

- Coordination with officials of d/s dams (Teesta-VI, TLDP-III and Teesta-IV dams) for actions to be taken regarding regulation of outflows from Teesta-VI and TLDP-III dams.

The communication details of the officials for coordinating the flow information are detailed at **Annexure - J**.

5. INUNDATION MAP/ AREAS

Index (Location) map, layout plan and sections of the dam are enclosed at **Annexure – A, L & M**. Google map of Teesta-V dam and reservoir is enclosed at **Annexure – N & O.**

5.1 Identification of Roads/ Villages likely to be affected in case of Flooding due to Dam Break

Roads and villages likely to be affected due to dam break have are being identified. Dam Break Analysis for Teesta-V dam has been carried out by NIH, Roorkee and summary of report is given in APPENDIX – 2. Further, for details of Dam Break Analysis, the report of National Institute of Hydrology (NIH), Roorkee may be referred.

5.2 Identifications of Safe Places

Safe place have already been identified in Dam Break Analysis for Teesta-V dam and photograph enclosed at pg 74-79 in Dam Break Analysis.

GLOSSARY OF TECHNICAL TERMS

Bench Mark: A permanent or temporary monument of known elevation above sea level; used as a vertical reference during construction and for topographical surveys.

Breach: An opening through a dam resulting from partial or total failure of the dam.

Dam: A barrier constructed across a watercourse for the purpose of storage, control or diversion of water.

Design Basis Earthquake: The earthquake which the structure is required to safely withstand with repairable damage. The intended use of this earthquake loading is for economic design of structures or components whose damage or failure would not lead to catastrophic loss.

Emergency: A condition which develops unexpectedly endangers structural integrity of a dam and / or downstream property & human life and requires immediate action.

Emergency Action Plan: A formal plan of procedures designed to minimize consequences to life & property in the event of an emergency at a dam.

Failure: The catastrophic breakdown of a dam, characterized by the sudden, rapid and uncontrolled release of impounded water.

Flood Plain: The downstream area that would be inundated or otherwise affected by the failure of a dam or by large flows.

Flood Profile: An elevation view showing the relationship of the water surface elevation and natural ground elevations for a discharge at a given location along longitudinal segments of a watercourse for a flood event. The flood event may either be a dam failure or a normal flow condition.

Flood Routing: The process of determining the amplitude of a flood wave progressively over time as it moves past a dam or downstream to successive points along a river or stream.

Headwater: The water immediately upstream of a dam. The water surface elevation varies due to fluctuations in inflow and the amount of water passed through the dam.

Hydrograph: A graph showing the discharge, stage, velocity or other hydraulic property with respect to time at a particular point on a watercourse.

Inflow Design Flood: The flood hydrograph used for the design of a dam and its appurtenant structures, particularly the spillway and outlet works and for determining maximum temporary storage and height of dam requirements.

Instrumentation: The use of special devices to obtain critical scientific measurements of engineering structures.

Inundation Map: A map showing areas that would be affected by flood conditions and / or by an uncontrolled release of reservoir water due to the failure of a dam.

Main Boundary Fault: A tectonic feature separating the Siwalik Formations of the Sub-Himalayas from the older rocks lying to their north.

Main Central Thrust: The Main Central Thrust is a major geological fault where the Indian Plate has pushed under the Eurasian Plate along 2200km of the Himalayan belt.

Maximum Credible Earthquake (MCE): The largest earthquake that appears capable of occurring under the known tectonic framework for a specific fault or seismic source, as based on geologic and seismologic data.

Peak ground acceleration: It is a measure of earthquake acceleration on the ground and is used to set building codes and design hazard risks.

Sensitivity Analysis: An analysis in which the relative importance of one or more variables thought to have an influence on results of the study being conducted is determined.

Spillway: A structure over or through which flood flows are discharged. If the flow is controlled by mechanical means, such as gates, it is considered a controlled spillway.

Tail water: The water in the natural stream immediately downstream from a dam. The water surface elevation varies with discharge from the reservoir.

APPENDIX – 1

LOCATION AND SALIENT FEATURES OF TEESTA-V DAM

The dam is located across river Teesta River about 2 km downstream of confluence of Teesta and Dikchu rivers. The salient features of Teesta-V Power Station are as below:

1.	**LOCATION**		
	State	:	Sikkim
	District	:	East Sikkim
	River	:	Teesta
2.	**HYDROLOGY**		
	Catchment area	:	4307 km^2
	Design Flood	:	9500 m^3/s (Revised to 14596 m^3/s by CWC in 2011)
	River diversion design flood	:	3251 $m^{3/}$s
3.	**RESERVOIR**		
	Maximum reservoir level	:	580.72 M
	Full reservoir level	:	579.00 M
	Minimum drawdown level	:	568.00 M
	Gross storage	:	9.61 MCM (As per Post Monsoon survey-2014)
	Live storage capacity	:	5.44 MCM (As per Post Monsoon survey-2014)
	Length along the river	:	5.1 KM (approx)
4.	**DAM**		
	Type	:	Concrete gravity
	Max. height above river bed	:	52.2 M
	Max. height above deepest foundation	:	88.6 M
	Elevation of top of dam	:	EL. 583.20 M
	Length at top	:	176.5 m
	Levels of Galleries		

	Overflow/Non-overflow block width		
	Operation Levels of passenger /goods Lift		
5.	**SPILLWAY**		
	Design flood	:	9500 m^3/sec (With 4 gates open)
	Spillway crest EL	:	540.0 M
	Type	:	Ogee shaped with gated sluices and flip bucket
	No. & Size of Spillway Radial gates	:	5 nos., 9 m (W) x 12 m (H)
	Energy dissipation	:	Flip bucket
	Max Tail Pool Level at PMF	:	550.0 M
6.	**DIVERSION TUNNEL**		
	Number	:	2
	Size and type	:	12.2 m Horse shoe-shaped
	Length	:	473 & 610 m
7.	**INTAKE STRUCTURE**		
	Number size of inlets	:	Three of 6.5m x 6.5 m
	Design discharge	:	350.84 m^3/s
	Invert level	:	EL 554.00 / 556.50 m
8.	**DESILITING CHAMBER**		
	Type		Dufour
	Length		250 m
	Number and size		Three; 19.7 m x 24.5 m
	Minimum particle size to be Removed		90 % of 0.2 mm or above
9.	**HEADRACE TUNNEL**		
	Number, Size & type	:	1no. 9.50 m dia, horse shoe type
	Length	:	17.2 km
	Design discharge	:	292.37 m^3/sec

	No. of Adits / Gated Adits		5 Nos./ 4 Nos.
10.	**SURGE SHAFT**		
	Diameter	:	30 m
	Height	:	93 m
	Area of orifice (gate groove)	:	24.95 sq.m
	Thickness of RCC lining		1.0 m
	Type	:	Semi underground (Restricted orifice)
	Maximum upsurge level	:	EL. 625.80 M
	Maximum downsurge level	:	EL. 542.00 M
11.	**PRESSURE SHAFT**		
	Number & Type	:	1 no. Circular, vertical, underground
	Diameter	:	8.50 m
	Length	:	157 m
12.	**PENSTOCKS**		
	Number	:	3 nos.
	Type	:	Underground steel lined
	Diameter (internal)	:	4.7 m
	Height	:	173.65 m
13.	**POWER HOUSE**		
	Type	:	Underground
	Installed capacity	:	510 MW
	Size of Machine Hall	:	118.5m (L) x 23m (W) x 47.5 m (H)
	Size of transformer cavern	:	100.5m (L) x 14.5m (W) x 10.7 m (H)
	No. & capacity of units	:	3 of 170 MW each
	Switchyard type	:	Indoor GIS with roof top Pothead yard, size 100 m x 30 m
	Type of turbine	:	Francis, vertical axis
	Peaking Capacity	:	4.30 hrs
	Max. Tail water level	:	EL 360.00 m(with 3 units)

	Min. tail water level	:	EL 359.00 m
	Extreme min. water level	:	EL 358.50 m
	Gross & Rated Net head	:	215 m (approx)/ 196.15 m
	Rated discharge	:	97.46 cumecs per unit
14.	**TAILRACE TUNNELS**		
	Tunnel shape	:	D-shaped, 3 nos
	Diameter (finished)	:	6.0 m
	Length	:	165 m, 175 m, 185 m
15.	**POWER GENERATION**		
	Installed capacity	:	510 MW (3 x 170 MW)
	Annual energy production in a 90%dependable year	:	2573 GWh

APPENDIX – 2

Dam Break Analysis for Teesta –V

The objective of dam break modelling or flood routing is to simulate the movement of a dam break flood wave along a valley or indeed any area 'downstream' that would flood as a result of dam failure. The key information required at any point of interest within this flood zone is generally:

- Time of first arrival of flood water
- Peak water level – extent of inundation
- Time of peak water level
- Depth and velocity of flood water (allowing estimation of damage potential)
- Duration of flooding

Dam break analysis in Teesta-V Power Station has been carried out on the basis of Probable Maximum Flood (PMF) with a discharge capacity of 14596 Cumecs. The present study mainly comprises of:

1. Dam break takes place when the Probable Maximum Flood (PMF) impinges into the reservoir when it is at FRL and Spillway gates are fully open.
2. PMF impinges into the reservoir when it is at FRL and Spillway gates are fully open.
3. 100 year return period flood impinges into the reservoir when it is at FRL and Spillway gates are fully open.

Out of the above three cases, case 1 (Dam break takes place when the reservoir is at FRL, PMF impinges in the reservoir and Spillway gates are open) gives the worst conditions. The inundation map (PMF and Dam break) for the worst condition is enclosed.

Further, for details of Dam Break Analysis, the report of National Institute of Hydrology (NIH), Roorkee may be referred.

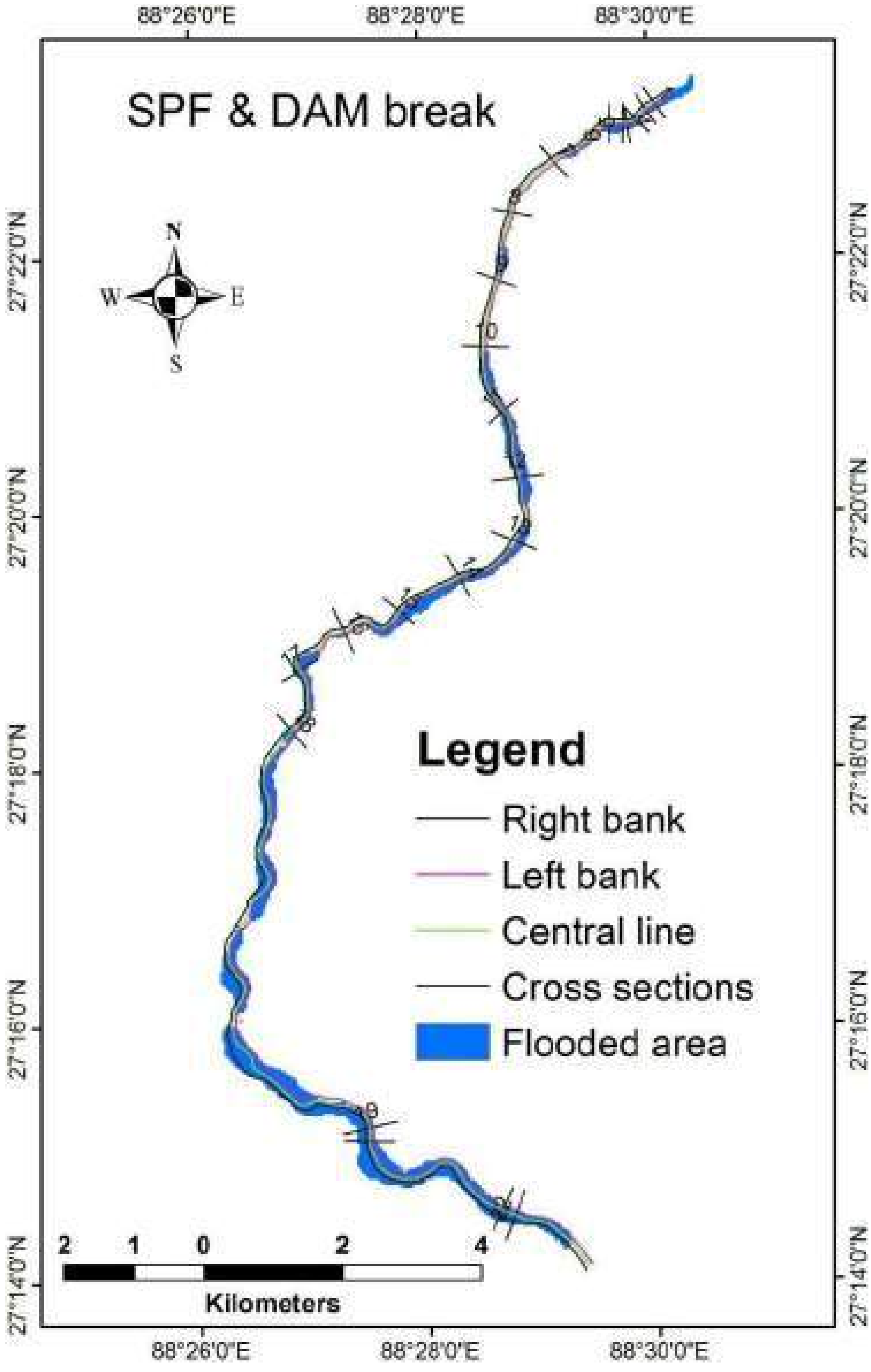


Figure: Flood inundation map (PMF and Dam Break)

APPENDIX – 3

EXERCISING & TRAINING OF EAP

Teesta-V Power Station has exercise the Emergency Action Plan (EAP) in coordination with State, local and tribal emergency management authorities. Exercises promote prevention, preparedness, and response to incidents and emergencies and may also be extended to include recovery operations. Exercising also demonstrates the EAP's effectiveness in an actual situation and demonstrates the readiness levels of key personnel. Periodic exercises result in an improved EAP as lessons learned are incorporated into the updated EAP document. Teesta-V Power Station includes State, local and tribal emergency authorities in exercise activities. This includes, but is not limited to, entities listed on the Notification Flowchart. To facilitate the participation of emergency management authorities, dam safety exercises also can be coordinated with, or integrated into, other event exercise scenarios for earthquakes, floods, hurricanes, and other hazards.

Discussion-based Exercises

Discussion-based exercises familiarize participants with current plans, policies, agreements, and procedures, or may be used to develop new plans, policies, agreements, and procedures. The following are types of discussion-based exercises:

- ***Seminar.*** A seminar is an informal discussion designed to orient participants to new or updated plans, policies, or procedures (e.g., a seminar to review a new Evacuation Standard Operating Procedure). Seminars should include internal discussions as well as coordination with emergency management authorities and other organizations with a role in EAP implementation.
- ***Workshop.*** A workshop resembles a seminar but is used to build specific products such as a draft plan or policy. For example, a Training and Exercise Plan Workshop is used to develop a Multi-Year Training and Exercise Plan.
- ***Tabletop Exercise.*** A tabletop exercise involves key personnel discussing simulated scenarios in an informal setting. Tabletop exercises can be used to assess plans, policies, and procedures.
- ***Games.*** A game is a simulation of operations that often involves two or more teams, usually in a competitive environment, using rules, data, and procedures designed to depict an actual or assumed real-life situation.

Operations-based Exercises

Operations-based exercises validate plans, policies, agreements and procedures; clarify roles and responsibilities; and identify resource gaps in an operational environment. Types of operations-based exercises are:

- ***Drill.*** A drill is a coordinated, supervised activity usually employed to test a single operation or function within a single entity, such as testing sirens and warning systems, calling suppliers, checking material on hand, and conducting a call-down drill of those listed on the Notification Flowchart.
- ***Functional Exercise.*** A functional exercise examines and/or validates the coordination, command, and control between various multi-agency coordination centers, such as Emergency Operation Centers (EOCs) and Joint Field Offices. A functional exercise does not involve any "boots on the ground" such as first responders or emergency officials responding to an incident in real time.
- ***Full-Scale Exercises.*** A full-scale exercise is a multi-agency, multi-jurisdictional, multi-discipline exercise involving functional (e.g., Joint Field Office, EOC, "boots on the ground" response to a simulated event, such as activation of the EOC and role-playing to simulate an actual dam failure).

Functional and full-scale exercises are considered comprehensive exercises that provide the necessary verification, training, and practice to improve the EAP and the operational readiness and coordination efforts of all parties responsible for responding to emergencies at a dam. The basic difference between these two exercise types is that a full-scale exercise involves actual field movement and mobilization; in a functional exercise, field activity is simulated. The primary objectives of a comprehensive exercise (functional and full-scale) are listed below:

- Reveal the strengths and weaknesses of the EAP, including specified internal actions, external notification procedures, and adequacy of other information, such as inundation maps.
- Reveal deficiencies in resources and information available to the dam owner and emergency management authorities.
- Improve coordination efforts between the dam owner and emergency management authorities. Close coordination and cooperation among all responsible parties is vital for a successful response to an actual emergency.
- Clarify the roles and responsibilities of the dam owner and emergency management authorities.
- Improve individual performance of the people who respond to the dam failure or other emergency conditions.
- Gain public recognition of the EAP.

Frequency of Exercises

The seminar, drill, tabletop exercise, and functional exercise have received the most emphasis in an EAP exercise program. The following are recommended frequencies for these exercise types.

Teesta-V Power Station, in consultation with emergency management authorities, has determined actual frequencies appropriate for the dam.

- Seminars with primary emergency management authorities – annually
- Drills to test the Notification Flowchart and emergency equipment/procedures – annually
- Tabletop exercise – every 3 to 4 years or before functional exercises
- Functional exercise – every 5 years

A full-scale exercise should be considered when there is a need to evaluate actual field movement and deployment. When a full-scale exercise is conducted, safety is a major concern because of the extensive field activity. If a dam owner has the capability to conduct a full-scale exercise, a commitment should be made to schedule and conduct the entire series of exercises listed above before conducting the full-scale exercise. At least one functional exercise should be conducted before conducting a full-scale exercise. Functional and full-scale exercises also should be coordinated with other scheduled exercises, whenever possible, to share emergency management resources and reduce costs.

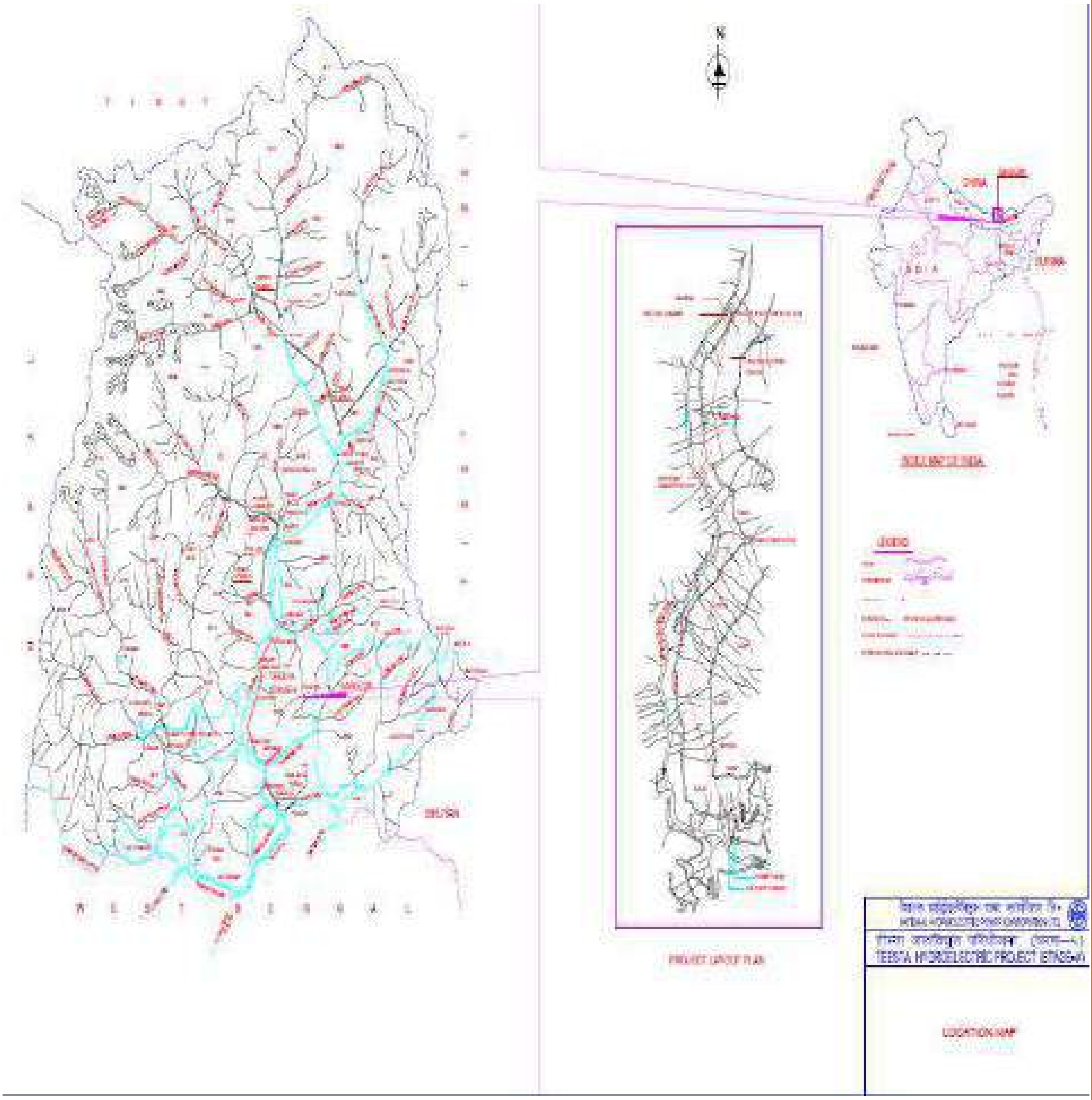
Evaluation of Exercises

Emergency exercises and equipment tests should be evaluated orally and in writing. Immediately after an exercise or actual emergency, an after-action review should be conducted with all involved parties to identify strengths and deficiencies in the EAP. The after-action review should focus on procedures and other information in the EAP, such as outdated telephone numbers on the Notification Flowchart, inundation maps with inaccurate information, and problems with procedures, priorities, assigned responsibilities, materials, equipment, and staff levels. The after-action review also should address the procedures that worked well and the procedures that did not work so well. Responses from all participants involved in the exercise should be considered. The after-action review should discuss and evaluate the events before, during, and after the exercise or actual emergency; actions taken by each participant; the time required to become aware of an emergency and to implement the EAP; and improvements for future emergencies.

After the after-action review has been completed, the EAP should be revised, as appropriate, and the revisions disseminated to all involved parties.

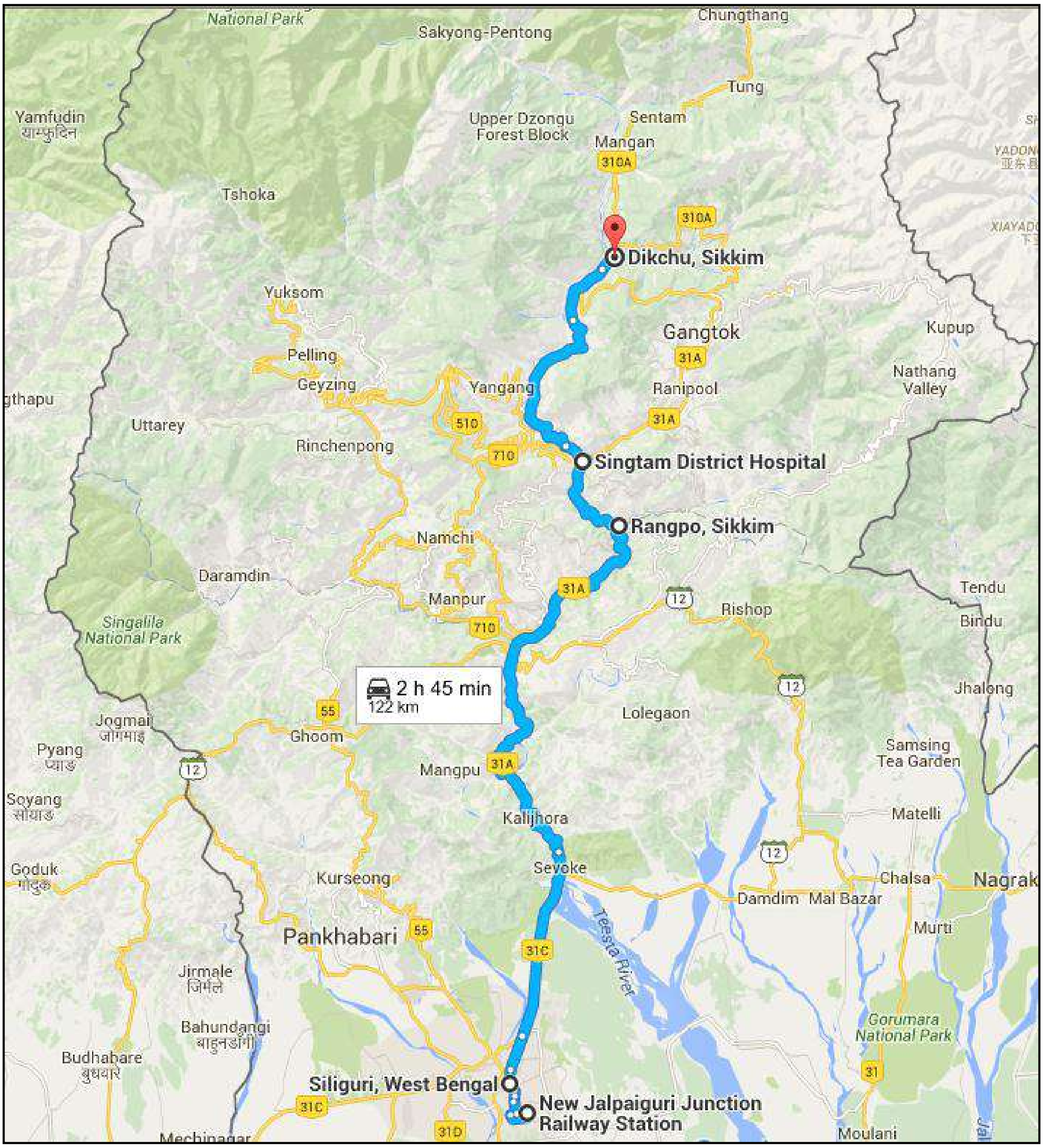
Annexure – A

LOCATION MAP OF TEESTA-V POWER STATION



Annexure – B

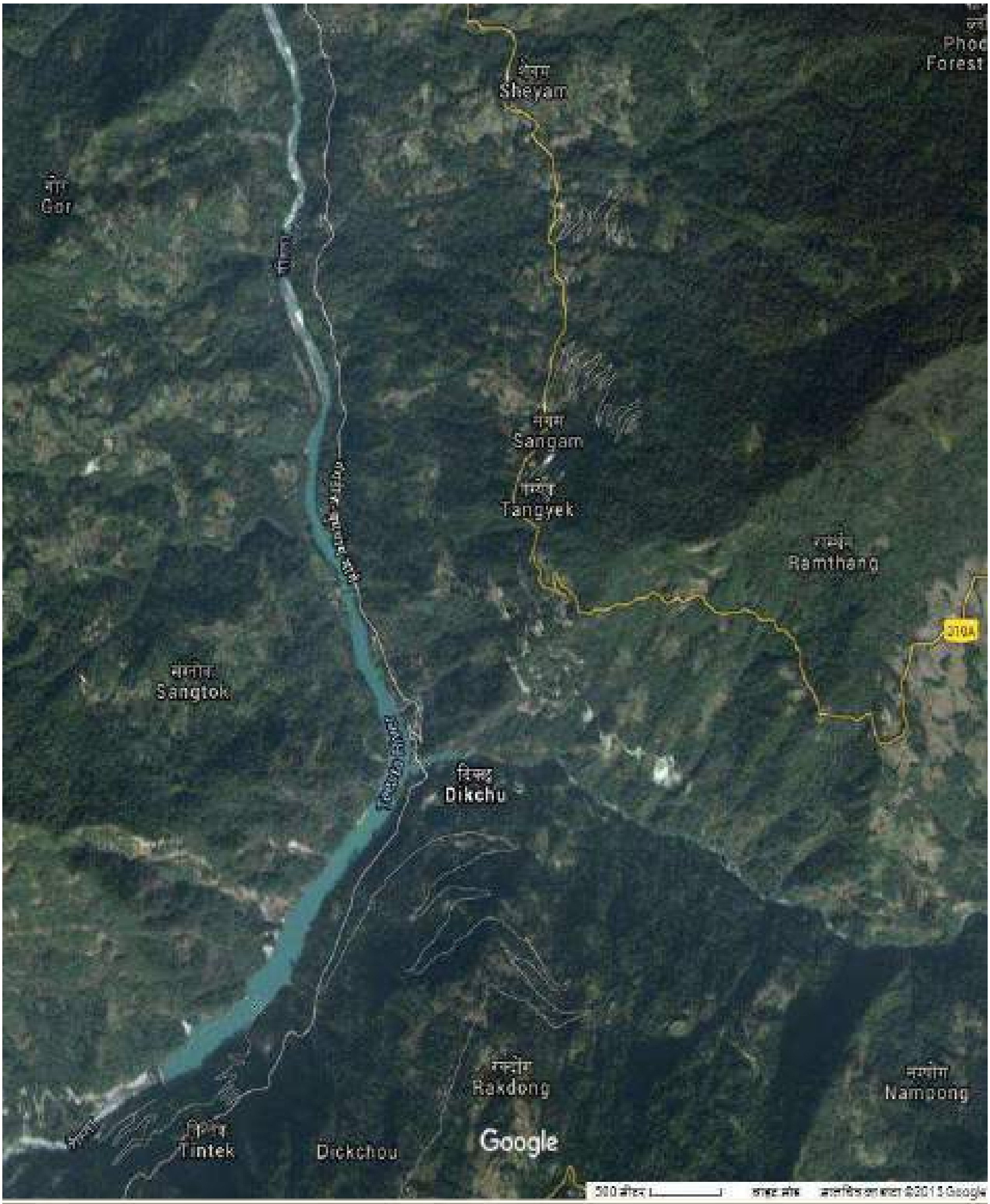
ROUTE CONNECTING TEESTA-V POWER STATION



- ➢ Nearest rail head at Siliguri/ New Jalapiguri (WB)– 110km/ 120 Kms connected by road (NH-31A)
- ➢ Nearest airport at Bagdogra, Siliguri – 125 Kms connected by NH-31A and NH-31

ANNEXURE-C

TEESTA-V RESERVOIR MAP (Curtsey: Google Inc.)

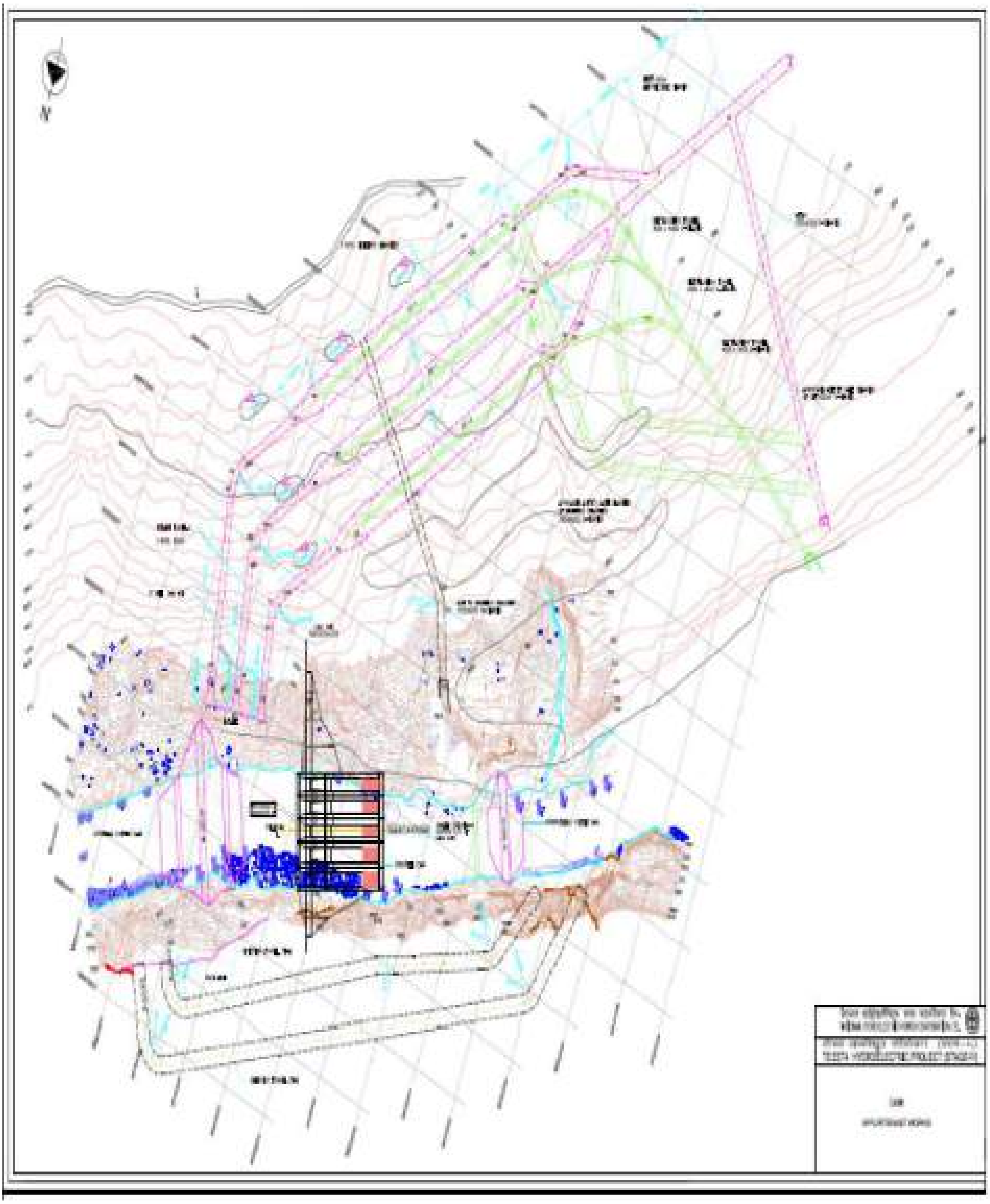


ANNEXURE-D

TEESTA-V DAM (Curtsey: Google Inc.)

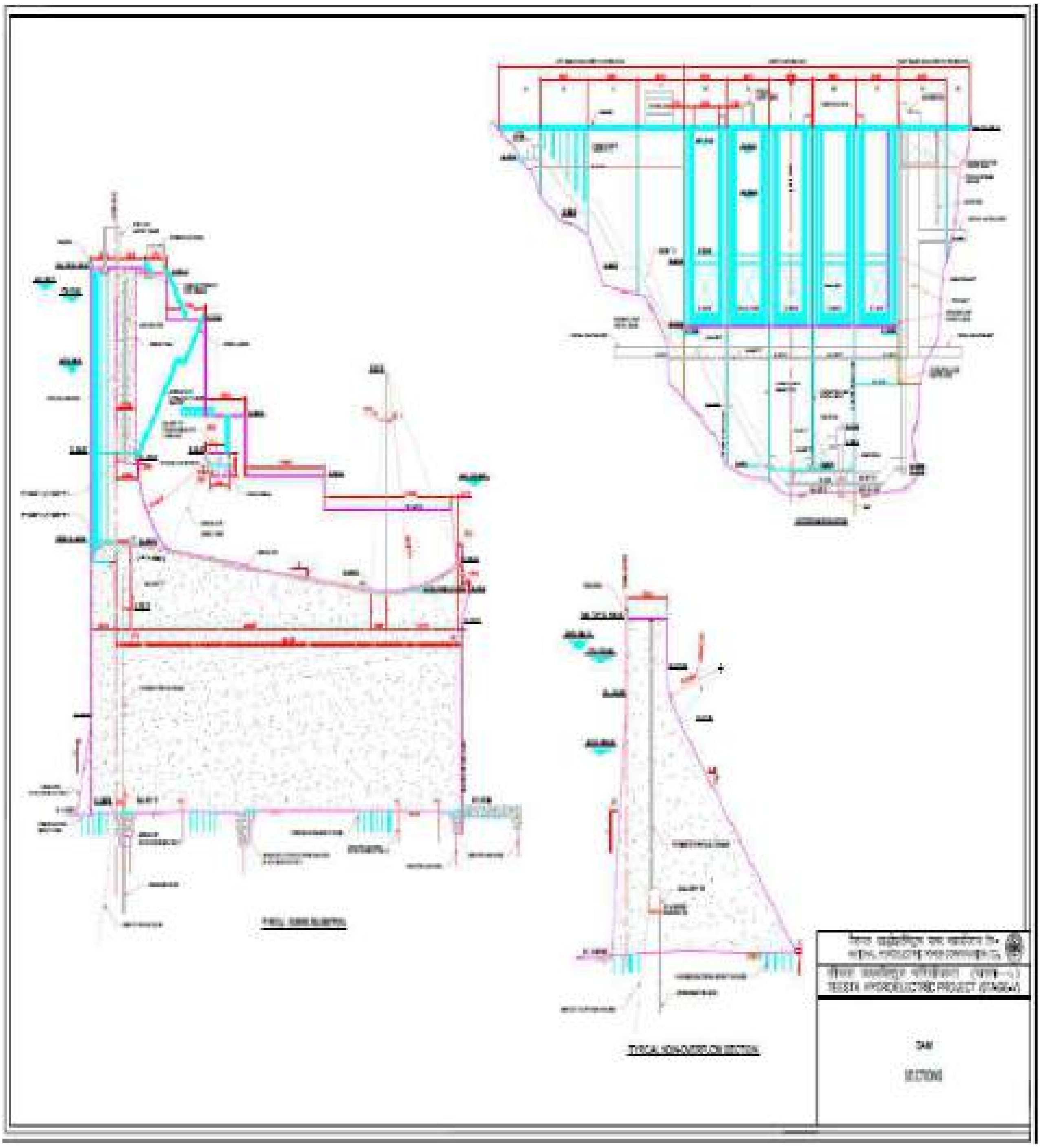
Annexure - E

<u>Dam area – Layout Plan</u>



Annexure - F

Concrete Dam -Typical Section

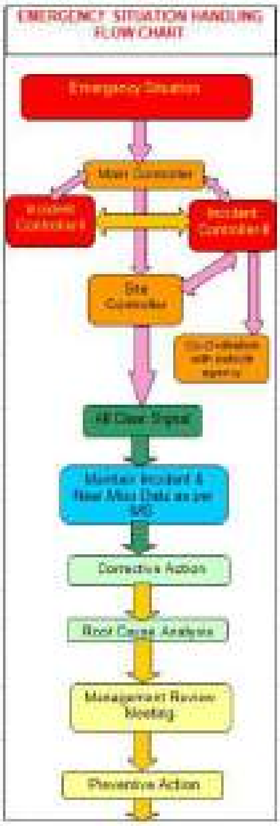


Annexure –G

NHPC Limited Teesta Power Station-V

Emergency Preparedness Plan

Sl No	Potential Emergency Situation	Main Controller	Site Controller	Incident Controller-I	Incident Controller-II	Frequency of Mock Drill	Min Resources Required / Preventive Measures
1	Fire at Vital Installation & Explosion in Pressure Vessels	Chief General Manager/ GM(Incharge)	Respective GM	Respective DGM/GM	Safety Officer	Bi-monthly	Fire Tenders , Fire Extinguishers, Fire Hydrant , Emulsifire System etc.
2	Spillage/Leakage of Hazardous Waste / Explosive Items	Respective General Manager	Respective Sr. Manager / Manager	Respective Mgr / DM	Respective Mgr / DM	NA	Capacity to Store Spillage of Hazardous Waste
3	Explosion of Gas Cylinders	Chief General Manager/ GM(Incharge)	Respective GM	Respective DGM/Sr. Manager	Safety Officer	NA	Hydrostatic Testing of Pressure vessels
4	Flood at Vital Installtion	Chief General Manager/ GM(In charge)	Respective GM	Respective Sr. Manager	Respective Sr.Manager/ Manager	Yearly	Dewatering Pumps, Boats , Life Jacket
5	Failure of Backup Power	Respective Sr.Manager / Manager	Respective Sr. Mgr / DM	Respective AM/Engineer / AE	Respective AM/Engineer /AE	Bi-monthly	Standy by DG Set , UPS , Battery Bank
6	Electrocution	Respective Sr.Manager / Manager	RespectiveSr. Mgr / DM	Respective AM/Engineer / AE	Respective AM/Engineer / AE	Half Yearly	Trained first Aiders , Stretcher
7	Loss of Ventilation	Sr.Manager / Manager	Sr.Mgr / DM	AM/Engineer / AE	AM/Engineer / AE	NA	Oxygen Level Detector
8	Blockade of approach Road of Power House & Dam due to Land Slide	General Manager (E)	Respective Sr.Mgr/ Mgr/ Dy. Mgr	Respective AM/Engineer / Junior Engineer	Respective AM/Engineer / Junior Engineer	NA	Availability of HEM Equipments
9	Accident of the Vehicle	Respective General Manager	Sr. Manager (SMD)	Mgr / DM	Safety Officer	Half Yearly	Availability of Recovery Van
10	Failure of Boat Engine/ Drowning of Boat	HoD-Dam /HMD	Mgr / DM	Mgr / DM	AM/Engineer / AE	Half Yearly	Life Jackets , Mobile Set or Walky Talky
11	Earthquake	Chief General Manager/ GM(Incharge)	Respective Sr. Mgr / Manager	SM (HR)	Safety Officer	Once a year	Monitor Situation Control Supply/ Distribution
12	Bomb Threat / Terrorist Attack	Chief General Manager/ GM(Incharge)	Inspector IRB	Respective Manager	Asst Commandant IRB	Monthly	CISF Battalion and Civil Administration



Important :

1. Follow Emergency Preparedness Flow Chart for handling any Emergency Situation.
2. If the Incident Controller II and Site Controller is of the same rank then senior executive will act as Incident Controller I.
3. Fire Control Room, headed by Safety Officer must have trained fireman, Fire Tender and necessary equipments.
4. First Aid Box are required for those sites where 100 Employees working.
5. Frequency of mockdrill as mentioned above are for entire power station. HOD will have to conduct mockdrill of emergency situations within 7 days of notification communicated .
6. The reports of mockdrill should be communicated to MR IMS with in 7 days after conducting of mockdrill.

Annexure – H(Chart-1)

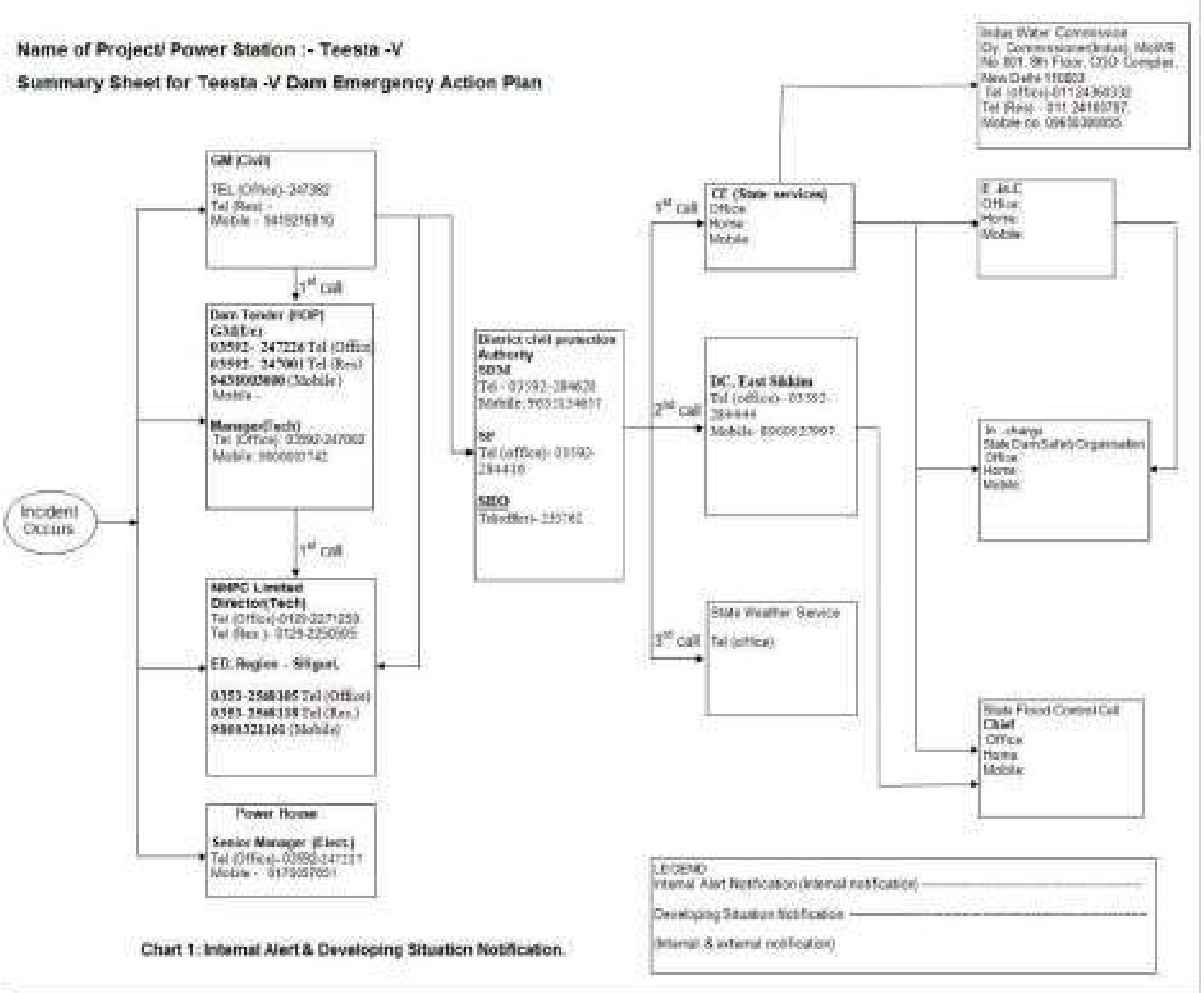


Chart 1: Internal Alert & Developing Situation Notification.

Annexure – H(Chart-2)

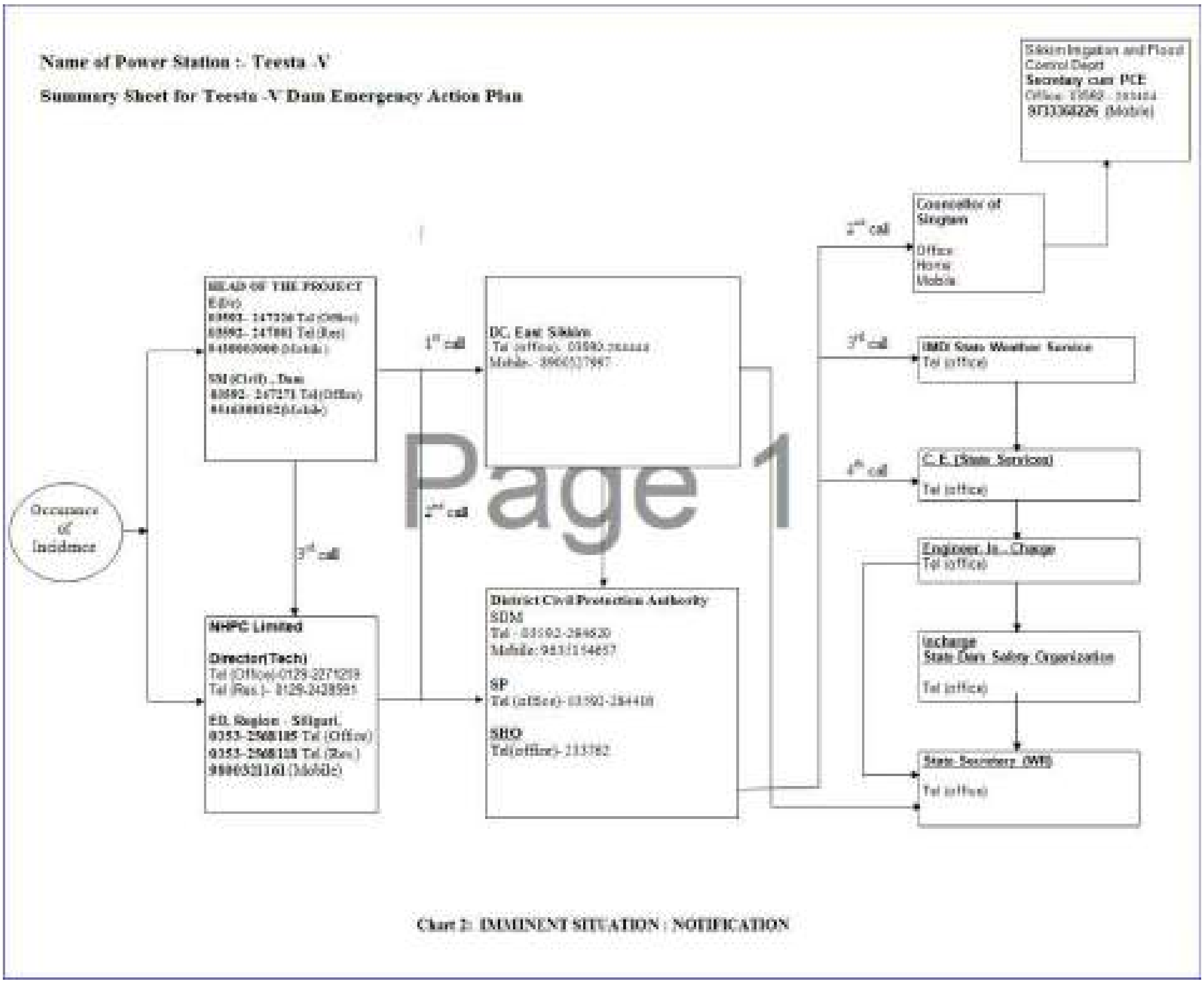


Chart 2: IMMINENT SITUATION : NOTIFICATION

Annexure - I

CONTACT NUMBERS OF NHPC KEY PERSONNEL & OTHER ORGANISATIONS

PART-A: Teesta-V Power Station, NHPC Limited

Sl.	Name / Designation	Intercom		Landline		Mobile No.
		Off	Res	Off	Res	
1	General Manager (I/c)	201	301	247226 247001		9419037195
2	General Manager (C)	220	320	247382		9419216810
3	Chief Medical Officer	310	710	247421 247446		9800055813
4	General Manager (E)	240	340	247401		9596330077
5	Dy. General Manager (HR), HR	280	380	247214		9774857977
6	Dy. General Manager (E), Procurement	270	370	247349		8945532333
7	Dy. General Manager (Finance)	260	360	247225		9800372881
8	Sr. Manager(M), Contract & HM	227	327			9932199991
9	Sr. Manager(E), PH	205	305			8170057851
10	D.C.M.O./ MO, Project Medical Services	311	711			8116949657
11	Sr. Manager (E), Safety	252	352			9800003742
12	Sr. Manager (C), Dam Civil	223	323			9546308102
13	Sr. Manager (E), EMD	242				9800848006
14	Sr. Manager (M), Mechanical	294	394			9933005795
15	Inspector IRB	470		247286		8145492874

Part-B: Important Numbers-Control Rooms/ Check points (Teesta-V PS)

1.	Emergency Control Room Admin. Gate (Security)	464		
2.	Hospital Emergency Room	333		9800003802
3.	Power House Control Room	400		9800003801
4.	66kV/ 11kV Substation	459		
5.	Dam Control Room			9800003701
6.	Fire Station Control Room	444	247005	
7.	IRB Check post (Dam site)			9800003543
8.	IRB Check post (PH Site)	462		9800003541
9.	IRB Check post-Main Gate (HQ)	222		9800003542
10.	Kendriya Vidyalaya, Balutar, Singtam	451	247282	

Part-C: NHPC Key Officials – Corporate Office and Other Projects

Sl.	Designation	Office	Residence	Mobile
1.	Director (Tech.) NHPC Faridabad	0129-2271259	0129-2428591 (R)	9958819003
2.	Executive Director Region - Siliguri	0353-2568105	0353-2568118 (R)	9800321161
3.	Executive Director-(Safety)	0129-2250846		9816534699
4.	Executive Director-(Security)	0129- 2278410	0129-2437648 (R)	8811072003
5.	Generation Monitoring Centre, O&M Div., C.O., Faridabad	0129-2250846		9816534699
6.	GM, Medical Services, C.O. Faridabad	0129-2250385		9810744010
7.	CGM/ GM (I/c), TLDP-III	03552-261018 (O)/ 261007 (Fax)	03552-261001 (R)	9818737410
8.	CGM/ GM(I/c), TLDP-IV	03552-279215 (O)/ 279252 (fax)	0353-2568636 (R)	9002091260
9.	CGM/ GM (I/c), Teesta-IV HE Project	03592-247219(o)/ 247267 (fax)	03592-247221 (R)	9800042355
10.	CGM/ GM (I/c), Rangit Power Station	03595-259510 (O)/ 2596639 (fax)	03595-259554 (R)	9438003000
11.	HOD, PID (Siliguri)	0353-2776432 (O)		
12.	HOP, Teesta Investigation Unit (TLDP-V, Rangit-II etc)			9800893028

Annexure - J

PART: A (LAW ENFORCEMENT OFFICIALS/ AGENCIES OF SIKKIM & WEST BENGAL)

		Office	Residence	Mobile
State Headquarter (Gangtok)				
1.	PCCF cum Secretary (Power), Govt. of Sikkim	202244	284228	9434084228
2.	Secretary, Irrigation & Flood Control Department	203404	203404	9434714441
3.	MD, Sikkim Power Dev. Corporation Ltd., Gangtok			
4.	DIGP- Police Intelligence, Gangtok	202747	284655	
5.	IGP/ DIGP- Police Control, Gangtok			
6.	SP- Traffic Control	234272 284180		
7.	State NDRF Unit, Gangtok	205314 202432		
8.	IRB Headquarter, Gangtok	237382		
9.	Civil Surgeon, Civil Hospital, Gangtok	202059 202944		
10.	Hospital, Sikkim Manipal Medical College, Gangtok	270389		
North District:				
11.	DC- North Sikkim	234856	234243	8116012999
12.	SDM- Mangan	234204	234205	9800237313
13.	SP- North District	234242	234185	
14.	SHO. Police Station Mangan	234246		
15.	SHO, PS- Dikchu			
16.	SHO, Makha Outpost			9609109630
17.	District Civil Hospital, Mangan	234244 234277		
18.	District Home guards	202371		
19.	Fire Control Room	234266		
20.	AE, local Sub-Station (power supply)			
21.	Gaon Budha - Concerned Panchayat			
22.	ASM- Concerned Anchal & Village			

East District:				
23.	DC- East Sikkim	284222		9434741997
24.	SDM- Gangtok	284620		9434084050
25.	SP, East Sikkim	284456		9434103263
26.	SHO, PS-Singtam	233762		8145892440
27.	SHO, PS-Rangpo	240835		8670615497
28.	District Home guards	202371		9434241414
29.	Fire Control Room	101, 202001		
30.	MO, Civil Hospital, Singtam	233757		9434178992
31.	AE, local Sub-Station (power supply)Singtam	233868		9434164405
32.	Gaon Budha - Concerned Panchayat			
33.	ASM- Concerned Anchal & Village			
South District:				
34.	DC- South Sikkim	263734		9434444222
35.	SDM- Namchi	264734		9563621382
36.	SP, South Sikkim	264630 263726	202681	7547965002
37.	SHO, PS-Melli	248203		
38.	District Home guards			
39.	Fire Control Room	263888		
40.	Civil Hospital, Melli	270245		
41.	AE, local Sub-Station (power supply)			
42.	Gaon Budha - Concerned Panchayat			
43.	ASM- Concerned Anchal & Village			
West Bengal:				
44.	DC- Darjeeling (WB)	0354-2254233 0354-2256201		
45.	DC- Jalpaiguri (WB)	03561-230127 03561-224811		
46.	SP, Darjeeling (WB)	0354-2257001		
47.	SP, Jalpaiguri (WB)	03561-230492		

PART: B (UPSTREAM AND DOWNSTREAM DAM OPERATORS/OWNERS)

Designation, Address & Email ID	Contact No.	Mobile No.
TEESTA-III HE PROJECT (OWNER-M/s TEESTA URJA LIMITED)		
HOP, Teesta-III H E Project	03592281081/ 281044	
Site Incharge- PH Site (Mangan)		
Site Incharge -Dam Site (Yumthang)		
Safety Officer		
TEESTA-VI HE PROJECT (OWNER-M/s LANCO INFRATECH LIMITED)		
HOP, Teesta-VI H E Project	03592284263	
Site Incharge- PH Site (Mangan)	03592246172	
Site Incharge -Dam Site (Yumthang)		
Safety Officer		
TLDP-III POWER STATION, RAMBI		
General Manager/HOP	261001,261002	9810893838
Risk Manager		
Safety Officer		9748304917
PH Control Room	261033	9933355186
Dam Control Room	261013	9933355187
TLDP-IV H.E. Project, KALIJHORA		
General Manager/ HOP		9002091260
Risk Manager		
Safety Officer		9999274063
PH Control Room		8945532608
Dam Control Room		9002090842

PART: C (OTHER CENTRAL/STATE AGENCIES, NEWS MEDIA ETC.)

Designation, Address & Email ID	Contact No.	Mobile No.
CWC, Siliguri Office	0353-2540262	
CWC, Gangtok Office	03592-231128	
BRO office, TF/RCC (local) Project Swastik	201218	
SSB, Singtam		
NDRF Team (Delhi Control Unit)	011-23092923	
CISF, Darjeeling Unit		8170019520
CRPF, Gangtok Unit		
Aakashvani, Gangtok	202636	
Local Print Media, Gangtok office		
Local AV Media, Gangtok office		
PTI, Gangtok Office		

Note: Information of this annexure will be updated by Sr. Manager (HR) time to time and to be displayed at pre identified places.

Annexure - K

PROJECT TASK FORCE

Sl . NO.	Name, Designation & Department	Landline	Intercom	Mobile No.
1.	Chairman/ HOP	247226 247001	201 301	9438003000
2.	General Manager(C)	247382	220	9419216810
3.	Chief Medical Officer	247421 247446	310 710	9800055813
4.	General Manager (E)	247401	240 340	9596330077
5.	Sr. Manager (E), IMS, Safety officer		252 352	9800003742
6.	Chief General Manager, (HR)	247214	280 380	9774857977
7.	Sr. Manager, (E) Power House	247262	205 305	8170057851
8.	SM/ Manager (C) Dam & Reservoir		223 323	9546308102
9.	Sr. Manager (M), Dam, HM		227 354	7978438987
10.	Sr. Manager (M),PH EM Works		416 516	9800003932
11.	Chief General Manager (Fin)	247225	260 360	9800372881
12.	D.C.M.O. Medical Services		311 711	8116949657
13.	Inspector/ IRB	247286	470	8145492874

Annexure - L1

LIST OF MATERIAL, LOCATION AND SOURCE

Sl. No.	Repair Material	Location	Source	Remarks
1	Cement	Siliguri	1. M/s S.K.Enterprises	
		Singtam	2. M/s Pankaj Agarwal	
2	River Sand	Rangpo/Makha/Manglay	1. M/s C.B.Chettri 2. M/s Naresh Chettri	
3	Pakur Sand	Pakur/Siliguri	M/s S.N.Marketting	
4	Coarse Aggregate	Pakur/Chipsu Khola,Dobari	1.M/s S.N.Marketting 2.M/s Dobari Stone Crystal Industry	
5	Admixtures	Siliguri	M/s Balaji Distributors	
6	Reinforcement Steel	Siliguri/Singtam	1. M/s S.K.Enterprises 2. M/s Pankaj Agarwal	
7	POL	Singtam	M/s Shiva Highway Enterprises	
		Near Sirwani Bridge, Yangang Pathing, South Sikkim	M/s Pathibara H.P.Pump, Near Sirwani Bridge, South Sikkim.	
8	Ready Mix Concrete	Sonarpur, WB	M/s ACC Limited	
9	HSD Bulk Supply	IOCL	Rangpo Depot,P.O.-Rangpo, East Sikkim	
10	Wires and Cables	Siliguri,Singtam	(i) M/s Poddar & Sons (ii) M/s Anil Traders	
11	Pumps & Motors, Generators	Siliguri	(i) M/s S.N.Marketing (ii) M/s Gajnan Goyal	
12	Overhead line items	Siliguri	(i) M/s Poddar & Sons (ii) M/s Anil Traders	
13	Electrical Consumables	Siliguri,Gangtok,Singtam	(i) M/s Poddar & Sons (ii) M/s Anil Traders	
14	POL	Singtam, Siliguri	(i) M/s Shiva Highway Enterprises (ii) M/s IOC	
15	Medicines Purchasing	Hill Cart Road, Siliguri, Joydeep Building	M/s City Drugs	
		Agrasen Road, Siliguri	M/s S.S.Drugs & Distributors	
		Matigraha, Paul Para, Siliguri	M/s Paul Brothers	
		Metro Point Gangtok, Sikkim	M/s Sikkim Medicine Mart	
16	Oxygen Concentrator,Nebulizer,Weighing Machine,Suction Machine and fumigator	Sevoke Road, 1st floor, Siliguri	M/s Basant Distributors	
17	Pulse oxy meter,Digital Weighing Machine, ECG Machine,Wheel Chair	Ground Floor,Sri Kunj,Radha Bazar,Kalabati Road, Khalpara, siliguri	M/s Sarowar Surgi Co.	

Annexure L2

LIST OF MATERIAL SUPPLIERS, ADDRESSES AND CONTACT NOS.

Sl. No.	Name of Supplier	Address	Contact No.	
			Landline	Mobile
1	M/s S.N.Marketing	Sevoke Road, Siliguri	2777764/ 2640900	9434050102
2	M/s C.B.Chettri	Singbel, East Sikkim	-	9800856214
3	M/s Pankaj Agarwal	Singtam, East Sikkim	235213	9832377934
4	M/s Shiva Highway Enterprises	Singtam, East Sikkim	233828	-
5	M/s Balaji Distributors	43, Pranami Mandir Road, Siliguri	266474	9800023432
6	M/s Naresh Chettri	Dikchu,East Sikkim	245691	9733293440
7	M/s S.K.Enterprises	Singtam, East Sikkim	-	-
8	M/s ACC Limited	Sonarpur, WB	24349907	9674168687
9	M/s Garuda Power Pvt. Ltd	Trading Account Branch Office, Alakananda,16, Devi Chowdhurani sarani, Millanpally, Siliguri-734001(WB)	3532504133	
10	M/s Aqua Machineries Pvt. Ltd., (Flood Dewatering Pump motor)	Plot No.-3821, GIDC,Phase-IV,Varva, Ahmedabad-382445, Gujarat	079-25840954, 25840145,25840915,25840240	
11	M/s Grundfos (drainage & Dewatering Pump)	Grundfos Pumps India Pvt Ltd., 118, Old Mahabalipuram Road, Thoraipakkam, Chennai-600096	044-45966800	
12	M/s B C Technomation Pvt Ltd., (Submerseable Dewatering Pumps)	M/s B C technomation Pvt Ltd, Plot No.-13, sec-A, Industrial Area, Govindpura, Bhopal-462023(MP)		
13	M/s Pathibara H.P.Pump	Near Sirwani Bridge, South Sikkim		9475080472
14	IOCL	Rangpo Depot P.O.-Rangpo, East Sikkim-737136		9434709268
15	M/s Gajran Goyal & CO	Sevoke Road, Siliguri	0353-2430269	
16	M/s Anil Traders	Sevoke Road, Siliguri	0353-2538969	
17	M/s Poddar & Sons	Sevoke Road, Siliguri	0353-2777437	
18	M/s Pankaj Agarwal	Singtam		9002487391 9832377934
19	M/s Bengal Trading Co.	Sevoke Road, Siliguri	0353-2431314	
20	M/s Excel Marketing Siliguri	Sevoke Road, Siliguri	0353-2522445	9832078667
21	M/s Sarowar Surgi Co.	Ground Floor,Sri Kunj,Radha Bazar,Kalahati Road, Khalpara, Siliguri		9830780009
22	M/s City Drugs	Hill Cart Road, Siliguri, Jaydeep Building		9474873412
23	M/s S.S.Drugs & Distributors	Agrasen Road, Siliguri		9733303304
24	M/s Paul Brothers	Matigraha, Paul Para, Siliguri		9832506211
25	M/s Sikkim Medicine Mart	Metro Point Gangtok, Sikkim		9434131390/9474525572
26	M/s Basant Distributors	Sevoke Road, 1st floor, Siliguri	0353-2432062	

Annexure-L3

List of equipments, its location.

Sl. No.	EQUIPMENT	Model	Quantity	LOCATION
1	FIRE TENDER	Ashok Leyland	01	Balutar
2	AMBULANCE	SML 48 TCD	02	Balutar/ Dam Site
3	TATA BUS	TATA	06	Balutar/ Dam site
4	CAT WHEEL DOZER	CAT 814 F	01	Balutar
5	DOZER	BEML BD 50	01	Balutar
6	ACE CRANE 10T	RHINO 110C	01	Balutar
7	TATA BACKHOE LOADER	JD 315 SE	01	Balutar
8	JCB LOADER	430 ZX	01	Balutar
9	CHICAGO PNEUMATIC DIESEL AIR COMPRESSOR	CP-425 CFM	01	Balutar
10	40T CRANE	ESCORT RT-40	01	Balutar
11	FORK LIFTER	CAP-8T	01	Balutar
12	Tractor	Escort	01	Balutar
13	Pick up Van	TATA 407	01	Balutar
14	TATA truck	TATA	02	Balutar
15	TATA tripper	TATA	02	Balutar
16	Water Tanker	TATA SF 1613	02	Balutar
18	Search Light (Chargable)			E/Store, EMD Division

LIST OF CONTRACTORS, ADDRESSES AND CONTACT NOS.

Annexure L4

Sl. No.	Name of Contractor	Address	Contact No.	
			Landline	Mobile
1	M/s Samallal & Brothers	2nd Floor, Radha Apartment, ISKON Mandir Road, Siliguri	2777881	9434012717
2	M/s S. N Marketting	Sevoke Road, Siliguri	2777764/ 2640900	9434050102
3	M/s C.B.Chettri	Singbel, East Sikkim	-	9800856214
4	M/s Naresh Chettri	Dikchu,East Sikkim	245691	9733293440
5	M/s Kajal Das	Singtam, East Sikkim	-	8670138996
6	M/s T.G. Lepcha	Lum, South Sikkim	-	9800215041
7	M/s B.K.Pandey	Singbel, East Sikkim	-	9800846363
8	M/s Singbel GPU Construction Co-operative Society Ltd (R&M) of Electrical system	Dipudara,Khamdong,East Sikkim	03592-233065	08116771703 09593280603
9	M/s Subash Khandal	Samdong, East Sikkim	-	9733209495
10	M/sSadhana Tamang	Singtam, East Sikkim	-	9733449347
11	M/s Samirul Alam	Singtam	-	9593261116
12	M/s GPO Singbel	Singbel	-	9800846363
13	M/s C.B.Gurung	Bakstar	-	9593772103
14	M/s Phal Man Kami	Samdong	-	9800196901
15	M/s Sushil Kumar Prasad	Singtam, East Sikkim	-	9434141159
16	M/s Mangal Singh Subba	San Sakyang Busta, East Sikkim	-	9647855733
17	M/s S.B.Tamang	Dipudara, East Sikkim	-	9800722443
18	M/s Chandranshu Construction	Samdong, East Sikkim	-	9563679344
19	M/s Tej Mani Pradhan	Serwani, East Sikkim	-	9734961740
20	M/s A.M.Construction	Siliguri	-	9832356532
21	M/s Tara Sharma	Gangtok	-	9434407529
22	M/s Sriniwas Agrawal	Siliguri	0353-2530254	9434057309
23	M/s Multitech Engineers	New Delhi	011-22734410	8527552322
24	M/s Thyssenkrupp Elevator(India) Pvt. Ltd.	Tadong, Gangtok-737102	3371739000	9836112044
25	M/s Anod Plasma Spray Ltd.	Kanpur, U.P.	-	5122691553
26	M/s Industrial Processors & Metalizers(P) Ltd.	Delhi	1127442472	
27	M/s Johnson Controls(I) Pvt. Ltd	Saltlake, Kolkata	3366071700	
28	M/s Vee Kay Engineers	Kanpur, U.P.	-	9307701035
29	M/s Deys Engineering Works	Kolkata	3324252429	9433153746
30	M/s Monarch Industrial Products (I) Pvt. Ltd	Theni, Tamilnadu	-	9600952069
31	M/s Mechanical Solutions	Bhatinda, Punjab	-	9876096950
32	M/s S.K Sales	Jalandhar, Punjab	-	9815431020
33	M/s Fibcotech	Meerut Cant, U.P.	0121-2668135	9759011010
34	M/s Purvanchal Engineering Projects	Bhopal	-	7504284292/9039700000
35	M/s Hydro Megas Pvt. Ltd.	Noida (UP)	0120-4622555	
36	M/s Gardener Denver Engineered Products India Pvt. Ltd., Plot No.-878,Opp-Gallops Industrial Park, Ahmadabad, Gujrat-382220	Plot No.-878,Opp-Gallops Industrial Park, Ahmadabad, Gujrat-382220	022-60984222	
37	M/s Encardio-Rite Electronics Pvt. Ltd.	Lucknow (UP)	-	9874988688
38	M/s Institution of Fire Engineers(India)	719,Jaina Tower-1, 7th floor, District Centre, Janakpuri, New Delhi-110058	011-41062025	
39	M/s Techno Fire Consultants	plot No.5,Syedjalal Garden,West Marredpally, Secundrabad-5000026	27808488	9391019323
40	M/s The Centre for Safety Management	Anandam NTPC Housing Society SB-184,Plot-3,Sector P-6 Builders Area, Greater Noida (UP)	-	9650992726
41	M/s Ellen Technologies & Consulting Pvt Ltd	205, 2nd floor, Vardhman Chamber-1, Commercial Complex, G-Block, Vikaspuri, New Delhi	011-28541888	
42	M/s Geeta Kumari Pradhan	Singtam, East Sikkim		9609927762
43	M/s Jamuna Gurung	Singtam, East Sikkim		8389029468

ANNEXURE - M

FORM-1

EMERGENCY EVENT / UNUSUAL OCCURRENCE REPORT

(For use when reporting emergencies or unusual occurrences other than earthquakes, oil and hazardous substance spills and bomb threats. For any of the three aforementioned emergencies, use the appropriate report form. Because this is a general form, there will be sections that do not pertain to the emergency. Only fill out those sections that are applicable to the emergency)

Date & Time: ________________ Location: ________________

Brief description of events (include caller's name and phone numbers):

Pertinent Data:

Size of affected area: ______________________________

Extent of damage: ______________________________

Effect on operations: ______________________________

Possible cause: ______________________________

Rates of discharge: ______________________________

Appearance of discharge: ______________________________

Surge shaft elevation:

Appearance of Surge shaft: ______________________________

Surge shaft rise rate: __________ Tailrace rise rate: ______

Weather conditions: ______________________________

Injuries / loss of life: ______________________________

Witness: __________________

Other: ____________________

ANNEXURE - N

F O R M 2

EARTHQUAKE DAMAGE REPORT

The Teesta-V dam (latitude: $27^{0}23'13"$N & longitude: $88^{0}30'13"$E) lies within Seismic Zone-IV where major damage can be expected from earthquakes. The dam has the possibility of being subject to moderate to severe ground shaking from nearby or, distant, moderate to large magnitude earthquakes.

Earthquake Damage Report:

Date: ___________ Time: _____________

Person Reporting Information: ____

Features Affected: ____

Description of Earthquake Effects*:

On structural conditions:

Type of damage (slides, subsidence etc.) ____

Location: ____

Severity: ____

Movement (direction, magnitude): ____

Deflection or Settlement Readings: ____

Effect on Adjoining Structures: ____

On Hydraulic Conditions: ____

Type of effect (leakage or stoppage)

Location: ____

Size of affected structure: ____

Estimated flow or change in flow: ____

Nature of discharge (including sediment): ____

Wave action damage: ____

Other: ____

Site Conditions:

Water surface elevation / stoppage: ______________________________

Location: ______________________________

Size of affected area: ______________________________

Estimated flow or change in flow: ______________________________

Nature of discharge (including sediment): ______________________________

Wave action damage: ______________________________

Other: ______________________________

Action:

Change in operation: ____

____

Emergency repairs: ____

____

Surveillance: ____

____

Regional assistance needed (examination): ______________________________

____

Public information provided: ______________________________________

____

* To facilitate analysis of conditions, a map should be prepared showing the location and extent of all damaged areas such as subsidence areas, seeped areas, springs and any other pertinent data, including the dates of readings and site conditions at the time of observation. This map should be revised periodically to show changing condition until they are stabilized.

ANNEXURE - O

FORM 3

BOMB THREAT REPORT

(Place this card under your telephone)

Question to ask:

1.	When is bomb going to explode? ----------	15	**CALLER'S VOICE**	
2.	Where is it right now? ----------------------	--------------Calm	------------- Nasal	
3.	What does it look like?	------------- Angry	--------------Stutter	
4.	What kind of packet is it?	------------Excited	--------------Lisps	
5.	What will cause it to explode?	------------- Slow	------------- Raspy	
6.	Did you place the bomb?	------------Rapid ----------------Soft ---------------Loud ----------Laughter --------------Crying -----------Normal ------------Distinct -------------Slurred	----------------Deep -------------Ragged -------------Clearing throat ------------Deep breathing ------------Cracking voice -------------Excited ------------Disguised ----------------Accent ----------------Familiar	
7.	Why?	If voice is familiar, who did it sound like?		
8.	What is your address?	16	**BACKGROUND SOUNDS**	
9.	What is your name?	-----Street noises	-----------------Factory	
10	**EXACT WORDING OF THE THREAT**	---------------Motor ----------Crockery -------------Voices --------PA system --------------Music ----House noises ------------Cellular ------------Office Machinery	-------------Machinery --------Animal noises --------------------clear --------------------static ---------------------local ---------long distance Other------------------------- -------------------------------	
	OTHER INFORMATION	17	**THREAT LANGUAGE**	
11	Sex of caller : M or F accent / race:	--Well-Spoken (educated) ----------------Foul -----------Irrational	-------------Incoherent ------------------Taped --------------Message read by threat maker	
12	Age --------- Length of call: --------------	18	**REMARKS**	
13	Number at which call is received ----------	Report call immediately to:------------------------ Phone No. ---- ----------- Date ---------------		
14	Time --------------- Date ----------------	Name : ---------- Position: ---------		

ANNEXURE-II
(DAM break analysis)

CHAPTER 1.0: INTRODUCTION

1.1 General

Dam, a very important hydraulic structure, has an economic importance in a country as it renders many benefits like supplying water for drinking, irrigation, industrial purposes, hydropower, recreational activities etc. Besides being multifunctional, it also provides safety to human lives and properties downstream by storing flood water temporarily in the reservoir and releasing it subsequently. Besides being an asset to a country, failure or collapse of a dam may lead to huge loss of human life and properties.

Dam breach may be summarized as the partial or catastrophic failure of a dam leading to uncontrolled release of water. Such an event can have a major impact on the land and communities downstream of the failed structure. A dam break may result in a flood wave up to tens of metre deep travelling along a valley at high speeds. The impact of such a wave on developed areas can be very devastating. Such destructive force causes an inevitable loss of life, if advance warning and evacuation was not possible. Additional features of such extreme flooding include movement of large amounts of sediment (mud) and debris along with the risk of distributing pollutants from any sources such as chemical works or mine workings in the flood risk area.

In spite of great advancements in design methodologies, failures of dams and water retaining structures still occur. Dam break is most likely to occur during the monsoons under the occurrence of extremely heavy storms (PMF) (when, there is hardly any storage space available in the dam). In this condition, the outflow from the dam will be combined with lateral inflows into the river from the areas downstream of the dam. The instances of dam breaks establish that hazard posed by dams, large and small alike, is catastrophic. As public awareness of these potential hazards grow and tolerance of catastrophic environmental impact and loss of life reduces, managing and minimizing the risk from individual structures has become an essential requirement, rather than the employment of a simple management plan.

There are various causes of failure of dams and each of them depends upon the type of dams. Common reasons for failure of dams are: earthquake, landslide, piping, seepage, overtopping, etc. Usually, the adjoining areas of the dams are highly fertile and cultivable leading to thick population of these areas and therefore, the safety of dams should be the very first priority. Though the probability of a dam failure, in general, is low but the consequences, e.g., high casualties, are devastating. Many case studies have resulted in two perspectives dealing with dam failure. First perspective gives answer to the question whether a dam will fail or not referring to the strength of material of which dam is built. It also deals with the breaching process of dam. Second perspective assumes a dam failure and studies its disastrous effects in the downstream areas. This leads to the preparation of the emergency action plans for dam failure.

The dam break flood resulting due to inadequate design or operational conditions or any other reasons, can cause catastrophe in regions downstream of which is densely populated and important establishments exist. The failure of a dam is carefully considered due to involvement of loss of lives and properties. Hence, dam break flood analysis has become important not only for new dams but also for reviewing the existing dams as most of these have been designed and constructed many years ago utilizing the limited historical data and the present design standards may not be met. It may be noted that dam break analyses of some of the dams have pointed out the inadequacy of their spillways capacity. A comprehensive multistage dam break flood analysis can be useful to justify the spillway design flood and to overcome unjustified public fears.

One of the preventive measures to deal with dam failure is to issue the flood warning to the people of the downstream reach. However, it is difficult to estimate the exact warning time of dam break flood at the very moment of dam break. Therefore, pre –determination of the warning time assumes various hypothetical dam break models for the safety of the dams. The final product of such hypothetical model is inundation details of downstream reach, water levels at different sections of downstream, time of reaching of the dam break flood at different sections etc.

A dam break study involves the following step:

- Identification of inflow hydrograph at the time of dam failure
- Routing the hydrograph through the channel network
- Calculating the water levels and discharge hydrograph at various sections of the downstream reach.

The popular models available for dam failure are the national weather service's DAMBRK model, one dimensional models (MIKE-11 and HEC-RAS), etc. Recently, new techniques related to remote sensing and GIS have also been successfully applied to prepare the input data for the dam break flood modelling and to prepare and visualize the flood inundation maps.

In this study, failure of dam has been considered in order to simulate the dam break flood and to study its nature and the effects in the downstream sites by using the MIKE11 software. The analysis provides the estimation of the dam break outflow hydrograph and information regarding the flood wave arrival time, flow velocity, discharge, water level etc.

1.2 Need for Dam break modelling

The first European Law on dam break was introduced in France in 1968 following the earlier Malpasset Dam failure that was responsible for more than 400 injuries. Since then many countries have also established requirements and in others, dam owners have established guidelines for assessment. In India, risk assessment and disaster management plan has been made a mandatory requirement while submitting application for environmental clearance in respect of river valley projects. Preparation of Emergency Action Plan after detailed dam break study has become a major component of dam safety programme of India.

The extreme nature of dam break floods means that flow conditions will far exceed the magnitude of most natural flood events. Under these conditions, flow will behave differently to conditions assumed for Normal River flow modelling and areas will be inundated, that are not normally considered. This makes dam break modelling a separate study for the risk management and emergency action plan.

The objective of dam break modelling or flood routing is to simulate the movement of a dam break flood wave along a valley or indeed any area ‘downstream’ that would flood as a result of dam failure. The key information required at any point of interest within this flood zone is generally:

- Time of first arrival of flood water
- Peak water level – extent of inundation
- Time of peak water level
- Depth and velocity of flood water (allowing estimation of damage potential)
- Duration of flooding

The nature, accuracy and format of information produced from a dam break analysis will be influenced by the end application of the data. For example:

Emergency Planning

To prepare a realistic emergency action plan, it will be necessary for the dam break analysis to provide:

- Inundation maps at a scale sufficient to determine the extent of and duration of flooding in relation to people at risk, properties and access routes
- Identification of structures (bridges etc.) likely to be damaged/destroyed
- Indication of main flow areas (damage potential of flow)
- Timing of the arrival and peak of the flood wave
- Identification of features likely to affect mobility / evacuation during and after the event including impact on infrastructure and the deposition and scour of debris and sediment.

Development Control

Development control will focus mainly on the extent of possible inundation resulting from different failure scenarios. Consideration may also be given to the characteristics of the population at risk.

1.3 Status of Dam Break Flood Simulation Modelling

The dam break modelling is an old problem in mathematical hydraulics and the concerned literature is extensive. The first solution was given in 1892 by Ritter, who used the method of characteristics to obtain a closed form solution for a dam of semi-infinite extent upon a horizontal bed with zero bed resistance. However, experimental and theoretical considerations showed that the solution is invalid in a region that starts near the leading edge of the flood wave and extends rapidly upstream with time, because of zero bed resistance assumption. In 1952, Dressler used a perturbation procedure to obtain a first order correction for resistance effect. Whitham obtained a second solution three years later by using a technique that was similar to the Pohlhansen method of boundary layer theory. Whitham's solution agreed with Dressler's results and he noted that his solution would not apply for large values of time since the width of the boundary layer grew very rapidly with time.

Afterwards, Sakkas and Strelkoff (1973), Chen and Armbruster (1980) have used the method of characteristics to obtain numerical solution for dam break problems on sloping beds. These solutions were for reservoirs of finite length and included the effects of bed resistance. But in almost all of these methods, it was assumed that the breach covers the entire dam and it occurs instantaneously. U.S. Army Corps of Engineers (1960) recognized the need to assume partial breaches, however, they assumed an instantaneous failure.

In 1965, Cristofano and in 1967, Harris and Wagner incorporated the partial time dependent breach formation in their models. Cheng Lung Chen (1980) developed a numerical model on the basis of an explicit scheme of the characteristic methods with specified time intervals. He also carried out some laboratory experiments for the verification of his model. Bruce Hunt (1982) used the kinematic approximation to obtain a simple, closed form solution for the failure of a dam on a dry, sloping channel. It was found that this solution becomes asymptotically valid after the flood wave has advanced about four reservoir lengths downstream. N. D. Katopodes and D. R. Schambar (1982) formulated five mathematical models based on equations ranging from the complete dynamic system to a simple normal depth kinematic wave equation. In 1984, they have presented a theory for flow through a partial dam failure. In this, the breach section is treated as an internal boundary condition that interrupts the continuous long wave occurring upstream and downstream of the dam.

The U.S. Army Corps of Engineers, HEC-1 dam break model (HEC-1, 1981) adopts storage routing techniques for routing of flood through reservoirs as well as through channels. National Weather Service (NWS) DAMBRK Model (1984) adopts dynamic routing techniques for routing of flood through channel and a choice of dynamic routing and storage routing for the reservoir, depending on the nature of flood wave movement in reservoir at the time of failure.

Singh and Snorrason (1984) carried out dam break flood studies using the above two models. They found that the flood stage profiles predicted by the NWS DAMBRK Model are smoother and more reasonable than those predicted by the HEC-1. For channels with relatively steep slopes, the methods compared fairly well, whereas for channels with mild slope, the HEC Model often predicted oscillatory, erratic flood stages, mainly due to its inability to route flood waves satisfactorily in non- prismatic channel.

Ralph A. Wurbs (1987) made a comparative evaluation of several dam break models. The models selected for comparison were : National Weather Service (NWS) Dam Break Flood Forecasting Model (DAMBRK); U.S. Army Corps of Engineers South-Western Division (SWD) Flow Simulation Models (FLOW SIM 1&2), U.S. Army Corps of Engineers Hydrologic Engineering Centre (HEC) Flood Hydrograph Package (HEC-1), Soil Conservation Service (SCS) Simplified Dam Breach Routing Procedure (TR66), NWS Simplified Dam break Flood Forecasting Models (SMPDBK), HEC dimensionless graphs procedure and the Military Hydrology Model (MILHY) developed by WES specially for military use. He concluded that a dynamic routing model should be used whenever a maximum practical level of accuracy is required and adequate man power, time and computer resources are available. According to him the NWS DAMBRK is the optimal choice of model for most practical applications.

DAMBRK model uses Saint Venant's equations for routing dam break floods in channels. For reasons of simplicity, generality, wide applicability and uncertainty in the actual failure mechanism, this model allows the failure timing interval and terminal size and shape of breach as input. It gives the extent of and the time of occurrence of flooding in the downstream valley by routing the outflow hydrograph through the valley. The dynamic wave method based on the complete equations of unsteady flow is the appropriate technique to route the dam break flood hydrograph. Terzidis and Strelkoff (1970) have demonstrated the applicability of the St.Venant's equations to simulate abrupt waves such as the dam break wave.

Gundalach and Thomas (1977) analyzed the dam break flood from Teton dam using a generalized unsteady flow computer program to determine the water surface elevations resulting from various breach sizes and roughness values (n). They found that neither the size of breaches tested (30 to 40% of the size of dam) nor the rates of failures assumed were very significant in predicting peak elevation at dam axis but the calculated peak flood elevations near the dam were very sensitive to n-values. Sakkas (1980) envisaged the development of dimensionless graphs for quick estimation of dam breach flood wave characteristics. These graphs would be useful in case when either the communication system or computation facilities are not available at the time of dam breach flood wave formation. Singh and Snorrason (1984) studied the sensitivity of outflow peaks and flood stages to the dam breach parameters. They have taken an earthen dam for the study and found that the breach outflow peaks are affected significantly by the base width of breach but less so by the water level in the reservoir at the time of breach formation. They also found that the ratio of outflow peak to inflow peak and the effect of time of failure on outflow decreases as the drainage area above the dam and impounded storage increases.

1.4 SCOPE OF THE STUDY

The scope of the present study is as follows:

1. Hydraulic model setup of river system including dam in a suitable mathematical modelling system.
2. Estimation of the failure time, terminal size and shape of the breach.
3. Simulation of dam breach and outflow flood hydrograph from the breached dam sections.

4. Simulation of the movement of the dam break flood wave in the downstream areas. Estimation of water surface profile through hydro-dynamic river flow modelling & determination of travel time, maximum water level reached, inundated areas, etc.
5. Pre-determination of the warning time of the dam break flood at the time of disaster.
6. Preparation of report as per EAP guidelines (issued by CWC) covering the following aspects:
   - (i) Methods & assumptions selected to identify the inundated areas and description of methodology & outputs of dam break modelling performed.
   - (ii) Prediction of outflow hydrograph due to dam breach for various conditions viz., PMF coupled with Dam breaks, PMF.
   - (iii) Routing of hydrograph through the d/s valley to get the maximum (safe) water levels and discharge along with time of travel at prominent locations of the river at d/s of the dam.
   - (iv) Longitudinal profile of the river up to study area for different situations, viz., PMF coupled with Dam breaks, PMF etc.
   - (v) Preparation of inundation maps under different situations viz. 100 year return flood, PMF coupled with Dam breaks and reservoir at FRL condition, PMF and 100 year return flood. Detailed inundation maps shall be prepared using high resolution DEM preferably at 10 m resolution and shall show hypothetical flood lines for all different situations, populated areas (villages/towns/cities) and roads at an acceptable scale and contour interval.

The present study for the Teesta V power station mainly comprises of:

1. Dam break takes place when the PMF impinges into the reservoir when it is at FRL and Spillway gates are fully open.
2. PMF impinges into the reservoir when it is at FRL and Spillway gates are fully open.
3. 100 year return period flood impinges into the reservoir when it is at FRL and Spillway gates are fully open.
4. Preparation of flood inundation maps and emergency action plan (EAP).

CHAPTER 2: THE STUDY AREA AND DATA AVAILABILITY

2.1 CATCHMENT DETAILS

The river Teesta is one of the main Himalayan River originating in the glaciers of Northern Sikkim at an elevation of 8500 m above mean sea level. It is being snow fed by the glacier Zemu, ChangameKhanpu, Talung etc. It is an international river which flows through the states of Sikkim and West Bengal in Indian Territory and then to Bangladesh.

The river in its longest course on Lachenchu originates as Chemuochu travelling mainly in western direction for about 17.5 Km and then takes a sharp southwards turn where after it is christened as Lachenchu. Travelling mainly in South West and then Southern direction for a distance of about 30 Km it is joined by Zemuchu on the right bank, which originates from Zemu glacier. Lachenchu traverses 15.9 Km from the confluence of Zemuchu before bieng joined by Lachung chu in the left bank just upstream of Chunthang. The river upto this reach generally flows in a very steep gradient and the slope of the Teesta river upto the confluence of Lachenchu and Lachung chu is about 1 in 20.

After confluence of Lachenchu and Lachung chu at Chungthang the river gradually increases in width and takes a wide loop flowing down to Singhik. Thereafter the river confluences with one of its major right bank tributaries the Tolungchu originating from the Tolung glacier. From Singhik the river flows Southwards towards Dikchu in very deep valley and further downstream is joined by the Dikchuchu on the left. From Dikchu the river flows in a big curve down to Singtam where it is joined by Rongichu at Singtam. Further downstream Rangpochu joins the Teesta at Rongpo. After Rangpo the Teesta river starts widening rapidly and is joined by the great Rangit at Melli Bazar on Sikkim-West Bengal border.

After a further flow in West Bengal in hills through steep and narrow gorges, rapids, it debauches into the plains near Sevoke. From Sevoke where the river enters in Terai, it flows continuously in South Eastern direction till it enters Bangladesh. After Sevoke, it becomes braided, flowing in several channels. Teesta finally falls into the river Brahamaputra near Raniganj town in Bangladesh.

CATCHMENT AREA

The watershed divide of the Teesta river is marked by international boundary with Nepal, Tibet and Bhutan. The catchment is roughly rectangular in shape and well drained by a number of tributaries. The total catchment area of the river Teesta is bounded by 26^0 15' 0" N and 28^0 07' 0" N latitutes and 88^0 0' 8" E and 88^0 53' 0" E longitudes. The catchment areas of Teesta river upto dam of Teesta V is 4307 Sq.km.

2.2 DATA REQUIREMENTS

Dam break flood analysis requires a range of data to depict accurately to the extent possible the topography and hydraulic conditions of the river course and dam break phenomenon. The important data required are;

(i) Cross sections of the river from dam site and up to location downstream of the dam to which the study is required
(ii) Elevation-surface area relationship of the reservoir
(iii) Rating curve of spillway and sluices
(iv) Salient features of the all hydraulic structures at the dam site and also in the study reach of the river
(v) Design flood hydrograph
(vi) Stage-discharge relationship at the last river cross section of the study area
(vii) Manning’s roughness coefficient for different reaches of the river under study
(viii) Rating curve of all the hydraulic structures in the study reach of the river

For the present study, the data supplied by NHPC Ltd. and data procured from NRSC have been used.

2.2.1 River cross sections

For dam break studies of Teesta V, the Teesta River for a length of 25 km downstream of the dam site. This stretch has been represented in the model by 22 number of cross sections taken at a suitable interval obtained from NHPC office. In the case of extreme floods the flood water spreads beyond the normal course of the river, where the resistance to flow will be high due to presence of bushes, vegetation etc. Considering the above the Manning's roughness coefficient for the entire study reach of the river has been taken as 0.040.

2.2.2 Reservoir and dam

The reservoir has been represented in the model by a separate reservoir branch and its elevation-surface area relation, which has been specified at Chainage “0” km of the reservoir branch, is given in Table-2.1. The dam has been placed at Chainage 500 m of the reservoir branch and dam breach parameters specified therein**.** The elevation capacity curves are shown in Figure 2.1.

Table-2.1: Reservoir Elevation-Area-Capacity of Teesta V

Sl. No.	Elevation (metre)	Reservoir Area (ha)	Reservoir Capacity (Mcum)
1	539	0.00	0.00
2	541	0.03	0.00
3	543	1.01	0.01
4	545	3.16	0.05
5	547	4.36	0.12
6	549	7.24	0.24
7	551	9.44	0.41
8	553	12.63	0.63
9	555	16.63	0.92
10	557	19.22	1.26
11	559	22.06	1.67
12	561	24.96	2.14
13	563	27.63	2.66
14	565	29.51	3.23
15	567	31.85	3.84
16	569	34.18	4.50
17	571	44.46	5.29
18	573	50.68	6.23
19	575	54.87	7.29
20	577	58.38	8.41
21	579	61.62	9.61
22	581	65.17	10.88

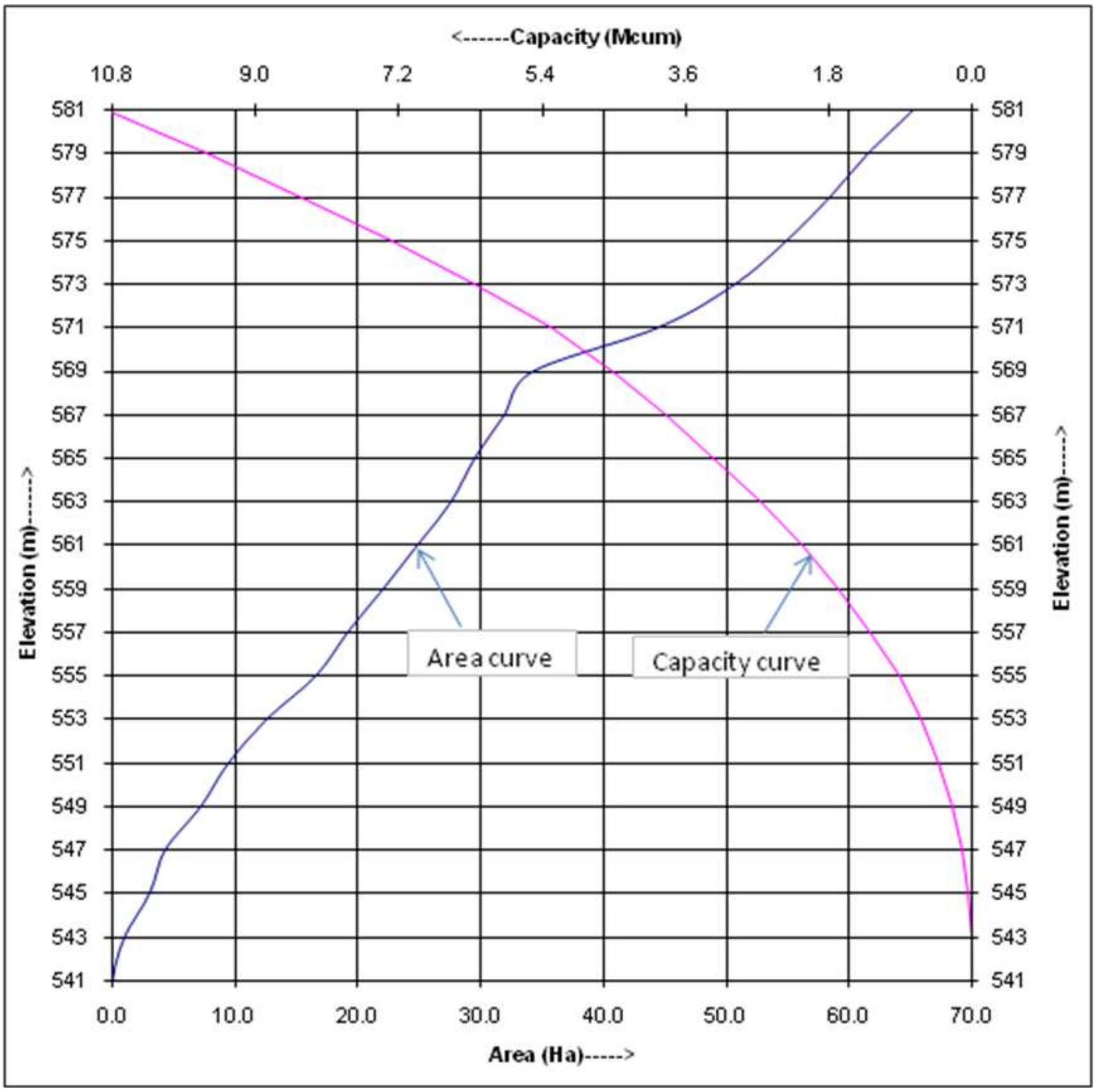


Fig.2.1: Reservoir Elevation-Area-Capacity Curve of Teesta V

2.2.3 Spillway

The spillway has been represented in the model by number and size of spillway gates. The same has been specified at Chainage 500 m of the spillway branch.

2.2.4 Probable Maximum Flood (PMF)

The design flood hydrograph which is the PMF for the present case has been used as for the upstream boundary of the dam break model set up. The same applied at chainage "0" km of the reservoir branch in the model set up, is given in Table-2.2 and shown in Figure 2.2.

Table-2.2 : Probable Maximum Flood (PMF)

TIME (HRS)	DISCHARGE (CUMECS)	TIME (HRS)	DISCHARGE (CUMECS)
0	349	24	4008
1	422	25	4153
2	885	26	4040
3	1613	27	3736
4	2461	28	3256
5	3387	29	2688
6	4379	30	2099
7	5424	31	1585
8	6420	32	1173
9	7720	33	867
10	9759	34	657
11	11991	35	523
12	13566	36	445
13	14596	37	400
14	14433	38	376
15	13498	39	362
16	11897	40	355
17	9940	41	352
18	7884	42	350
19	6132	43	349
20	4764	44	349
21	3919	45	349
22	3693		
23	3842		

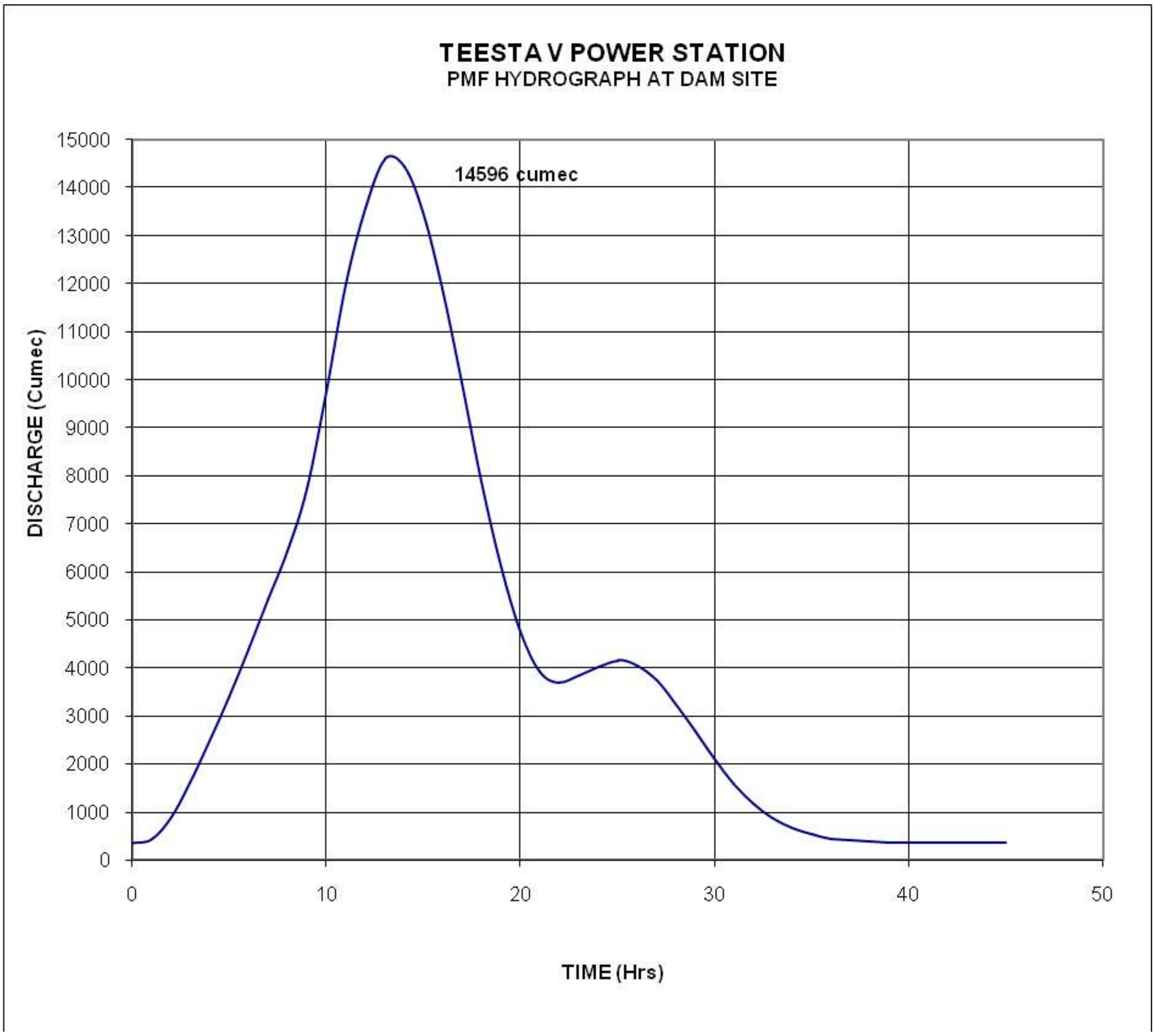


Figure 2.2 PMF hydrograph

2.2.5 Downstream boundary

In order to avoid its influence in the study reach normally the downstream boundary should be applied at a distant location from the last river cross section of study reach. The same has been worked out using Manning's equation and applied at a location 20 km downstream of Teesta V.

2.3 Salient Feature of the Project

The salient features of the Teesta V Dam are given in Table 2.3.

Table 2.3 Salient Features

TEESTA Power Station Stage - V SALIENT FEATURES		
Location		
State	:	Sikkim
District	:	East Sikkim
River	:	Teesta
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 (MRL)	:	EL. 580.72 m
Full Reservoir Level (FRL)	:	EL. 579.00 m
Minimum Draw Down Level (MDDL)	:	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 elevation	:	EL 540.00 m
Number and Size of sluices	:	Five (Each 9.0 m wide, 12.0 m high)
Max. Tail pool Level (at PMF)	:	EL 550.00
Diversion Tunnels		
Number & Shape	:	Two nos., Horse-shoe shaped
Diameter (finished)	:	12.2 m
Length	:	473 m & 610 m
Intake Structure		
Number & size of inlets	:	Three nos. of 6.5 m 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 ; 19.7 m 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	:	174.0 m
Underground Power House		
Installed capacity	:	510 MW (3 units of 170 MW each)
Dimensions of machine hall	:	118.5 m (L) x 23 m (W) x 47.5 m (H)
Dimensions of transformer cavern	:	100.5 m (L) x 14.5 m (W) x 10.7 m (H)
Switchyard type	:	Indoor GIS with roof top pothead yard of size 100 m x 30 m
Type of turbine	:	Francis, vertical axis
Spacing of units axis	:	22.5 m
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, 185m
Power Generation Figures		
Installed capacity	:	510 MW
Annual energy (in 90% dependable year)	:	2573 GWh

CHAPTER 3.0: DAMBREAK MODELLING

3.1 DAM BREACH MODELLING

All dams, regardless of their design or construction, have increased forces applied to them during extreme events which increase the potential risk of failure. Therefore, a dam breach analysis is usually conducted to determine the ultimate discharge from a hypothetical breach of a dam under such events. The outcome is a breach hydrograph from dam failure with a flood wave immediately downstream of the dam, which is routed throughout the river system to determine the flood arrival time, peak flow, and the depth of flow at downstream locations. The assumptions regarding dam breach parameters are critical for dam break modelling. Thus, reasonable values for the breach size and development time along with feasible breach geometry are needed to make a realistic estimate of the outflow hydrographs. Nonetheless, determining the size and growth rate for breaches is an inexact science while they are key parameters in dam break models. Therefore, the estimation of the breach parameters yield a significant source of uncertainty in the results and in turn downstream inundation extends.

Dam failures are often caused by over topping of the dam due to inadequate spillway capacity during large inflow to the reservoir from heavy precipitation runoff. Dam failures may also be caused by seepage or piping through the dam or along internal conducts, slope embankment slides; earthquake damage and liquefaction of earthen dams from earthquakes and land slide generated waves in the reservoir. Usually the response time available for warning is much shorter than for precipitation-runoff-floods. The protection of the public from the consequences of dam failures has taken an increasing importance as population has concentrated in areas vulnerable to dam break disasters.

Occurrence of a series of dam failures has increasingly focused attention of project managers on the need to evaluate flash floods due to dam failure and for routing them through downstream areas, susceptible to heavy losses, so that potential hazards might be evaluated. From these inundated areas, flow depths and flow velocities can be estimated for different hypothetical dam failure situations. With the help of such studies it could be possible to issue warnings to the downstream public and prepare strategies for disaster management when there is a failure of dam. The main difficulty in using the mathematical models is the failure description adopted in the model. Under these circumstances, a suitable assumption with regard to the adjustment of actual failure mode to suit the model failure mode is necessary.

3.2 HYDRODYNAMIC MODELLING

Generally, dam break modelling can be carried out by either i) scaled physical hydraulic models, or ii) mathematical simulation using computer. A modern tool to deal with this problem is the mathematical model, which is most cost effective and reasonably solves the governing flow equations of continuity and momentum by computer simulation.

Mathematical modelling of dam breach floods can be carried out by either one dimensional analysis or two dimensional analyses. In one dimensional analysis, the information about the magnitude of flood, i.e., discharge and water levels, variation of these with time and velocity of flow through breach can be obtained in the direction of flow. In the case of two dimensional analyses, the additional information about the inundated area, variation of surface elevation and velocities in two dimensions can also be forecasted. One dimensional analysis is generally accepted when valley is long and narrow and the flood wave characteristics over a large distance from the dam are of main interest. On the other hand, when the valley widens considerably downstream of dam and large area is likely to be flooded, two dimensional analysis is necessary.

The essence of dam break modelling is hydrodynamic modelling, which involves finding solution of two partial differential equations originally derived by Barre De Saint Venant in 1871. The equations are:

i. **Conservation of mass (continuity) equation**

$$(\partial Q/\partial X) + \partial(A + A_0) / \partial t - q = 0$$

ii. **Conservation of momentum equation**

$$(\partial Q/\partial t) + \{ \partial(Q^2/A)/\partial X \} + g A ((\partial h/\partial X) + S_f + S_c) = 0$$

where, Q = discharge;

A = active flow area;

A_0 = inactive storage area;

h = water surface elevation;

q= lateral outflow;

x = distance along waterway;

t = time;

S_f = friction slope;

S_c= expansion contraction slope and

g = gravitational acceleration.

3.3 SELECTION OF MODEL

Selection of an appropriate model to undertake dam break flood routing is essential to ensure the right balance between modelling accuracy and cost (both in terms of software cost and time spent in developing & running the model).

Numbers of commercial software are available for carrying out dam break modelling. A brief description of a number of models available for dam break modelling is as follows:

HR BREACH Model:

The HR BREACH model is a numerical model that predicts breach growth through flood embankments and embankment dams made from different material types and construction. It combines hydraulics, soil mechanics and structural analysis into a single breach prediction model. The model also balances speed and complexity against usability and the need for a practical tool to support dambreak analyses, flood risk assessments and the possible development of evacuation and emergency action plans (Tucker et. al., 2002).

The HR BREACH Model is capable of simulation of composite or zoned structures, also including grass or rock embankment surface protection, simulation through both homogenous and non cohesive soils, and breach initiation through piping and / or over flow.

SOBEK 1D2D Flood Model:

SOBEK is a powerful modelling suite for flood forecasting, optimisation of drainage systems, control of irrigation systems, sewer overflow design, river morphology, salt intrusion and surface water quality. The components within the SOBEK modelling suite simulate the complex flows and the water related processes in almost any system. The components represent phenomena and physical processes in an accurate way in one dimensional (1D) network systems and on two dimensional (2D) horizontal grids. It is the ideal tool for guiding the designer in making optimum use of resources Vanderkimpen P. et. al., 2009.

SOBEK offers one software environment for the simulation of all management problems in the areas of river and estuarine systems, drainage and irrigation systems and wastewater and storm water systems. This allows for combinations of flow in closed conduits, open channels, rivers overland flows, as well as a variety of hydraulic, hydrological and environmental processes.

HEC RAS:

HEC-RAS is a one-dimensional steady flow hydraulic model designed to aid hydraulic engineers in channel flow analysis and floodplain determination. The results of the model can be applied in floodplain management and flood insurance studies.

The program is one-dimensional, meaning that there is no direct modeling of the hydraulic effect of cross section shape changes, bends, and other two- and three-dimensional aspects of flow. The program was developed by the US Department of Defense, Army Corps of Engineers in order to manage the rivers, harbors, and other public works under their jurisdiction; it has found wide acceptance by many others since its public release in 1995 (USACE , 2001).

FLO – 2D:

FLO-2D is a dynamic flood routing model that simulates channel flow, unconfined overland flow and street flow. It simulates a flood over complex topography and roughness while reporting on volume conservation, the key to accurate flood distribution. The model uses the full dynamic wave momentum equation and a central finite difference routing scheme with eight potential flow directions to predict the progression of a flood hydrograph over a system of square grid elements.

FLO-2D is a FEMA approved hydraulic model for riverine studies and unconfined flood analyses.FLO-2D can be applied to complex flood problems including: river flooding, levee breach, split flows, unconfined alluvial fan and floodplain flows and detailed urban flooding. It is used by agencies and consultants in over 30 countries (U.S. Army Corps of Engineers, 2008)

DAMBRK:

A dam-break flood forecasting model (DAMBRK) is described and applied to two actual dam-break flood waves. The model consists of a breach component which utilizes simple parameters to provide a temporal and geometrical description of the breach. The model computes the reservoir outflow hydrograph resulting from the breach via a broad-crested weir flow approximation, which includes effects of submergence from downstream tailwater depths and corrections for approach velocities. Also, the effects of storage depletion and upstream inflows on the computed outflow hydrograph are accounted for through storage routing within the reservoir.

The basic component of the DAMBRK model is a dynamic routing technique for determining the modifications to the dambreak flood wave as it advances through the downstream valley, including its travel time and resulting water surface elevations. The dynamic routing component is based on a weighted four-point, nonlinear finite-difference solution of the one- dimensional equations of unsteady flow (Saint-Venant equations) which allows variable time and distance steps to be used in the solution procedure. Provisions are included for routing supercritical flows, subcritical flows, or a spontaneous mixture of each, and incorporating the effects of downstream obstructions such as road-bridge embankments and/or other dams, routing mud/debris flows, pressurized flow, landslide-generated reservoir waves, accounting for volume and flow losses during the routing of the dambreak wave, considering the effects of off-channel (dead storage), floodplains, and floodplain compartments. Model input/output may be in either English or metric units. DAMBRK, developed by NWS (National Weather service station of United States), is commonly used dam break simulation software and estimates the breach outflow hydrograph. Dam and reservoir parameters such as crest height are required inputs. Breach characteristics such as size, shape and time of formation of the breach are also input to the model and derived empirically (Fread et.al., 1988).

BEED:

The model estimates reservoir water level, breach bottom elevation, and discharge with routing downstream. The user can utilize the model in FORTRAN 77 and BASIC computer languages. The model calculates sediment discharge employing Einstein Brown bed-load formula, relating the initiation and cessation of sediment motion to the hydrodynamic lift forces and particle submerged weight as a function of the inverse of Shield’s dimensionless shear stress.

The model is used as a steady uniform flow formula. It explicitly account for side slope instability and collapsing. It uses the contour method to analyze the mechanics of slope collapsing assuming saturated soil conditions (Tucker et.al., 2002).

DEICH-P:

The model calculates breach formation in homogeneous dams with or without a cohesive core by solving the flow and Exner equation in combination with a sediment transport formula. DEICH-P describes the breach shape with a relationship between bottom and side slope erosion rates using a coefficient similar to MIKE11. The model transforms the calculated eroded breach volume with kinematics assumptions into vertical or side erosion change (Tucker et.al., 2002) .

SMPDBK:

The Simplified Dam-Break (SMPDBK) was developed by the National Weather Service (NWS) for predicting downstream flooding produced by a dam failure. This program is still capable of producing the information necessary to estimate flooded areas resulting from dam-break floodwaters while substantially reducing the amount of time, data, and expertise required to run a simulation of the more sophisticated unsteady NWS DAMBRK, or now called FLDWAV. The SMPDBK method is useful for situations where reconnaissance level results are adequate, and when data and time available to prepare the simulation are sparse. Unlike the more sophisticated versions of DAMBRK and FLDWAV, the SMPDBK method does not account for backwater effects created by natural channel constrictions of those due to such obstacles as downstream dams or bridge embankments.

DWOPER:

An unsteady flow dynamic routing model (one-dimensional Saint-Venant equations) for a single channel or network (dendritic and/or bifurcated) of channels for free surface or pressurized flow. It is a computerized hydraulic routing program whose algorithms incorporate the complete one-dimensional equations of unsteady flow. It can be used on a single river or system of rivers where storage routing methods are inadequate due to the effects of backwater, tides and mild channel bottom slopes. The model is based on the complete one-dimensional St. Venant equations. A weighted four-point nonlinear implicit finite difference scheme is used to obtain solutions to the St. Venant equations using a Newton-Raphson iterative technique.

3.4 MIKE 11 model

In the present study MIKE 11 model has been used. The core of the MIKE 11 system consists of the HD (hydrodynamic) module, which is capable of simulating unsteady flows in a network of open channels. The results of a HD simulation consist of time series of water levels and discharges. MIKE 11 hydrodynamic module is an implicit, finite difference model for unsteady flow computation. The model can describe sub-critical as well as supercritical flow conditions through a numerical description, which is altered according to the local flow conditions in time and space.

Advanced computational modules are included for description of flow over hydraulic structures, including possibilities to describe structure operation. The formulations can be applied for looped networks and quasi two-dimensional flow simulation on flood plains. The computational scheme is applicable for vertically homogeneous flow conditions extending from steep river flows to tidal influenced tributaries.

The following three approaches simulate branches as well as looped systems.

i) **Kinematic wave approach**: The flow is calculated from the assumption of balance between the friction and gravity forces. The simplification implies that the Kinematic wave approach cannot simulate backwater effects.

ii) **Diffusive wave approach**: In addition to the friction and gravity forces, the hydrostatic gradient is included in this description. This allows the user to take downstream boundaries into account, and thus, simulate backwater effects.

iii) **Dynamic wave approach**: Using the full momentum equation, including acceleration forces, the user is able to simulate fast transients, tidal flows, etc., in the system.

Depending on the type of problem, the appropriate description can be chosen. The dynamic and diffusive wave descriptions differ from kinematic wave description by being capable of calculating backwater effects. The solution algorithm for the different flow descriptions is identical in the inner programme structure, implying that the user does not have to distinguish between the different computational levels, when running the program. In the instant case, dynamic wave approach was adopted for a better simulation.

Hydrodynamic module utilizes a space staggered grid consisting of alternating **h** and **Q** points, i.e., points where water levels (**h**) and discharges (**Q**) are computed sequentially. Topographic data are entered at the **h** points, and discharge relations are evaluated at **Q** points. During simulations, the complete non-linear equations of open channel flow are solved numerically at the grid points at specified time intervals for the given boundary conditions.

3.4.1 Solution technique

In order to obtain a stable solution to the finite difference scheme, two conditions viz. (i) Velocity condition and (ii) Courant condition have to be satisfied.

(i) Velocity condition: $(V.\Delta t/\Delta x) \leq$ 1-2

(ii) Courant condition: $C_r = [(V+\sqrt{(g.d)}).\Delta t]/\Delta x \leq$ 10-15

C_r is the Courant number, **v** is the cross-sectional mean velocity, **g** is the acceleration due to gravity, **d** is the mean depth, Δ**t** is the time step, Δ**x** is the space step (the distance between adjacent **h**-points)

The most important considerations determining the selection of space and time steps for a particular model application are the expected wave lengths and duration of the wave period, and the ability to adequately resolve the channel topography. The space step length must be chosen ensuring a sufficient number of points along the channel axis to resolve the expected waves. The wavelength is determined by the wave period and the speed of propagation. A second concern is the adequate resolution of rapid changes in topography along the channel axis, and this may require extra grid points. The time step must be selected so that all expected significant wave periods are adequately resolved in time. As the duration of tidal waves is generally shorter than flood waves, the time step of a hydrodynamic model, which simulates tidal flows requires a shorter time step than that used in flood wave computations.

The solution to the combined system of equations at each time step is performed in a computational grid consisting of alternative **Q**-point and **h**-point, i.e. points where the discharge "Q" and water level "h" respectively, are computed at each time step. A typical layout of channel section with computational net is shown in Fig. 3.1.

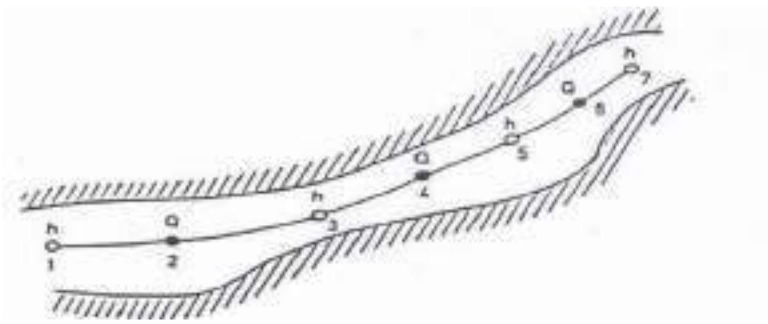


Fig. 3.1 Layout of channel section

The computational grid is generated by the model on the basis of the user requirements. **Q**-points are always placed midway between neighbouring **h**-points, while the distance between

h-point may differ. The discharge will, as a rule, be defined as positive in the positive x-direction (increasing chainage).

3.4.2 Boundary conditions in general

The boundary conditions in MIKE 11 are distinguished between external and internal boundary conditions. Internal boundary conditions are (i) links at nodal points, (ii) structures, (iii) internal inflows, and (iv) wind friction. External boundary conditions may consist of (i) constant values for **h** or **Q**, (ii) time varying values for **h** or **Q**, and (iii) relation between **h** and **Q**.

Generally, model boundaries should be chosen at points, where either water level or discharge measurements are available so that the model is used for predictive purposes. It is important that the selected boundary locations lie outside the range of influences of any anticipated changes in the hydraulic system.

The structure description combines a wide range of elements covering weirs, narrow cross-sections, flood plains, reservoirs operations, etc., and which can be regarded as an internal boundary condition. The description is obtained by replacing the momentum equation with an h-Q-h relation or an h-Q relation. The grid to be used to describe a structure will consist of **h**-point on both side, and a **Q**-point at the structure.

Lateral inflows can also be accommodated in MIKE 11 Hydrodynamic module (HD). The lateral inflows are specified at **h**-points, and are included in the continuity description.

3.4.3 Topographical requirement and discretization

MIKE 11 HD is a physical modelling system, and hence, data related to the detailed physical characteristics of the study area must be obtained, if realistic results are to be expected. Topographic data are necessary to provide an adequate geometrical and topographical description of the river system, flood plains, and all important structures.

First, the layout of the channel network is determined, and all significant channels identified, including the locations of the main channel confluences and bifurcations. Flood cells subject to inundation must be delimited, and the network of discharge exchange between the flood cells and the main river channels need to be identified.

Cross-sections are required at regular intervals along the river. These must extend up to the river bank to encompass any natural or man-made river embankments. In the model schematization, the available cross-sections are placed at **h**-points. The cross-sections should be representative of the entire channel reach between the adjacent **Q**-points. Hence, channels which exhibit highly irregular cross-sectional variations require denser grid, and hence, have greater data requirements.

The equations of one dimensional flow assume a horizontal water level surface across the channel section. Where flow occurs over wide flood plains, which are separated from the main river channel by natural levees or man made embankments, a purely one dimensional description is no longer adequate. The description of such areas, called flood cells, is readily accommodated by MIKE 11 module through linking of the individual cells via an appropriate discharge formulation. For example, where the flood cell boundary constitutes a road or flood embankment, the discharge relation describing the exchange of flows between the cells by overtopping of the embankment is a simple weir formulation. Where flood cells are interconnected by road culverts, the standard culvert formulation of MIKE 11 HD may be used.

Longitudinal profiles along the flood cell embankments, which lie directly adjacent to the main river are also required to establish the locations and levels at which overbank spilling may occur. Similar profiles are required along the embankments or roads, which separate the individual flood cells, if overbank spilling is possible. Topographic input for flood cells consists of a flooded area / water level elevation relation, such that the storage characteristics for each cell may be identified.

Possible sources of data for the topographical input include contour maps, hydrographic charts, aerial photographs, satellite imagery, etc. However, in the majority of cases, sufficiently detailed information can only be obtained from controlled field surveys. It is essential that all topographical data levels relate to a common fixed reference level, preferably mean sea level.

Besides topographic data, hydrometric data are necessary to enable the model to be calibrated against actual events, and thus, provide a basis for verification of the chosen schematization. Hydrometric data are also required at the model boundaries for any subsequent operation of the model. The main types of hydrometric data required are water levels and discharges.

3.5 MIKE 11 Model set-up

The Dam Break Module in MIKE 11 simulates the outflow hydrograph resulting from the failure of a dam. The model set-up consists of a single or several channels, reservoirs, dam break structures and other auxiliary dam structures such as spillways, bottom outlets etc. As the flood propagation due to the dam break will be of highly unsteady nature, the river course needs to be described accurately through the use of as many cross-sections as possible, particularly where the cross-section is changing rapidly. Further, the cross-sections should extend as far as possible to cover the highest modelled water level, which normally will be in excess of the highest recorded flood level. If the modelled water level exceeds the highest level in the cross-section for a particular location, MIKE 11 will extrapolate the processed Data as a vertical wall, and this will give conservative results.

3.5.1 River channel set-up

The river channel set-up for dam break modelling is the same as for the HD model except that the dam break structure is located in a separate reservoir branch, which contains 3 calculation points, i.e., two **h**-points and one **Q**-point. If a spillway is added to the dam, it can be described as a separate branch with 3 calculation points. The dam and spillways are located at a **Q**-point. The river set-up with a dam and, with dam and spillway are shown in Fig. 3.2 and Fig. 3.3 respectively.

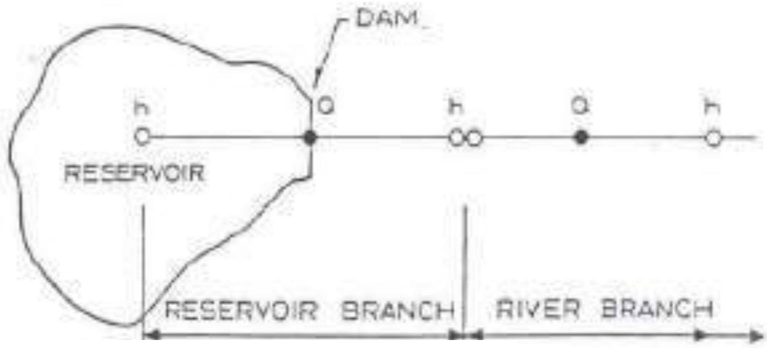


Fig. 3.2: River set up with dam

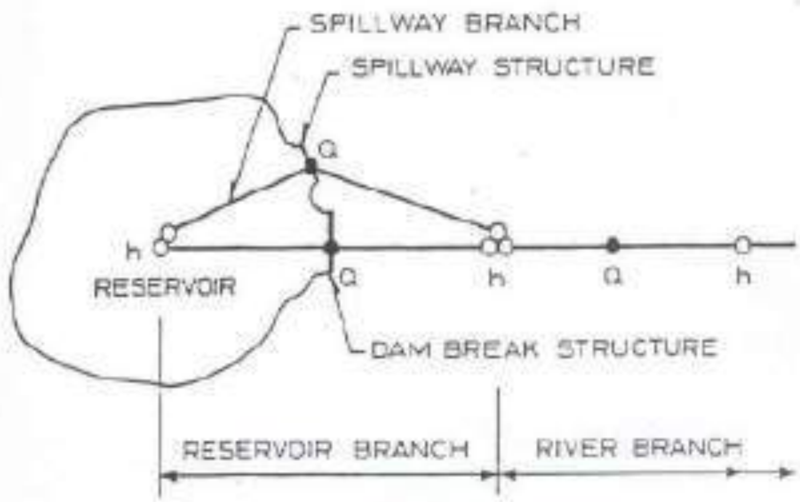


Fig. 3.3: River set up with dam and spillway

3.5.2 Description of reservoir and appurtenant structures

Reservoir

To obtain an accurate description of the reservoir storage characteristics, the reservoir is normally modelled as a single **h**-point in the model. This will usually correspond to the upstream boundary of the model, where also the inflow hydrograph is also specified.

The description of the reservoir storage is entered in the processed data. The surface storage area of the dam is described as a function of the water level and it is entered as additional flooded area. The lowest water level given for the reservoir should be somewhere below the final breach elevation of the dam.

The cross-sectional area is set to a large finite value and is used only for calculating the inflow head loss into the breach. The inflow head loss can be calculated as :

$\Delta H = (V_s^2 /2g)\ C_i[1-(A_s / A_{res})]$

Where, V_s = Velocity through the breach

C_i = Inflow head loss coefficient

A_s = Flow area through the breach, and

A_{res} = Cross-sectional area of the reservoir

In order to obtain a reasonable head loss description it is only necessary that $A_{res} >> A_s$ so that $[1-(A_s / A_{res})] = 1$. The hydraulic radiusis set to any non-zero value.

The total surface area of the reservoir is calculated as:

A_{total} = b.2Δx + Additional flooded area

Since the total surface area is already described by the additional flooded area, the first term should be equal to zero. Therefore, the width b should be set to zero.

Dam

At the **Q** point, where the dam break structure is located, the momentum equation is replaced by an equation, which describes the flow through the structure. As the momentum equation is not used at the **Q** point, the Δx – step is of no relevance. The maximum Δx for the river branch, where the dam is to be placed should, therefore, be greater than the distance between two cross-sections in the reservoir branch, so that no cross-section is interpolated between the actual cross-sections.

Spillways and other structures

At the node, where two branches meet (Fig 8) the surface flooded area is taken as the sum of the individual flooded areas specified at the **h**-points. Therefore, if the reservoir storage has already been specified at the reservoir **h**-point, the spillway **h**-point should not contain any flooded areas. Both the width b, and the "additional flooded area" should be set to zero and other parameters such as the cross-sectional area and hydraulic radius should be the same as for the reservoir.

3.5.3 Boundary conditions for dam break modelling

The boundary conditions must be specified at both upstream and downstream limits of the model. The upstream boundary will generally be an inflow into the reservoir at the first reservoir **h**-point. The downstream boundary will generally be a stage-discharge relationship at the last cross section of the set up.

3.6 Specifications of dam break structures

The following information relating to dam break structures need to be specified:

(i) Geometrical specifications

(ii) Breach characteristics

(iii) Failure moment, and

(iv) Failure mode

3.6.1 Breach development

Earth and Rockfill dams usually do not collapse instantaneously, but they develop breaches, which increase gradually. The failure time may vary between a few minutes up to a few hours, depending on amongst other, the dam geometry and the construction material. The development of the breach determines the breach outflow hydrograph, and an accurate description of the breach development is, therefore, required in “near field” dam breach studies. In the “far-field” studies, an accurate flood routing procedure is of more importance, because the outflow variation is rapidly damped out as the flood propagates downstream.

3.6.2 Failure modes

The dam break module of MIKE 11 allows selection of one of various breach development modes. Either linear failure mechanism or an erosion based formulation may be selected. The linear failure mode assumes a linear increase in the breach dimensions in time between specified limits. In the erosion based mode, the increase in breach dimensions is calculated from the prevailing hydraulic conditions in the breach, and from the given geometrical data. For both modes, limits of the final breach width and level are specified. These may be determined, for example, by the original valley embankments.

a) Linear failure modes

The necessary data required to fully specify a linear dam failure are shown in Fig. 3.4. In addition, the user specifies the duration of the breach development and whether the failure is to commence at a given time, or is initiated by overtopping of the dam. This facility has applications in simulating the cascading failure of several dams located on the same river.

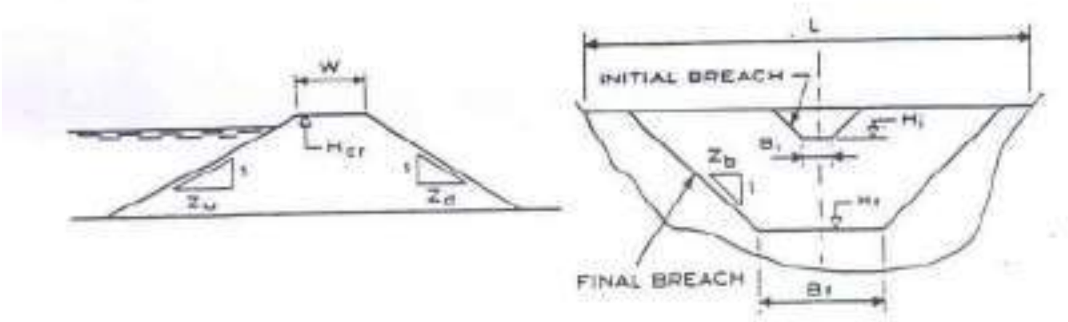


Fig. 3.4: Breach parameters for linear mode

b) Erosion based failure

The enlargement of the breach in earth fill dams from erosion of the dam core material may also be determined from sediment transport considerations. Erosion based breach formulations are based on sediment continuity equation for the breach. Numerous sediment transport formulae are available, of which two have been implemented in the breach formulation, being those of Engelund-Hansen (1967), and Meyer-Peter and Muller (1947). Modelling of the variation of the width of the breach is more difficult to relate to the classical theories of sediment transport. Due to the development of a wall boundary layer along the often very steep side walls of the breach, the theories for bed load and suspended load do not apply. As an approximation, the sediment transport at the sloping walls is assumed to be proportional to that in the central part of the breach. The coefficient of proportionality (side erosion index) is of the order of 0.5 – 1.0.

3.7 Initial Conditions

Though in many cases, dam failure may occur on a dry river bed downstream of the dam, but such conditions are not possible in MIKE 11, which require a finite depth of water, in order to ensure “the continuity” of the finite difference algorithm. Therefore, before a dam break is actually simulated, it is necessary to create a steady state “hot-start” file, which can be used for all subsequent dam break simulation. This file is created by:

(i) Giving a lateral inflow at the first **h**-point in the river

(ii) Setting the inflow into the reservoir to zero, and

(iii) Specifying the dam break structure to fail by overtopping, ensuring that the dam crest level is greater than the specified reservoir level.

Initial conditions (water level and discharge) must be specified in HD parameter file, including the reservoir level, at which the dam break simulation should commence. The set-up should be run until a steady state condition is reached (i.e., Q=constant=lateral inflow up to the downstream boundary).

3.8 Dam break simulations

The dam break simulation may be carried out using the hotstart file generated as mentioned above, specifying the upstream boundary as the inflow hydrograph. The time step depends upon the slope of the river bed and should be selected of the order of 0.5 to 5 minutes according to the slope.

CHAPTER-4: CREATTION OF DATA BASE

4.1 GENERAL

In the dam break assessment, the outflow hydrograph as a result of the dam failure is obtained which determines the characteristics of the downstream flood wave along the downstream channel topography. This outflow hydrograph is calculated by MIKE 11 analysis using hydrodynamic module. The steps followed during this project is as follows:

1. Collection of the spatial and temporal data.
2. Generation of the DEM and extraction of cross sections of downstream reach using HEC_GeoRAS.
3. Export of cross section and network etc. to MIKE 11 model.
4. Development of the hydrodynamic model:
    - Generation of the cross section, i.e., creation of the cross section file in MIKE 11.
    - Generation of the river networks, i.e., creation of the Network file.
    - Selection of the hydrodynamic parameters, i.e., creation of the hydrodynamic file.
    - Selection of the boundary conditions, i.e., creation of the boundary file.
5. Analysis by MIKE 11, i.e., running of the hydrodynamic model by MIKE 11.
6. The results obtained using MIKE 11 has been exported HEC_GeoRAS for flood inundation mapping.

In this chapter, steps 1, 2 and 3 have been presented and described while steps 4, 5 and 6 are presented in the next chapter.

4.2 CREATION OF DATA BASE

The following steps have been adopted to complete this study.

In this study, (HEC-RAS) Hydraulic Engineering Centre - River Analysis System has been used. HEC-RAS is an integrated system of software developed by US Army Corps of Engineers to perform one dimensional analysis and model flow through natural rivers and other channels. It is used for flow channel analysis and flood plain determination. The system comprises of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities.

The data representation and model interpretation for River Analysis can be simplified using a Geographic Information System (GIS). HEC-GeoRAS provides Graphical User Interface (GUI) that enables creation of file containing attribute data from an existing Digital Terrain

Model (DTM). At a later stage, after running the simulation, the water surface profile data can be exported to HEC-RAS again to perform flood plain mapping.

4.2.1. Preparation of geometric data using HEC GeoRAS

- Identify the river reach to be modeled and download the satellite imagery covering the study area.
- Correct methods (Geometrically and Radiometrically) have been applied on satellite imagery. Projection system and Datum are selected as Universal Traverse Marketer (WGS_1984_UTM_Zone_45N),
- Main channel and river banks are delineated from the corrected satellite imagery by digitizing and their attributes are calculated.
- Using HEC GeoRAS, stream centerline, bank lines, flow paths and XS cut-lines are created. Here, flow path represents a set of lines along mass of flow in each of the main channel, left overbank and right over bank.
- The centerline, bank line and flow-path are digitized using the imagery.
- The RiverID, stationID, flowpath-type are manually entered as a part of nomenclature.
- Digital Elevation Model (DEM) for the area is derived from CARTOSAT (10 m resolution, as per TOR). From the DEM, a Triangular Irregular Network (TIN) model is prepared using ArcGIS. From this DEM, cross sections have been generated, but these cross sections were having certain errors when seen on the overall area. Therefore the cross sections have been obtained from TLDIII office.
- The cross-section (XS) cutlines are drawn across the river centerline from left bank to right bank, perpendicular to the river centerline.
- After this the created files are transferred to MIKE 11 software.
- The results from MIKE 11 transferred to HEC RAS for flood inundation mapping. For this purpose, the Cartosat DEM has been corrected using actual elevation taken from cross section data. The correction is explained as follows:

CARTOSAT DEM (10 m resolution) has been corrected for improving the better results in flood inundation modeling. The total 80 points have been selected for correction of DEM and those are located in every cross sections which have taken by field survey. The LR method has been applied to remove the bias of the datasets by *Durai and Bhradwaj 2014.* The equation has given below.

$$Y = aX + b$$

Where 'X' is the elevation of DEM and 'Y' is the observed elevation. The coefficients 'a' and 'b' represent the model biases, 'b' is the systematic bias, and 'a' is a bias based on elevation.

The accuracy assessment has been carried out by the by three indices, such as, root mean square error (RMSE), normalized mean square error (NMSE)and correlation coefficient (CC), Duhan and Pandey (2014).

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(a) Root mean square error $RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2}$

(b) Normalized mean square error $NMSE = \frac{\frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2}{(S_{obs})^2}$

(c) Correlation coefficient $CC = \frac{N\sum(y_i \times \hat{y}_i) - (\sum y_i) \times (\sum \hat{y}_i)}{\sqrt{\left[N\sum y_i^2 - (\hat{y}_i)^2\right] \times \left[N\sum y_i^2 - (\hat{y}_i)^2\right]}}$

Here, y_i and $\hat{y}_i$ represent actual elevation and elevation from DEMs respectively. N denotes the number of observation. A small value of the RMSE and NMSE indicates less discrepancy between the observed and predicted series, thus provides better prediction accuracy, while higher values of CC give better accuracy.

The elevation of CARTOSAT DEM and actual have compared in Figure 4.1 in before bias correction and after correction. A significant different of elevation (CARTOSAT and actual) has been shown in CARTOSAT DEM from actual. The RMSE, NMSE and CC values are 42.08, 188.77 and 0.76 at before bias correction. After bias correction, RMSE,NMSE and CC values are 3.71, 1.47 and 0.92 respectively. The corrected DEM has been used for flood inundation in next chapter.

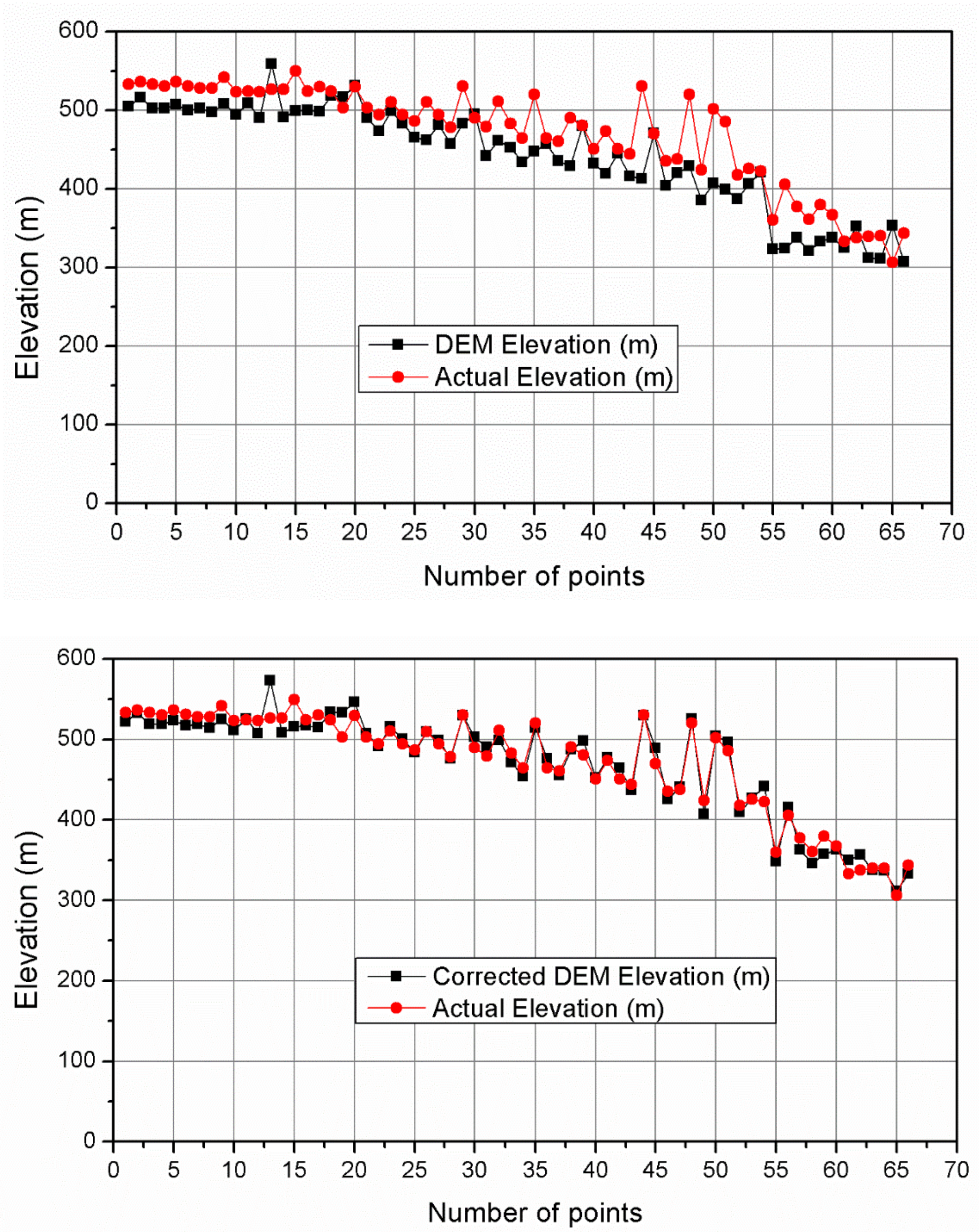


Figure 4.1: Comparison of elevation difference between actual and corrected DEM

Table 4.1: Accuracy statistics

Sl. No	Methods	Before correction	After correction
1	RMSE	24.86	13.48
2	NMSE	9.02	2.78
4	CC	0.96	0.98

RMSE=Root mean square errorNMSE=Normalized Mean Square errorand CC= correlation coefficient (Duhan and Pandey, 2014).

Satellite imagery and DEM are shown in the selected study area (Figure 4.2). River banks and main channel of the river have been extracted using Satellite imagery.

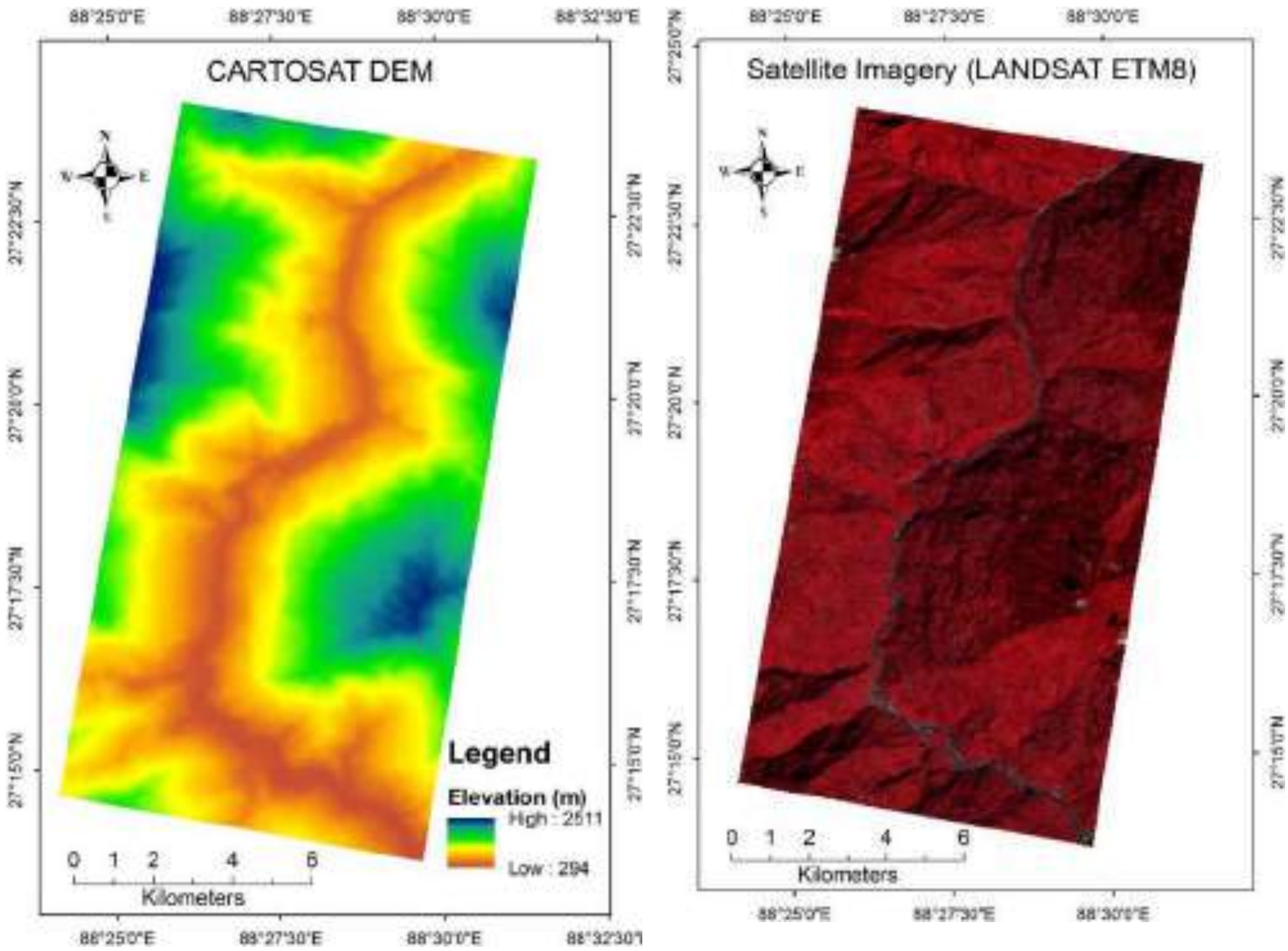


Figure 4.2: Satellite imagery of the region (Landsat-ETM8 with 30 m resolution in the left side) and CARTOSAT DEM in the right side (10m resolution)

Digitizing the required layers**:** In the option **RAS Geometry** use > **Create RAS layers. S**tream centerline, bank lines, flow paths and XS cut-lines are created as shown below (Figure 4.3).

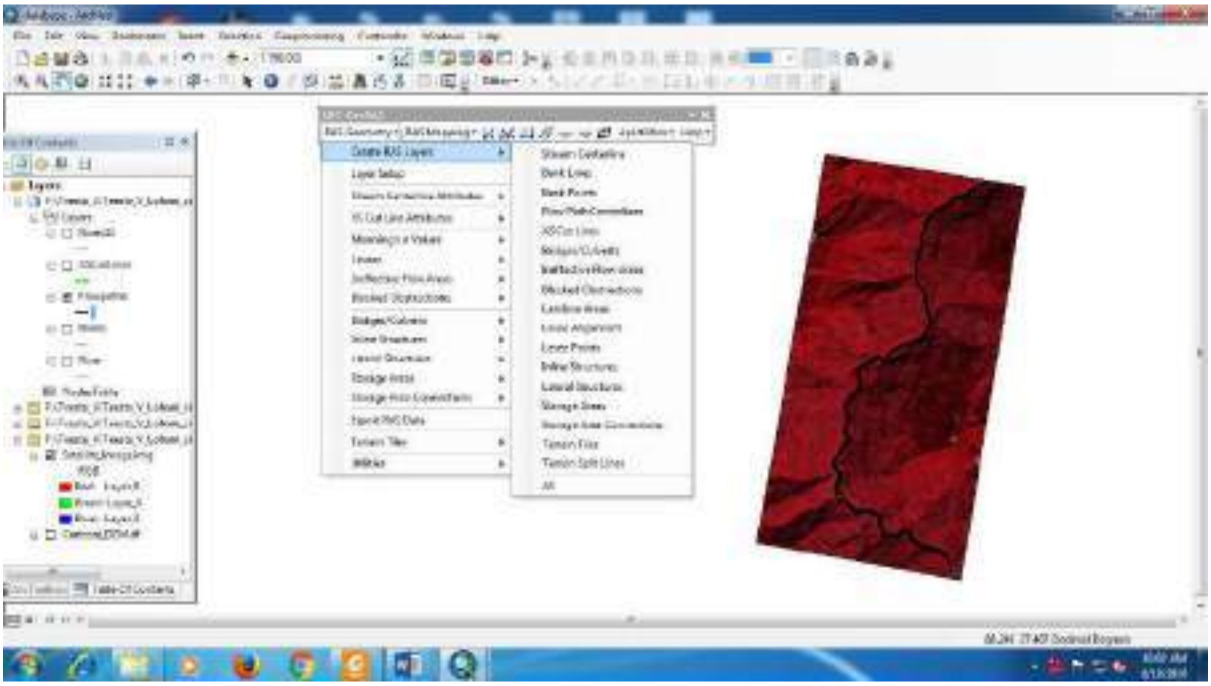


Figure 4.3: Option for creation of stream centerline, bank lines, flow paths and XS cut-lines

The centerline, bank line and flow-path are digitized with the help of the image (Figure 4.4). The attributes of each layer like RiverID, FromTo station, flow-path type are entered.

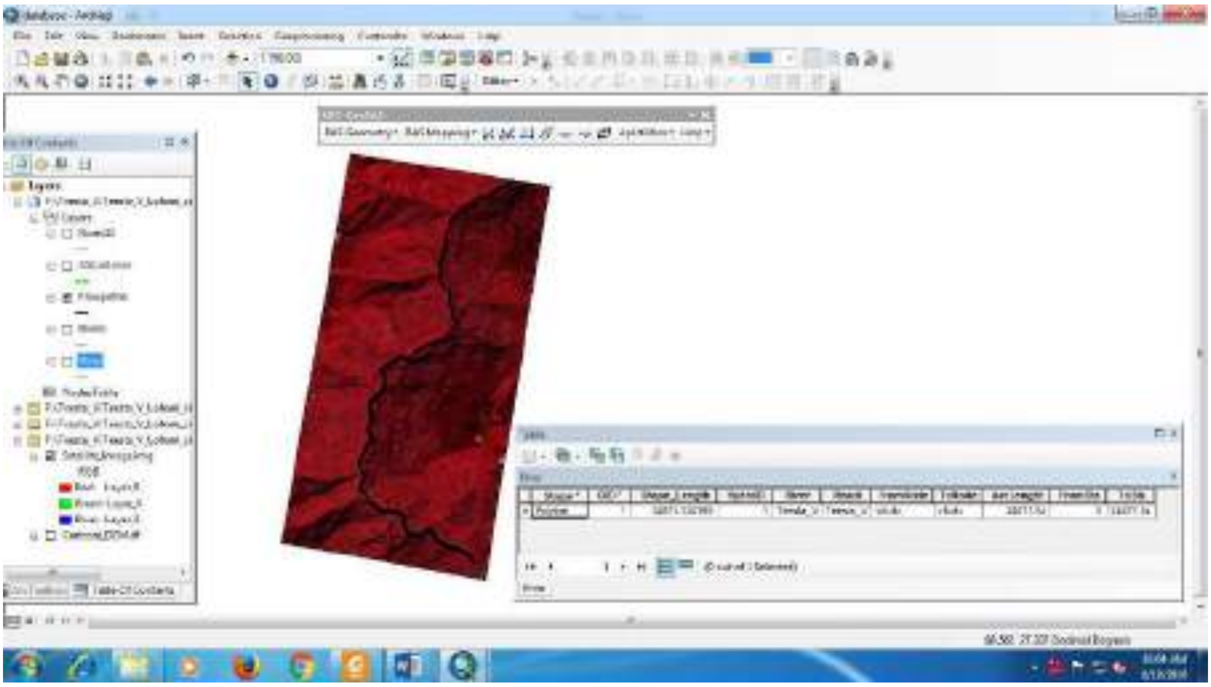


Figure 4.4: Centerline, bank line and flow path have digitized

Next the cross-section co-ordinates are added as a point shape file. The XS cut-lines are drawn with reference to these points from left bank to right bank along the direction of flow and perpendicular to the flow paths (Figure 4.5). The XS cutline on google earth is shown in Figure 4.6.

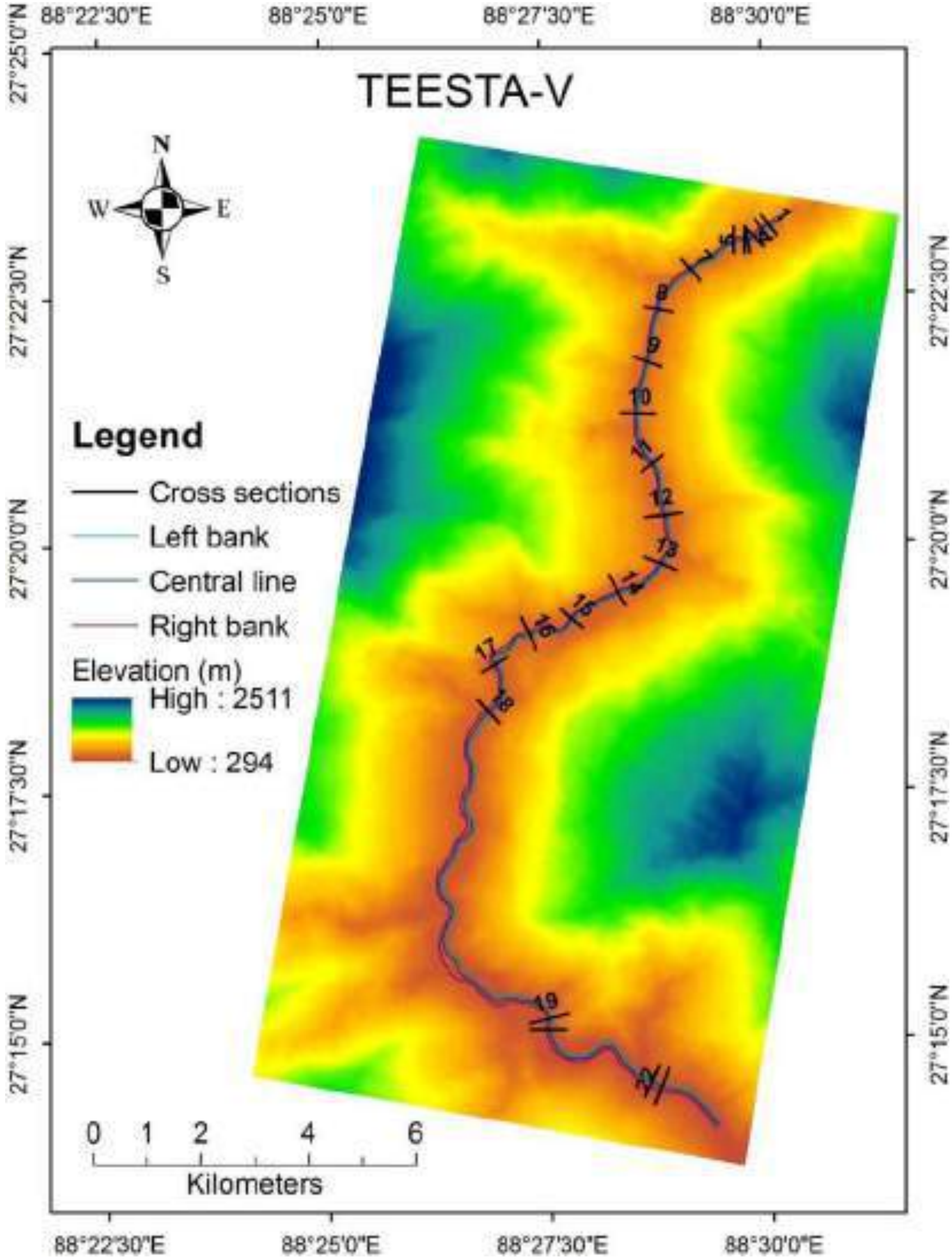


Figure 4.5: XS cutline (22 cross section) and their attributes

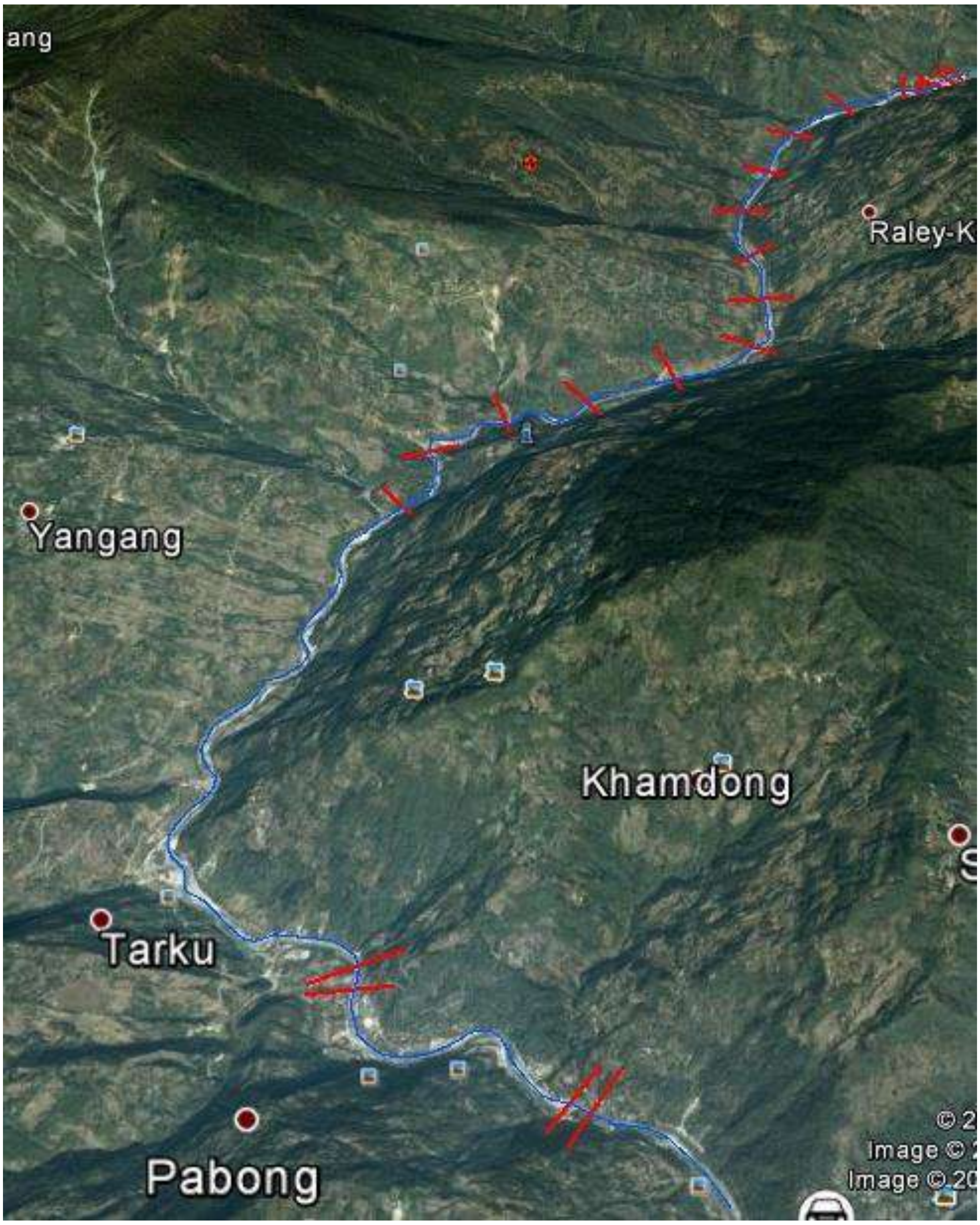
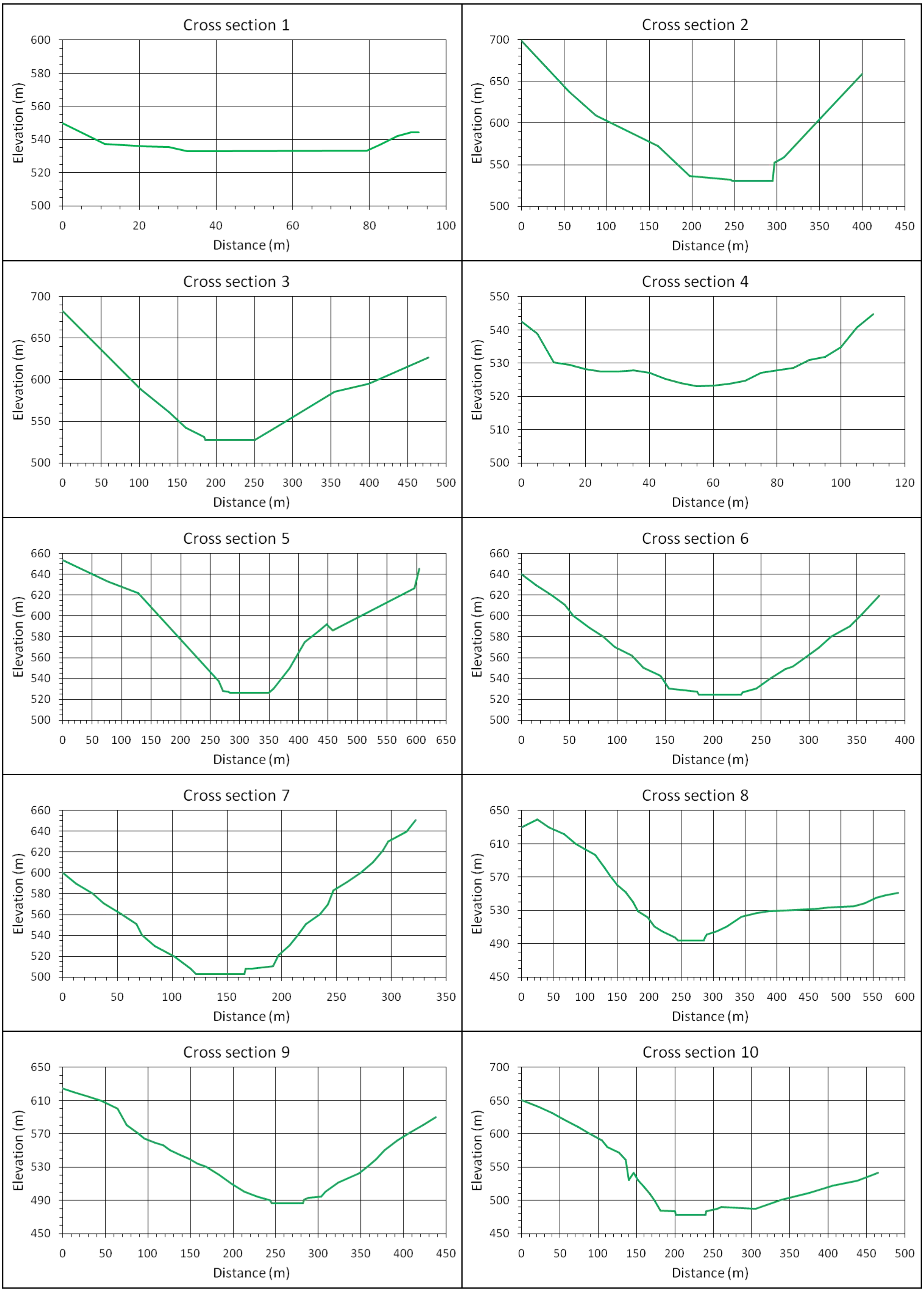
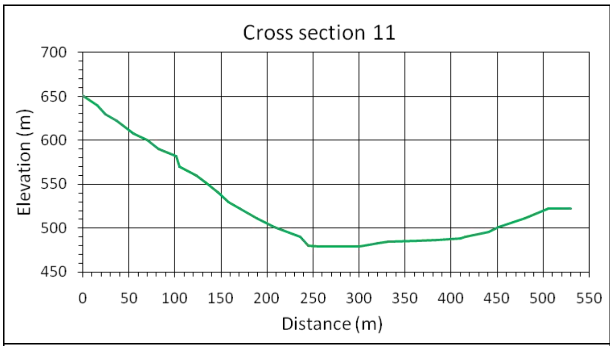
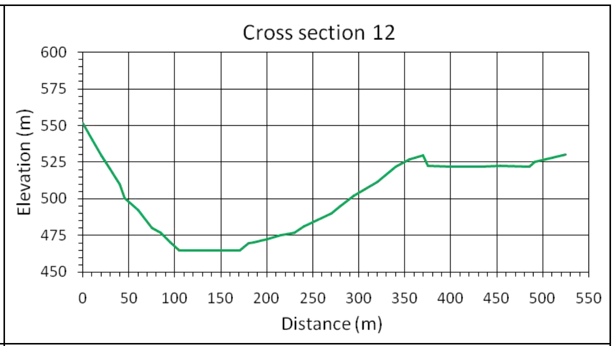


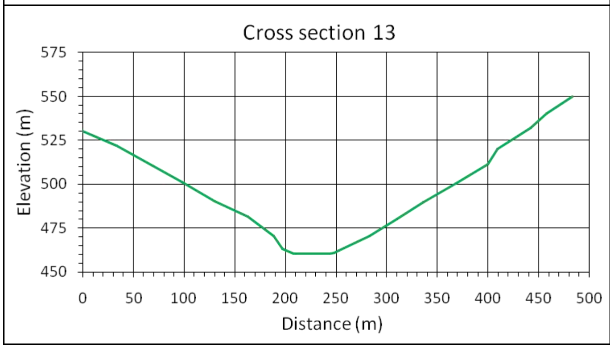
Figure 4.6: Attributes of cross section

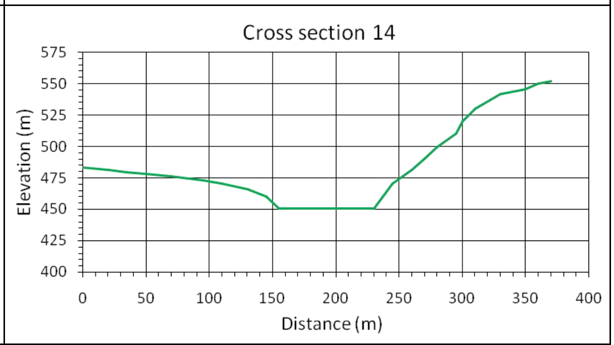
Length of the selected part of the Teesta River is 20 km (approx.). Cross sections have been taken at suitable interval and the total number of cross section is 22. The Profile of cross sections has been shown in Figure 4.6. These cross sections have been exported to MIKE 11 for further use in modeling.

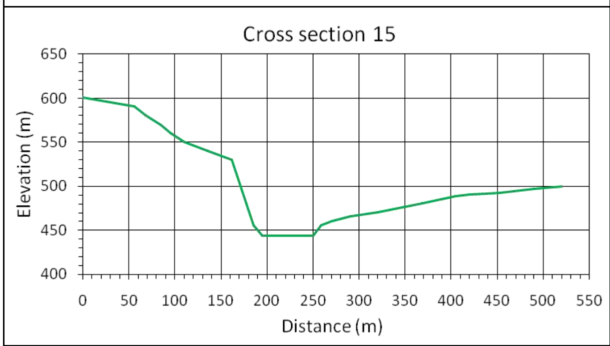

Cross section 1
Cross section 2
Cross section 3
Cross section 4
Cross section 5
Cross section 6
Cross section 7
Cross section 8
Cross section 9
Cross section 10
Elevation (m)
Distance (m)

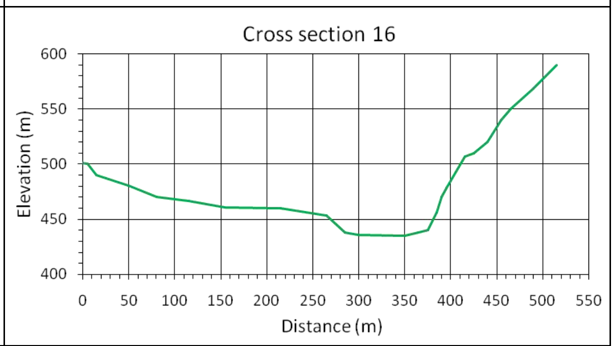

Cross section 11
Elevation (m)
700
650
600
550
500
450
0 50 100 150 200 250 300 350 400 450 500 550
Distance (m)

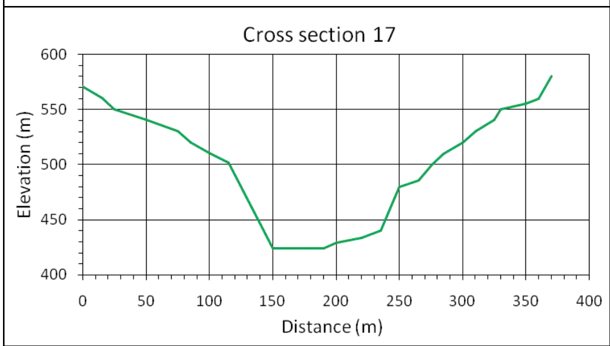

Cross section 12
Elevation (m)
600
575
550
525
500
475
450
0 50 100 150 200 250 300 350 400 450 500 550
Distance (m)

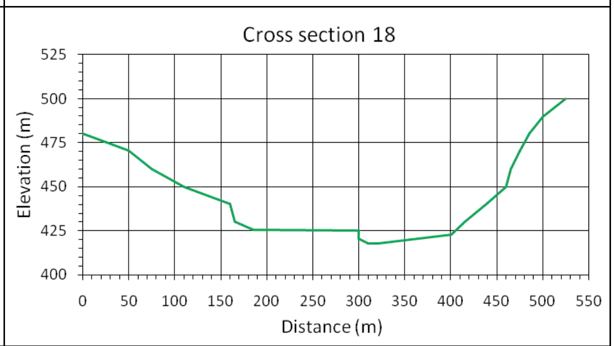

Cross section 13
Elevation (m)
575
550
525
500
475
450
0 50 100 150 200 250 300 350 400 450 500
Distance (m)

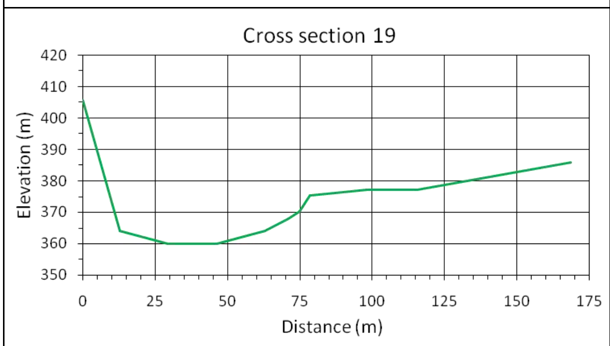

Cross section 14
Elevation (m)
575
550
525
500
475
450
425
400
0 50 100 150 200 250 300 350 400
Distance (m)

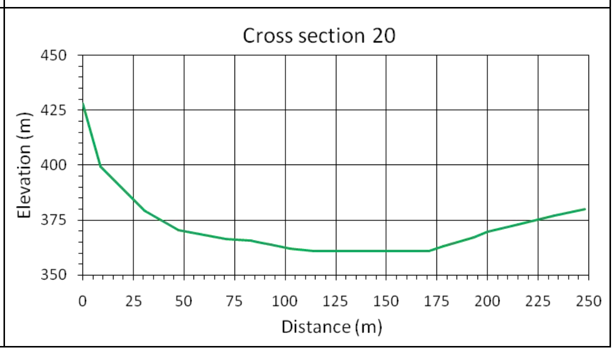

Cross section 15
Elevation (m)
650
600
550
500
450
400
0 50 100 150 200 250 300 350 400 450 500 550
Distance (m)


Cross section 16
Elevation (m)
600
550
500
450
400
0 50 100 150 200 250 300 350 400 450 500 550
Distance (m)


Cross section 17
Elevation (m)
600
550
500
450
400
0 50 100 150 200 250 300 350 400
Distance (m)


Cross section 18
Elevation (m)
525
500
475
450
425
400
0 50 100 150 200 250 300 350 400 450 500 550
Distance (m)


Cross section 19
Elevation (m)
420
410
400
390
380
370
360
350
0 25 50 75 100 125 150 175
Distance (m)


Cross section 20
Elevation (m)
450
425
400
375
350
0 25 50 75 100 125 150 175 200 225 250
Distance (m)

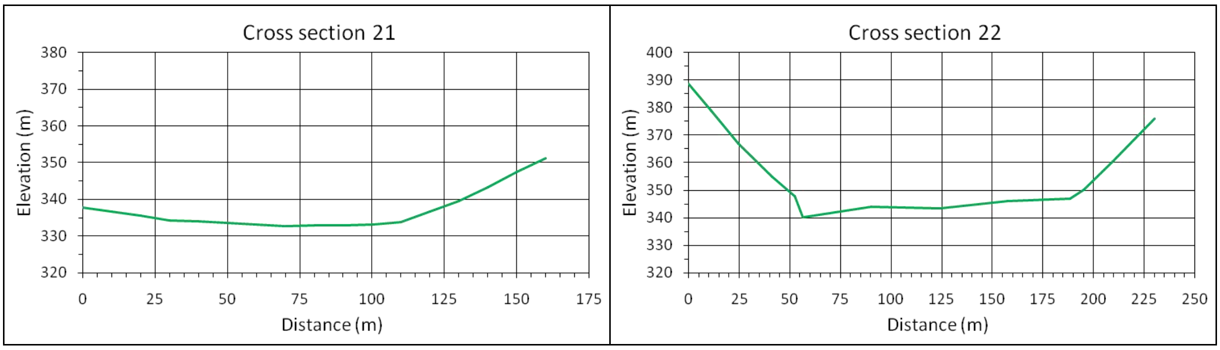


Figure 4.7: Cross sections (22 nos.)

CHAPTER 5: DAM BREAK AND HYDRO-DYNAMIC SIMULATIONS

5.1 Selection of dam breach parameters

Estimation of the dam break flood will depend on time of failure, extent of overtopping before failure, size, shape and time of the breach formation, etc., which are called dam breach parameters. The breach characteristics that are needed as input to the existing dam break models are: i) Initial and final breach width; ii) Shape of the breach; iii) Time duration of breach development, and iv) Reservoir level at time of start of breach. The predominant mechanism of breach formation is, to a large extent, dependent on the type of dam and the cause due to which the dam failed.

A study of the different dam failures indicate that concrete arch and gravity dams breach by sudden collapse, overturning or sliding away of the structure due to inadequate design or excessive forces that may result from overtopping, earthquakes and deterioration of the abutment or foundation material.

As per the UK Dam Break Guidelines and U.S. Federal Energy Regulatory Commission (FERC) Guidelines, in the case of concrete gravity dams, the breach width should be taken 0.2-0.5 times the crest length of the dam. The breach development time for gravity dam should be about 0.2 hour. The breach depth can be taken corresponding to the relatively weaker locations in the dam such as galleries etc. or the zero storage elevation of the reservoir.

For the present case the gross storage of the reservoir is only 10.88 M cum, hence in case of any dam breach the storage is not capable to further increase the size of breach, as the reservoir will get emptied rapidly. Considering this fact, it is appropriate to assume a breach width 40m. Accordingly, the breach parameters given in table-5.1 have been selected for this study.

Table-5.1: Breach Parameters

<table>
<tr><th colspan="2">Breach Level (m)</th><th rowspan="2">Breach Width (m)</th><th rowspan="2">Breach Slope</th><th rowspan="2">Breach Development Time (Minutes)</th><th rowspan="2">Remarks</th></tr>
<tr><th>Initial</th><th>Final</th></tr>
</table>

583.2	540	40	0	10	The final breach level is assumed at El 540 m which is close to the zero storage elevation of the reservoir

5.2 Critical conditions for dam break study

The critical condition for a dam break study is when the reservoir is at FRL and the inflows are close to the design flood hydrograph (PMF). Accordingly, in the present study, first the reservoir routing has been carried out by impinging the PMF into the reservoir, assuming that the water level in reservoir is at FRL and the spillway gates are fully open. The time series of reservoir level during routing the PMF through the reservoir is given in Plate-1. In order to analyse dam break flooding different cases have been considered. These are given below:

1. Dam break takes place when the PMF impinges into the reservoir when it is at FRL and Spillway gates are fully open.
2. PMF impinges into the reservoir when it is at FRL and Spillway gates are fully open.
3. 100 year return period flood impinges into the reservoir when it is at FRL and Spillway gates are fully open.

5.3 Dam break takes place when the PMF impinges into the reservoir when it is at FRL and Spillway gates are fully open (case 1)

Taking the above breach parameter given in Table 5.1, dam break conditions have been simulated. In the simulation it has been assumed that the dam breach starts after the impingement of the PMF and when the PMF peak enters the reservoir and the spillway gates are fully open. The dam breach flood hydrograph just downstream of the dam, Spillway flood hydrograph and flood hydrograph 23.40 km downstream to dam are given in Plate-1.The maximum discharge and water level obtained at the different locations along the river reach are given in Table-5.2 and 5.3 respectively.

Longitudinal profile of Maximum water level (Case 1) is given in Figure 5.1. Flood Hydrograph at different locations for Case-1 is given in appendix (Table -1).

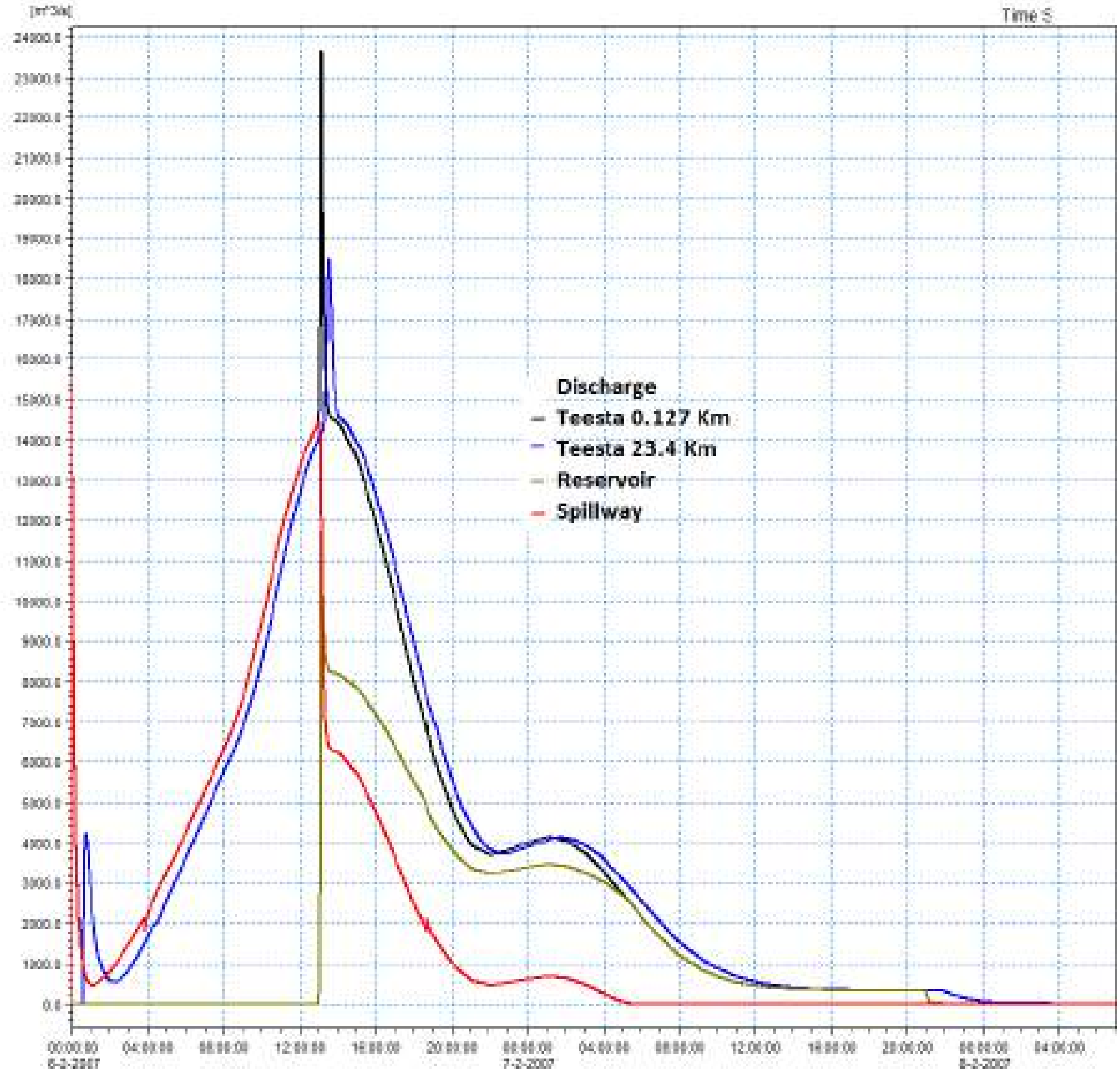


Plate-1: Flood Hydrographs at Dam site, spillway and 23.4 km downstream from Dam (Case-1)

Table-5.2 : Maximum discharge due to dam breach flood (breach width 40m and breach depth 43.5 m)

Teesta River (Chainage From Dam) Km.	Maximum Discharge (m^3/s)	Time
127	23657.07	06-02-2007 13:10
327	23406.76	06-02-2007 13:10
500	23152.77	06-02-2007 13:10
675	22886.19	06-02-2007 13:11
775	22907.61	06-02-2007 13:11
900	22929.58	06-02-2007 13:11
1500	22899.35	06-02-2007 13:11

2500	22278.06	06-02-2007 13:11
3500	21775.47	06-02-2007 13:11
4500	21492.52	06-02-2007 13:12
5500	21057.86	06-02-2007 13:14
6500	20684.77	06-02-2007 13:15
7500	20297.23	06-02-2007 13:17
8500	20100.2	06-02-2007 13:18
9500	19922.9	06-02-2007 13:18
10500	19821.3	06-02-2007 13:18
11500	19732.53	06-02-2007 13:19
12500	19676.33	06-02-2007 13:21
13468.8	19510.81	06-02-2007 13:22
14406.3	19374.79	06-02-2007 13:22
15343.8	19256.66	06-02-2007 13:23
16281.3	19154.46	06-02-2007 13:25
17218.8	19068.85	06-02-2007 13:26
18156.3	19000.08	06-02-2007 13:26
19093.8	18952.63	06-02-2007 13:27
20031.3	18913.31	06-02-2007 13:29
20625	18890.67	06-02-2007 13:29
21175	18843.26	06-02-2007 13:30
22025	18720.68	06-02-2007 13:30
22875	18585.15	06-02-2007 13:32
23400	18519.58	06-02-2007 13:33

Note : The dates shown are relative dates as used in MIKE11 model simulation

Table-5.3 : Maximum water level due to dam breach flood (breach width 40m and breach depth 43.5 m)

Teesta River (Chainage From Dam) Km	Minimum bed Level (m)	Maximum Water Level (m)	Time
0	538.18	553.807	06-02-2007 13:10
254	533.09	548.923	06-02-2007 13:10
400	530.52	546.352	06-02-2007 13:11
600	527.65	543.925	06-02-2007 13:11
750	526.28	542.26	06-02-2007 13:11
800	526.28	541.69	06-02-2007 13:11
1000	524.30	539.385	06-02-2007 13:11
2000	502.70	522.367	06-02-2007 13:11
3000	494.10	513.931	06-02-2007 13:12
4000	486.40	506.245	06-02-2007 13:14
5000	478.89	498.007	06-02-2007 13:15
6000	478.89	492.486	06-02-2007 13:15
7000	464.50	481.861	06-02-2007 13:17
8000	460.50	477.106	06-02-2007 13:18

9000	450.40	467.666	06-02-2007 13:18
10000	444.00	461.405	06-02-2007 13:19
11000	435.20	450.655	06-02-2007 13:21
12000	423.60	441.917	06-02-2007 13:21
13000	417.60	431.485	06-02-2007 13:22
13937.5	410.40	424.219	06-02-2007 13:23
14875	403.20	417.053	06-02-2007 13:25
15812.5	396.00	410.03	06-02-2007 13:26
16750	388.80	403.197	06-02-2007 13:26
17687.5	381.60	396.661	06-02-2007 13:27
18625	374.40	390.459	06-02-2007 13:27
19562.5	367.20	384.384	06-02-2007 13:29
20500	360.77	377.567	06-02-2007 13:30
20750	360.77	373.67	06-02-2007 13:30
21600	351.415	365.315	06-02-2007 13:32
22450	342.057	359.885	06-02-2007 13:33
23300	340.054	358.207	06-02-2007 13:33

Note : The dates shown are relative dates as used in MIKE11 model simulation

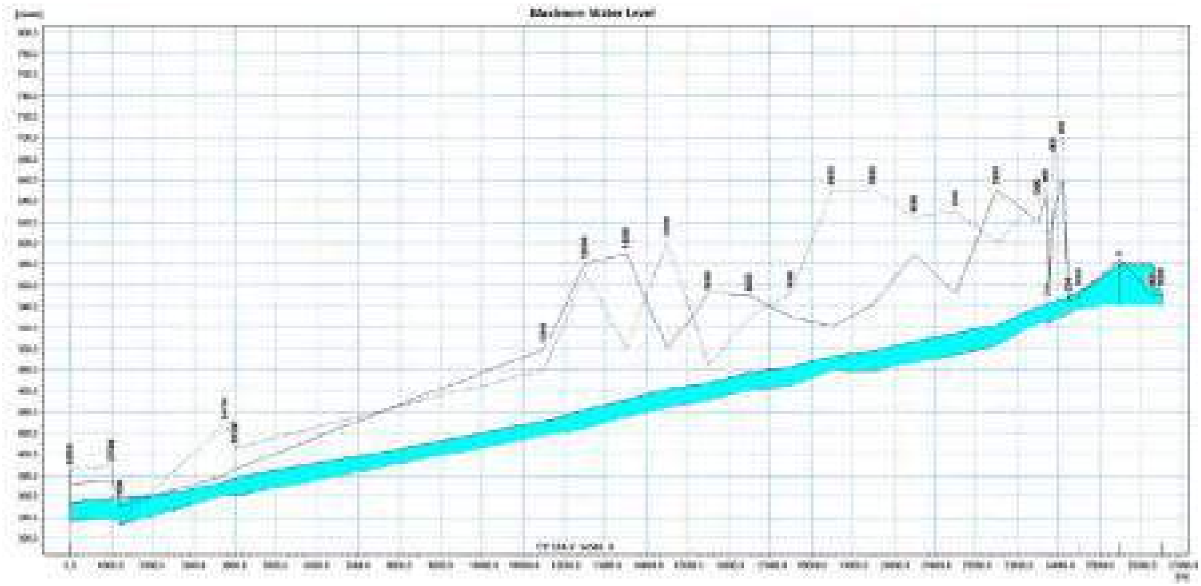


Figure:5.1: Longitudinal profile of Maximum water level (Case 1)

5.4 PMF impinges into the reservoir when it is at FRL and Spillway gates are fully open (Case 2):

Taking the above breach parameter given in Table 5.1, the PMF routing into the river has been simulated considering that the spillway gates are fully open. The flood hydrograph just downstream of the dam and at 23.4 km downstream from dam are given in Plate-2.

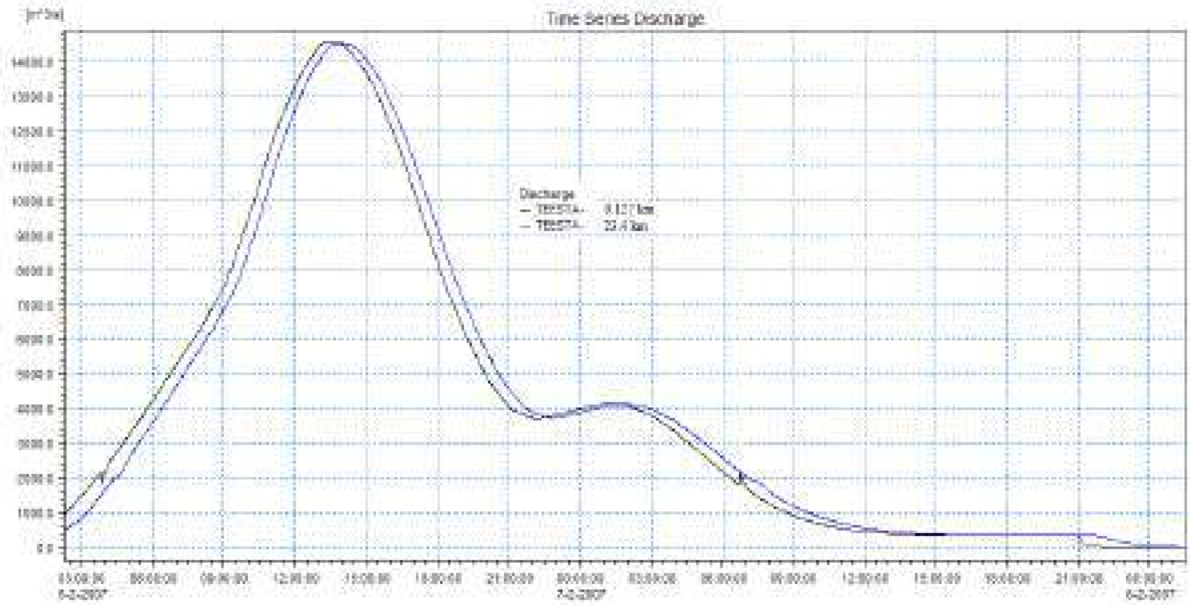


Plate-2: Flood Hydrographs at Dam sit and 23.4 km downstream from Dam

To know the maximum discharge and water levels at different locations of Teesta River downstream of the dam due to occurrence of PMF, when spillway gates are fully open, the simulation has been run. The maximum discharge and water level obtained at the different locations along the river reach are given in Table-5.4 and 5.5 respectively.

Longitudinal profile of Maximum water level (Case 2) is given in Figure 5.2. Flood Hydrograph at different locations for Case-2 is given in appendix (Table -2).

Table-5.4: Maximum discharge due to occurrence of PMF with no dam breach and spillway gates fully open

Teesta River (Chainage From Dam) Km	Maximum Discharge (m^3/s)	Time
127	14539.08	06/02/2007 13:21
327	14539.061	06-02-2007 13:21
500	14539.036	06-02-2007 13:21
675	14539.001	06-02-2007 13:21
775	14538.997	06-02-2007 13:22
900	14538.993	06-02-2007 13:22
1500	14538.93	06/02/2007 13:22
2500	14538.682	06-02-2007 13:22
3500	14538.382	06-02-2007 13:23
4500	14538.145	06-02-2007 13:25

5500	14537.72	06-02-2007 13:26
6500	14537.373	06-02-2007 13:27
7500	14536.876	06-02-2007 13:29
8500	14536.622	06-02-2007 13:30
9500	14536.356	06-02-2007 13:30
10500	14536.226	06-02-2007 13:32
11500	14536.029	06-02-2007 13:33
12500	14535.869	06-02-2007 13:33
13468.8	14535.374	06-02-2007 13:36
14406.3	14535.075	06-02-2007 13:37
15343.8	14534.776	06-02-2007 13:37
16281.3	14534.483	06-02-2007 13:38
17218.8	14534.204	06-02-2007 13:40
18156.3	14533.957	06-02-2007 13:41
19093.8	14533.758	06-02-2007 13:41
20031.3	14533.624	06-02-2007 13:42
20625	14533.536	06-02-2007 13:42
21175	14533.394	06-02-2007 13:44
22025	14532.873	06-02-2007 13:45
22875	14532.211	06-02-2007 13:47
23400	14531.909	06-02-2007 13:48

Table-5.5 : Maximum water level due to occurrence of PMF with no dam breach and spillway gates fully open

Teesta River (Chainage From Dam)	Minimum bed Level (m)	Maximum Water Level (m)	Time
0	538.18	550.304	06/02/2007 13:18
254	533.09	545.512	06/02/2007 13:18
400	530.52	542.997	06/02/2007 13:21
600	527.65	540.601	06/02/2007 13:22
750	526.28	538.991	06/02/2007 13:21
800	526.28	538.468	06/02/2007 13:18
1000	524.30	536.309	06/02/2007 13:22
2000	502.70	518.765	06/02/2007 13:21
3000	494.10	510.637	06/02/2007 13:22
4000	486.40	503.283	06/02/2007 13:22
5000	478.89	495.414	06/02/2007 13:25
6000	478.89	490.385	06/02/2007 13:26
7000	464.50	479.282	06/02/2007 13:27
8000	460.50	474.564	06/02/2007 13:30
9000	450.40	464.975	06/02/2007 13:30
10000	444.00	458.771	06/02/2007 13:30
11000	435.20	448.319	06/02/2007 13:32
12000	423.60	439.616	06/02/2007 13:33
13000	417.60	430.04	06/02/2007 13:34

13937.5	410.40	422.769	06/02/2007 13:33
14875	403.20	415.551	06/02/2007 13:34
15812.5	396.00	408.456	06/02/2007 13:38
16750	388.80	401.543	06/02/2007 13:37
17687.5	381.60	394.888	06/02/2007 13:40
18625	374.40	388.576	06/02/2007 13:41
19562.5	367.20	382.491	06/02/2007 13:42
20500	360.77	375.728	06/02/2007 13:42
20750	360.77	372.119	06/02/2007 13:41
21600	351.415	363.577	06/02/2007 13:44
22450	342.057	357.935	06/02/2007 13:45
23300	340.054	356.391	06/02/2007 13:45

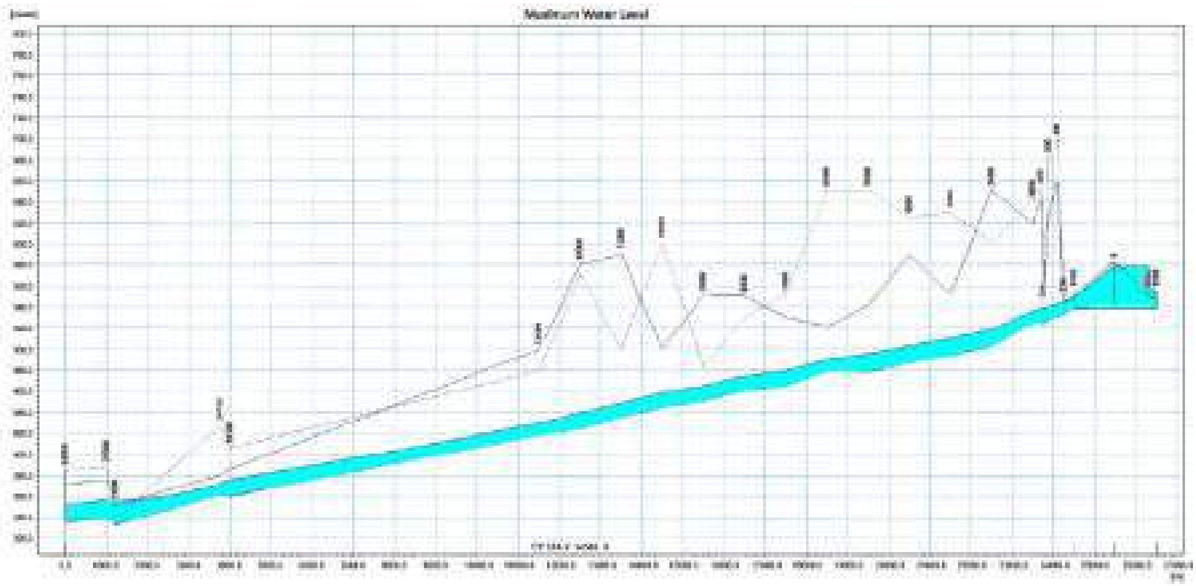


Figure 5.2: Longitudinal profile of Maximum water level (Case 2)

5.5 100 year return period flood impinges into the reservoir when it is at FRL and Spillway gates are fully open (Case 3):

Taking the above breach parameter given in Table 5.1, the 100 year flood routing into the river has been simulated considering that the spillway gates are fully open. The flood hydrograph at spillway and at 23.4 km downstream from dam are given in Plate-2.

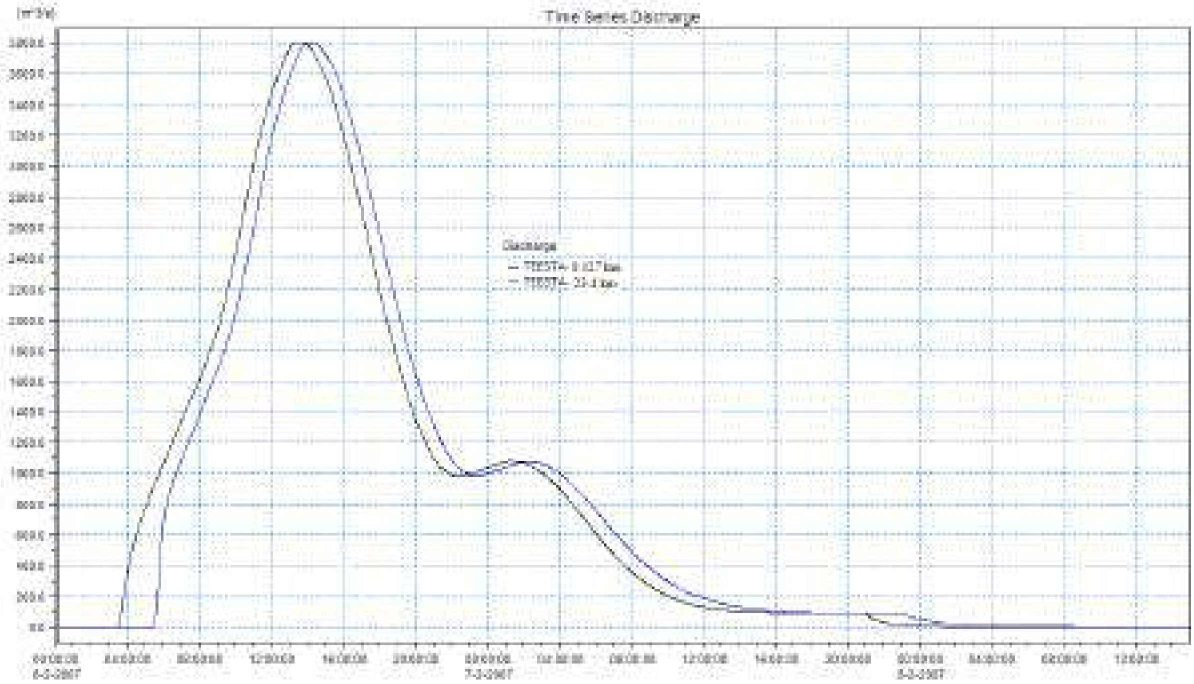


Plate-3: Flood Hydrographs at Spillway and 23.4 km downstream from Dam

To know the maximum discharge and water levels at different locations of TeestaRiver downstream of the dam due to occurrence of 100 year flood, when spillway gates are fully open, the simulation has been run. The maximum discharge and water level obtained at the different locations along the river reach are given in Table-5.6 and 5.7 respectively. Longitudinal profile of Maximum water level (Case 3) is given in Figure 5.3. Flood Hydrograph at different locations for Case-3 is given in appendix (Table -3).

Table-5.6: Maximum discharge due to occurrence of 100 Year flood with no dam breach and spillway gates are fully open

Teesta River (Chainage From Dam)	Maximum Discharge (m^3/s)	Time
127	3804.686	06-02-2007 13:18
327	3804.682	06-02-2007 13:18
500	3804.674	06-02-2007 13:18
675	3804.663	06-02-2007 13:19
775	3804.662	06-02-2007 13:19
900	3804.66	06-02-2007 13:19
1500	3804.625	06-02-2007 13:21
2500	3804.479	06-02-2007 13:22
3500	3804.298	06-02-2007 13:23
4500	3804.115	06-02-2007 13:26
5500	3803.836	06-02-2007 13:27
6500	3803.688	06-02-2007 13:30

7500	3803.469	06-02-2007 13:32
8500	3803.367	06-02-2007 13:33
9500	3803.215	06-02-2007 13:34
10500	3803.13	06-02-2007 13:36
11500	3802.997	06-02-2007 13:37
12500	3802.879	06-02-2007 13:38
13468.8	3802.715	06-02-2007 13:41
14406.3	3802.536	06-02-2007 13:42
15343.8	3802.369	06-02-2007 13:45
16281.3	3802.211	06-02-2007 13:47
17218.8	3802.059	06-02-2007 13:48
18156.3	3801.911	06-02-2007 13:51
19093.8	3801.798	06-02-2007 13:52
20031.3	3801.712	06-02-2007 13:52
20625	3801.687	06-02-2007 13:53
21175	3801.639	06-02-2007 13:55
22025	3801.449	06-02-2007 13:56
22875	3800.951	06-02-2007 13:59
23400	3800.757	06-02-2007 14:00

Table-5.7: Maximum water level due to 100 year flood and no dam breach considering spillway gates are fully open

Teesta River (Chainage From Dam)	Minimum bed Level (m)	Maximum Water Level (m)	Time
0	538.18	544.1	06-02-2007 13:15
254	533.09	539.218	06-02-2007 13:15
400	530.52	536.754	06-02-2007 13:15
600	527.65	534.062	06-02-2007 13:17
750	526.28	532.634	06-02-2007 13:17
800	526.28	532.24	06-02-2007 13:17
1000	524.30	530.399	06-02-2007 13:18
2000	502.70	510.851	06-02-2007 13:18
3000	494.10	502.764	06-02-2007 13:21
4000	486.40	495.607	06-02-2007 13:23
5000	478.89	488.822	06-02-2007 13:25
6000	478.89	484.949	06-02-2007 13:30
7000	464.50	472.057	06-02-2007 13:30
8000	460.50	467.47	06-02-2007 13:30
9000	450.40	457.185	06-02-2007 13:30
10000	444.00	450.995	06-02-2007 13:33
11000	435.20	441.562	06-02-2007 13:34
12000	423.60	432.417	06-02-2007 13:37
13000	417.60	425.21	06-02-2007 13:37

13937.5	410.40	417.945	06-02-2007 13:40
14875	403.20	410.583	06-02-2007 13:40
15812.5	396.00	403.274	06-02-2007 13:45
16750	388.80	396.041	06-02-2007 13:45
17687.5	381.60	388.933	06-02-2007 13:48
18625	374.40	382.031	06-02-2007 13:49
19562.5	367.20	375.404	06-02-2007 13:51
20500	360.77	368.91	06-02-2007 13:51
20750	360.77	366.515	06-02-2007 13:52
21600	351.415	357.369	06-02-2007 13:52
22450	342.057	350.268	06-02-2007 13:57
23300	340.054	349.662	06-02-2007 14:00

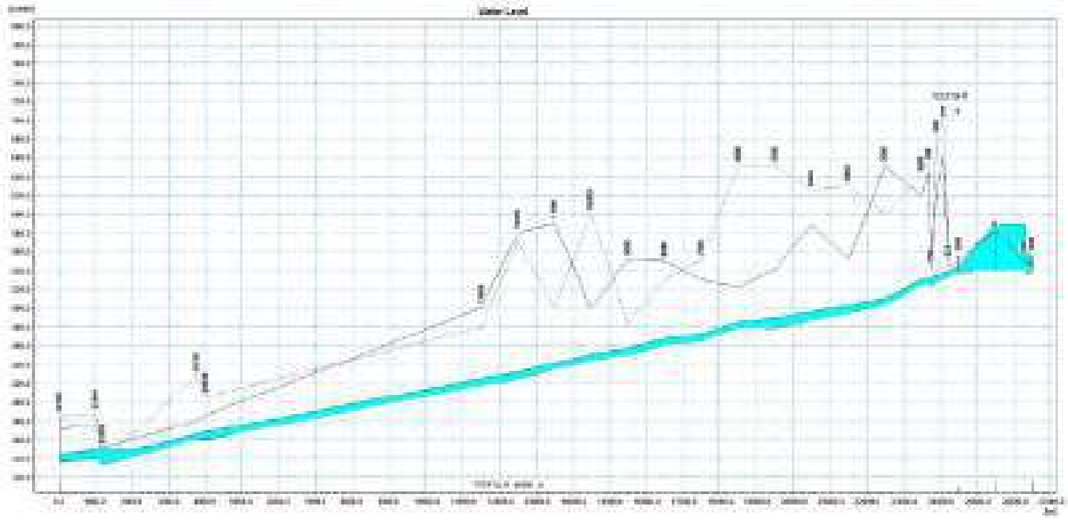


Figure 5.3: Longitudinal profile of Maximum water level (Case 3)

Out of the above three cases, case 1 (Dam break takes place when the reservoir is at FRL, PMF impinges in the reservoir and Spillway gates are open) gives the worst conditions. Therefore, maximum water levels given in table 5.8 have been taken in HEC-GEORAS to get flood inundation maps and described in next chapter.

5.6 ASSUMPTIONS

Modelling process is nothing but approximation of a physical phenomenon through which the physical phenomenon and its effects can be studied. Thus, as in the case of any other modelling process, dam break modelling has inherent approximations through assumptions. The foremost assumptions are in the hydrodynamic equations (Saint Venant equations), which are derived on the basis of the following assumptions:

(1) The water is incompressible and homogeneous i.e. without significant variation in density.

(2) The bottom slope is small.

(3) The wave lengths are large compared to the water depth. This ensures that the flow everywhere can be regarded as having a direction parallel to the bottom, i.e., vertical accelerations can be neglected and a hydrostatic pressure variation along the vertical can be assumed.

(4) The flow is sub-critical.

The other assumptions are associated with the breach parameters, especially, breach width and breach depth, which has great impact on flood peak and arrival times. Dam break floods create a large amount of transported debris. This may accumulate at constricted cross sections, where it acts as a temporary dam and partially or completely restricts the flow, resulting variation in water level at the downstream locations. This aspect has also been neglected due to limitations in modelling of such a complicated physical process. This limitation also has an effect on the conservative side only.

Even with the assumptions outlined above, dam break modelling serves very useful purpose, as it provides reasonable extent of inundation under different situations enabling preparation of Emergency Action Plan/ Disaster Management Plan.

6.0 EMERGENCY ACTION PLANS (EAP) FOR TEESTA V POWEER STATION

6.1 Introduction

The term "dam failure" suggests a single event - a quickly-rising super flood of fast flowing water presumably varying in scale (depending on the volume of water released) and in human impact (depending on the size of the downstream population) but otherwise of similar character wherever it may occur. In fact, of course, dam-failure floods can be quite different depending on both environmental conditions and mode of failure, and these differences are likely to be of great significance in terms of defining appropriate emergency responses.

Emergency planning is obviously most effective given a sound advance appreciation of the nature of the event which is envisaged. In the case of a flood resulting from dam failure, there are perhaps two principal features above all others which must be understood if the plan for it is to have utility. These relate to warning time and the likely bounds of the area which will be inundated. Neither can be known with precision, partly because dam failure has not yet occurred at the site of any existing dam and empirical data are therefore lacking, but partly too because no two floods emanating from the same location would ever be identical. Warning time is a critical variable in planning the emergency response to flooding and ensuring that the impacts of floods are effectively mitigated. This is particularly so in the case of dam-failure floods, which almost by definition arise more quickly and affect more people than do "natural" floods and which create more difficult problems in terms of the need to mount larger scale evacuation operations under more severe time constraints. Moreover, in some instances the amount of time which would elapse between dam failure and the cutting of escape routes would be very small - too small, in fact, too allow all the potential victims to be evacuated in time. It is therefore vital that warning be seen in terms of time before the dam wall begins to break as well as after.

The Emerging Action Plans (EAPs) are required to outline “who does what, where, when and how” in an emergency situation or unusual occurrence affecting the dam. The need for EAPs was also emphasized by the Dam Safety Bill, 2010, which was introduced in the Lok Sabha on August 30, 2010, and subsequently referred to the Parliamentary Standing Committee on Water Resources for examination. Passing of the Bill was recommended by the Parliamentary Standing Committee subject to compliance of its recommendations and observations.

However, with the dissolution of the 15th Lok Sabha, the Bill had come to a lapse. The enactment of the Dam Safety Bill is now required to be taken up afresh; and case is under process.

The EAP is the primary safeguard in reducing loss of life from dam failure. The EAP identifies potential emergency conditions at the dam and specifies the pre-planned actions to be followed to minimize loss of life and property damage. The EAP contains inundation maps to identify the areas subject to flooding in the unlikely event of dam failure. EAPs are critical in identifying areas downstream from dams requiring warning and evacuation in event of dam failure. Documented cases have demonstrated that warning and evacuation time can dramatically influence the loss of life.

6.2 Responsibilities

6.2.1 Owner's responsibility

The owner's responsibility format is given below (related information in the form is to be filled by the Department):

Owner's responsibility Format

(i) **(Dam Owner's) ___________________ office**
As the dam owner, the _____________ is responsible for maintaining a safedam, which includes management of operations, maintenance, repair &rehabilitation functions.
Additionally, in an emergency situation, the dam owner, or designee, isresponsible for making internal and external notifications, implementingresponse and mitigation actions at the dam and documenting all activities.
(ii) (**Dam Supervisory Office) __________________**
The ________________ is responsible for performing (list specific aspects ofduties delegated by dam owner) ________________________.

(iii) (If applicable, additional levels of Dam Supervisory office) _______
The ____________________ is responsible for performing (list specific aspectsof duties delegated by dam owner) __________________

(iv) (If applicable) 24 hour Control or Operation Centre _________
The ____________ is responsible for performing (list specific aspects of duties delegated by dam owner) __________________.

(v) (If applicable, Operator Supervisory Office) _________
The ____________ is responsible for performing (list specific aspects of dutiesdelegated by dam owner) __________________.

(vi) Dam Operator

The Dam Operator, employed by _______________, resides (location of DamOperator's residence) at _______________. The Dam Operator is responsiblefor performing (list specific aspects of duties delegated by dam owner).

The owner's responsibility format given above should up updated periodically.

6.2.2 Local Emergency Management Authority

Local Emergency Management Authority, i.e., Local, District and Stateauthorities are responsible for beginning the call down sequence initiating andcoordinating emergency operations, carrying out warning and evacuation ofpopulations at risk and other response actions under their authorities.

6.2.3 Responsibility for notification

The dam owner is responsible for notifying theappropriate officials when flooding is anticipated, or a failure is imminent orhas occurred. However, under certain circumstances, such as when failure isimminent or has occurred, the responsibility and authority for notification mayhave to be delegated to the dam operator or a local official.

The India Meteorological Department (IMD), Central Water Commission and /or other State and Central agencies have the general responsibility for issuingflood warnings. It will, therefore, be desirable to notify the IMD, CWC or otherappropriate agency of any pending or actual dam break flooding, so that itsfacilities can enhance warnings being issued.

6.2.4 Responsibility for evacuation, rescue & relief

In the federal set up of India, the basic responsibility for undertaking rescue, relief and rehabilitation measures in the event of a disaster is that of the State Government concerned. At the State level, response relief and rehabilitation are handled by Departments of Relief & Rehabilitation. The State Crisis Management Committee is set up under the Chairmanship of Chief Secretary, who is the highest executive functionary in the State. All the concerned Departments and organisations of the State and Central Government Departments located in the State are represented in this Committee. This Committee reviews the action taken for response and relief and gives guidelines/directions as necessary.

Generally a control room is established under the Relief Commissioner. The control room is in constant touch with the climate monitoring/forecasting agencies and monitors the action being taken by various agencies in performing their responsibilities.

The district level is the key level for disaster management and relief activities. The Collector / District Magistrate is the chief administrator in the district. He is the focal point in the preparation of district plans and in directing, supervising and monitoring calamities for relief. A District level Coordination and Relief Committee is constituted and is headed by the Collector as Chairman with participation of all other related government and non governmental agencies and departments in addition to the elected representatives. The Collector is required to maintain close liaison with the district and the State Governments as well as the nearest units of Armed Forces/Central police organisations andother relevant Central Government organisations like Ministries of Communications, Water Resources, Health, Drinking Water, Surface Transport, who could supplement the efforts of the district administration in therescue and relief operations. The efforts of the Government and nongovernmental organisations for response and relief are coordinated by theCollector/ District Magistrate. The District magistrate / Collector and the Coordination Committee under him reviews preparedness measures prior to an impending hazard and coordinate response when the hazard strikes. As all the Departments of the State Government at the district level report to the Collector, there is an effective coordination mechanism ensuring holistic response.

The existing mechanism for disaster management prevailing in the State concerned should be utilized for warning, evacuation, rescue & relief planning. However, it should not be assumed that the governmental entities are the only way for evacuation of people. There may be situations in which routine notification and evacuation will not suffice, as in the case of a resident located just below the dam. In this case, it should be arranged to notify and evacuate that person directly. This procedure should be coordinated with the appropriate public officials.

6.2.5 EAP Coordinator’s responsibility

It is advisable to designate an EAP coordinator, who will be responsible for EAP–related activities, including (but not limited to) preparing revisions to the EAP, establishing training seminars, coordinating EAP drills, etc.

6.2.6 Approval of the plan

The EAP should be signed by all parties (Dam Safety division and state and district administration) involved in the plan, where they indicate their approval of the plan and agree to their responsibilities in its execution. Including the approval signatures is essential in an EAP, as it assures that all parties involved are aware of and understand the EAP and agree to do their assigned roles, as soon as an emergency takes place.

6.3 Emergency procedures

6.3.1 Emergency identification, evaluation & classification

(i)A listing of the conditions or events which could lead to or indicate anexisting or potential emergency is given below:

(1) Extreme storm

(2) Landslide

(3) Earthquake

(4) Overtopping

(5) Structural damage

(6) Piping

(7) Equipment malfunction

(8) Foundation failure

(9) Sabotage

The above unusual situations can be divided into 3 categories:

(a) Hydrologic: These are related to flooding due large releases, seepage, slumping, piping, embankment cracking, embankment deformation, embankment overtopping, movement of concrete section(sliding or over turning) settlement, failure of spillway gates or supporting structures, spillway & outlet works releases, equipment malfunction, etc.

(b) Earthquake: These are related to impact of earthquake at dam which could lead to embankment piping, embankment cracking, embankment deformation, liquefaction and movement of concrete section, etc.

(c) All other events: These are related to hazardous material spills /releases, equipment failures, security / criminal actions, fish / wildlife impacts, wildfires, structural fires, landslides, extreme storm, sabotage, etc. One or more of the above unusual situations will initiate declaration of an emergency for internal alert or external alert.

(ii) A brief description of the means by which potential emergencies will be identified, including the data & information collection system, monitoring arrangements, surveillance, inspection procedures and other provisions for early detection of conditions indicating an existing or potential emergency. Emergency events occur with unusual situations varying degrees of severity and predictability. An emergency may develop gradually and be steadily monitored providing ample response time. Conversely, an emergency may develop suddenly requiring immediate emergency response to prevent devastating loss of life or impacts to structures or the environment. The following definitions are used to classify emergency events according to an ascending and progressive order of severity to which the dam downstream or off-site population, structures or environment are threatened. Condition may dictate that situation is classified as imminent without passing through the less severe situations. A smooth transition should occur, if the situation is classified as “developing” prior to “imminent.”

Assessment of degree of seriousness of unusual situation is required. It may be classified as the Blue, Yellow, Orange and Red level alert according to their seriousness. Guidelines lie mainly in the interface between the internal and external emergency planning, being the two main aspects of the following:

(a) **Definition of alert levels:** If an incident happen with the dam or problem arises related with the dam over its foundations or with landslides into the reservoir, earthquakes, adverse meteorological situations or any other, alert must be given to civil protection system. The gravity of the problem may obviously vary with the situation, but in order to assure that all the entities involved in emergency actions are behaving in accordance with the situation, the alert levels need to be previously defined, and must be the same for the internal and external emergency plan of each dam. These alert levels are established in colours, from Blue, the lowest level that corresponds to a routine or normal situation, to Red, corresponding to a serious or catastrophic situation. Its underlying philosophy relates the gravity of dam problems with the expected impacts in the downstream valley and the likelihood of the total dam rupture.

(b) **Alert and warning systems:** When facing problematic situation, the entity exploring the dam must judge the corresponding alert level and notify the civil protection system, in order to allow the development of the necessary actions, according to the situation. If the dam rupture is very likely (orange alert level) or imminent (red level), give “external alert” signal and the entity exploring the dam must warn population downstream of the dam. In orange level, the warning indicates people to be ready for evacuation and in red alert to evacuate quickly. Given that a dam rupture can be very sudden, it is assumed that people leaving up to a certain distance downstream of the dam have to evacuate by their own means, with no time to wait for civil protection help.

(iii) Procedures, aids, instructions and provisions for interpreting information and data to assess the severity and magnitude of any existing or potential emergency should be clearly defined.

6.3.2 Notification procedures

Teesta V Power station Safety division should prepare a listing of all persons to be notified in the event when an emergency condition develops. This list should include individual names and position, titles, locations, mobile, office & home telephone numbers and radio communication frequencies and call signals (if available) for owner personnel, public officials and other personnel, including alternates. For each type of emergency situation, it is to be clearly indicated who is to make a call, to whom it is to be made and in what priority. The number of persons to be notified by each responsible individual in the notification plan should be kept to a minimum. The number of calls will in some cases be governed by what other responsibilities the caller has been assigned.

The following individuals or agencies, where applicable, should be considered for inclusion in the notification procedures:

(i) Residents and property owners located immediately downstream of the dam within the area of potential inundation, where available warning time is very limited.
(ii) Owner personnel
(iii) Law enforcement officials
(iv) Operators of upstream and downstream dams or water-retention facilities
(v) Appropriate State and local agencies
(vi) Managers and operators of recreation facilities
(vii) Others, as appropriate

A spokesperson is to be nominated by the department for disseminate information. The news media, including radio, television and newspapers, should be utilized to the extent available and appropriate. Use of news media should be pre-planned to the extent possible by the dam owner and / or public officials. Notification of the news media may be done by the dam owner or by public officials, depending on the type of emergency. Notification plans should define emergency situations for which each medium will be utilized and should include an example of a news release that would be the most effective for each possible emergency.

Format for notification:

(i) This is (name, title, agency) ___________ monitoring ___________ dam.
(ii) The date is ______________ and the time is ________.

(iii) The conditions at the dam are (describe situation and include damages, outflows, reservoir elevation, potential or actual failure and non hydrological hazard, etc.).

(iv) We will notify you if the conditions at the dam change. We will give you the next briefing at __________ hours or sooner.

(v) For further information, contact __________________ at______________.

(vi) This message will be sent to you in the text form of (fax or other).

Table 6.1:Alert levels for Dam Break Planning

Type of alert	**Alert level**	**Situation**	**Response system**	**Engineer in charge Actions**
INTERNAL ALERT	Blue	No immediate off-site impact anticipated or detection of anomalies in the dam or other events that do not compromise the structural dam safety nor its operational elements, and do not make unviable the dam observation system. Situation is stable or developing very slowly. The gravity of existing problems must let belief that no consequences are expected in the valley downstream of the dam.	Direct Command System	1. Measures to solve problem. 2. Give internal alert signal of blue level. 3. Make notification in chart No.1. Inform to: - Dam Owner (CE)
	Yellow	Existence of anomalies or events that might comprise up to some degree. The structure and / or operational dam safety or the dam observation system, assuming that eventual small consequences downstream the dam can happen: 1. Existence of meteorological adverse conditions; 2. Detection of anomalies in: - dam structural elements, or; - dam operational elements, or - dam observation system. 3. Existence of foundation problems 4. Situation is developing slowly	Direct Command System	1.Measures to solve problem 2.Give internal alert signal of yellow level 3. Make notifications in chart No.1 4. Inform to - Dam owner (CE) - EE - E-in-C - District Collector (if necessary)
EXTERNAL ALERT	Orange	Situation with high probability of dam failure, belief that it might not be possible to control the situation, and might cause serious consequences downstream of the dam: 1. Detection of severe anomalies in - dam structural elements, or - dam operational elements 2. Existence of severe foundation problems 3. Occurrence of floods with high recurrence interval. 4. Dam owner / operator need assistance from outside agencies or jurisdiction. 5. Situation is progressing rapidly. 6. “Some amount of time” is available for analysis, decisions and mitigation to be made before off-site impact may occur. Incident Command System 1. Measure to solve problem. 2. Give external alert signal of orange level. 3. Implement Incident Command System.		

		4. Make notification in chart No.2 5. Inform to - District Collector - CE - E-in-C - State Flood Control Cell 6. Warning – Population downstream the dam to be ready for evacuation.		
	Red	Situation of inevitable catastrophe 1. Imminence of dam failure 2. Dam failure 3. "Little or no time is available" for analysis, decisions & mitigation to be made before downstream of dam impacts occur. 4. Situation is worsened and a breach is apprehended. 5. "Little or no time is available" for analysis, decisions and mitigation to be made before off-site impact occur.	Incident Command System	1. Give external alert signal of red level. 2. Make notification in chart No.2. 3. Informs to: - Authority - Dam owner (EE, CE) - Civil protection (District Collector) Commissioner - E-in-C - State Flood Control Cell - Warning: Population downstream of the dam to evacuate quickly.
ACTION		Dam is failing or failed		1. Call and coordinate with - Civil Protection (Collector & SP) - -CE 2. Inform Commissioner and E-in-C 3. Ensure official notifications are made.

6.4 Inundation Maps

An inundation map is used to depict areas that could flood if a dam fails, and must be included in the EAP. If appropriate for the level of effort used in calculations, inundation maps should also show the time to flood (the time from the breach to the time that critical structures are flooded) and the time to peak flow.

The detail and complexity of inundation mapping depends on the expected impact of a dam failure flood on downstream population and infrastructure. For small and intermediate dams with limited downstream development, a narrative description of the affected areas and a generalized inundation map noting the potentially impacted downstream structures may suffice. For large and many intermediate-size dams, or for small dams with substantial development downstream, detailed inundation maps will be fundamentally important.

A detailed inundation map is prepared using the results of a simplified or full breach analysis carried out by a professional engineer. Whenever communities or significant number of dwellings are located in the floodplain downstream of a dam, or for large dams with complex floodplains, detailed inundation maps are usually needed for the development of an adequate evacuation plan.

These maps should show an outline of the area that would be inundated in the event of a dam failure at sufficient scale and in enough detail to identify scale and in enough detail to identify areas, including dwellings, roads,, low-water crossings, and other critical structures (schools, assisted-living facilities, hospitals, etc.) likely to be directly affected.

Information must also be included on approximate depth of flooding and velocity of flows along with travel time for floods to reach specific locations. Generally, mapping involves superimposing the inundation area outline on an existing map, aerial photograph, or satellite image. Clarity and simplicity of the displayed inundation areas are of utmost importance. Lines delineating the inundated areas should be thick enough or distinct in form (for example, solid, dashed, dotted) to identify the dam-failure inundation limits as the main feature of the map, but not so bold that they mask features that would be inundated by a dam failure.

An inundation map is a map depicting the d/s areas vulnerable to inundation by the dam break flood. The results of flow analysis were exported to ‘ArcGIS’ from ‘MIKE 11’ for inundation mapping and depth mapping. The various steps which can be followed are:

- Maximum water level of every cross section has been taken as the output for inundation and depth mapping.

- ❖Open 'ArcGIS' and join all maximum water levels with their corresponding cross sections in a separated attribute column.
- ❖Create a continuous water surface layer by interpolation technique using maximum water level of all cross sections. For this, use 'Topo to Raster' tool under 'interpolation type' in 'Spatial Analyst Tools' in 'ArsGIS'.
- ❖Layer of maximum water level is to be deducted from the actual elevation layer (DEM) for getting the flood inundation and depth map using 'raster calculator' tool under 'Spatial Analyst Tools' in 'ArsGIS'. In the output layer, the positive values of all locations (raster) will indicate the flood depth and the area will be considered as flood extent. Finally, flood inundation and depth maps can be prepared using a suitable layout.
- ❖Flood inundation map can further be converted into KMZ extension file from raster or vector file using 'To KML' tool under conversion tools in ArcGIS. As the results are better visualized in the form of KMZ files that can be opened in Google Earth.

The flood inundation map and depth maps are shown as figures 6.1 to 6.6 for the three cases. From these figure, at locations below the dam and their subsequent markings, it can be seen which areas are likely to be submerged in case of dam break and disaster management plan can be worked out. A combined flood inundation map is shown in Figure 6.7. In this figure area under A presents common area which is flooded due to all three cases. B presents the additional area due to PMF. C presents the additional area due to SPF with dam break. All the inundation maps are also shown on google earth in figures 6.8 to 6.12.

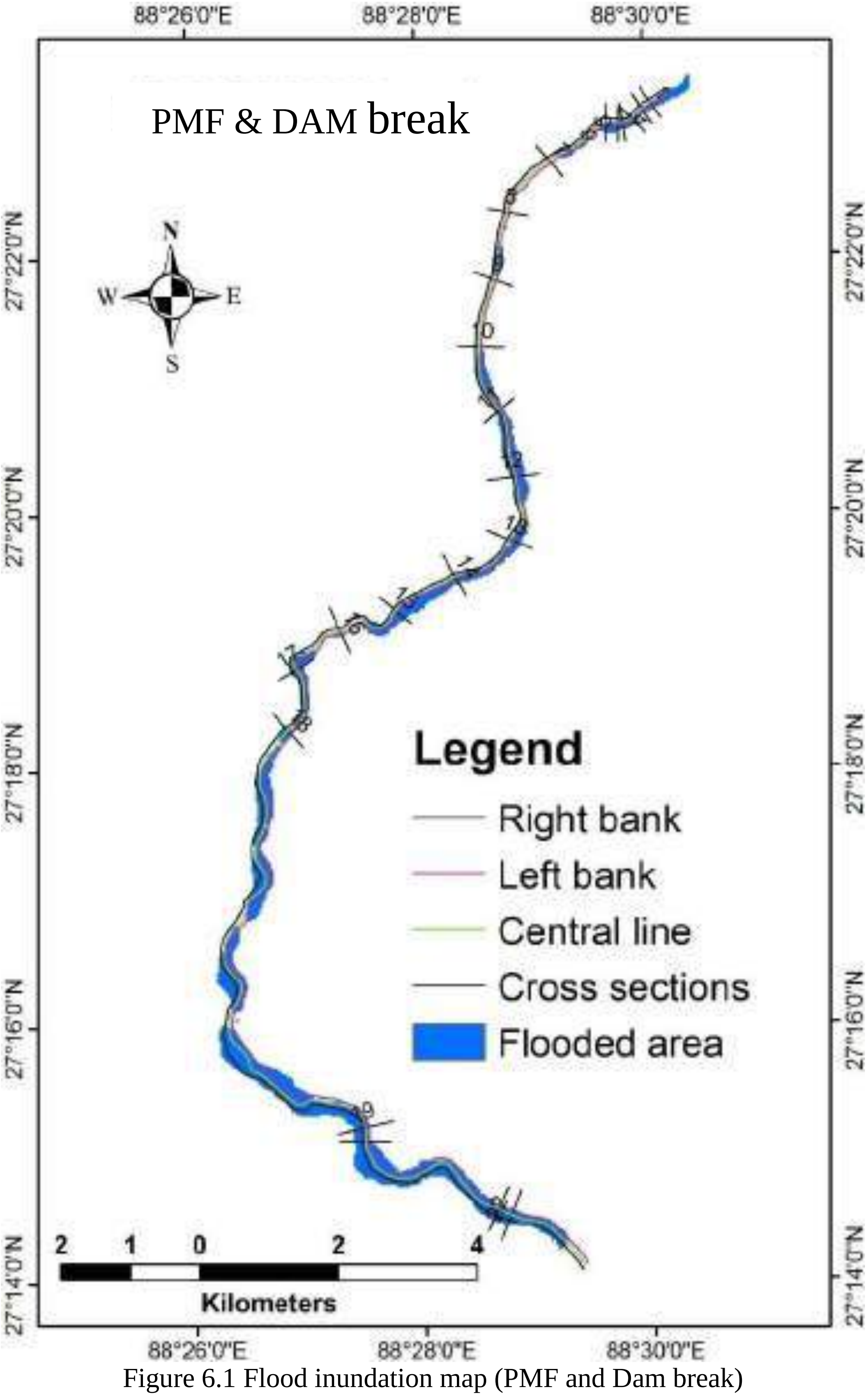


Figure 6.1 Flood inundation map (PMF and Dam break)

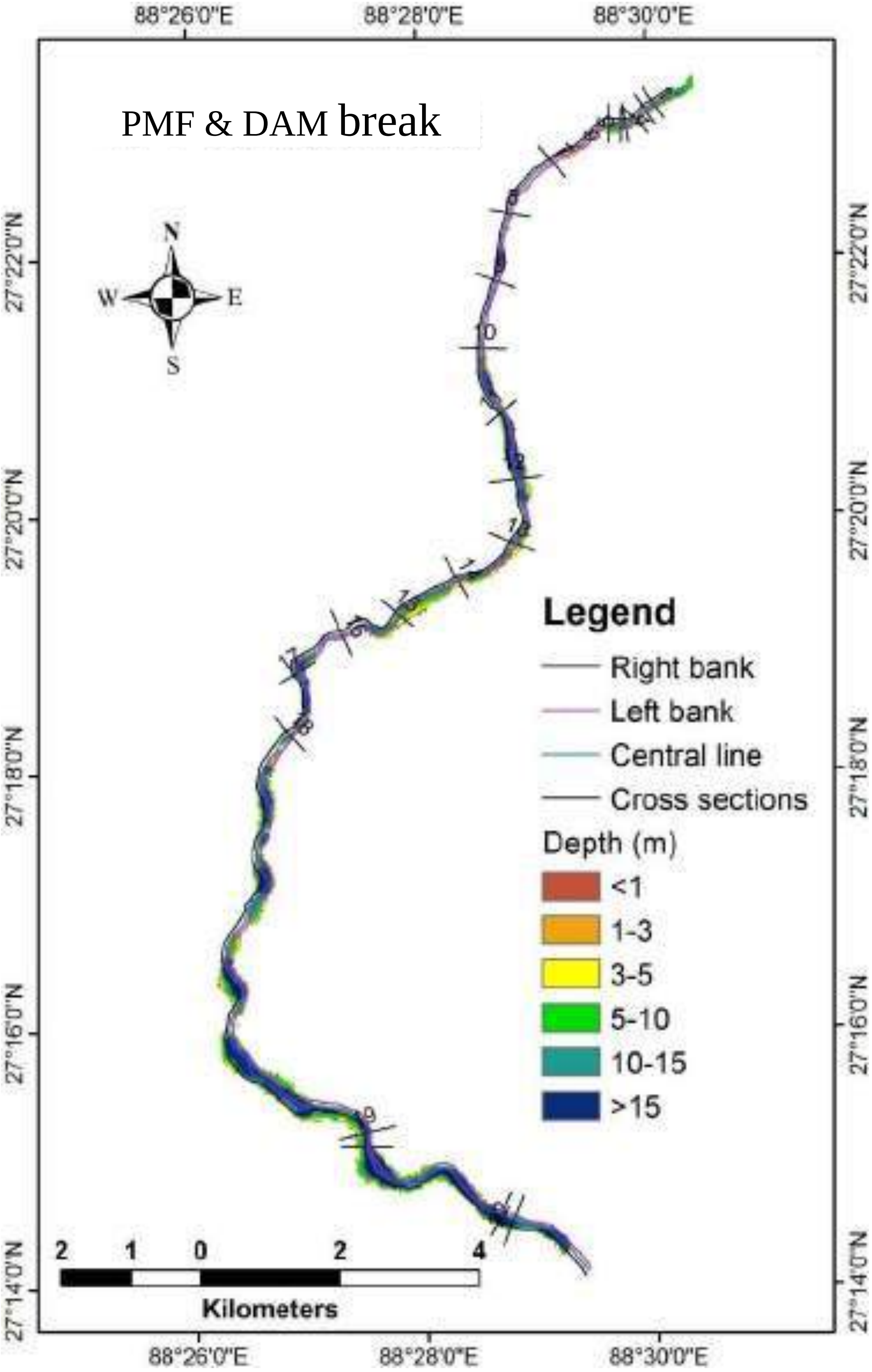


Figure 6.2 Flood depth map (PMF and Dam break)

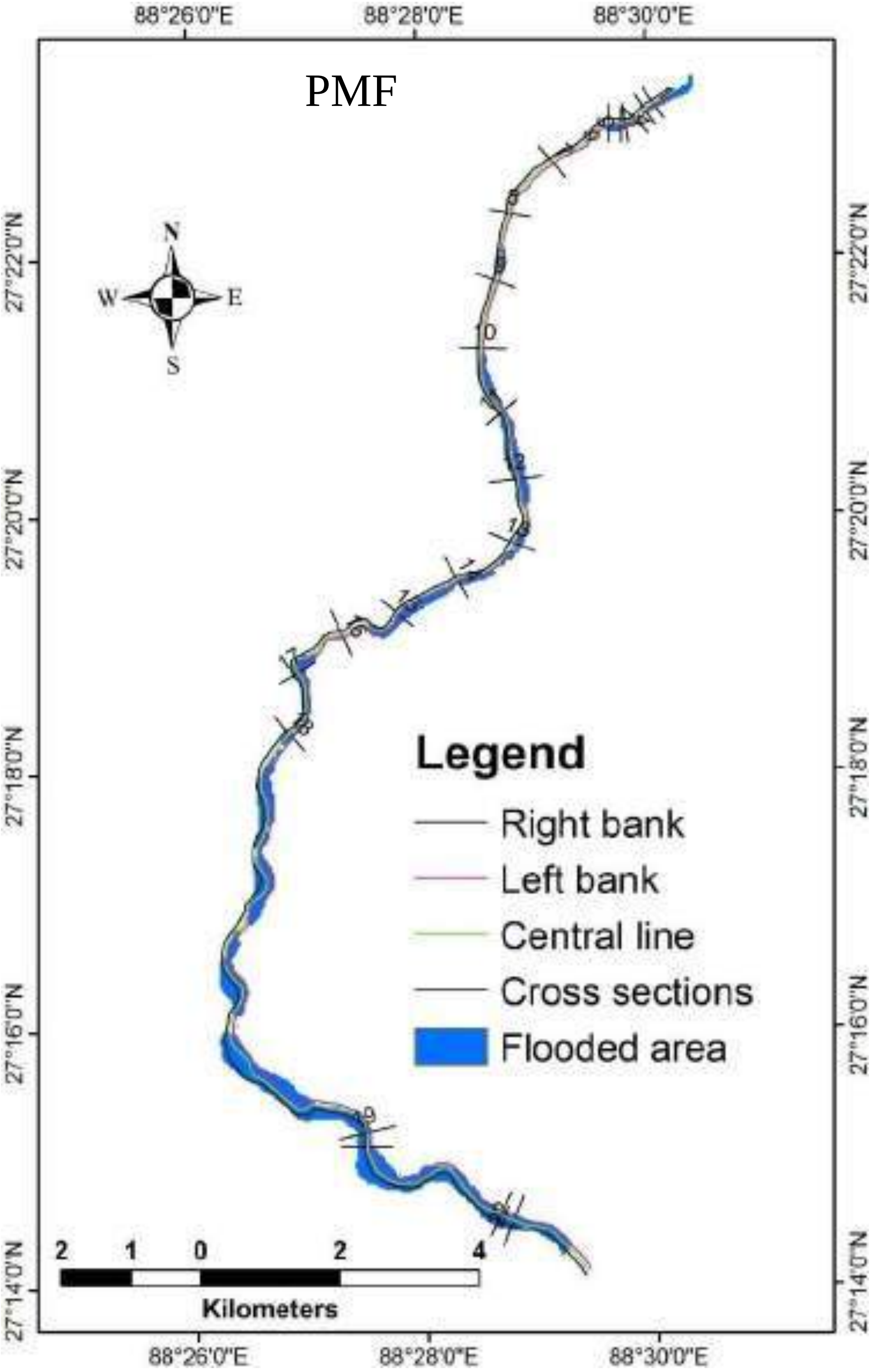


Figure 6.3 Flood inundation map (PMF)

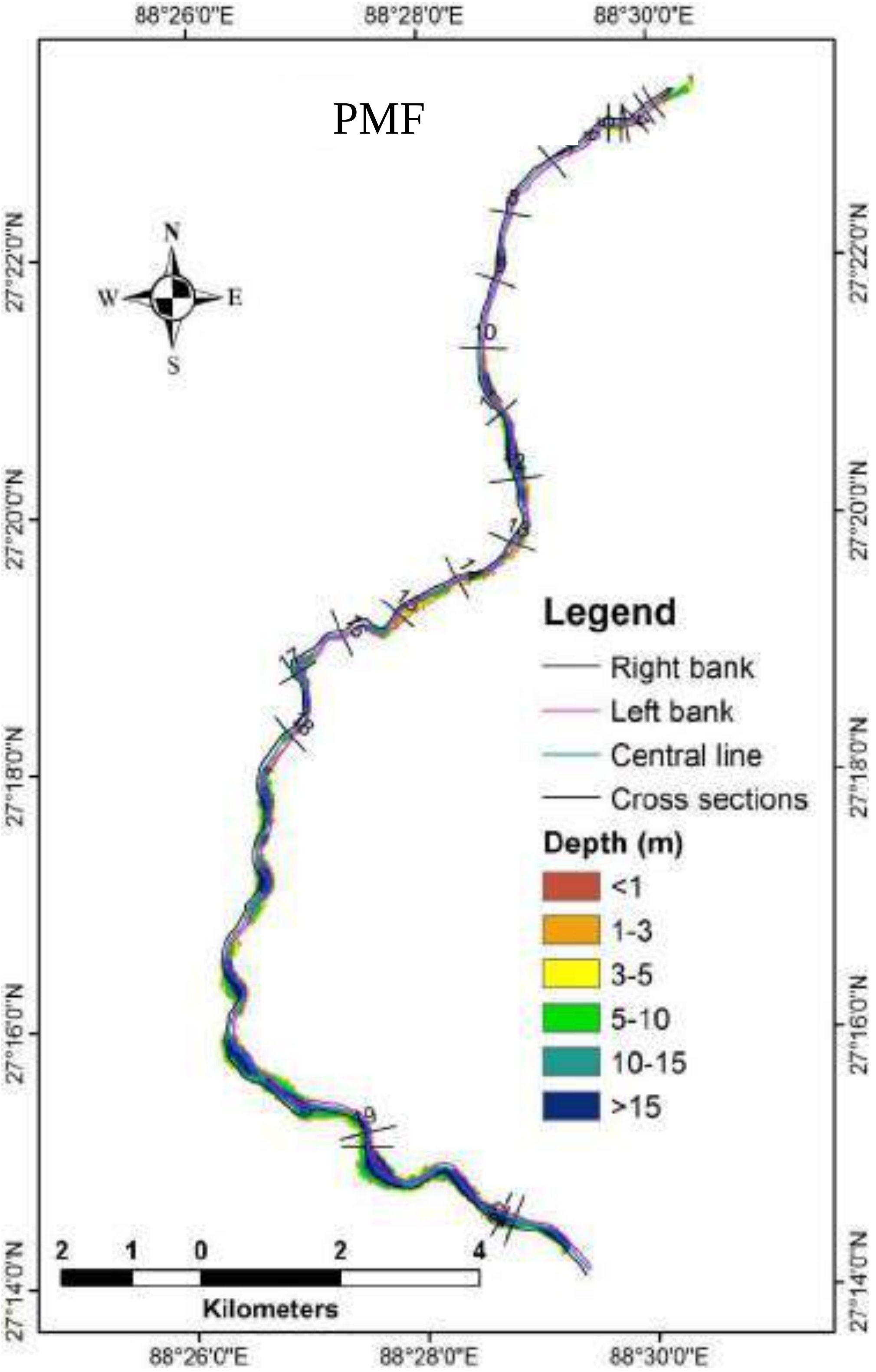


Figure 6.4 Flood depth map (PMF)

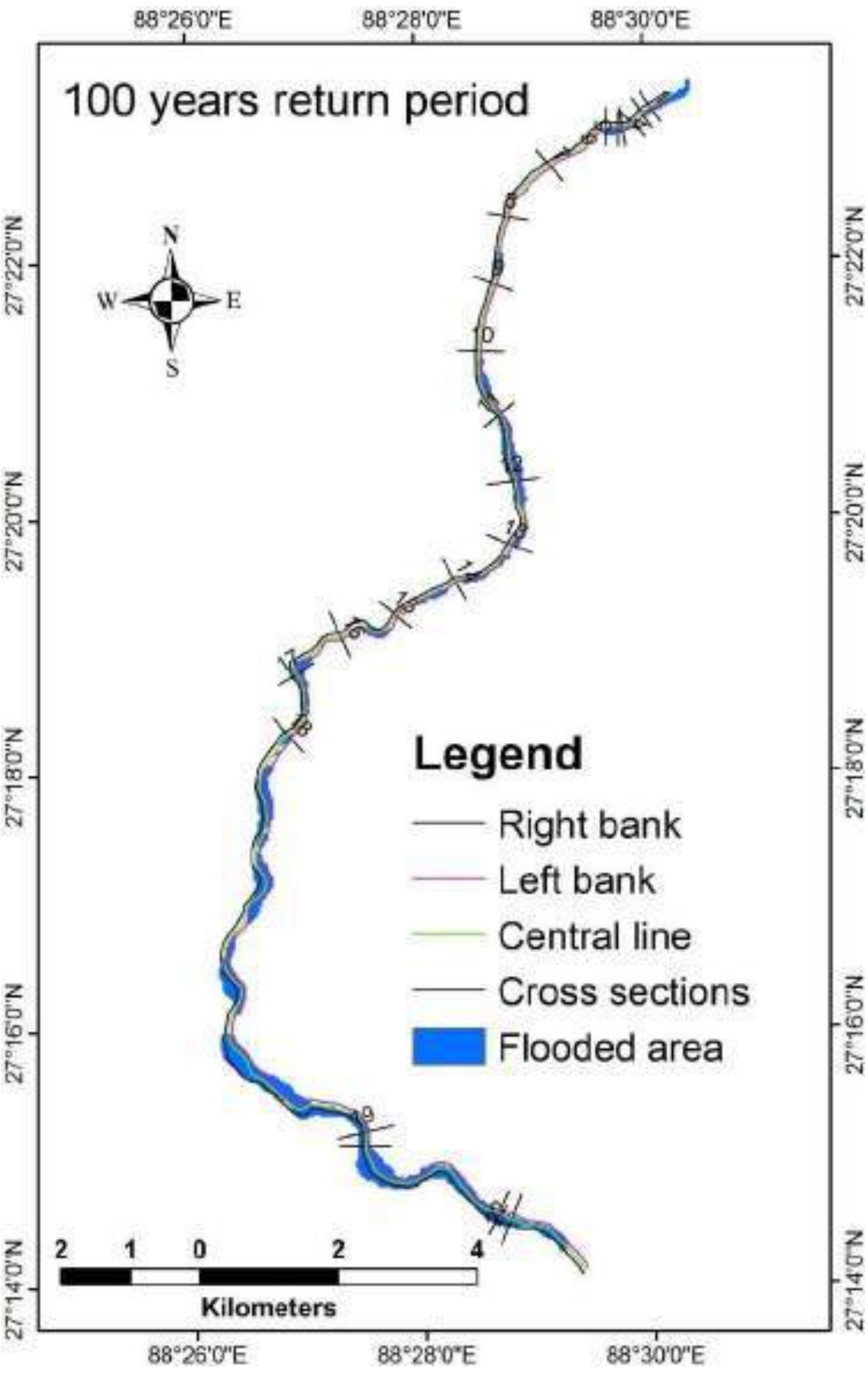


Figure 6.5 Flood inundation map (100 year return period)

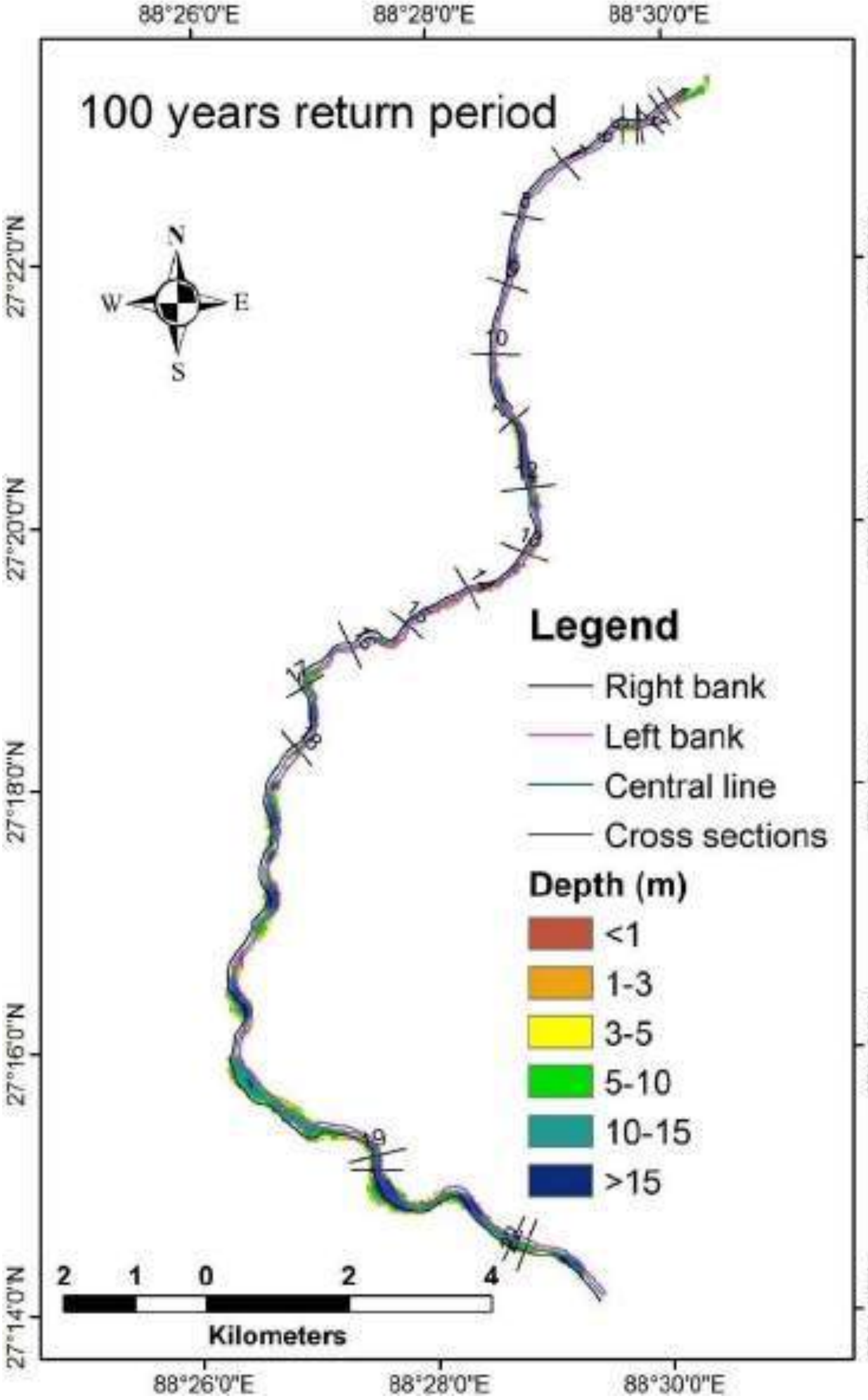


Figure 6.6 Flood depth map (100 year return flood)

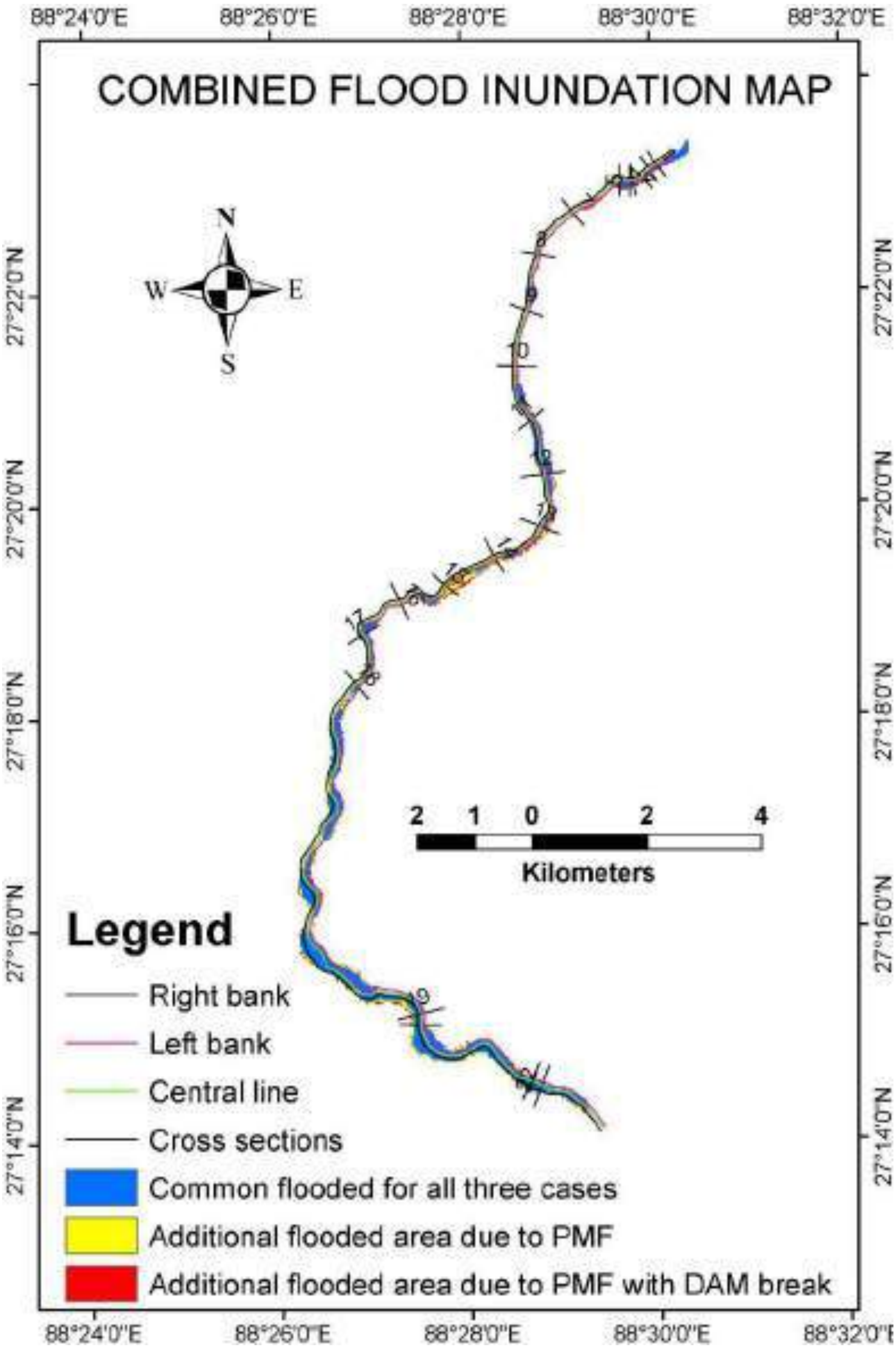


Figure 6.7 Combined map

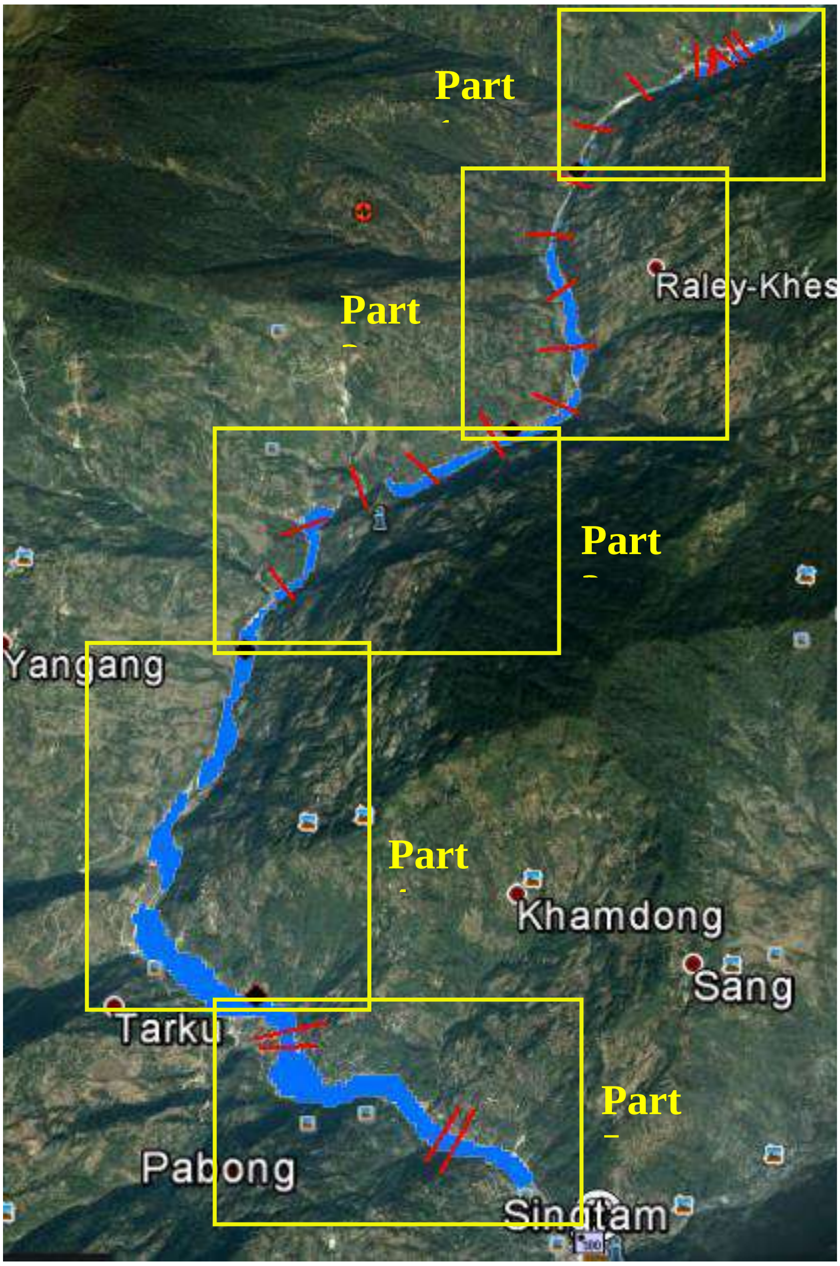


Figure 6.8: Different parts of the study area

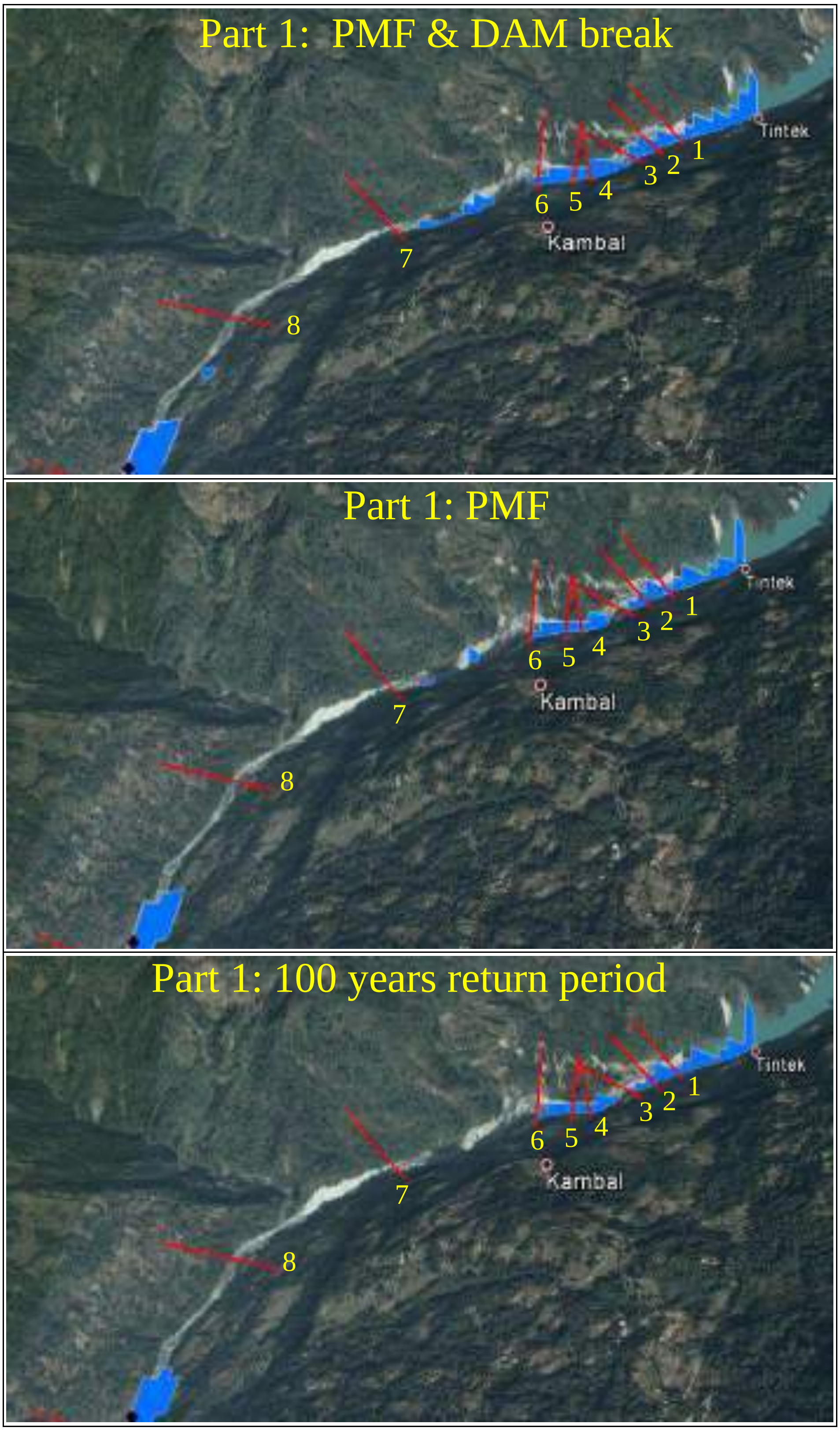


Figure 6.9: Flood inundation at Part 1

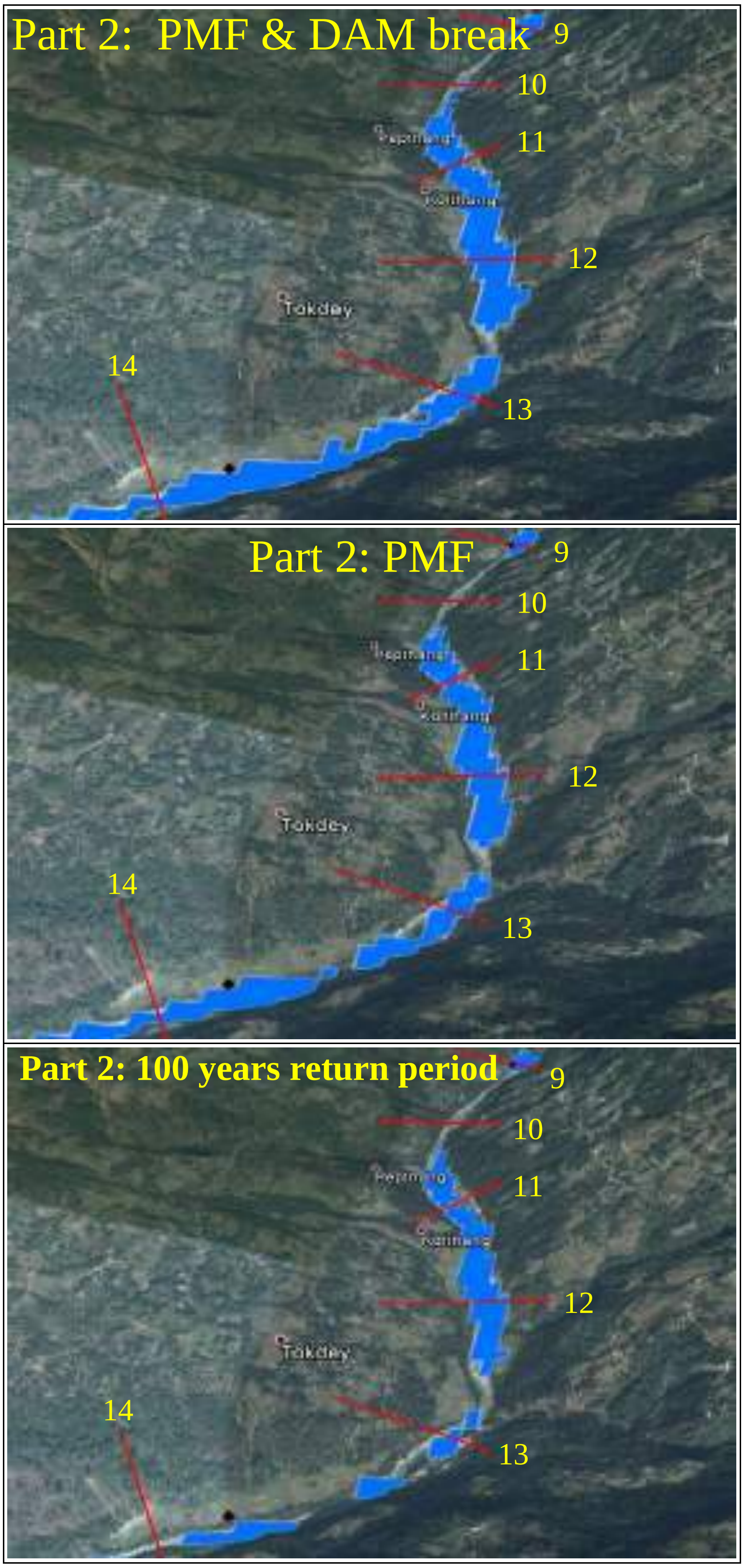


Figure 6.10: Flood inundation at Part 2

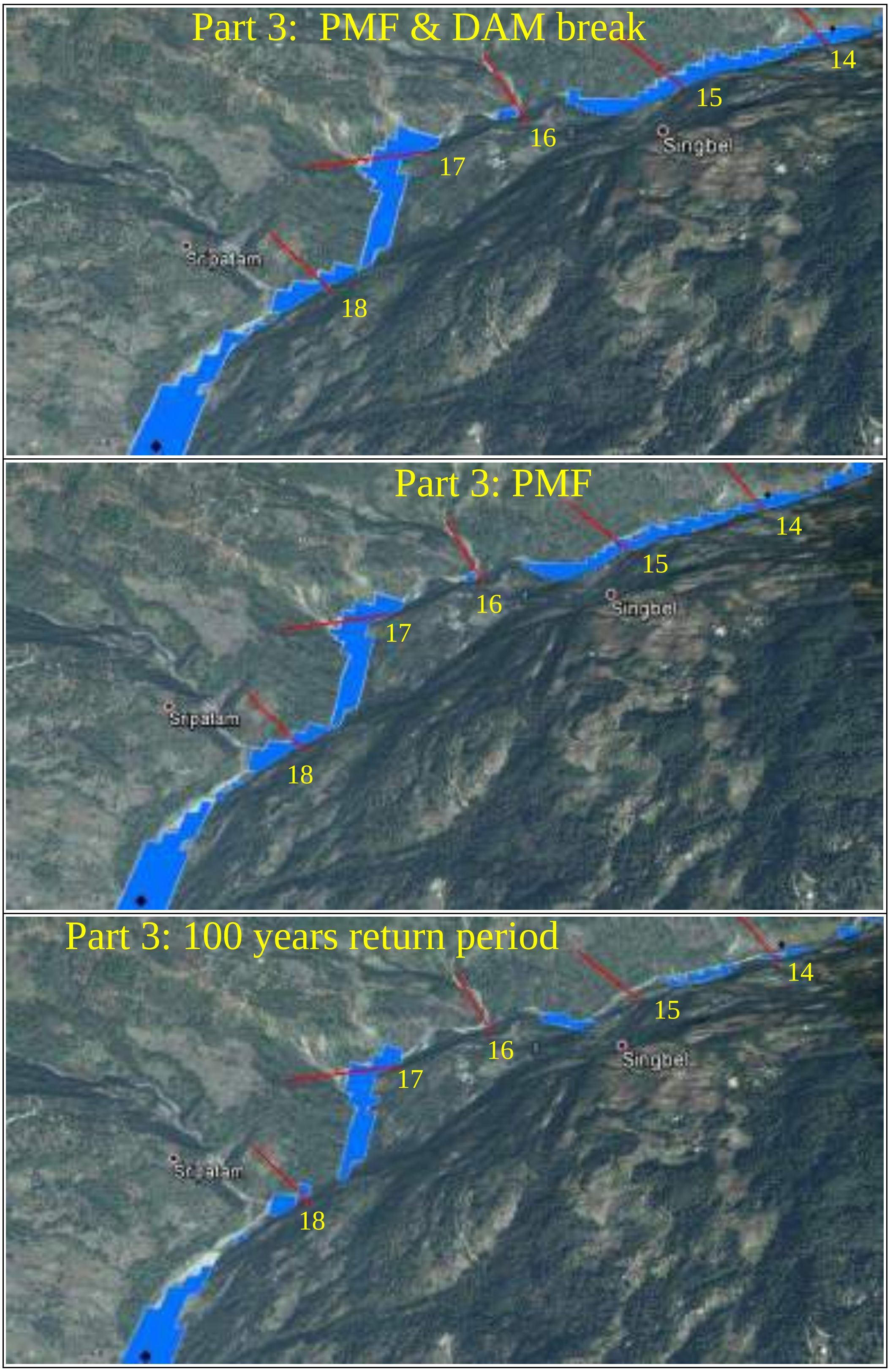


Figure 6.11: Flood inundation at Part 3

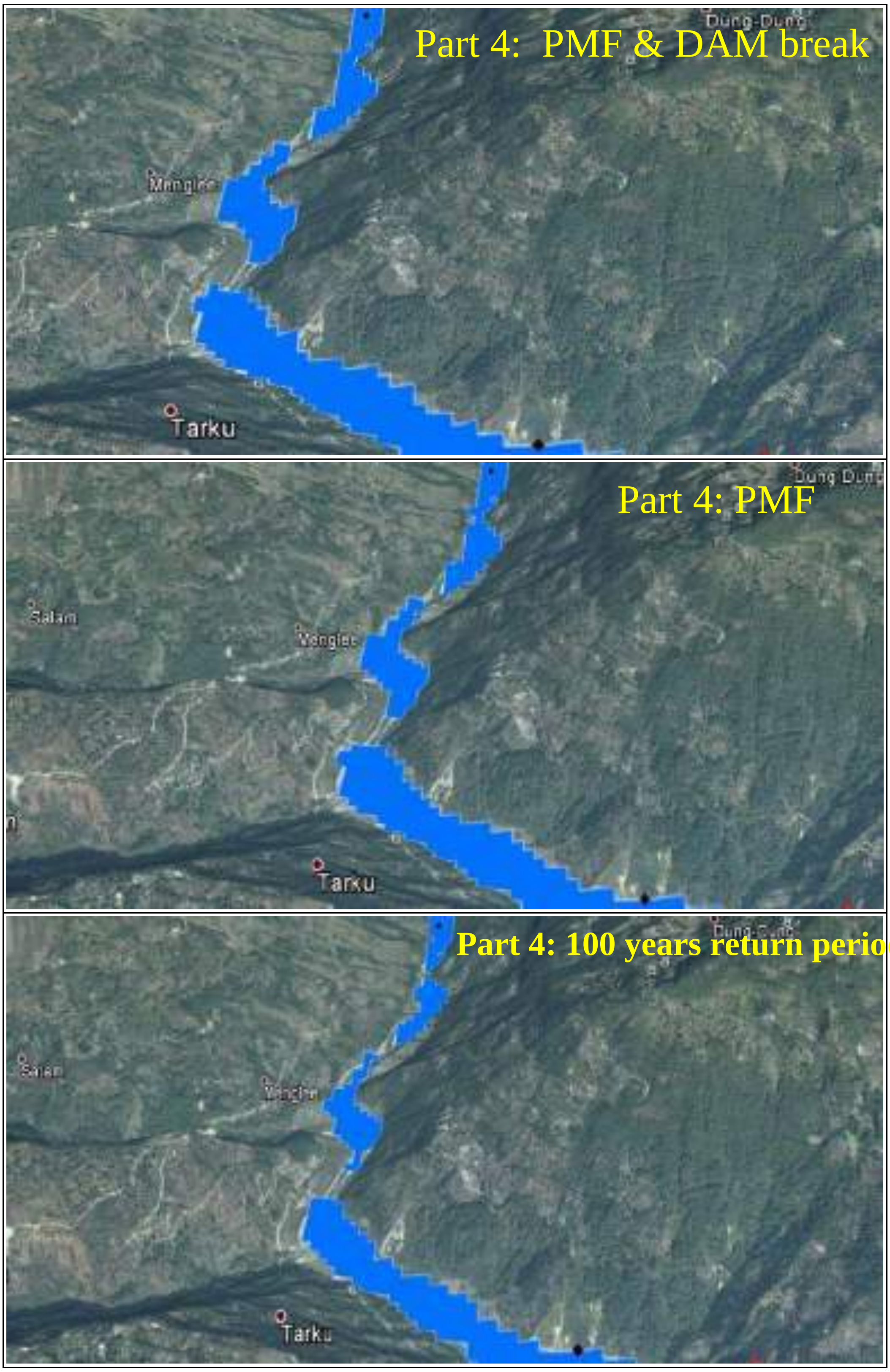


Figure 6.12: Flood inundation at Part 4

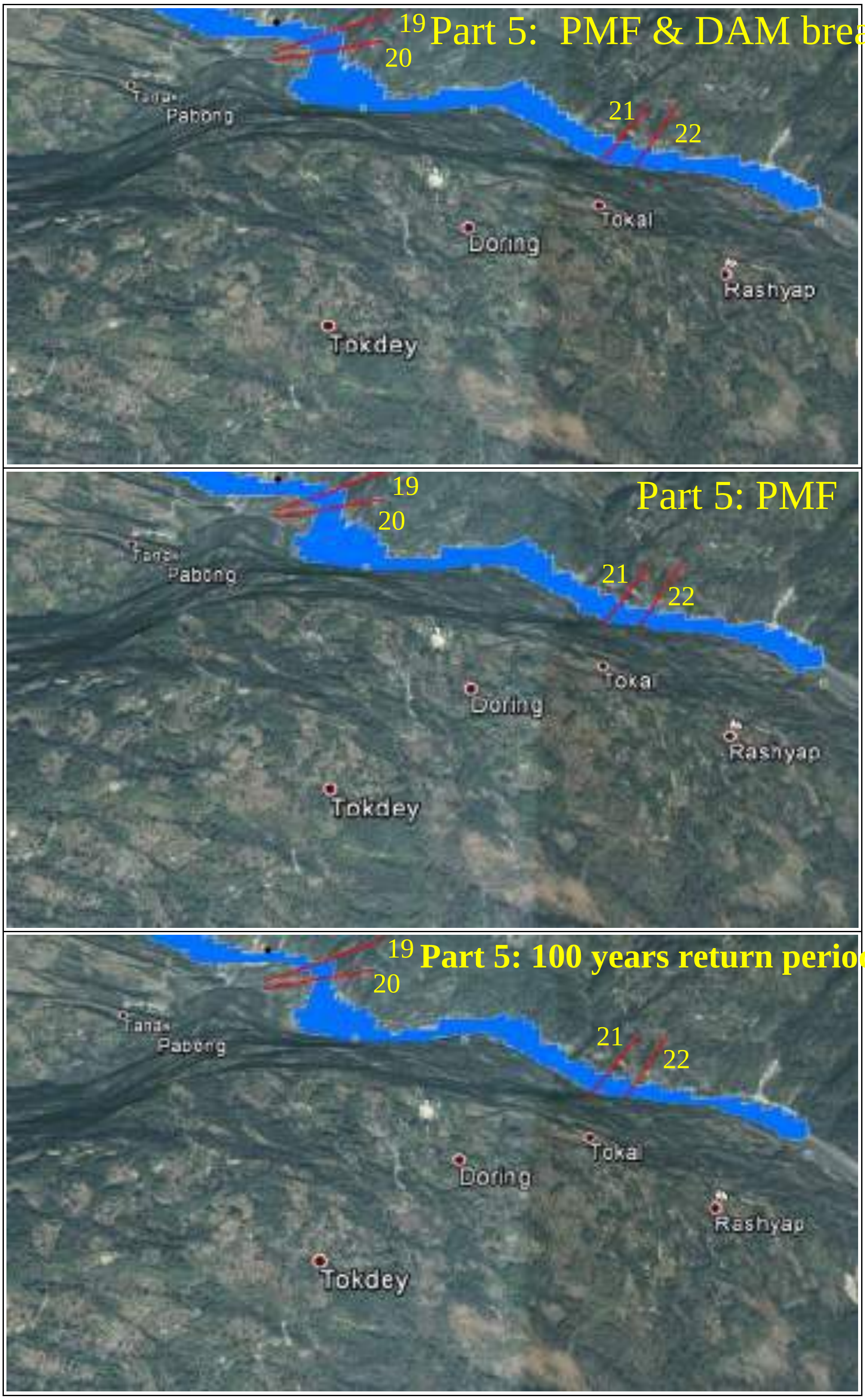


Figure 6.13: Flood inundation at Part 5

CHAPTER 7: CONCLUSIONS

Flood warning to the public downstream when there is dam break failure is one of the preventive measures in avoiding dam disaster or reducing the losses In this study, a dam break analysis of Teesta V power station done using the hydrodynamic module of the MIKE11 software (developed by Danish Hydraulic Institute) to estimate the amount of the dam break flood at different sections of the downstream reach along with the speed, water level, discharge and its timing to reach that particular section. The input data set for the model was prepared by extracting information from available data provided by sponsoring authority and judicious assumption of some parameters.

Three cases have been considered in the study and they are given below:

1. Dam break takes place when the PMF impinges into the reservoir when it is at FRL and Spillway gates are fully open.
2. PMF impinges into the reservoir when it is at FRL and Spillway gates are fully open.
3. 100 year return period flood impinges into the reservoir when it is at FRL and Spillway gates are fully open.

The outflow hydrographs of the hypothetical dambreak flood at different locations have been studied. For finalization of the model parameters simulations have been carried out with various combinations of breach width and breach time to identify these parameters for the severe most flood resulting from failure of the dam. The maximum discharge, minimum and maximum bed level

Out of the above three cases, case 1 (Dam break takes place when the reservoir is at FRL, PMF impinges in the reservoir and Spillway gates are open) gives the worst conditions. Therefore, maximum water levels from this case have been taken in HEC-GEORAS to get flood inundation maps. The flood inundation maps for other cases have also been prepared. The flood inundation maps for all the cases are presented in last chapter.

ANNEXURE-III
(Project Schedule)

TEESTA - V POWER STATION
(3x170 MW)

PROJECT SCHEDULE

OWNER/CLIENT:	NHPC LIMITED (A GOVERNMENT OF INDIA NAVRATNA ENTERPRISE)
SUPPLIER:	

TEESTA - V POWER STATION (3x170 MW)

A	First Submission	27.03.2025	AK	DT	SA
Rev	Modifications	Date	Prepared By	Checked By	Approved By

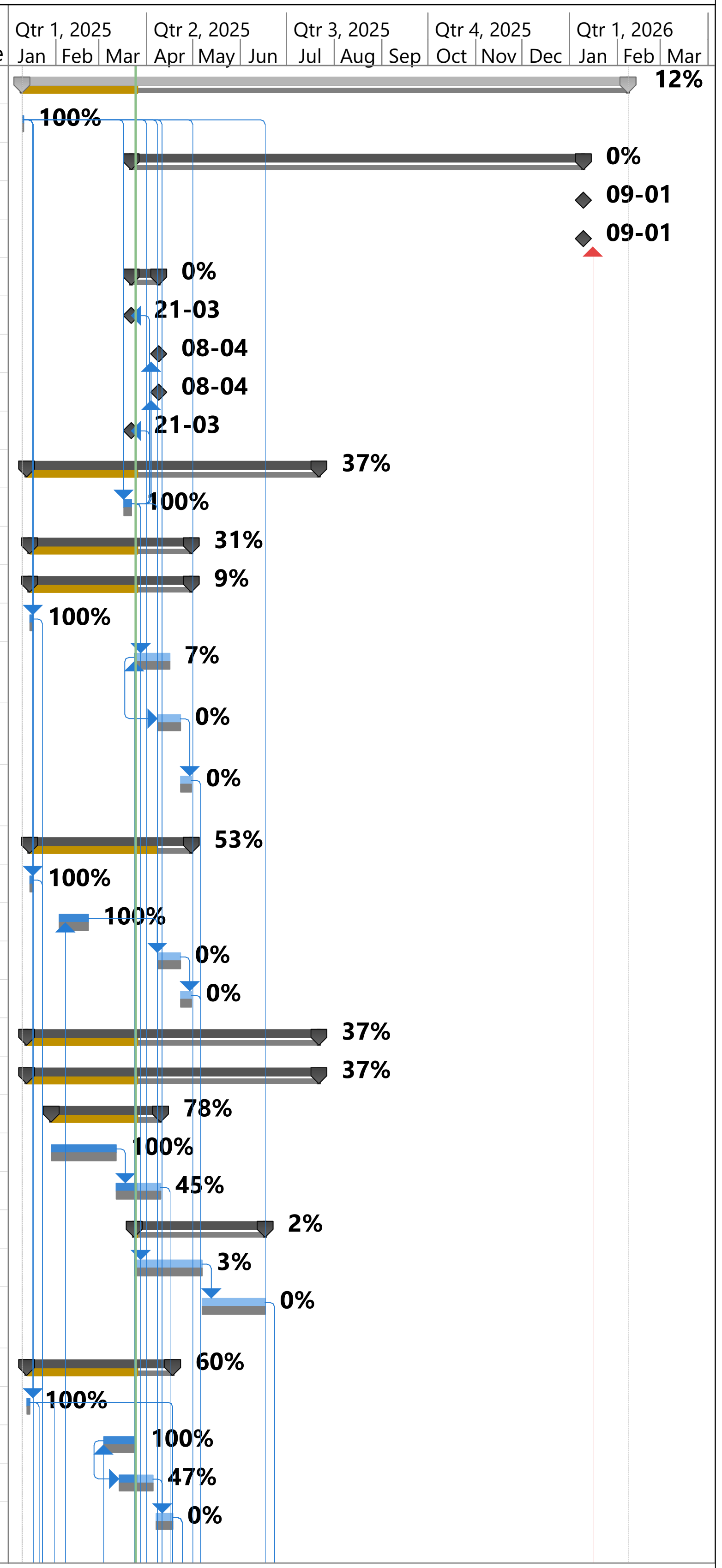
PROJECT SCHEDULE

Client	NHPC	Prepared by	AK	05.03.2025	File name	
Plant	TEESTA - V POWER STATION	Cheked by	DT	05.03.2025		
Project No.	GEMC-511687772389747	Approved by	SA	05.03.2025	File	

ANDRITZ	**Internal No.**		= +
	Document No.	TS-V-GEN-06-ES-001	**Rev** A · Page 1 of 12 · **A4**

ANDRITZ

ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
0	**TEESTA V**	**272 days**	**10-01-2025**	**07-02-2026**	**272 days**	**10-01-2025**	**07-02-2026**	**12%**	**12%**
1	Contract commencement date	1 day	10-01-2025	10-01-2025	1 day	10-01-2025	10-01-2025	100%	100%
2	**Milestones**	**203 days**	**21-03-2025**	**09-01-2026**	**203 days**	**21-03-2025**	**09-01-2026**	**0%**	**0%**
3	**Project Milestone**	**0 days**	**09-01-2026**	**09-01-2026**	**0 days**	**09-01-2026**	**09-01-2026**	**0%**	**0%**
4	Commissioning U1	0 days	09-01-2026	09-01-2026	0 days	09-01-2026	09-01-2026	0%	0%
5	**Customer Interface Milestone**	**11 days**	**21-03-2025**	**08-04-2025**	**11 days**	**21-03-2025**	**08-04-2025**	**0%**	**0%**
6	GIS civil Drawings	0 days	21-03-2025	21-03-2025	0 days	21-03-2025	21-03-2025	100%	100%
7	Existing XLPE Cable Layout	0 days	08-04-2025	08-04-2025	0 days	08-04-2025	08-04-2025	0%	0%
8	Existing Earthing Layout	0 days	08-04-2025	08-04-2025	0 days	08-04-2025	08-04-2025	0%	0%
9	Existing Fire Fighting drawings	0 days	21-03-2025	21-03-2025	0 days	21-03-2025	21-03-2025	100%	100%
10	**Design & Engineering**	**134 days**	**13-01-2025**	**21-07-2025**	**134 days**	**13-01-2025**	**21-07-2025**	**37%**	**37%**
11	Reverse Engineering & Fingerprint Measurement	5 days	17-03-2025	21-03-2025	5 days	17-03-2025	21-03-2025	100%	100%
12	**Mechanical Auxiliaries**	**73 days**	**15-01-2025**	**29-04-2025**	**73 days**	**15-01-2025**	**29-04-2025**	**31%**	**31%**
13	**Fire Fighting**	**73 days**	**15-01-2025**	**29-04-2025**	**73 days**	**15-01-2025**	**29-04-2025**	**9%**	**9%**
14	Engg(MBOP) Fire Fighting System -PS release	2 days	15-01-2025	16-01-2025	2 days	15-01-2025	16-01-2025	100%	100%
15	Engg(MBOP) Fire Fighting System -Post Order Drawing Receipt	15 days	24-03-2025	15-04-2025	15 days	24-03-2025	15-04-2025	7%	7%
16	Engg(MBOP) Fire Fighting System -Post Order Engineering	10 days	08-04-2025	22-04-2025	10 days	08-04-2025	22-04-2025	0%	0%
17	Engg(MBOP) Fire Fighting System-Post Order Drawing Approval	5 days	23-04-2025	29-04-2025	5 days	23-04-2025	29-04-2025	0%	0%
18	**EOT Crane**	**73 days**	**15-01-2025**	**29-04-2025**	**73 days**	**15-01-2025**	**29-04-2025**	**53%**	**53%**
19	Engg(MBOP) EOT Crane -PS release	2 days	15-01-2025	16-01-2025	2 days	15-01-2025	16-01-2025	100%	100%
20	Engg(MBOP) EOT Crane -Post Order Drawing Receipt	15 days	03-02-2025	21-02-2025	15 days	03-02-2025	21-02-2025	100%	100%
21	Engg(MBOP) EOT Crane -Post Order Engineering	10 days	08-04-2025	22-04-2025	10 days	08-04-2025	22-04-2025	0%	0%
22	Engg(MBOP) EOT Crane -Post Order Drawing Approval	5 days	23-04-2025	29-04-2025	5 days	23-04-2025	29-04-2025	0%	0%
23	**Electrical Power System**	**134 days**	**13-01-2025**	**21-07-2025**	**134 days**	**13-01-2025**	**21-07-2025**	**37%**	**37%**
24	**Basic & Detail Engineering EPS**	**134 days**	**13-01-2025**	**21-07-2025**	**134 days**	**13-01-2025**	**21-07-2025**	**37%**	**37%**
25	**400KV Cable layout**	**49 days**	**29-01-2025**	**09-04-2025**	**49 days**	**29-01-2025**	**09-04-2025**	**78%**	**78%**
26	Engg(EPS) 400 KV Cable layout	30 days	29-01-2025	11-03-2025	30 days	29-01-2025	11-03-2025	100%	100%
27	Engg(EPS) 400 KV Cable layout-Approval	20 days	12-03-2025	09-04-2025	20 days	12-03-2025	09-04-2025	45%	45%
28	**400KV Potyard Structures Engg**	**60 days**	**24-03-2025**	**16-06-2025**	**60 days**	**24-03-2025**	**16-06-2025**	**2%**	**2%**
29	Engg(EPS) 400 KV Potyard Structures Engg	30 days	24-03-2025	06-05-2025	30 days	24-03-2025	06-05-2025	3%	3%
30	Engg(EPS) 400 KV Potyard Structures Engg -Approval	29 days	07-05-2025	16-06-2025	29 days	07-05-2025	16-06-2025	0%	0%
31	**420KV GIS System**	**67 days**	**13-01-2025**	**17-04-2025**	**67 days**	**13-01-2025**	**17-04-2025**	**60%**	**60%**
32	Engg(EPS) GIS System -PS release	2 days	13-01-2025	14-01-2025	2 days	13-01-2025	14-01-2025	100%	100%
33	Engg(EPS) GIS System -Post Order Drawing Receipt	15 days	04-03-2025	24-03-2025	15 days	04-03-2025	24-03-2025	100%	100%
34	Engg(EPS) GIS System -Post Order Engineering	15 days	14-03-2025	04-04-2025	15 days	14-03-2025	04-04-2025	47%	47%
35	Engg(EPS) GIS System -Post Order Drawing Approval	8 days	07-04-2025	17-04-2025	8 days	07-04-2025	17-04-2025	0%	0%



Status Date 25-03-2025

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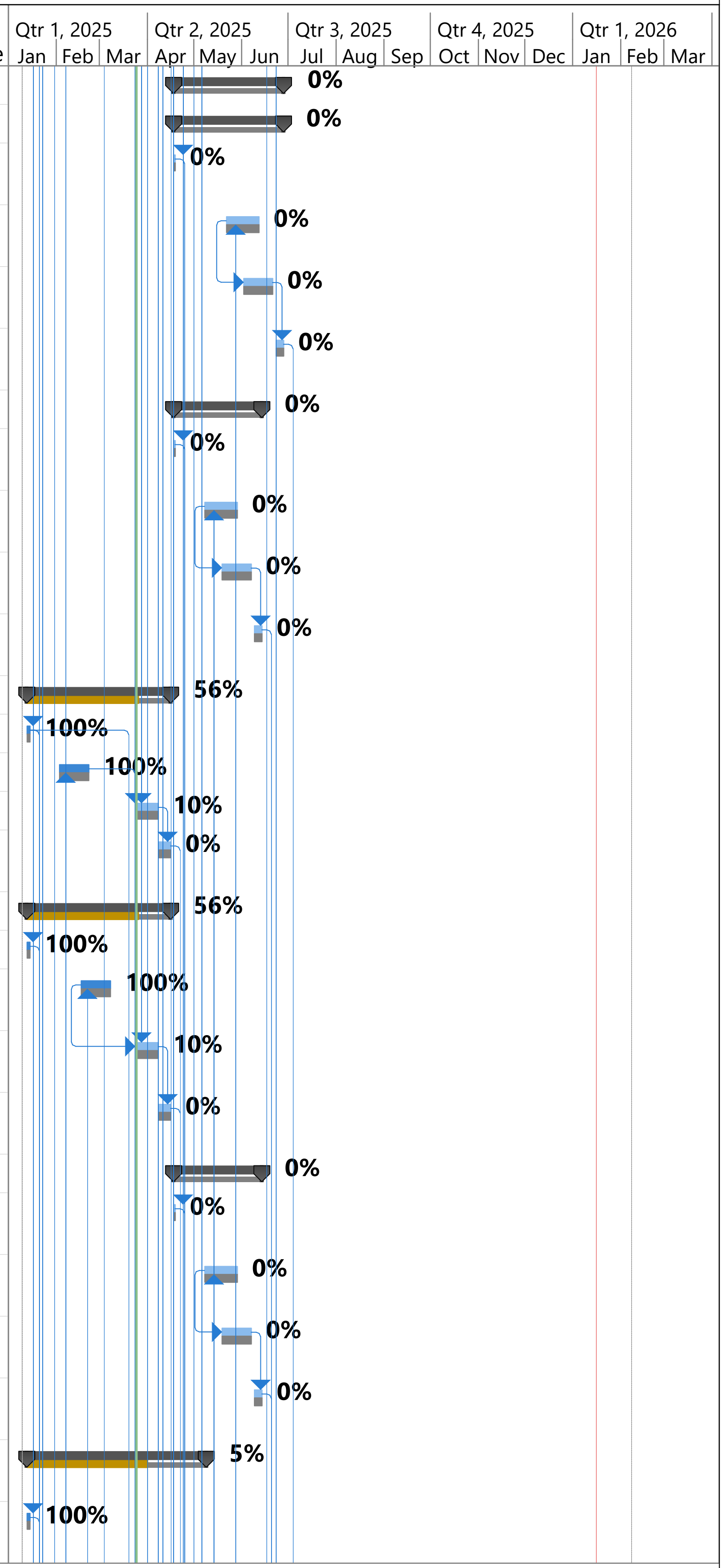
Critical		Split		Finish-only	]	Summary Progress		Deadline	
Critical Split		Task Progress		Duration-only		Summary		Baseline	

ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
36	**420KV GIS Monitoring System**	**51 days**	**18-04-2025**	**27-06-2025**	**51 days**	**18-04-2025**	**27-06-2025**	**0%**	**0%**
37	**Gas Density Monitoring System**	**51 days**	**18-04-2025**	**27-06-2025**	**51 days**	**18-04-2025**	**27-06-2025**	**0%**	**0%**
38	Engg(EPS) Gas Density Monitoring System -PS release	1 day	18-04-2025	18-04-2025	1 day	18-04-2025	18-04-2025	0%	0%
39	Engg(EPS) GIS Monitoring System -Post Order Drawing Receipt	15 days	22-05-2025	11-06-2025	15 days	22-05-2025	11-06-2025	0%	0%
40	Engg(EPS) GIS Monitoring System -Post Order Engineering	15 days	02-06-2025	20-06-2025	15 days	02-06-2025	20-06-2025	0%	0%
41	Engg(EPS) GIS Monitoring System -Post Order Drawing Approval	5 days	23-06-2025	27-06-2025	5 days	23-06-2025	27-06-2025	0%	0%
42	**Partial Discharge Monitoring System**	**41 days**	**18-04-2025**	**13-06-2025**	**41 days**	**18-04-2025**	**13-06-2025**	**0%**	**0%**
43	Engg(EPS) Partial Discharge Monitoring System -PS release	1 day	18-04-2025	18-04-2025	1 day	18-04-2025	18-04-2025	0%	0%
44	Engg(EPS) GIS Monitoring System -Post Order Drawing Receipt	15 days	08-05-2025	28-05-2025	15 days	08-05-2025	28-05-2025	0%	0%
45	Engg(EPS) GIS Monitoring System -Post Order Engineering	15 days	19-05-2025	06-06-2025	15 days	19-05-2025	06-06-2025	0%	0%
46	Engg(EPS) GIS Monitoring System -Post Order Drawing Approval	5 days	09-06-2025	13-06-2025	5 days	09-06-2025	13-06-2025	0%	0%
47	**400KV XLPE Cables**	**65 days**	**13-01-2025**	**15-04-2025**	**65 days**	**13-01-2025**	**15-04-2025**	**56%**	**56%**
48	Engg(EPS) XLPE Cables -PS release	2 days	13-01-2025	14-01-2025	2 days	13-01-2025	14-01-2025	100%	100%
49	Engg(EPS) XLPE Cables -Post Order Drawing Receipt	15 days	03-02-2025	21-02-2025	15 days	03-02-2025	21-02-2025	100%	100%
50	Engg(EPS) XLPE Cables -Post Order Engineering	10 days	24-03-2025	07-04-2025	10 days	24-03-2025	07-04-2025	10%	10%
51	Engg(EPS) XLPE Cables -Post Order Drawing Approval	5 days	08-04-2025	15-04-2025	5 days	08-04-2025	15-04-2025	0%	0%
52	**400KV XLPE Cables Termination**	**65 days**	**13-01-2025**	**15-04-2025**	**65 days**	**13-01-2025**	**15-04-2025**	**56%**	**56%**
53	Engg(EPS) XLPE Cables Termination -PS release	2 days	13-01-2025	14-01-2025	2 days	13-01-2025	14-01-2025	100%	100%
54	Engg(EPS) XLPE Cables Termination -Post Order Drawing Receipt	15 days	17-02-2025	07-03-2025	15 days	17-02-2025	07-03-2025	100%	100%
55	Engg(EPS) XLPE Cables Termination -Post Order Engineering	10 days	24-03-2025	07-04-2025	10 days	24-03-2025	07-04-2025	10%	10%
56	Engg(EPS) XLPE Cables Termination -Post Order Drawing Approval	5 days	08-04-2025	15-04-2025	5 days	08-04-2025	15-04-2025	0%	0%
57	**400KV XLPE Cable PD Monitoring System**	**41 days**	**18-04-2025**	**13-06-2025**	**41 days**	**18-04-2025**	**13-06-2025**	**0%**	**0%**
58	Engg(EPS) XLPE Cable PD Monitoring System -PS release	1 day	18-04-2025	18-04-2025	1 day	18-04-2025	18-04-2025	0%	0%
59	Engg(EPS) XLPE Cable PD Monitoring System -Post Order Drawing Receipt	15 days	08-05-2025	28-05-2025	15 days	08-05-2025	28-05-2025	0%	0%
60	Engg(EPS) XLPE Cable PD Monitoring System -Post Order Engineering	15 days	19-05-2025	06-06-2025	15 days	19-05-2025	06-06-2025	0%	0%
61	Engg(EPS) XLPE Cable PD Monitoring System -Post Order Drawing Approval	5 days	09-06-2025	13-06-2025	5 days	09-06-2025	13-06-2025	0%	0%
62	**400KV XLPE Cable Distributed temperature system (DTS)**	**82 days**	**13-01-2025**	**08-05-2025**	**82 days**	**13-01-2025**	**08-05-2025**	**5%**	**5%**
63	Engg(EPS) XLPE Cable Distributed temperature system -PS release	2 days	13-01-2025	14-01-2025	2 days	13-01-2025	14-01-2025	100%	100%

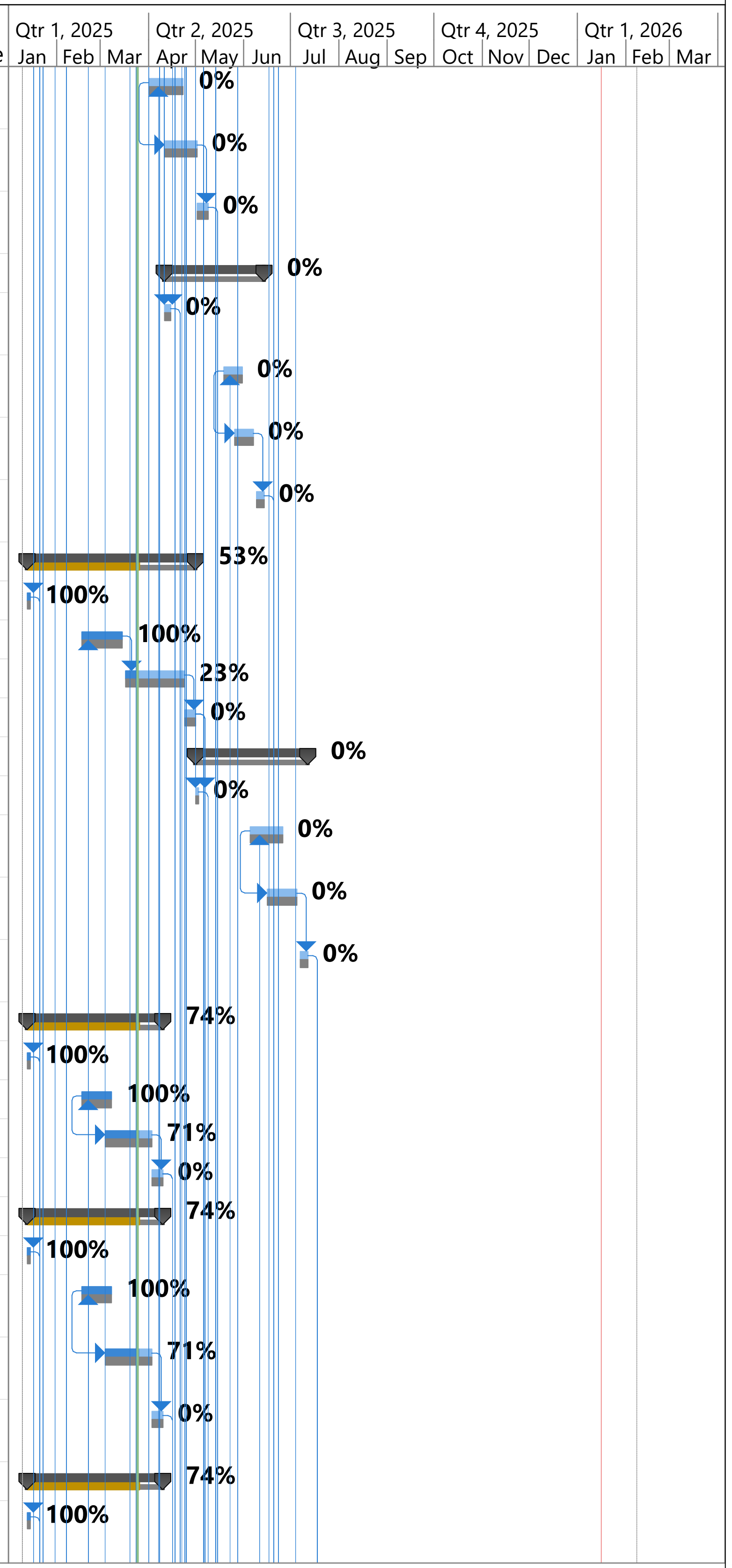


Status Date 25-03-2025

Baseline Milestone
Baseline Summary
Critical
Critical Split
Critical Progress
Task
Split
Task Progress
Manual Task
Start-only
Finish-only
Duration-only
Baseline Split
Milestone
Summary Progress
Summary
Manual Summary
Project Summary
Deadline
Baseline

ANDRITZ

ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
64	Engg(EPS) XLPE Cable Distributed temperature system -Post Order Drawing Receipt	15 days	01-04-2025	22-04-2025	15 days	01-04-2025	22-04-2025	0%	0%
65	Engg(EPS) XLPE Cable Distributed temperature system -Post Order Engineering	15 days	11-04-2025	01-05-2025	15 days	11-04-2025	01-05-2025	0%	0%
66	Engg(EPS) XLPE Cable Distributed temperature system -Post Order Drawing Approval	5 days	02-05-2025	08-05-2025	5 days	02-05-2025	08-05-2025	0%	0%
67	**400KV XLPE Cable- Structures, SVL, Clamps**	**46 days**	**11-04-2025**	**13-06-2025**	**46 days**	**11-04-2025**	**13-06-2025**	**0%**	**0%**
68	Engg(EPS) XLPE Cable- Structures, SVL, Clamps -PS release	2 days	11-04-2025	14-04-2025	2 days	11-04-2025	14-04-2025	0%	0%
69	Engg(EPS) XLPE Cable- Structures, SVL, Clamps -Post Order Drawing Receipt	10 days	19-05-2025	30-05-2025	10 days	19-05-2025	30-05-2025	0%	0%
70	Engg(EPS) XLPE Cable- Structures, SVL, Clamps -Post Order Engineering	10 days	26-05-2025	06-06-2025	10 days	26-05-2025	06-06-2025	0%	0%
71	Engg(EPS) XLPE Cable- Structures, SVL, Clamps -Post Order Drawing Approval	5 days	09-06-2025	13-06-2025	5 days	09-06-2025	13-06-2025	0%	0%
72	**Diesel Generator Set**	**76 days**	**13-01-2025**	**30-04-2025**	**76 days**	**13-01-2025**	**30-04-2025**	**53%**	**53%**
73	Engg(EPS) DG Set -PS release	2 days	13-01-2025	14-01-2025	2 days	13-01-2025	14-01-2025	100%	100%
74	Engg(EPS) DG Set -Post Order Drawing Receipt	20 days	17-02-2025	14-03-2025	20 days	17-02-2025	14-03-2025	100%	100%
75	Engg(EPS) DG Set -Post Order Engineering	26 days	17-03-2025	23-04-2025	26 days	17-03-2025	23-04-2025	23%	23%
76	Engg(EPS) DG Set -Post Order Drawing Approval	5 days	24-04-2025	30-04-2025	5 days	24-04-2025	30-04-2025	0%	0%
77	**Diesel Generator Set (Stacks & Structures)**	**52 days**	**01-05-2025**	**11-07-2025**	**52 days**	**01-05-2025**	**11-07-2025**	**0%**	**0%**
78	Engg(EPS) DG Set (Stack & Structure) -PS release	2 days	01-05-2025	02-05-2025	2 days	01-05-2025	02-05-2025	0%	0%
79	Engg(EPS) DG Set (Stack & Structure) -Post Order Drawing Receipt	15 days	05-06-2025	25-06-2025	15 days	05-06-2025	25-06-2025	0%	0%
80	Engg(EPS) DG Set (Stack & Structure) -Post Order Engineering	15 days	16-06-2025	04-07-2025	15 days	16-06-2025	04-07-2025	0%	0%
81	Engg(EPS) DG Set (Stack & Structure) -Post Order Drawing Approval	5 days	07-07-2025	11-07-2025	5 days	07-07-2025	11-07-2025	0%	0%
82	**400KV Potyard**	**61 days**	**13-01-2025**	**09-04-2025**	**61 days**	**13-01-2025**	**09-04-2025**	**74%**	**74%**
83	Engg(EPS) Potyard -PS release	2 days	13-01-2025	14-01-2025	2 days	13-01-2025	14-01-2025	100%	100%
84	Engg(EPS) Potyard -Post Order Drawing Receipt	15 days	17-02-2025	07-03-2025	15 days	17-02-2025	07-03-2025	100%	100%
85	Engg(EPS) Potyard -Post Order Engineering	21 days	04-03-2025	02-04-2025	21 days	04-03-2025	02-04-2025	71%	71%
86	Engg(EPS) Potyard -Post Order Drawing Approval	5 days	03-04-2025	09-04-2025	5 days	03-04-2025	09-04-2025	0%	0%
87	**400KV Lightining Arrester**	**61 days**	**13-01-2025**	**09-04-2025**	**61 days**	**13-01-2025**	**09-04-2025**	**74%**	**74%**
88	Engg(EPS) Lightining Arrester -PS release	2 days	13-01-2025	14-01-2025	2 days	13-01-2025	14-01-2025	100%	100%
89	Engg(EPS) Lightining Arrester -Post Order Drawing Receipt	15 days	17-02-2025	07-03-2025	15 days	17-02-2025	07-03-2025	100%	100%
90	Engg(EPS) Lightining Arrester -Post Order Engineering	21 days	04-03-2025	02-04-2025	21 days	04-03-2025	02-04-2025	71%	71%
91	Engg(EPS) Lightining Arrester -Post Order Drawing Approval	5 days	03-04-2025	09-04-2025	5 days	03-04-2025	09-04-2025	0%	0%
92	**400KV Capacitive Voltage Transformer (CVT)**	**61 days**	**13-01-2025**	**09-04-2025**	**61 days**	**13-01-2025**	**09-04-2025**	**74%**	**74%**
93	Engg(EPS) Capacitive Voltage Transformer -PS release	2 days	13-01-2025	14-01-2025	2 days	13-01-2025	14-01-2025	100%	100%

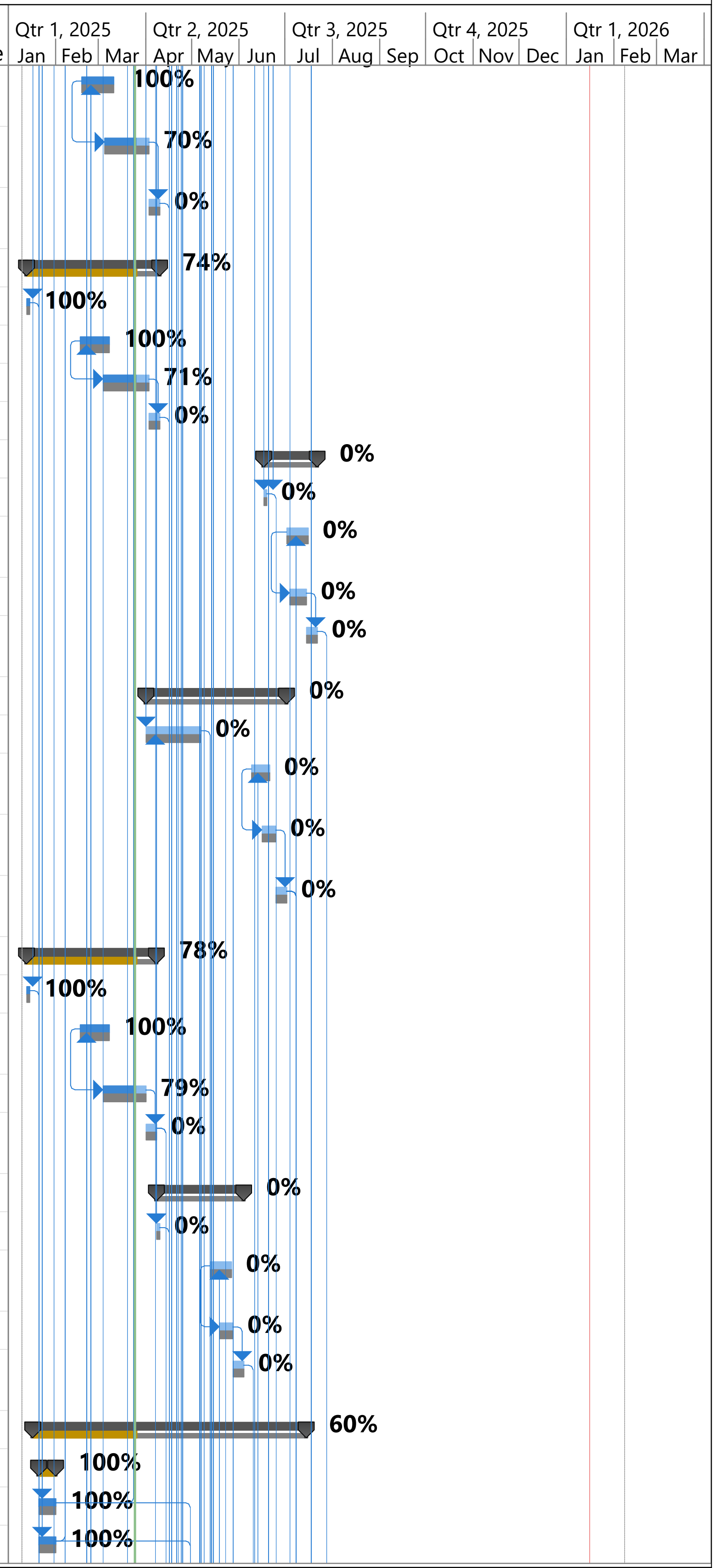


Status Date 25-03-2025

Baseline Milestone	Critical Progress	Manual Task	Baseline Split	Manual Summary
Baseline Summary	Task	Start-only	Milestone	Project Summary
Critical	Split	Finish-only	Summary Progress	Deadline
Critical Split	Task Progress	Duration-only	Summary	Baseline

ANDRITZ

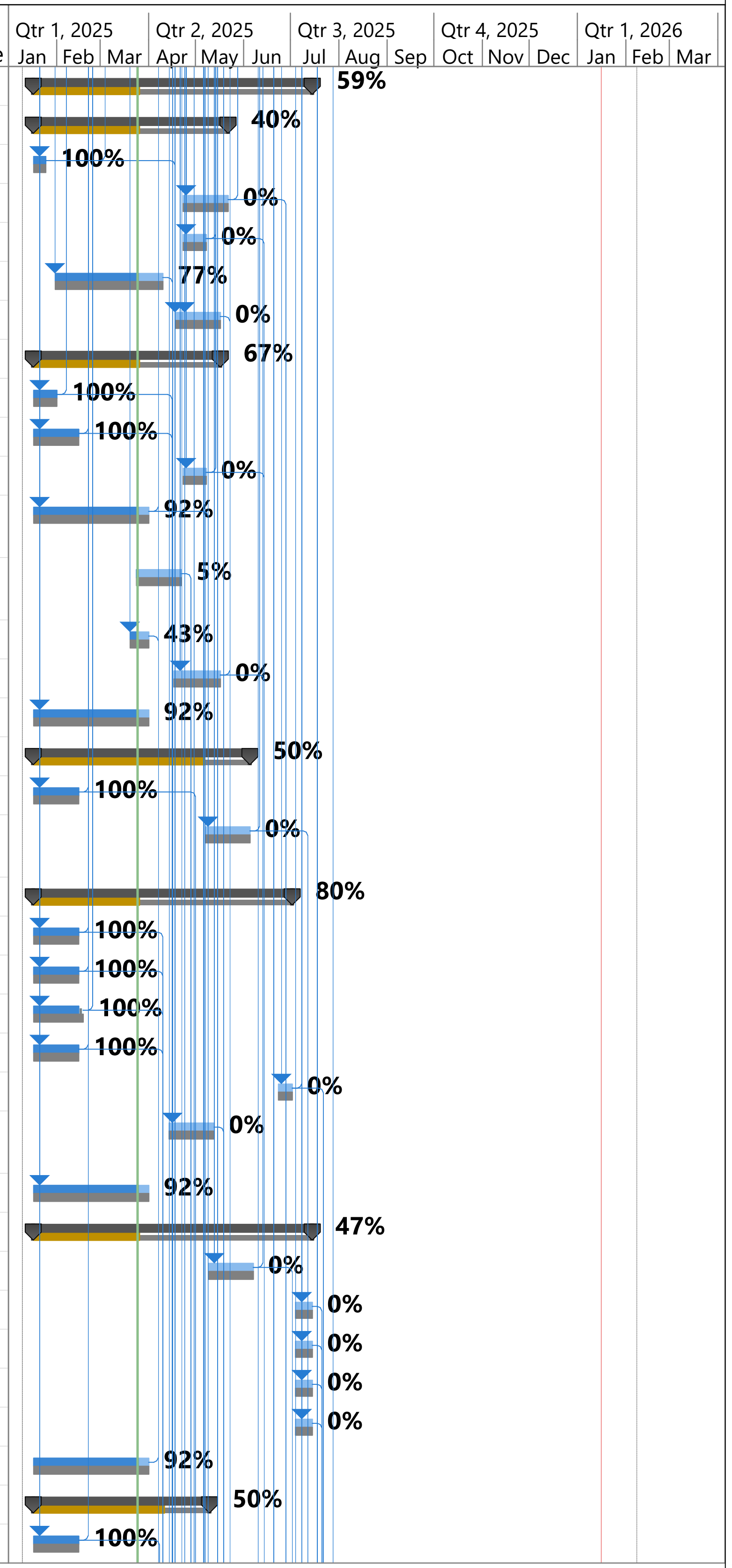
ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
94	Engg(EPS) Capacitive Voltage Transformer -Post Order Drawing Receipt	15 days	18-02-2025	10-03-2025	15 days	18-02-2025	10-03-2025	100%	100%
95	Engg(EPS) Capacitive Voltage Transformer -Post Order Engineering	20 days	05-03-2025	02-04-2025	20 days	05-03-2025	02-04-2025	70%	70%
96	Engg(EPS) Capacitive Voltage Transformer -Post Order Drawing Approval	5 days	03-04-2025	09-04-2025	5 days	03-04-2025	09-04-2025	0%	0%
97	**400KV Wave trap**	**61 days**	**13-01-2025**	**09-04-2025**	**61 days**	**13-01-2025**	**09-04-2025**	**74%**	**74%**
98	Engg(EPS) Wave Trap -PS release	2 days	13-01-2025	14-01-2025	2 days	13-01-2025	14-01-2025	100%	100%
99	Engg(EPS) Wave Trap -Post Order Drawing Receipt	15 days	17-02-2025	07-03-2025	15 days	17-02-2025	07-03-2025	100%	100%
100	Engg(EPS) Wave Trap -Post Order Engineering	21 days	04-03-2025	02-04-2025	21 days	04-03-2025	02-04-2025	71%	71%
101	Engg(EPS) Wave Trap -Post Order Drawing Approval	5 days	03-04-2025	09-04-2025	5 days	03-04-2025	09-04-2025	0%	0%
102	**400KV Potyard Structures**	**25 days**	**17-06-2025**	**21-07-2025**	**25 days**	**17-06-2025**	**21-07-2025**	**0%**	**0%**
103	Engg(EPS) Potyard Structure -PS release	2 days	17-06-2025	18-06-2025	2 days	17-06-2025	18-06-2025	0%	0%
104	Engg(EPS) Potyard Structure -Post Order Drawing Receipt	10 days	02-07-2025	15-07-2025	10 days	02-07-2025	15-07-2025	0%	0%
105	Engg(EPS) Potyard Structure -Post Order Engineerin	7 days	04-07-2025	14-07-2025	7 days	04-07-2025	14-07-2025	0%	0%
106	Engg(EPS) Potyard Structure -Post Order Drawing Approval	5 days	15-07-2025	21-07-2025	5 days	15-07-2025	21-07-2025	0%	0%
107	**Illumination System**	**66 days**	**01-04-2025**	**01-07-2025**	**66 days**	**01-04-2025**	**01-07-2025**	**0%**	**0%**
108	Engg(EPS) Illumination System -PS release	25 days	01-04-2025	06-05-2025	25 days	01-04-2025	06-05-2025	0%	0%
109	Engg(EPS) Illumination System -Post Order Drawing Receipt	10 days	09-06-2025	20-06-2025	10 days	09-06-2025	20-06-2025	0%	0%
110	Engg(EPS) Illumination System -Post Order Engineering	7 days	16-06-2025	24-06-2025	7 days	16-06-2025	24-06-2025	0%	0%
111	Engg(EPS) Illumination System -Post Order Drawing Approval	5 days	25-06-2025	01-07-2025	5 days	25-06-2025	01-07-2025	0%	0%
112	**Cabling System**	**59 days**	**13-01-2025**	**07-04-2025**	**59 days**	**13-01-2025**	**07-04-2025**	**78%**	**78%**
113	Engg(EPS) Cabling System -PS release	2 days	13-01-2025	14-01-2025	2 days	13-01-2025	14-01-2025	100%	100%
114	Engg(EPS) Cabling System -Post Order Drawing Receipt	15 days	17-02-2025	07-03-2025	15 days	17-02-2025	07-03-2025	100%	100%
115	Engg(EPS) Cabling System -Post Order Engineering	19 days	04-03-2025	31-03-2025	19 days	04-03-2025	31-03-2025	79%	79%
116	Engg(EPS) Cabling System -Post Order Drawing Approval	5 days	01-04-2025	07-04-2025	5 days	01-04-2025	07-04-2025	0%	0%
117	**Earthing System**	**41 days**	**08-04-2025**	**03-06-2025**	**41 days**	**08-04-2025**	**03-06-2025**	**0%**	**0%**
118	Engg(EPS) Earthing System -PS release	2 days	08-04-2025	09-04-2025	2 days	08-04-2025	09-04-2025	0%	0%
119	Engg(EPS) Earthing System -Post Order Drawing Receipt	10 days	13-05-2025	26-05-2025	10 days	13-05-2025	26-05-2025	0%	0%
120	Engg(EPS) Earthing System -Post Order Engineering	7 days	19-05-2025	27-05-2025	7 days	19-05-2025	27-05-2025	0%	0%
121	Engg(EPS) Earthing System -Post Order Drawing Approval	5 days	28-05-2025	03-06-2025	5 days	28-05-2025	03-06-2025	0%	0%
122	**Procurement**	**125 days**	**17-01-2025**	**14-07-2025**	**125 days**	**17-01-2025**	**14-07-2025**	**60%**	**60%**
123	**Mechanical Auxiliaries**	**9 days**	**21-01-2025**	**31-01-2025**	**9 days**	**21-01-2025**	**31-01-2025**	**100%**	**100%**
124	PO(MBOP) Fire Fighting System	9 days	21-01-2025	31-01-2025	9 days	21-01-2025	31-01-2025	100%	100%
125	PO(MBOP) EOT Crane	9 days	21-01-2025	31-01-2025	9 days	21-01-2025	31-01-2025	100%	100%



Status Date 25-03-2025

Baseline Milestone		Critical Progress		Manual Task		Baseline Split		Manual Summary	
Baseline Summary		Task		Start-only		Milestone		Project Summary	
Critical		Split		Finish-only		Summary Progress		Deadline	
Critical Split		Task Progress		Duration-only		Summary		Baseline	

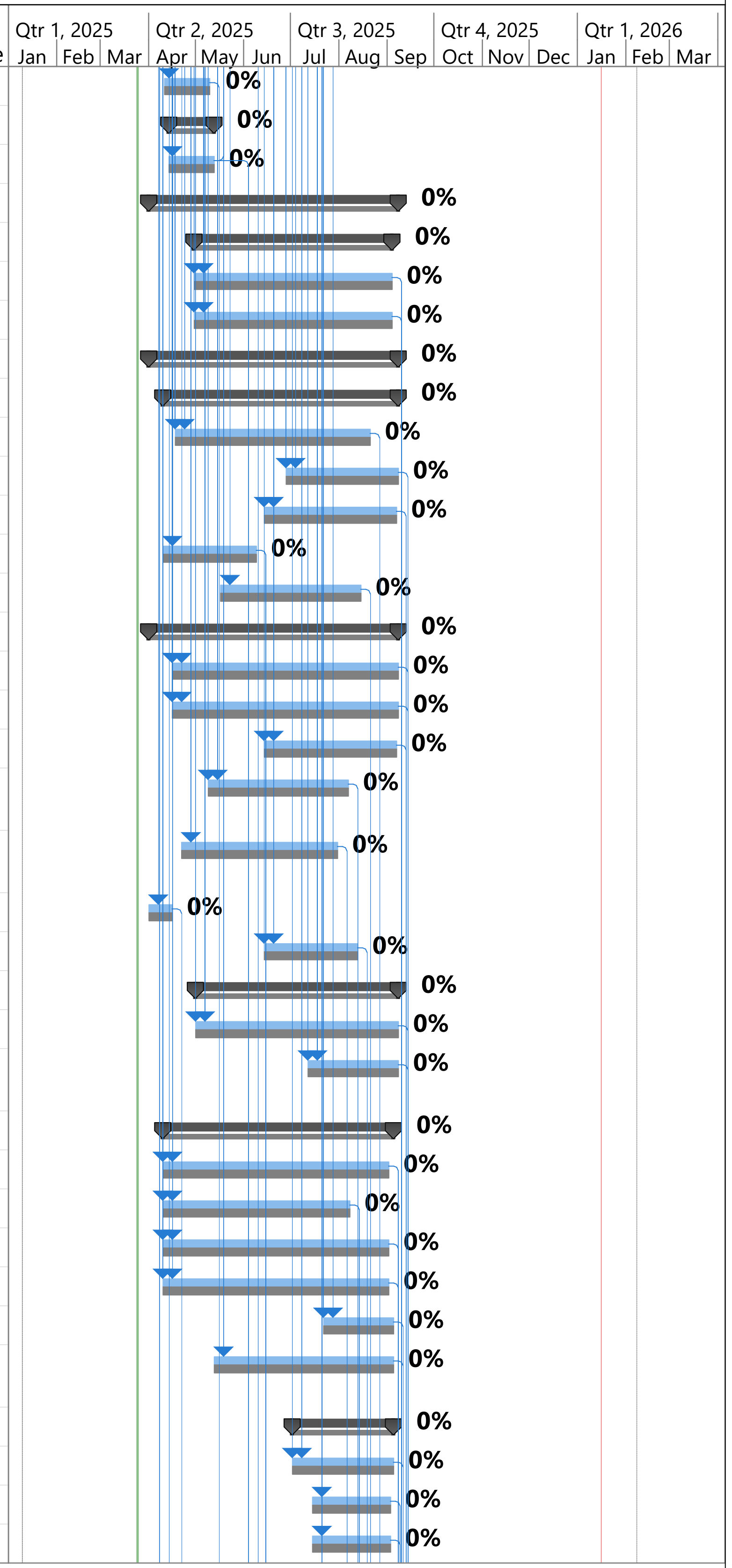
ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
126	**Electrical Power System**	**125 days**	**17-01-2025**	**14-07-2025**	**125 days**	**17-01-2025**	**14-07-2025**	**59%**	**59%**
127	**GIS**	**87 days**	**17-01-2025**	**21-05-2025**	**87 days**	**17-01-2025**	**21-05-2025**	**40%**	**40%**
128	PO(EPS) 420KV GIS System	6 days	17-01-2025	24-01-2025	6 days	17-01-2025	24-01-2025	100%	100%
129	PO(EPS) Gas Density Monitoring System	21 days	23-04-2025	21-05-2025	21 days	23-04-2025	21-05-2025	0%	0%
130	PO(EPS) Partial Discharge Monitoring System	11 days	23-04-2025	07-05-2025	11 days	23-04-2025	07-05-2025	0%	0%
131	PO(EPS) 420KV GIS-Tools	48 days	31-01-2025	09-04-2025	48 days	31-01-2025	09-04-2025	77%	77%
132	PO(EPS) GIB Sealing	21 days	18-04-2025	16-05-2025	21 days	18-04-2025	16-05-2025	0%	0%
133	**HV Cables**	**84 days**	**17-01-2025**	**16-05-2025**	**84 days**	**17-01-2025**	**16-05-2025**	**67%**	**67%**
134	PO(EPS) 400KV XLPE Cables	11 days	17-01-2025	31-01-2025	11 days	17-01-2025	31-01-2025	100%	100%
135	PO(EPS) 400KV XLPE Cable Terminations	21 days	17-01-2025	14-02-2025	21 days	17-01-2025	14-02-2025	100%	100%
136	PO(EPS) 400KV XLPE Cable PD Monitoring System	11 days	23-04-2025	07-05-2025	11 days	23-04-2025	07-05-2025	0%	0%
137	PO(EPS) 400KV XLPE Cable Distributed temperature system (DTS)	51 days	17-01-2025	31-03-2025	51 days	17-01-2025	31-03-2025	92%	92%
138	PO(EPS) 400KV XLPE Cable CT for Overcurrent Protection	19 days	24-03-2025	21-04-2025	19 days	24-03-2025	21-04-2025	5%	5%
139	PO(EPS) 400KV XLPE Cable Drums	7 days	20-03-2025	31-03-2025	7 days	20-03-2025	31-03-2025	43%	43%
140	PO(EPS) 400KV XLPE Cable- Structures, SVL, Clamps	22 days	17-04-2025	16-05-2025	22 days	17-04-2025	16-05-2025	0%	0%
141	PO(EPS) 400KV XLPE Cables Structure designer	51 days	17-01-2025	31-03-2025	51 days	17-01-2025	31-03-2025	92%	92%
142	**Diesel Generator**	**97 days**	**17-01-2025**	**04-06-2025**	**97 days**	**17-01-2025**	**04-06-2025**	**50%**	**50%**
143	PO(EPS) Diesel Generator Set	21 days	17-01-2025	14-02-2025	21 days	17-01-2025	14-02-2025	100%	100%
144	PO(EPS) Diesel Generator Set (Tank, Stacks, Structures, Piping)	21 days	07-05-2025	04-06-2025	21 days	07-05-2025	04-06-2025	0%	0%
145	**Potyard**	**116 days**	**17-01-2025**	**01-07-2025**	**116 days**	**17-01-2025**	**01-07-2025**	**80%**	**80%**
146	PO(EPS) 400KV Potyard	21 days	17-01-2025	14-02-2025	21 days	17-01-2025	14-02-2025	100%	100%
147	PO(EPS) Lightining Arrester (LA)	21 days	17-01-2025	14-02-2025	21 days	17-01-2025	14-02-2025	100%	100%
148	PO(EPS) Capacitive Voltage Transformer (CVT)	22 days	17-01-2025	17-02-2025	22 days	17-01-2025	17-02-2025	100%	100%
149	PO(EPS) Wave trap	21 days	17-01-2025	14-02-2025	21 days	17-01-2025	14-02-2025	100%	100%
150	PO(EPS) Potyard Structures	7 days	23-06-2025	01-07-2025	7 days	23-06-2025	01-07-2025	0%	0%
151	PO(EPS) String insulator, ACSR conductor, Clamps & Connectors	21 days	14-04-2025	12-05-2025	21 days	14-04-2025	12-05-2025	0%	0%
152	PO(EPS) Potyard Structure designer	51 days	17-01-2025	31-03-2025	51 days	17-01-2025	31-03-2025	92%	92%
153	**Illumination System**	**125 days**	**17-01-2025**	**14-07-2025**	**125 days**	**17-01-2025**	**14-07-2025**	**47%**	**47%**
154	PO(EPS) Illumination System	21 days	09-05-2025	06-06-2025	21 days	09-05-2025	06-06-2025	0%	0%
155	PO(EPS) Fixtures	7 days	04-07-2025	14-07-2025	7 days	04-07-2025	14-07-2025	0%	0%
156	PO(EPS) Sockets	7 days	04-07-2025	14-07-2025	7 days	04-07-2025	14-07-2025	0%	0%
157	PO(EPS) LDBs	7 days	04-07-2025	14-07-2025	7 days	04-07-2025	14-07-2025	0%	0%
158	PO(EPS) Lightning Mast	7 days	04-07-2025	14-07-2025	7 days	04-07-2025	14-07-2025	0%	0%
159	PO(EPS) Illumination System designer	51 days	17-01-2025	31-03-2025	51 days	17-01-2025	31-03-2025	92%	92%
160	**MV/LV Cables**	**79 days**	**17-01-2025**	**09-05-2025**	**79 days**	**17-01-2025**	**09-05-2025**	**50%**	**50%**
161	PO(EPS) Cabling System	21 days	17-01-2025	14-02-2025	21 days	17-01-2025	14-02-2025	100%	100%



Status Date 25-03-2025

Baseline Milestone	◇	Critical Progress		Manual Task		Baseline Split		Manual Summary	
Baseline Summary		Task		Start-only	[	Milestone	◆	Project Summary	
Critical		Split		Finish-only	]	Summary Progress		Deadline	
Critical Split		Task Progress		Duration-only		Summary		Baseline	

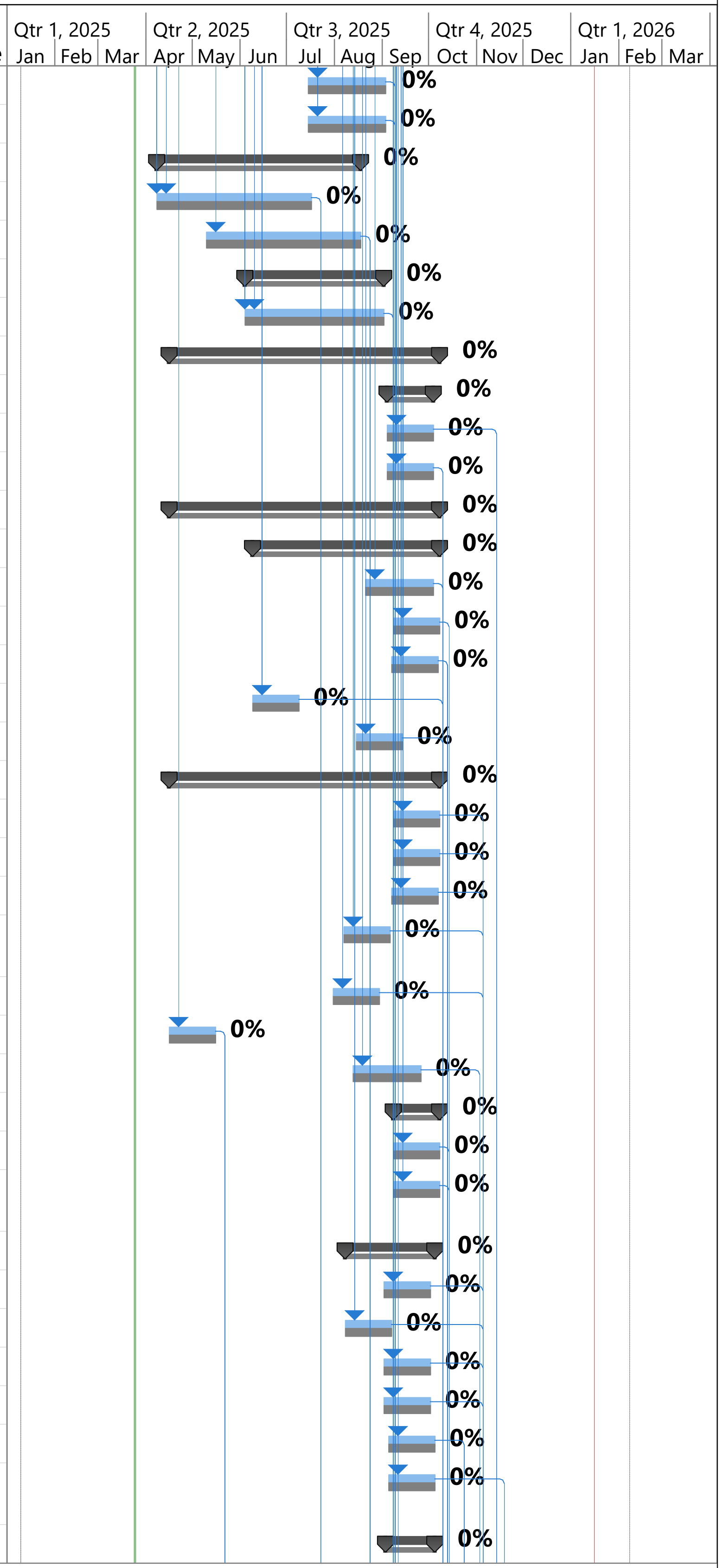
ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
162	PO(EPS) Cable Tray	21 days	11-04-2025	09-05-2025	21 days	11-04-2025	09-05-2025	0%	0%
163	**Earthing System**	**21 days**	**14-04-2025**	**12-05-2025**	**21 days**	**14-04-2025**	**12-05-2025**	**0%**	**0%**
164	PO(EPS) Earthing System	21 days	14-04-2025	12-05-2025	21 days	14-04-2025	12-05-2025	0%	0%
165	**Manufacturing (Mfg. Outsourced)**	**113 days**	**01-04-2025**	**07-09-2025**	**113 days**	**01-04-2025**	**07-09-2025**	**0%**	**0%**
166	**Mechanical Auxilairies**	**90 days**	**30-04-2025**	**03-09-2025**	**90 days**	**30-04-2025**	**03-09-2025**	**0%**	**0%**
167	Proc(MBOP) Fire Fighting System	90 days	30-04-2025	03-09-2025	90 days	30-04-2025	03-09-2025	0%	0%
168	Proc(MBOP) EOT Crane	90 days	30-04-2025	03-09-2025	90 days	30-04-2025	03-09-2025	0%	0%
169	**Electrical Power System**	**113 days**	**01-04-2025**	**07-09-2025**	**113 days**	**01-04-2025**	**07-09-2025**	**0%**	**0%**
170	**GIS**	**106 days**	**10-04-2025**	**07-09-2025**	**106 days**	**10-04-2025**	**07-09-2025**	**0%**	**0%**
171	Proc(EPS) 420KV GIS System	125 days	18-04-2025	20-08-2025	125 days	18-04-2025	20-08-2025	0%	0%
172	Proc(EPS) Gas Density Monitoring System	72 days	28-06-2025	07-09-2025	72 days	28-06-2025	07-09-2025	0%	0%
173	Proc(EPS) Partial Discharge Monitoring System	85 days	14-06-2025	06-09-2025	85 days	14-06-2025	06-09-2025	0%	0%
174	Proc(EPS) 420KV GIS-Tools	60 days	10-04-2025	08-06-2025	60 days	10-04-2025	08-06-2025	0%	0%
175	Proc(EPS) 420KV GIB Sealing	90 days	17-05-2025	14-08-2025	90 days	17-05-2025	14-08-2025	0%	0%
176	**HV Cables**	**113 days**	**01-04-2025**	**07-09-2025**	**113 days**	**01-04-2025**	**07-09-2025**	**0%**	**0%**
177	Proc(EPS) 400KV XLPE - Cable	145 days	16-04-2025	07-09-2025	145 days	16-04-2025	07-09-2025	0%	0%
178	Proc(EPS) 400KV XLPE Cable Termination	145 days	16-04-2025	07-09-2025	145 days	16-04-2025	07-09-2025	0%	0%
179	Proc(EPS) 400KV XLPE Cable PD Monitoring System	85 days	14-06-2025	06-09-2025	85 days	14-06-2025	06-09-2025	0%	0%
180	Proc(EPS) 400KV XLPE Cable Distributed temperature system (DTS)	90 days	09-05-2025	06-08-2025	90 days	09-05-2025	06-08-2025	0%	0%
181	Proc(EPS) 400KV XLPE Cable CT for Overcurrent Protection	100 days	22-04-2025	30-07-2025	100 days	22-04-2025	30-07-2025	0%	0%
182	Proc(EPS) 400KV XLPE Cable Drums	15 days	01-04-2025	15-04-2025	15 days	01-04-2025	15-04-2025	0%	0%
183	Proc(EPS) 400KV XLPE Cable- Structures, SVL, Clamps	60 days	14-06-2025	12-08-2025	60 days	14-06-2025	12-08-2025	0%	0%
184	**Diesel Generator**	**91 days**	**01-05-2025**	**07-09-2025**	**91 days**	**01-05-2025**	**07-09-2025**	**0%**	**0%**
185	Proc(EPS) Diesel Generator Set	130 days	01-05-2025	07-09-2025	130 days	01-05-2025	07-09-2025	0%	0%
186	Proc(EPS) Diesel Generator Set (Tank, Stacks, Structures, Piping)	58 days	12-07-2025	07-09-2025	58 days	12-07-2025	07-09-2025	0%	0%
187	**Potyard**	**105 days**	**10-04-2025**	**04-09-2025**	**105 days**	**10-04-2025**	**04-09-2025**	**0%**	**0%**
188	Proc(EPS) 400KV Potyard	145 days	10-04-2025	01-09-2025	145 days	10-04-2025	01-09-2025	0%	0%
189	Proc(EPS) Lightining Arrester	120 days	10-04-2025	07-08-2025	120 days	10-04-2025	07-08-2025	0%	0%
190	Proc(EPS) 400KV Capacitive Voltage Transformer	145 days	10-04-2025	01-09-2025	145 days	10-04-2025	01-09-2025	0%	0%
191	Proc(EPS) 400KV Wave trap	145 days	10-04-2025	01-09-2025	145 days	10-04-2025	01-09-2025	0%	0%
192	Proc(EPS) 400KV Potyard Structures	45 days	22-07-2025	04-09-2025	45 days	22-07-2025	04-09-2025	0%	0%
193	Proc(EPS) String insulator, ACSR conductor, Clamps & Connectors	115 days	13-05-2025	04-09-2025	115 days	13-05-2025	04-09-2025	0%	0%
194	**Illumination System**	**46 days**	**02-07-2025**	**04-09-2025**	**46 days**	**02-07-2025**	**04-09-2025**	**0%**	**0%**
195	Proc(EPS) Illumination System	65 days	02-07-2025	04-09-2025	65 days	02-07-2025	04-09-2025	0%	0%
196	Proc(EPS) Fixtures	50 days	15-07-2025	02-09-2025	50 days	15-07-2025	02-09-2025	0%	0%
197	Proc(EPS) Sockets	50 days	15-07-2025	02-09-2025	50 days	15-07-2025	02-09-2025	0%	0%



Status Date 25-03-2025

Baseline Milestone | Critical Progress | Manual Task | Baseline Split | Manual Summary
Baseline Summary | Task | Start-only | Milestone | Project Summary
Critical | Split | Finish-only | Summary Progress | Deadline
Critical Split | Task Progress | Duration-only | Summary | Baseline

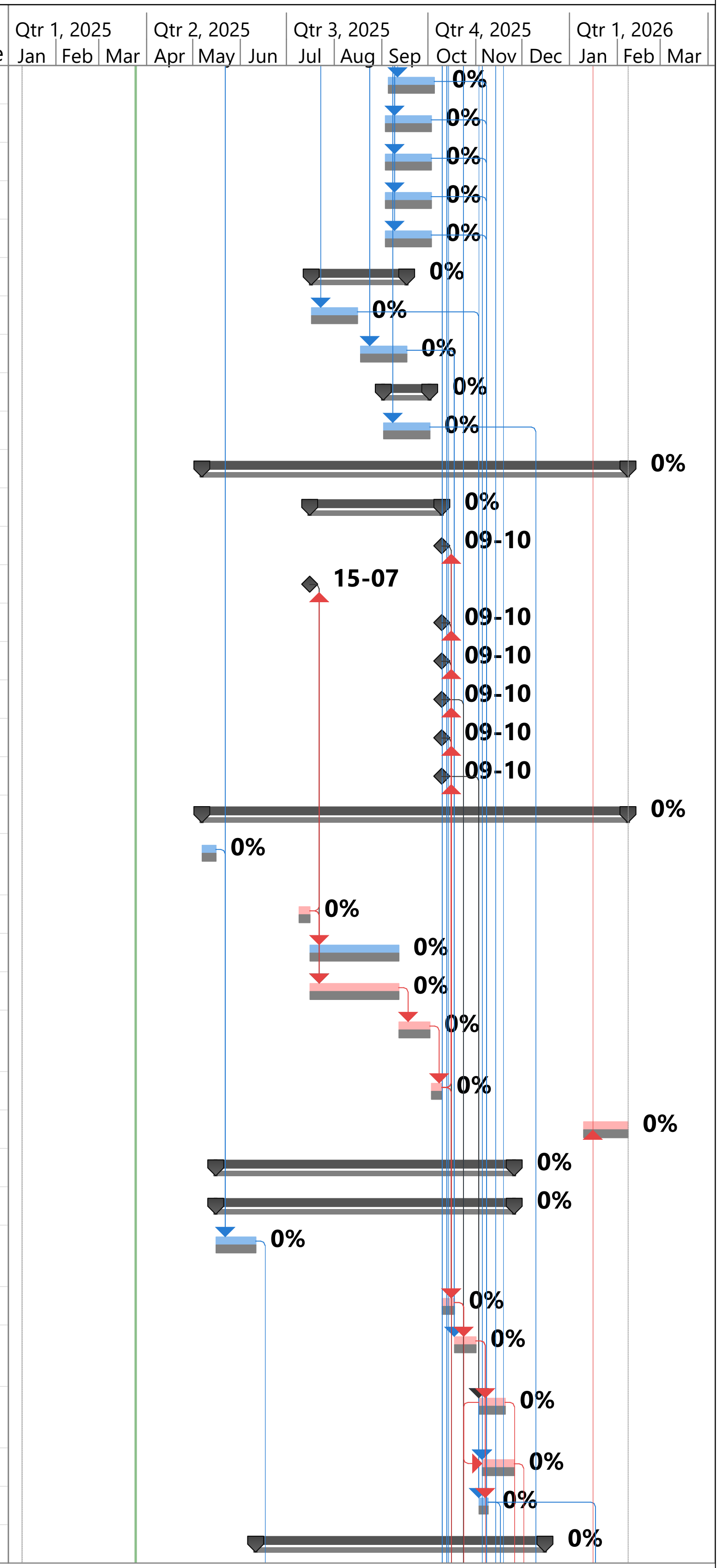
ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
198	Proc(EPS) LDBs	50 days	15-07-2025	02-09-2025	50 days	15-07-2025	02-09-2025	0%	0%
199	Proc(EPS) Lightning Mast	50 days	15-07-2025	02-09-2025	50 days	15-07-2025	02-09-2025	0%	0%
200	**MV/LV Cables**	**93 days**	**08-04-2025**	**17-08-2025**	**93 days**	**08-04-2025**	**17-08-2025**	**0%**	**0%**
201	Proc(EPS) Cabling System	100 days	08-04-2025	16-07-2025	100 days	08-04-2025	16-07-2025	0%	0%
202	Proc(EPS) Cable Tray	100 days	10-05-2025	17-08-2025	100 days	10-05-2025	17-08-2025	0%	0%
203	**Earthing System**	**63 days**	**04-06-2025**	**01-09-2025**	**63 days**	**04-06-2025**	**01-09-2025**	**0%**	**0%**
204	Proc(EPS) Earthing System	90 days	04-06-2025	01-09-2025	90 days	04-06-2025	01-09-2025	0%	0%
205	**Transportation to Site**	**122 days**	**16-04-2025**	**07-10-2025**	**122 days**	**16-04-2025**	**07-10-2025**	**0%**	**0%**
206	**Mechanical Auxiliaries**	**20 days**	**04-09-2025**	**03-10-2025**	**20 days**	**04-09-2025**	**03-10-2025**	**0%**	**0%**
207	Log(MBOP) Fire Fighting System	30 days	04-09-2025	03-10-2025	30 days	04-09-2025	03-10-2025	0%	0%
208	Log(MBOP) EOT Crane	30 days	04-09-2025	03-10-2025	30 days	04-09-2025	03-10-2025	0%	0%
209	**Electrical Power System**	**122 days**	**16-04-2025**	**07-10-2025**	**122 days**	**16-04-2025**	**07-10-2025**	**0%**	**0%**
210	**GIS**	**84 days**	**09-06-2025**	**07-10-2025**	**84 days**	**09-06-2025**	**07-10-2025**	**0%**	**0%**
211	Log(EPS) 420KV GIS System	30 days	21-08-2025	03-10-2025	30 days	21-08-2025	03-10-2025	0%	0%
212	Log(EPS) Gas Density Monitoring System	30 days	08-09-2025	07-10-2025	30 days	08-09-2025	07-10-2025	0%	0%
213	Log(EPS) Partial Discharge Monitoring System	30 days	07-09-2025	06-10-2025	30 days	07-09-2025	06-10-2025	0%	0%
214	Log(EPS) 420KV GIS-Tools	30 days	09-06-2025	08-07-2025	30 days	09-06-2025	08-07-2025	0%	0%
215	Log(EPS) 420KV GIB Sealing	30 days	15-08-2025	13-09-2025	30 days	15-08-2025	13-09-2025	0%	0%
216	**HV Cables**	**122 days**	**16-04-2025**	**07-10-2025**	**122 days**	**16-04-2025**	**07-10-2025**	**0%**	**0%**
217	Log(EPS) 400KV XLPE - Cable	30 days	08-09-2025	07-10-2025	30 days	08-09-2025	07-10-2025	0%	0%
218	Log(EPS) XLPE Cable Termination	30 days	08-09-2025	07-10-2025	30 days	08-09-2025	07-10-2025	0%	0%
219	Log(EPS) XLPE Cable PD Monitoring System	30 days	07-09-2025	06-10-2025	30 days	07-09-2025	06-10-2025	0%	0%
220	Log(EPS) XLPE Cable Distributed temperature system (DTS)	30 days	07-08-2025	05-09-2025	30 days	07-08-2025	05-09-2025	0%	0%
221	Log(EPS) XLPE Cable CT for Overcurrent Protection	30 days	31-07-2025	29-08-2025	30 days	31-07-2025	29-08-2025	0%	0%
222	Log(EPS) Cable Drums	30 days	16-04-2025	15-05-2025	30 days	16-04-2025	15-05-2025	0%	0%
223	Log(EPS) XLPE Cable-Structures, SVL, Clamps	30 days	13-08-2025	25-09-2025	30 days	13-08-2025	25-09-2025	0%	0%
224	**Diesel Generator**	**20 days**	**08-09-2025**	**07-10-2025**	**20 days**	**08-09-2025**	**07-10-2025**	**0%**	**0%**
225	Log(EPS) Diesel Generator Set	30 days	08-09-2025	07-10-2025	30 days	08-09-2025	07-10-2025	0%	0%
226	Log(EPS) Diesel Generator Set (Tank, Stacks & Structures)	30 days	08-09-2025	07-10-2025	30 days	08-09-2025	07-10-2025	0%	0%
227	**Potyard**	**38 days**	**08-08-2025**	**04-10-2025**	**38 days**	**08-08-2025**	**04-10-2025**	**0%**	**0%**
228	Log(EPS) 400KV Potyard	30 days	02-09-2025	01-10-2025	30 days	02-09-2025	01-10-2025	0%	0%
229	Log(EPS) Lightining Arrester	30 days	08-08-2025	06-09-2025	30 days	08-08-2025	06-09-2025	0%	0%
230	Log(EPS) Capacitive Voltage Transformer	30 days	02-09-2025	01-10-2025	30 days	02-09-2025	01-10-2025	0%	0%
231	Log(EPS) Wave trap	30 days	02-09-2025	01-10-2025	30 days	02-09-2025	01-10-2025	0%	0%
232	Log(EPS) Potyard Structures	30 days	05-09-2025	04-10-2025	30 days	05-09-2025	04-10-2025	0%	0%
233	Log(EPS) String insulator, ACSR conductor, Clamps & Connectors	30 days	05-09-2025	04-10-2025	30 days	05-09-2025	04-10-2025	0%	0%
234	**Illumination System**	**21 days**	**03-09-2025**	**04-10-2025**	**21 days**	**03-09-2025**	**04-10-2025**	**0%**	**0%**



Status Date 25-03-2025

Baseline Milestone		Critical Progress		Manual Task		Baseline Split		Manual Summary	
Baseline Summary		Task		Start-only		Milestone		Project Summary	
Critical		Split		Finish-only		Summary Progress		Deadline	
Critical Split		Task Progress		Duration-only		Summary		Baseline	

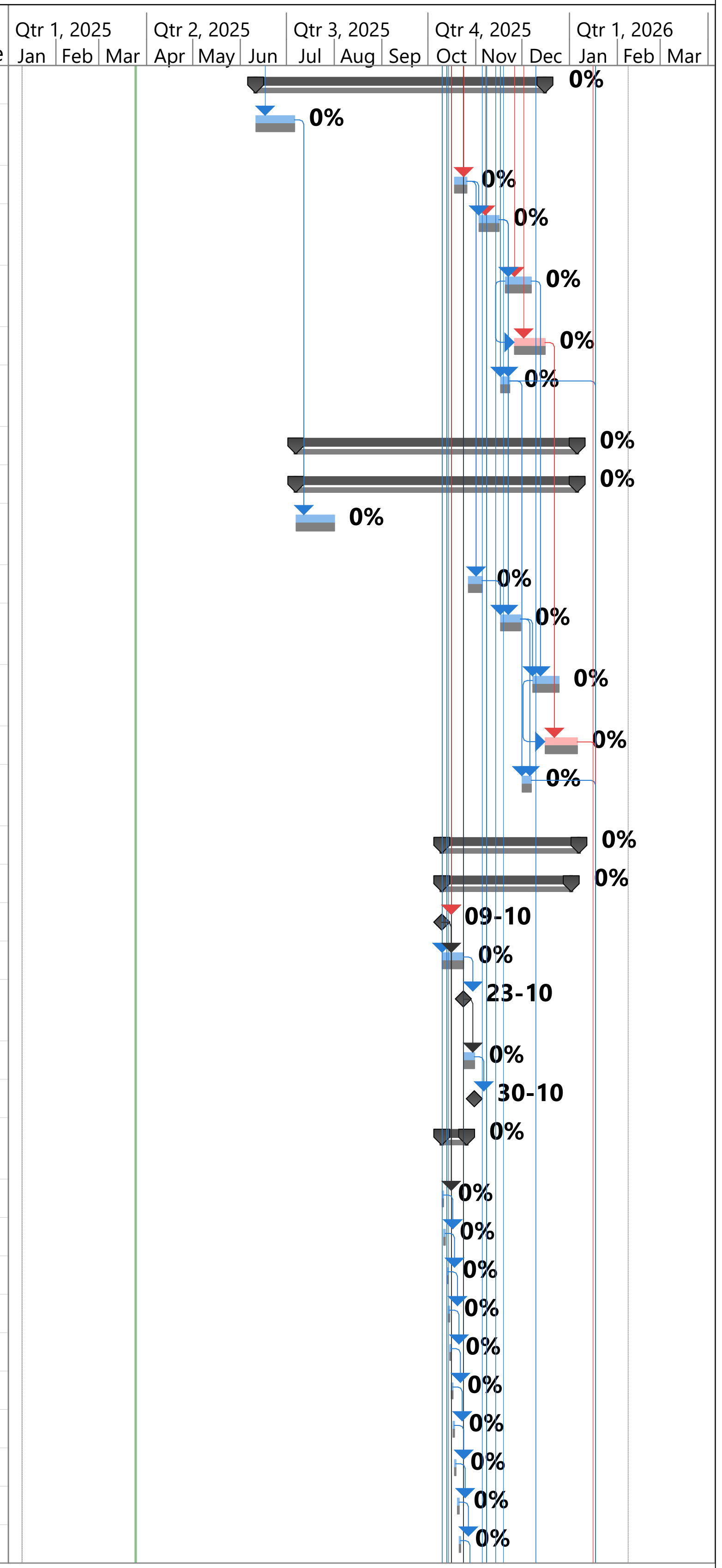
ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
235	Log(EPS) Illumination System	30 days	05-09-2025	04-10-2025	30 days	05-09-2025	04-10-2025	0%	0%
236	Log(EPS) Fixtures	30 days	03-09-2025	02-10-2025	30 days	03-09-2025	02-10-2025	0%	0%
237	Log(EPS) Sockets	30 days	03-09-2025	02-10-2025	30 days	03-09-2025	02-10-2025	0%	0%
238	Log(EPS) LDBs	30 days	03-09-2025	02-10-2025	30 days	03-09-2025	02-10-2025	0%	0%
239	Log(EPS) Lightning Mast	30 days	03-09-2025	02-10-2025	30 days	03-09-2025	02-10-2025	0%	0%
240	**MV/LV Cables**	**43 days**	**17-07-2025**	**16-09-2025**	**43 days**	**17-07-2025**	**16-09-2025**	**0%**	**0%**
241	Log(EPS) Cabling System	30 days	17-07-2025	15-08-2025	30 days	17-07-2025	15-08-2025	0%	0%
242	Log(EPS) Cable Tray	30 days	18-08-2025	16-09-2025	30 days	18-08-2025	16-09-2025	0%	0%
243	**Earthing System**	**21 days**	**02-09-2025**	**01-10-2025**	**21 days**	**02-09-2025**	**01-10-2025**	**0%**	**0%**
244	Log(EPS) Earthing System	30 days	02-09-2025	01-10-2025	30 days	02-09-2025	01-10-2025	0%	0%
245	**Site I&C**	**191 days**	**07-05-2025**	**07-02-2026**	**191 days**	**07-05-2025**	**07-02-2026**	**0%**	**0%**
246	**Customer Milestones**	**59 days**	**15-07-2025**	**09-10-2025**	**59 days**	**15-07-2025**	**09-10-2025**	**0%**	**0%**
247	Unit Shutdown	0 days	09-10-2025	09-10-2025	0 days	09-10-2025	09-10-2025	0%	0%
248	Storage Area available	0 days	15-07-2025	15-07-2025	0 days	15-07-2025	15-07-2025	0%	0%
249	GIS area with good illumination in Power House	0 days	09-10-2025	09-10-2025	0 days	09-10-2025	09-10-2025	0%	0%
250	Handing of GIS crane beam for EOT erection	0 days	09-10-2025	09-10-2025	0 days	09-10-2025	09-10-2025	0%	0%
251	Readiness of Potyard foundations	0 days	09-10-2025	09-10-2025	0 days	09-10-2025	09-10-2025	0%	0%
252	Readiness of DG foundations	0 days	09-10-2025	09-10-2025	0 days	09-10-2025	09-10-2025	0%	0%
253	Readiness of XLPE cable foundations/Trench	0 days	09-10-2025	09-10-2025	0 days	09-10-2025	09-10-2025	0%	0%
254	**Site Activities**	**191 days**	**07-05-2025**	**07-02-2026**	**191 days**	**07-05-2025**	**07-02-2026**	**0%**	**0%**
255	Mobilisation team from Supplier for Dismantling of 400 KV XLPE cables	8 days	07-05-2025	15-05-2025	8 days	07-05-2025	15-05-2025	0%	0%
256	Mobilisation	6 days	09-07-2025	15-07-2025	6 days	09-07-2025	15-07-2025	0%	0%
257	Site infrastructure: Camp furnishing and readiness	48 days	16-07-2025	11-09-2025	48 days	16-07-2025	11-09-2025	0%	0%
258	Site infrastructure: Stores construction	48 days	16-07-2025	11-09-2025	48 days	16-07-2025	11-09-2025	0%	0%
259	Site materials receiving arrangements (cranes manpower tools)	16 days	12-09-2025	01-10-2025	16 days	12-09-2025	01-10-2025	0%	0%
260	Handing over of site by NHPC	6 days	03-10-2025	09-10-2025	6 days	03-10-2025	09-10-2025	0%	0%
261	Demobilisation	24 days	10-01-2026	07-02-2026	24 days	10-01-2026	07-02-2026	0%	0%
262	**Unit 1**	**133 days**	**16-05-2025**	**25-11-2025**	**133 days**	**16-05-2025**	**25-11-2025**	**0%**	**0%**
263	**EPS**	**133 days**	**16-05-2025**	**25-11-2025**	**133 days**	**16-05-2025**	**25-11-2025**	**0%**	**0%**
264	Dismantling and Re-rolling of existing 400 KV XLPE Cables	22 days	16-05-2025	10-06-2025	22 days	16-05-2025	10-06-2025	0%	0%
265	Dismantling of existing LV and control cables	7 days	10-10-2025	17-10-2025	7 days	10-10-2025	17-10-2025	0%	0%
266	Cable Support Systems LV (CAT outside - new GIS) partly	12 days	18-10-2025	31-10-2025	12 days	18-10-2025	31-10-2025	0%	0%
267	Cable Support Systems XLPE (CAT outside - new GIS) partly	15 days	03-11-2025	19-11-2025	15 days	03-11-2025	19-11-2025	0%	0%
268	XLPE Power Cables laying & terminations	18 days	05-11-2025	25-11-2025	18 days	05-11-2025	25-11-2025	0%	0%
269	LV Power and Control Cables laying & teminations	6 days	03-11-2025	08-11-2025	6 days	03-11-2025	08-11-2025	0%	0%
270	**Unit 2**	**129 days**	**11-06-2025**	**15-12-2025**	**129 days**	**11-06-2025**	**15-12-2025**	**0%**	**0%**



Status Date 25-03-2025

Baseline Milestone	Critical Progress	Manual Task	Baseline Split
Manual Summary	Baseline Summary	Task	Start-only
Milestone	Project Summary	Critical	Split
Finish-only	Summary Progress	Deadline	Critical Split
Task Progress	Duration-only	Summary	Baseline

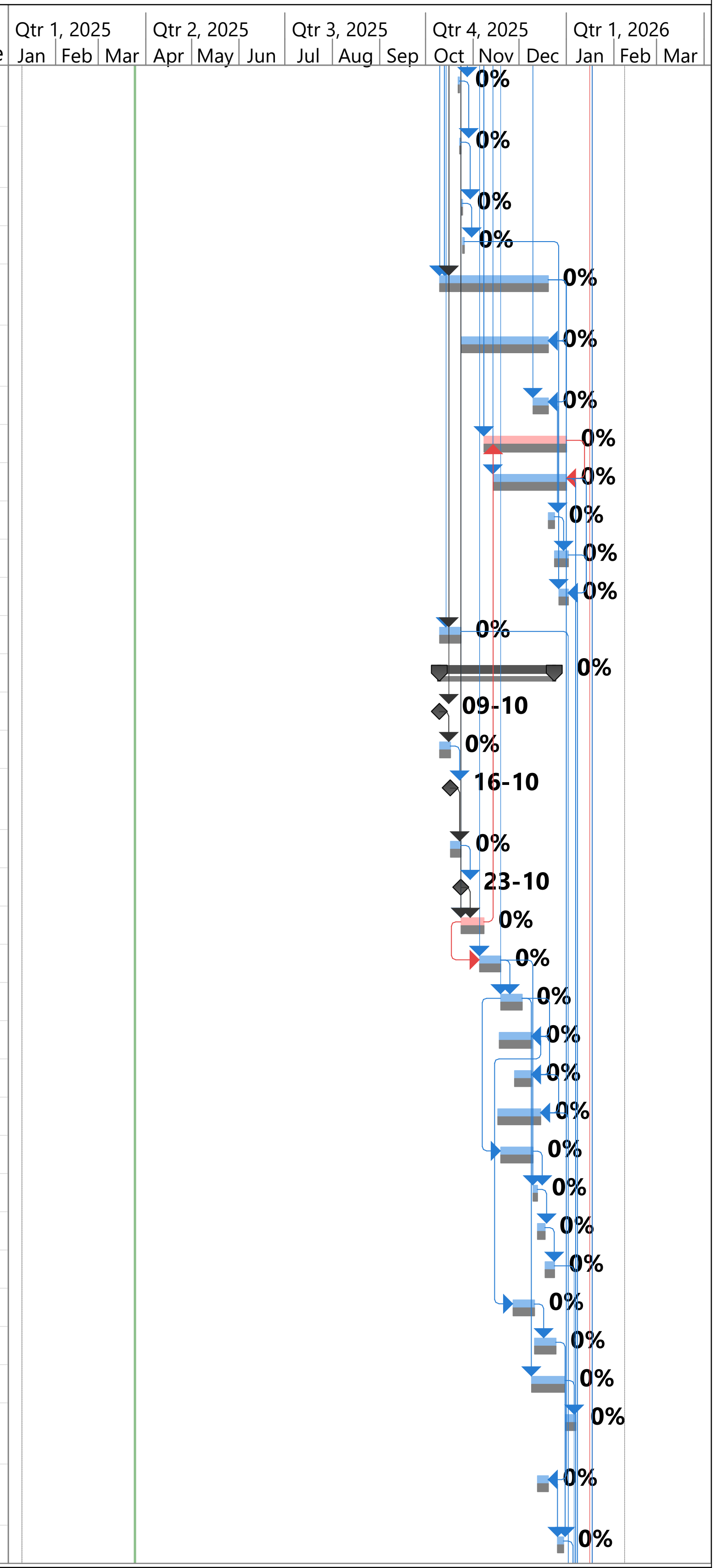
ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
271	**EPS**	**129 days**	**11-06-2025**	**15-12-2025**	**129 days**	**11-06-2025**	**15-12-2025**	**0%**	**0%**
272	Dismantling and Re-rolling of existing 400 KV XLPE Cables	22 days	11-06-2025	05-07-2025	22 days	11-06-2025	05-07-2025	0%	0%
273	Dismantling of existing LV and control cables	7 days	18-10-2025	25-10-2025	7 days	18-10-2025	25-10-2025	0%	0%
274	Cable Support Systems LV (CAT outside - new GIS) partly	12 days	03-11-2025	15-11-2025	12 days	03-11-2025	15-11-2025	0%	0%
275	Cable Support Systems XLPE (CAT outside - new GIS) partly	15 days	20-11-2025	06-12-2025	15 days	20-11-2025	06-12-2025	0%	0%
276	XLPE Power Cables laying & terminations	17 days	26-11-2025	15-12-2025	17 days	26-11-2025	15-12-2025	0%	0%
277	LV Power and Control Cables laying& teminations (GT-GIS)	6 days	17-11-2025	22-11-2025	6 days	17-11-2025	22-11-2025	0%	0%
278	**Unit 3**	**125 days**	**07-07-2025**	**05-01-2026**	**125 days**	**07-07-2025**	**05-01-2026**	**0%**	**0%**
279	**EPS**	**125 days**	**07-07-2025**	**05-01-2026**	**125 days**	**07-07-2025**	**05-01-2026**	**0%**	**0%**
280	Dismantling and Re-rolling of existing 400 KV XLPE Cables	22 days	07-07-2025	31-07-2025	22 days	07-07-2025	31-07-2025	0%	0%
281	Dismantling of existing LV and control cables	7 days	27-10-2025	04-11-2025	7 days	27-10-2025	04-11-2025	0%	0%
282	Cable Support Systems LV (CAT outside - new GIS) partly	12 days	17-11-2025	29-11-2025	12 days	17-11-2025	29-11-2025	0%	0%
283	Cable Support Systems XLPE (CAT outside - new GIS) partly	15 days	08-12-2025	24-12-2025	15 days	08-12-2025	24-12-2025	0%	0%
284	XLPE Power Cables laying & terminations	17 days	16-12-2025	05-01-2026	17 days	16-12-2025	05-01-2026	0%	0%
285	LV Power and Control Cables laying& teminations (GT-GIS)	6 days	01-12-2025	06-12-2025	6 days	01-12-2025	06-12-2025	0%	0%
286	**Common EPS / Electrical**	**60 days**	**09-10-2025**	**06-01-2026**	**60 days**	**09-10-2025**	**06-01-2026**	**0%**	**0%**
287	**420kV GIS System**	**57 days**	**09-10-2025**	**01-01-2026**	**57 days**	**09-10-2025**	**01-01-2026**	**0%**	**0%**
288	GIS Building Crane beam ready	0 days	09-10-2025	09-10-2025	0 days	09-10-2025	09-10-2025	0%	0%
289	GIS EOT crane (10T) installation	12 days	10-10-2025	23-10-2025	12 days	10-10-2025	23-10-2025	0%	0%
290	GIS building plinth ready for primary earthmat intallation	0 days	23-10-2025	23-10-2025	0 days	23-10-2025	23-10-2025	0%	0%
291	Primary earthmat intallation (NHPC)	6 days	24-10-2025	30-10-2025	6 days	24-10-2025	30-10-2025	0%	0%
292	GIS EQP primary foundations ready (NHPC)	0 days	30-10-2025	30-10-2025	0 days	30-10-2025	30-10-2025	0%	0%
293	**Shifting of existing panels from old building to new GIS control room**	**9 days**	**10-10-2025**	**25-10-2025**	**9 days**	**10-10-2025**	**25-10-2025**	**0%**	**0%**
294	PHC - 04 nos	1 day	10-10-2025	10-10-2025	1 day	10-10-2025	10-10-2025	0%	0%
295	400KV Line Protection - 04 nos	1 day	11-10-2025	11-10-2025	1 day	11-10-2025	11-10-2025	0%	0%
296	400kVTransformer feeder - 06 nos	1 day	13-10-2025	13-10-2025	1 day	13-10-2025	13-10-2025	0%	0%
297	400KV Bus Coupler Protection - 01 no	1 day	14-10-2025	14-10-2025	1 day	14-10-2025	14-10-2025	0%	0%
298	400kV Bus Bar/Breaker Failure - 02 nos	1 day	15-10-2025	15-10-2025	1 day	15-10-2025	15-10-2025	0%	0%
299	Illumination Panel - 02 no HVAC Panel - 01 no	1 day	16-10-2025	16-10-2025	1 day	16-10-2025	16-10-2025	0%	0%
300	Optical Fiber Cable Interface PMU - 02 no	1 day	17-10-2025	17-10-2025	1 day	17-10-2025	17-10-2025	0%	0%
301	Power Line Carrier for Line 1 (ABB BPL) - 06 nos	1 day	18-10-2025	18-10-2025	1 day	18-10-2025	18-10-2025	0%	0%
302	200 V DC Distribution Board-3 (GIS) - 01 no.	1 day	20-10-2025	20-10-2025	1 day	20-10-2025	20-10-2025	0%	0%
303	DC 48V Board for Pothead yard - 01 no.	1 day	21-10-2025	21-10-2025	1 day	21-10-2025	21-10-2025	0%	0%



Status Date 25-03-2025

Baseline Milestone		Critical Progress		Manual Task		Baseline Split		Manual Summary	
Baseline Summary		Task		Start-only		Milestone		Project Summary	
Critical		Split		Finish-only		Summary Progress		Deadline	
Critical Split		Task Progress		Duration-only		Summary		Baseline	

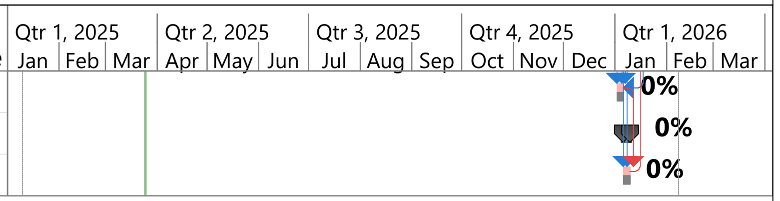
ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
304	RTU panel for Transmitting data to ERLDC/NLDC - 01 no	1 day	22-10-2025	22-10-2025	1 day	22-10-2025	22-10-2025	0%	0%
305	LOOP DACS Panel Owned and Managed By Powergrid (ULDC) - 01 no	1 day	23-10-2025	23-10-2025	1 day	23-10-2025	23-10-2025	0%	0%
306	11kV Switchgear - 08 nos	1 day	24-10-2025	24-10-2025	1 day	24-10-2025	24-10-2025	0%	0%
307	415V Potyard DB & Main & Emergency LDB	1 day	25-10-2025	25-10-2025	1 day	25-10-2025	25-10-2025	0%	0%
308	420kV GIS (06 bays) installation (incl. secondary foundations)	60 days	10-10-2025	19-12-2025	60 days	10-10-2025	19-12-2025	0%	0%
309	GIS Control & Protection system (inl. cable tray & cabling)	48 days	24-10-2025	19-12-2025	48 days	24-10-2025	19-12-2025	0%	0%
310	Secondary Earthing System	9 days	10-12-2025	19-12-2025	9 days	10-12-2025	19-12-2025	0%	0%
311	Illumination System installation	45 days	08-11-2025	31-12-2025	45 days	08-11-2025	31-12-2025	0%	0%
312	Firefighting Sys (Hydrant-FDA) installation	40 days	14-11-2025	31-12-2025	40 days	14-11-2025	31-12-2025	0%	0%
313	Tests prior to handover for commissioning	3 days	20-12-2025	23-12-2025	3 days	20-12-2025	23-12-2025	0%	0%
314	Electrical Tests (FQP)	7 days	24-12-2025	01-01-2026	7 days	24-12-2025	01-01-2026	0%	0%
315	Dry commissioning	5 days	27-12-2025	01-01-2026	5 days	27-12-2025	01-01-2026	0%	0%
316	Diesel Generator	12 days	10-10-2025	23-10-2025	12 days	10-10-2025	23-10-2025	0%	0%
317	**Switchyard Outdoor Systems**	**51 days**	**09-10-2025**	**23-12-2025**	**51 days**	**09-10-2025**	**23-12-2025**	**0%**	**0%**
318	PHY trenches ready for primary earthmat NHPC)	0 days	09-10-2025	09-10-2025	0 days	09-10-2025	09-10-2025	0%	0%
319	Primary earthmat installation (NHPC)	6 days	10-10-2025	16-10-2025	6 days	10-10-2025	16-10-2025	0%	0%
320	PHY foundations ready for soleplates intallation (NHPC)	0 days	16-10-2025	16-10-2025	0 days	16-10-2025	16-10-2025	0%	0%
321	Installation of sole plates and clearance to civil	6 days	17-10-2025	23-10-2025	6 days	17-10-2025	23-10-2025	0%	0%
322	PHY EQP foundation ready (NHPC)	0 days	23-10-2025	23-10-2025	0 days	23-10-2025	23-10-2025	0%	0%
323	Erection of Steel Structures	12 days	24-10-2025	07-11-2025	12 days	24-10-2025	07-11-2025	0%	0%
324	Equipments (HV / MV / LV) installations	12 days	05-11-2025	18-11-2025	12 days	05-11-2025	18-11-2025	0%	0%
325	Lines& Busbar installation (including stringing of line	12 days	19-11-2025	02-12-2025	12 days	19-11-2025	02-12-2025	0%	0%
326	Cable Support System & Cablng	18 days	18-11-2025	08-12-2025	18 days	18-11-2025	08-12-2025	0%	0%
327	Secondary Earthing System	9 days	28-11-2025	08-12-2025	9 days	28-11-2025	08-12-2025	0%	0%
328	Illumination System installation	24 days	17-11-2025	14-12-2025	24 days	17-11-2025	14-12-2025	0%	0%
329	Firefighting Sys (Hydrant) installation	18 days	19-11-2025	09-12-2025	18 days	19-11-2025	09-12-2025	0%	0%
330	Test prior to handover to commissioning	3 days	10-12-2025	12-12-2025	3 days	10-12-2025	12-12-2025	0%	0%
331	Electrical Tests (FQP)	4 days	13-12-2025	17-12-2025	4 days	13-12-2025	17-12-2025	0%	0%
332	Dry Commissioning	5 days	18-12-2025	23-12-2025	5 days	18-12-2025	23-12-2025	0%	0%
333	LV & MV Cable Support Systems GIS-PHY	12 days	27-11-2025	10-12-2025	12 days	27-11-2025	10-12-2025	0%	0%
334	LV Power and Control Cabling GIS-PHY	12 days	11-12-2025	24-12-2025	12 days	11-12-2025	24-12-2025	0%	0%
335	420kV GIB installation GIS-PHY 150 mts	18 days	09-12-2025	30-12-2025	18 days	09-12-2025	30-12-2025	0%	0%
336	Online PD Monitoring System for XLPE Cables (OEM turnkey scope)	6 days	31-12-2025	06-01-2026	6 days	31-12-2025	06-01-2026	0%	0%
337	Control and Protection System incl. Control Room (NHPC)	6 days	13-12-2025	19-12-2025	6 days	13-12-2025	19-12-2025	0%	0%
338	Test prior to handover to commissioning	3 days	26-12-2025	29-12-2025	3 days	26-12-2025	29-12-2025	0%	0%



Status Date 25-03-2025

Baseline Milestone · Baseline Summary · Critical · Critical Split · Critical Progress · Task · Split · Task Progress · Manual Task · Start-only · Finish-only · Duration-only · Baseline Split · Milestone · Summary Progress · Summary · Manual Summary · Project Summary · Deadline · Baseline

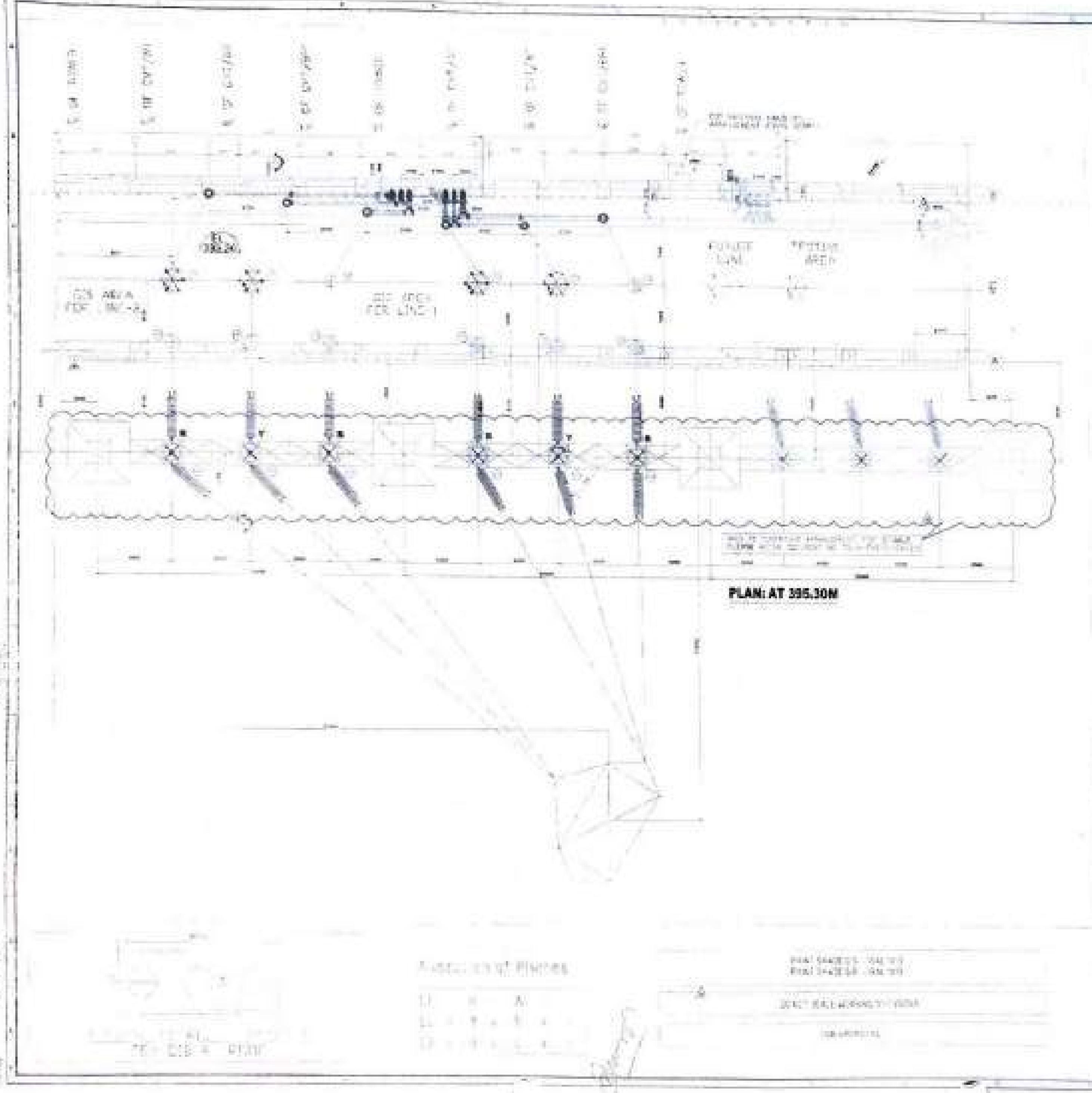
ID	Task Name	Signoff Duration	Signoff Start	Signoff Finish	Duration	Start	Finish	PP %	% Complete
339	Overall Dry commisioning (NHPC)	3 days	02-01-2026	05-01-2026	3 days	02-01-2026	05-01-2026	0%	0%
340	**Wet Commissioning**	**4 days**	**06-01-2026**	**09-01-2026**	**4 days**	**06-01-2026**	**09-01-2026**	**0%**	**0%**
341	Complete Commissioning EPS	4 days	06-01-2026	09-01-2026	4 days	06-01-2026	09-01-2026	0%	0%



Status Date 25-03-2025

Baseline Milestone	Critical Progress	Manual Task	Baseline Split	Manual Summary
Baseline Summary	Task	Start-only	Milestone	Project Summary
Critical	Split	Finish-only	Summary Progress	Deadline
Critical Split	Task Progress	Duration-only	Summary	Baseline

ANNEXURE-IV
(Overall layout plan)



TEESTA - V POWER STATION
(3x170 MW)

NHPC LIMITED

420 kV GIS - Plan Layout

1:150

ANDRITZ

TS-V-GIS-02-GA-102