CLIMATE-RESILIENT DAMS AND
HYDROPOWER INFRASTRUCTURE
INTEGRATING
ENVIRONMENTAL SUSTAINABILITY
IN PLANNING AND DEVELOPMENT

Comprehensive Early Warning System for Vulnerable Hydro Projects

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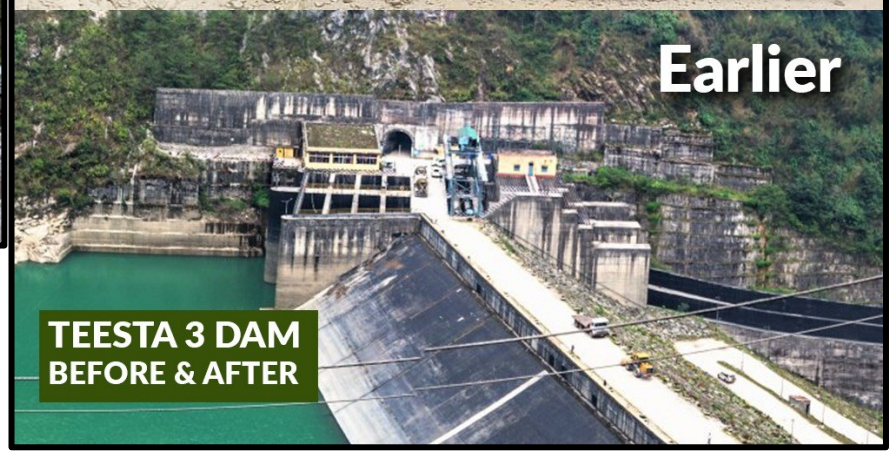
Need of an Early Warning System

KEDARNATH - 2013



- Increase in risk of extreme precipitation and flooding in India due to climate change
- Hydro Project's proneness to multiple Geohazards like landslides, cloudburst, flash floods, Earthquakes, Avalanches, Glacial Lake Outburst Flood (GLOF), and Landslide Lake Outburst Flood (LLOF)

Early Warning System & Key Elements

The United Nations Office for Disaster Risk Reduction (UNDRR) defines an Early Warning Systems as "an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events".

Recommendation by Central Authorities

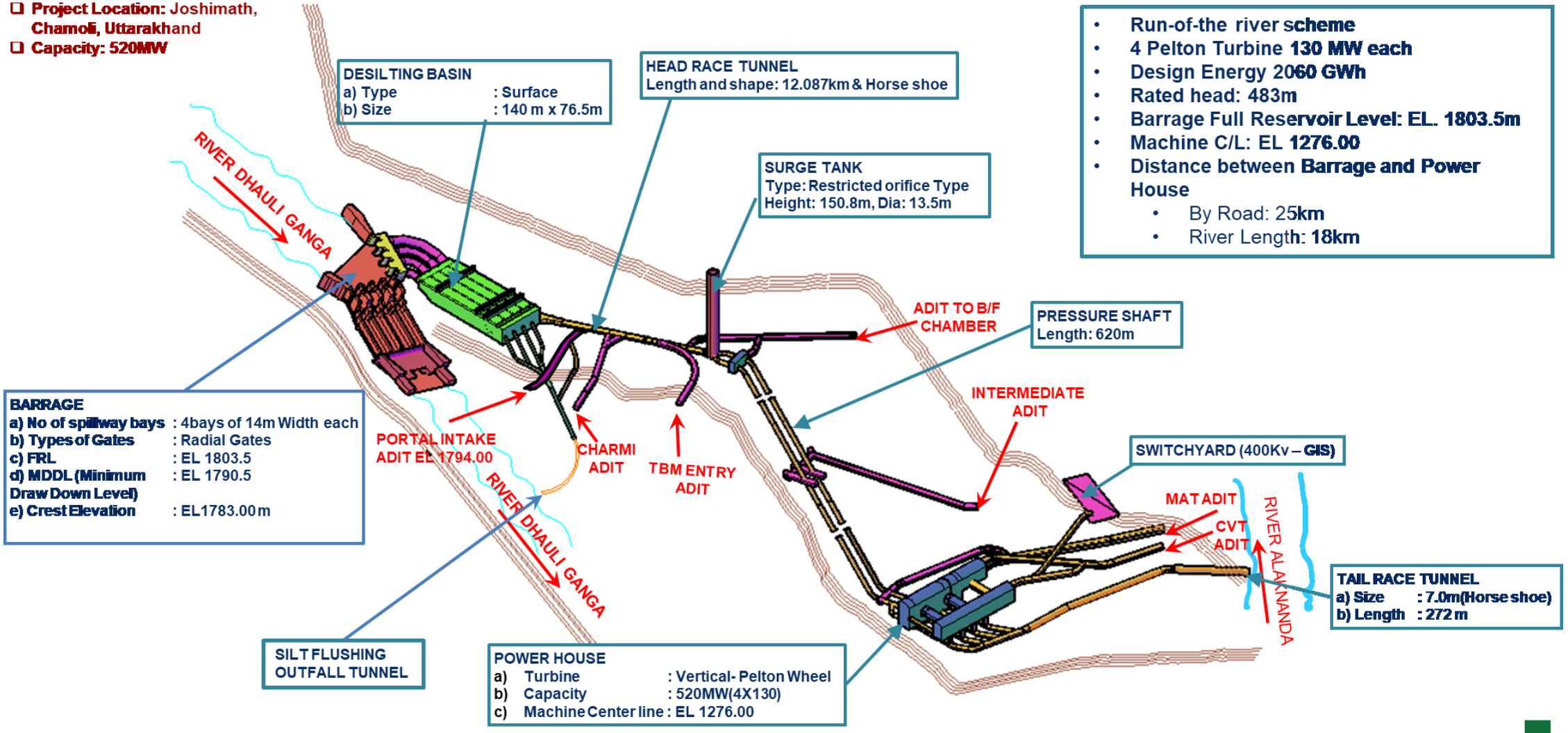
Post Chamoli disaster, MoP, Govt. of India constituted a committee on 23.03.2021 under the chairmanship of chairperson, CEA. The committee report was discussed by MoP on 06.08.2021 and 03.11.2021 and following were recommended.

- A system of 24 X 7 surveillance be created for each Hydroelectric Project in the Hilly Regions with a full proof communicating system.
- It is suggested that the provision of existing early warning system for a Hydropower Project be included in the DPR of the Project in the preconstruction stage itself.
- The "Central Control and Command Station" needs to be a mandatory component of the hydro power projects.
- All Hydropower Projects should install real time flood forecasting system with the help of Automatic Weather Stations/ G&D Sites/Radar based level sensors in the upstream of the project sites
- The project developer may carry out the task of digitization of river catchment up to appropriate distance in upstream so that appropriate lead time is known.
- Mapping of the glacial lakes/water bodies in the catchment area of Hydro Projects should be carried out for regular monitoring.

It was further directed that "Tapovan Vishnugad Hydro Power Plant will be a model hydro project for surveillance of catchment area for implementation of all elements for an effective early warning system that will serve as a model for all other hydro power plants."

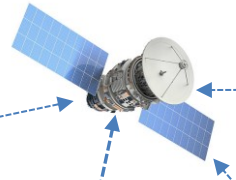
Tapovan Vishnugad HEP – Project Layout

- **Project Location:** Joshimath, Chamoli, Uttarakhand
- **Capacity: 520MW**



- Run-of-the river scheme
- 4 Pelton Turbine 130 MW each
- Design Energy 2060 GWh
- Rated head: 483m
- Barrage Full Reservoir Level: EL. 1803.5m
- Machine C/L: EL 1276.00
- Distance between Barrage and Power House
  - By Road: 25km
  - River Length: 18km

Manual Monitoring System at TVHEP



24 X 7 monitoring with satellite phones

Manning at Suraithota (Dhauliganga level - 15Km from Barrage)

24 X 7 monitoring with satellite phones

Manning at Govindghat (Alaknanda River Level- 15km from Powerhouse)

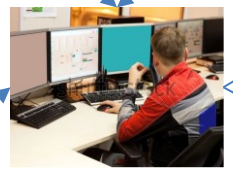
24 X 7 monitoring with satellite phones

Manning at Raini Village (Dhaulganga and Rishiganga River levels – 6 kms from Barrage

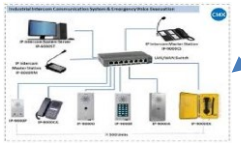
Tapovan Barrage Area

cameras

Ladders

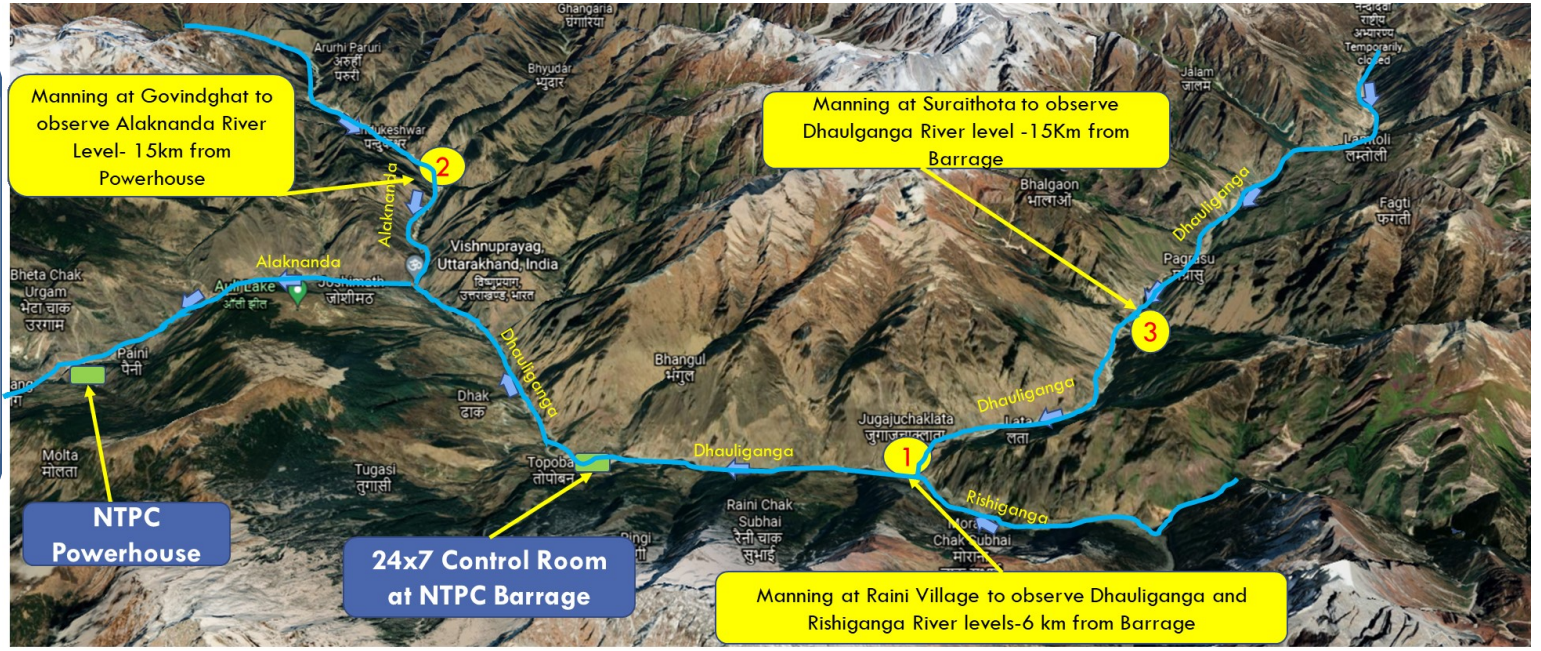


Sirens

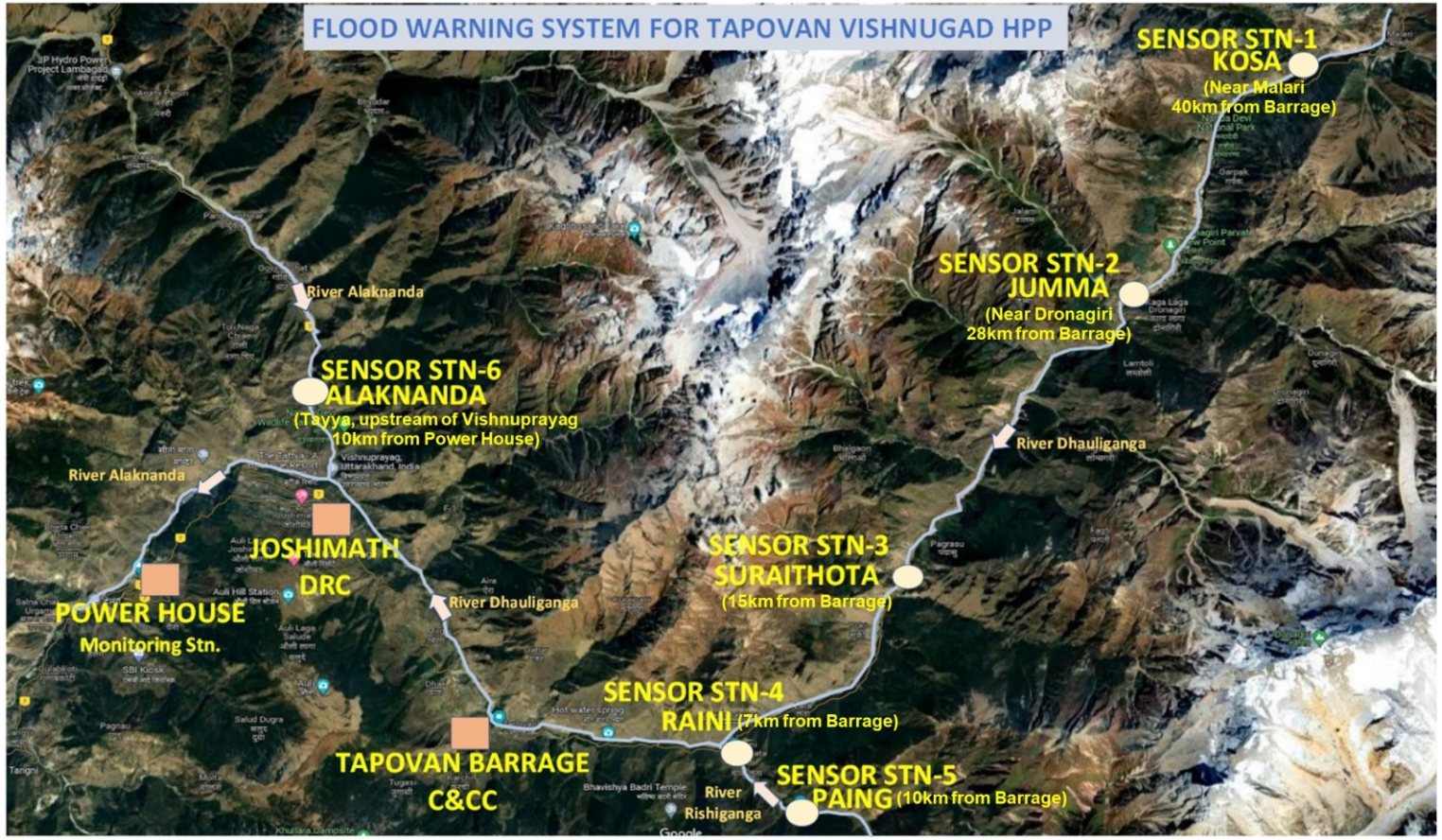


PA System

24 X 7 Manned Control Room

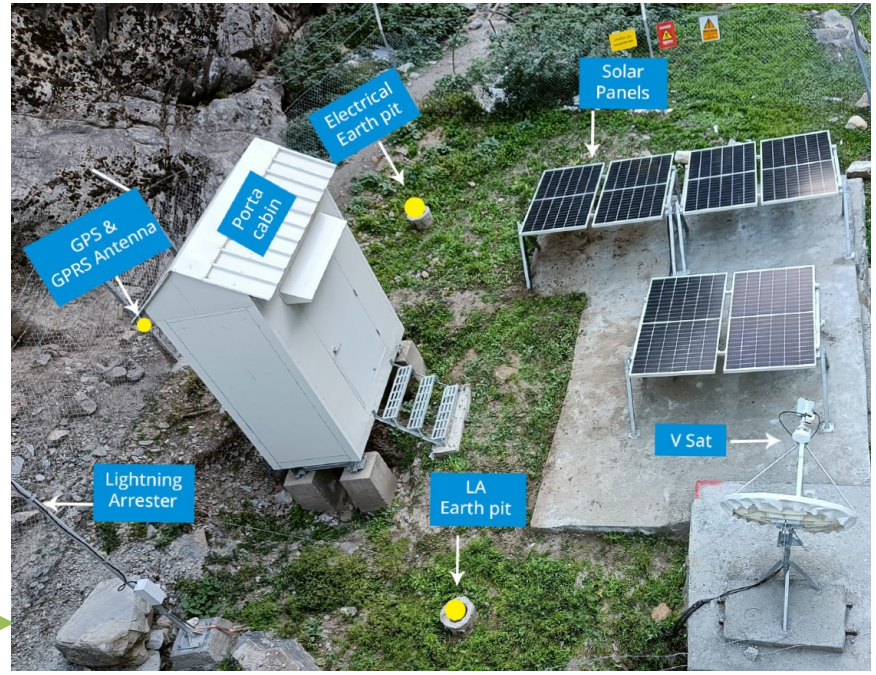


Automated Flood Warning System



Location of already installed 6 Sensor Stations for TVHEP

Level & Velocity Sensors



Communication and Power Back-up system at Sensor location

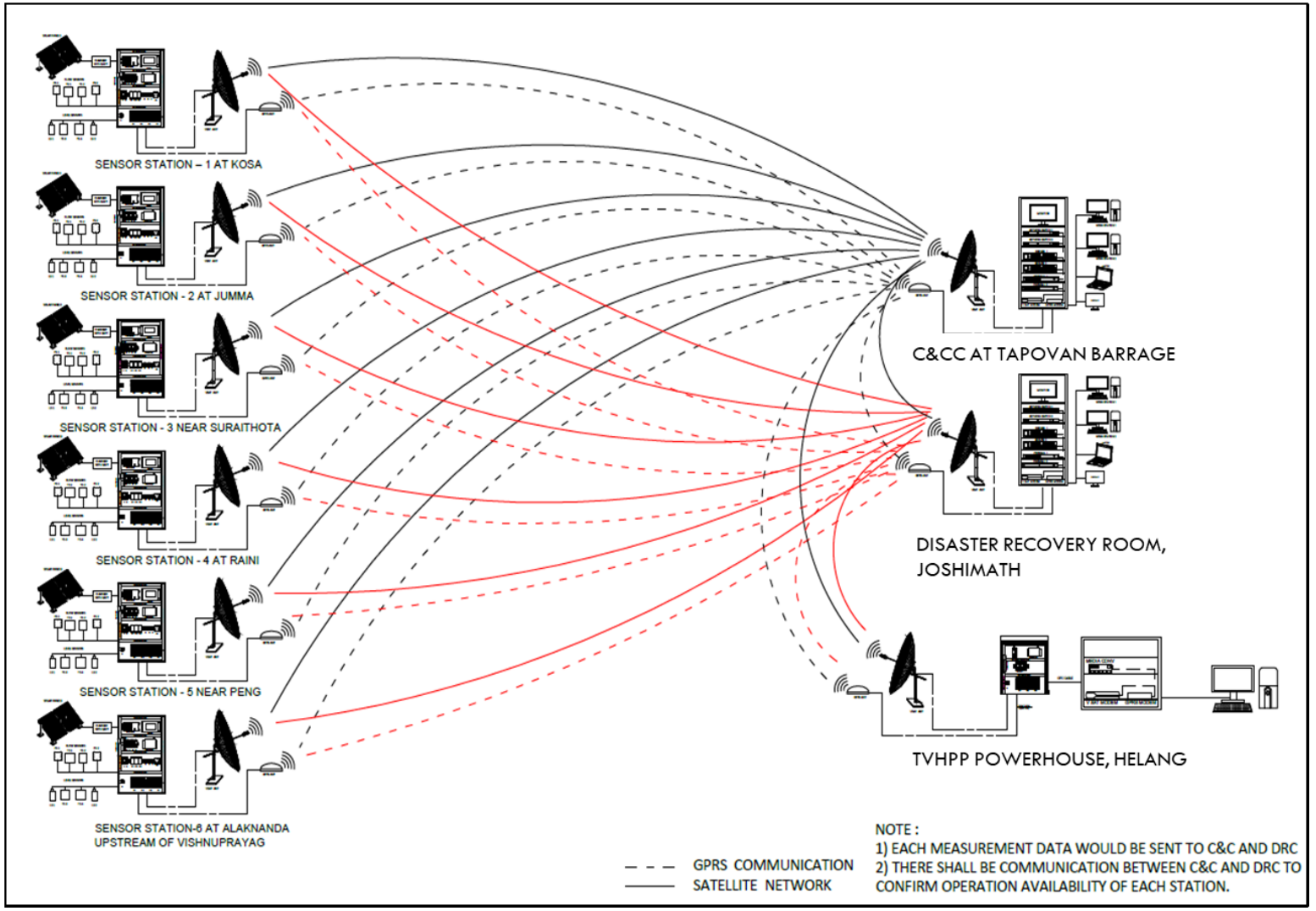
System Architecture

Installations

- 6 Sensor Stations
- Command & Control Centre (Barrage)
- Disaster Recovery Centre
  - Joshimath (Office)
- Monitoring Station (Power House)

Connectivity

- VSAT
  - Extended C-Band 256 kbps (128 kbps Up & Down link) – Longer wavelength
- Cellular (Dual SIM)



Command & Control Centre/ Disaster Recovery

Parallel and Independent

Receive, Store, Display & Process Sensor Data

IT Infrastructure

- Application & DMZ Servers
- Workstations & Display
- ⑩ Historical Storage Device
- IT Security Equipment

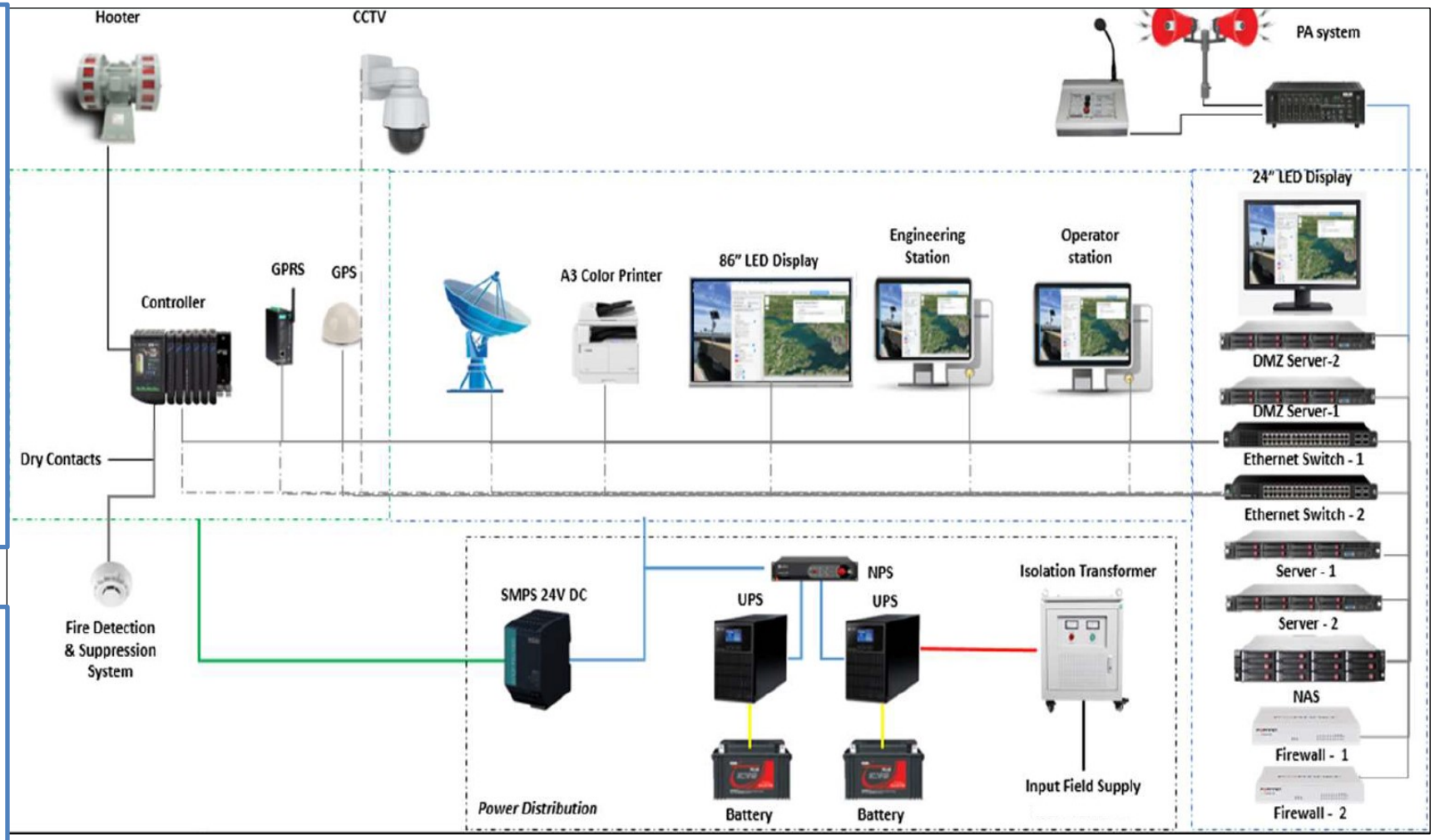
Command & Control Centre/ Disaster Recovery

Alarm Dissemination

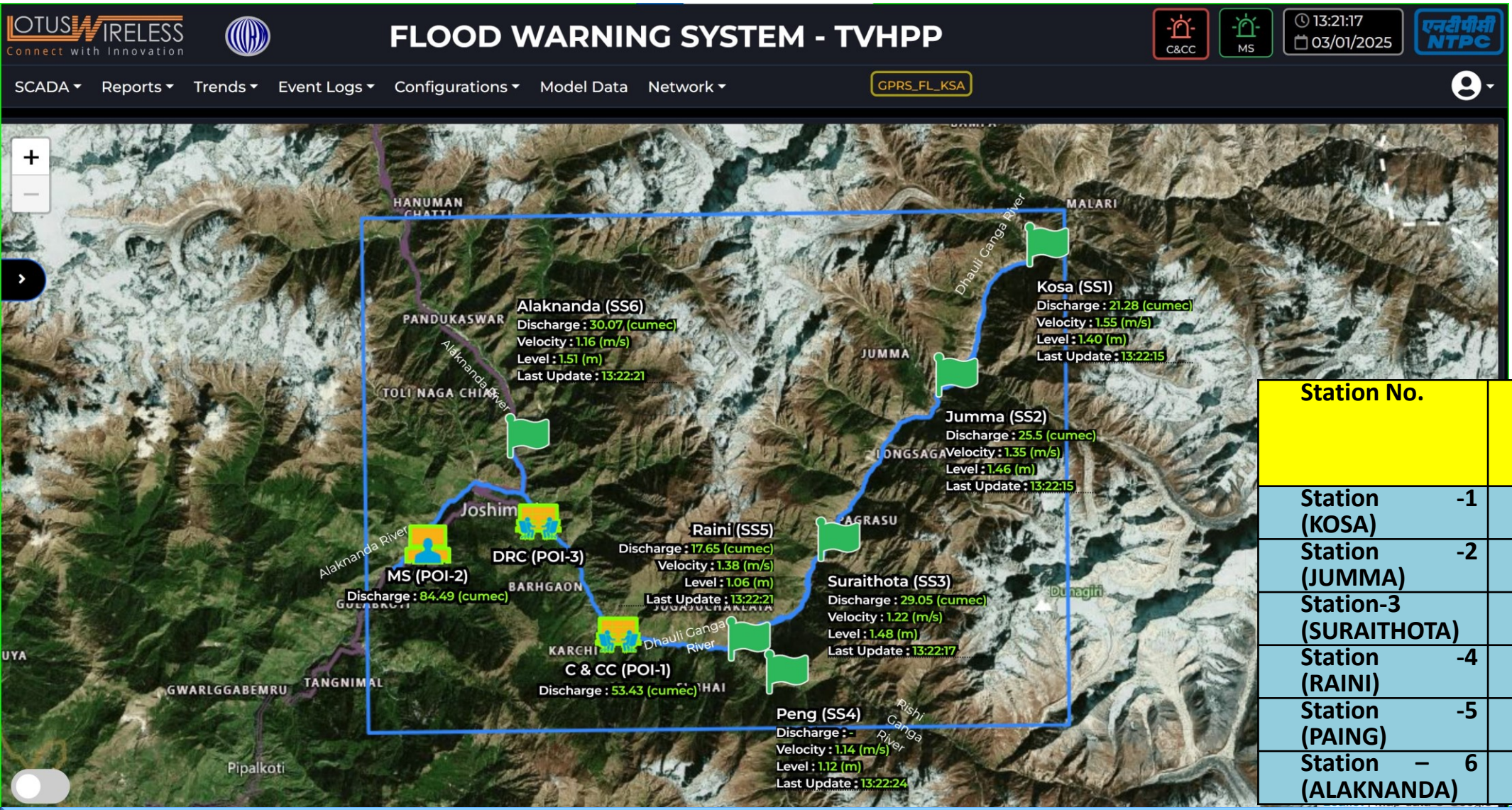
- Motorized Siren
- Public Address System
- Automated Messages & emails
- Automated Pre-recorded message on mobile – Repeated ring till pickup of cell

Utilities

- Power Supply with UPS
- Fire Protection
- CCTV



AUTOMATED FLOOD WARNING SYSTEM DISPLAY

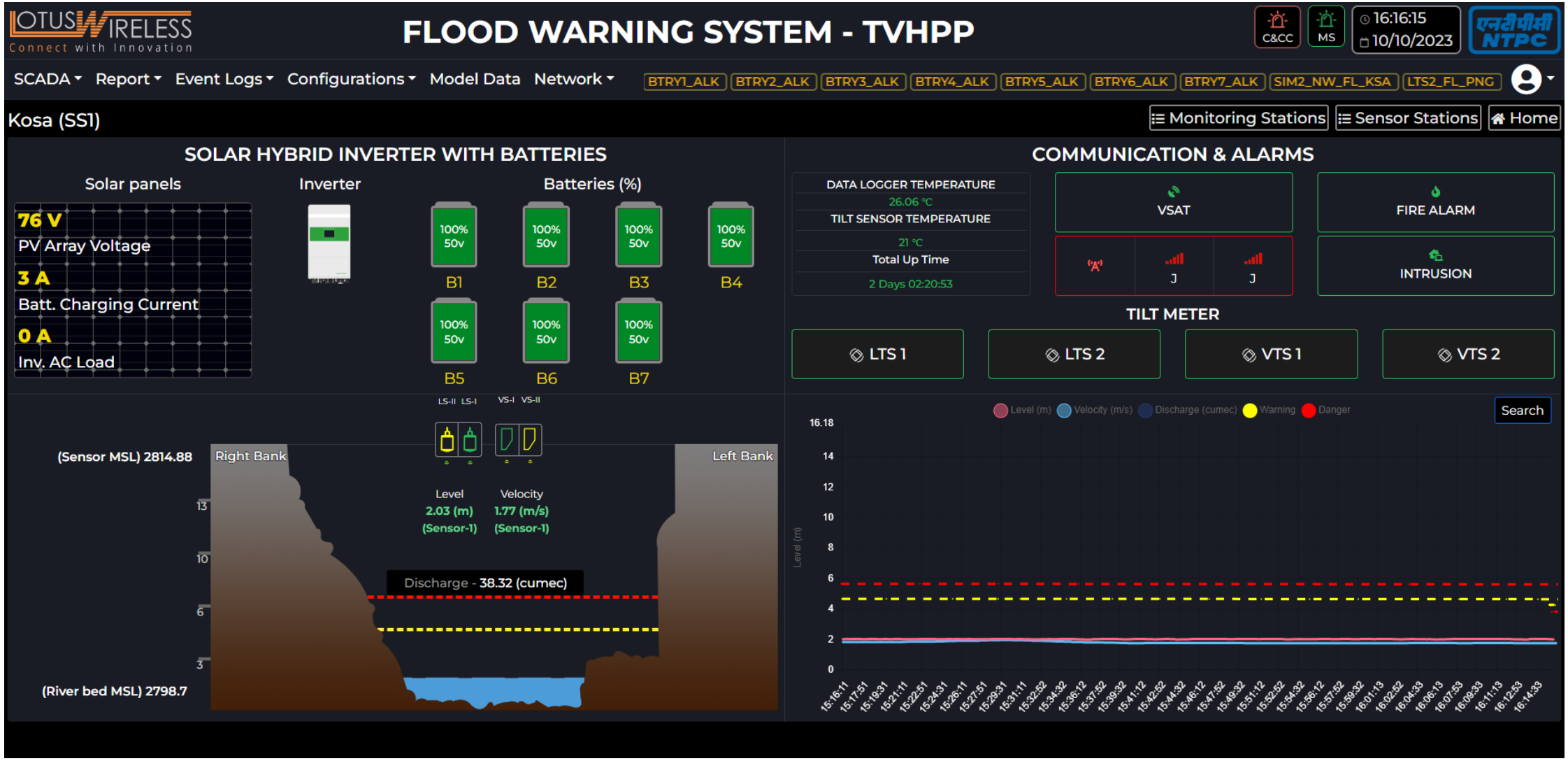


Normal - Green
Alert – Amber
Warnings – Red
Set for:

a) High water level
b) High velocity
c) Rate of rise
d) Extreme low levels

Station No.	Distance from Barrage (km)	Approx. Lead time (in Min.)
Station -1 (KOSA)	40	60
Station -2 (JUMMA)	28	42
Station-3 (SURAITHOTA)	15	25
Station -4 (RAINI)	7	11
Station -5 (PAING)	10	15
Station – 6 (ALAKNANDA)	10 from PH	16

Automated Flood Warning System Display



Comprehensive Early Warning System

Under Development

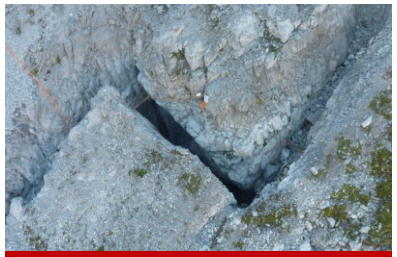
Comprehensive Early Warning System

Analytical Solutions Required

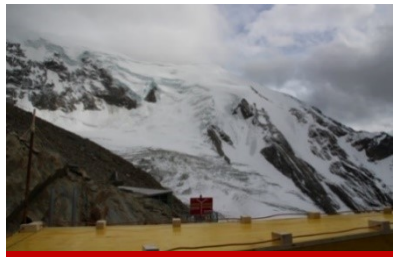
Challenge – How to achieve lead time of 60 minutes

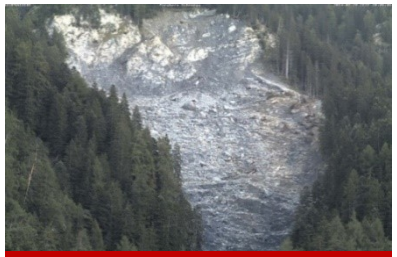
- Geotechnical Sensor based Monitoring
- Subsidence Monitoring & Analysis
- Creation of Micro-catchment areas & Flow Modelling
- Avalanche, Slope & Landslide Monitoring
- Flood Forecasting & Nowcasting
- Monitoring Glacial Lakes and Streams
- Aerial and Satelite Image analytics
- Geo Spatial Modelling & Computer Vision
- Continuous Weather Monitoring

Holistic Monitoring required for Vulnerable Hydro Projects

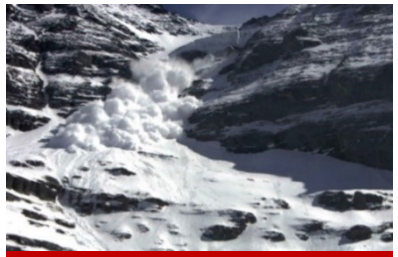

Rockfall


Floods


Glaciers


Landslides


Glacier Lakes


Avalanches

Debris/Mud Flows


Cloudburst

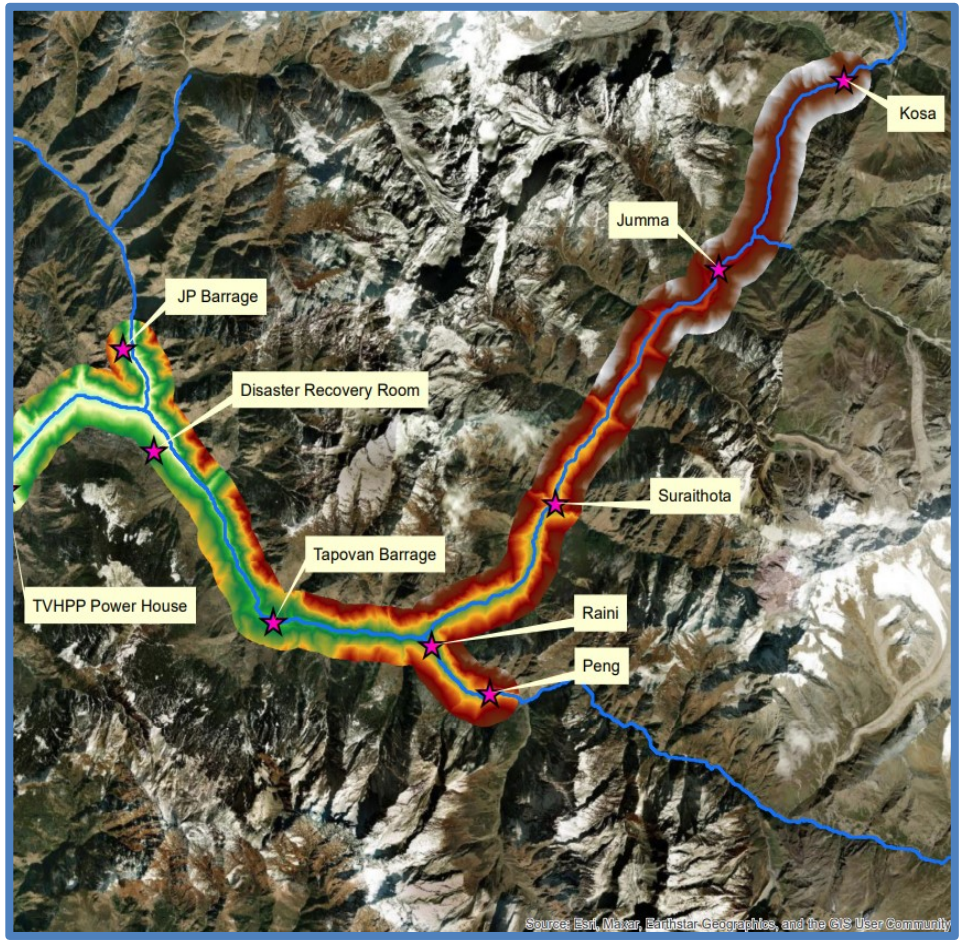

People

Comprehensive Early Warning System – Under Development

GLOF	FLOODS	GEO-HAZARDS
• Technical Collaboration and Capacity Building on Landslide and GLOF hazard assessment	• Development of Flood Forecasting System & Its Integration with Existing Flood Warning System	• Seismic Monitoring of the Catchment area for Early Warning of Geo-Hazard Incidents

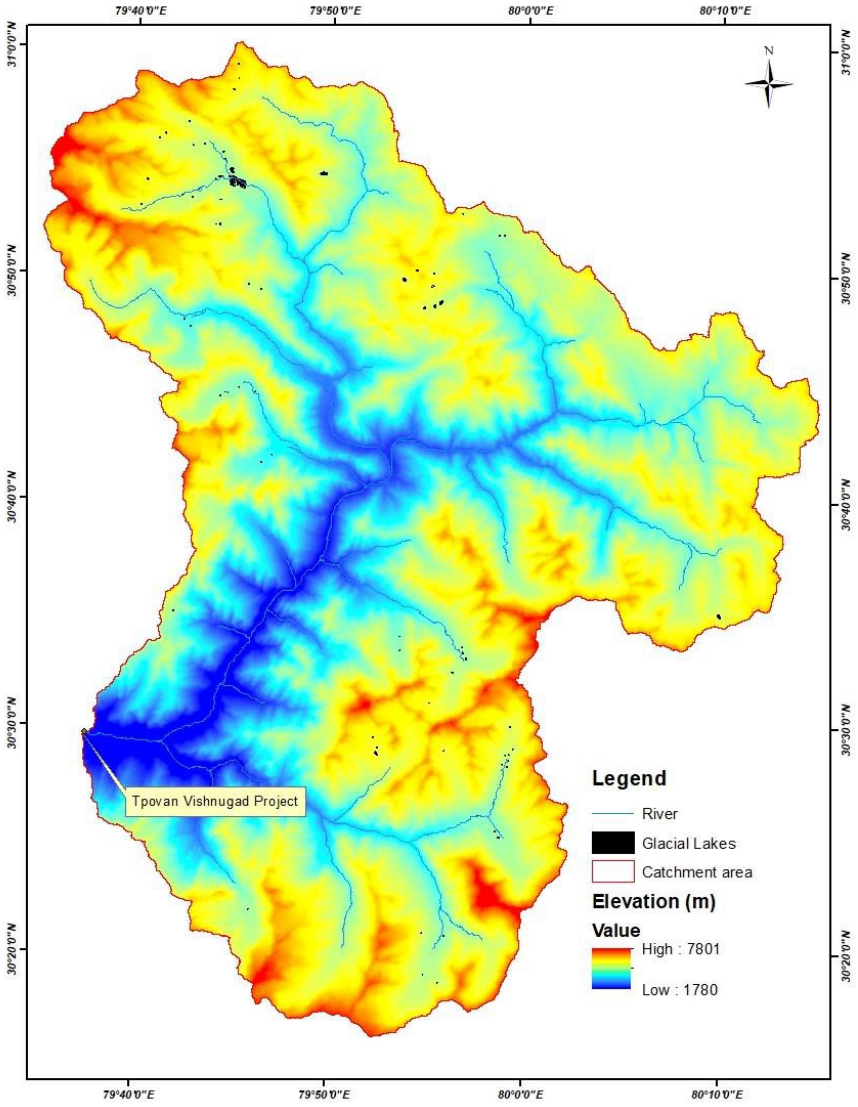
Avalanche monitoring is also being done by DGRE and Regular operational **avalanche** warning is issued by **DGRE** to the Army and civilian population in the snow bound regions of north-west **Himalayas**.

Hazard mapping of Catchment Area



- Topographical map showing drainage/river/road networks, permanent and temporary structures.
- Digital Elevation Model
- Land Use Land Cover (LULC) Maps
- Mapping of glacial lakes and landslide lakes.
- Snow cover distribution with variation in snow line.
- Landslide hazard zonation maps

Catchment Area & Glacial Lakes



GLOF study using high resolution satellite imagery include:

- Mapping of all the glacial lakes in the catchment area;
- Dam Break Analysis for the selected vulnerable lake.

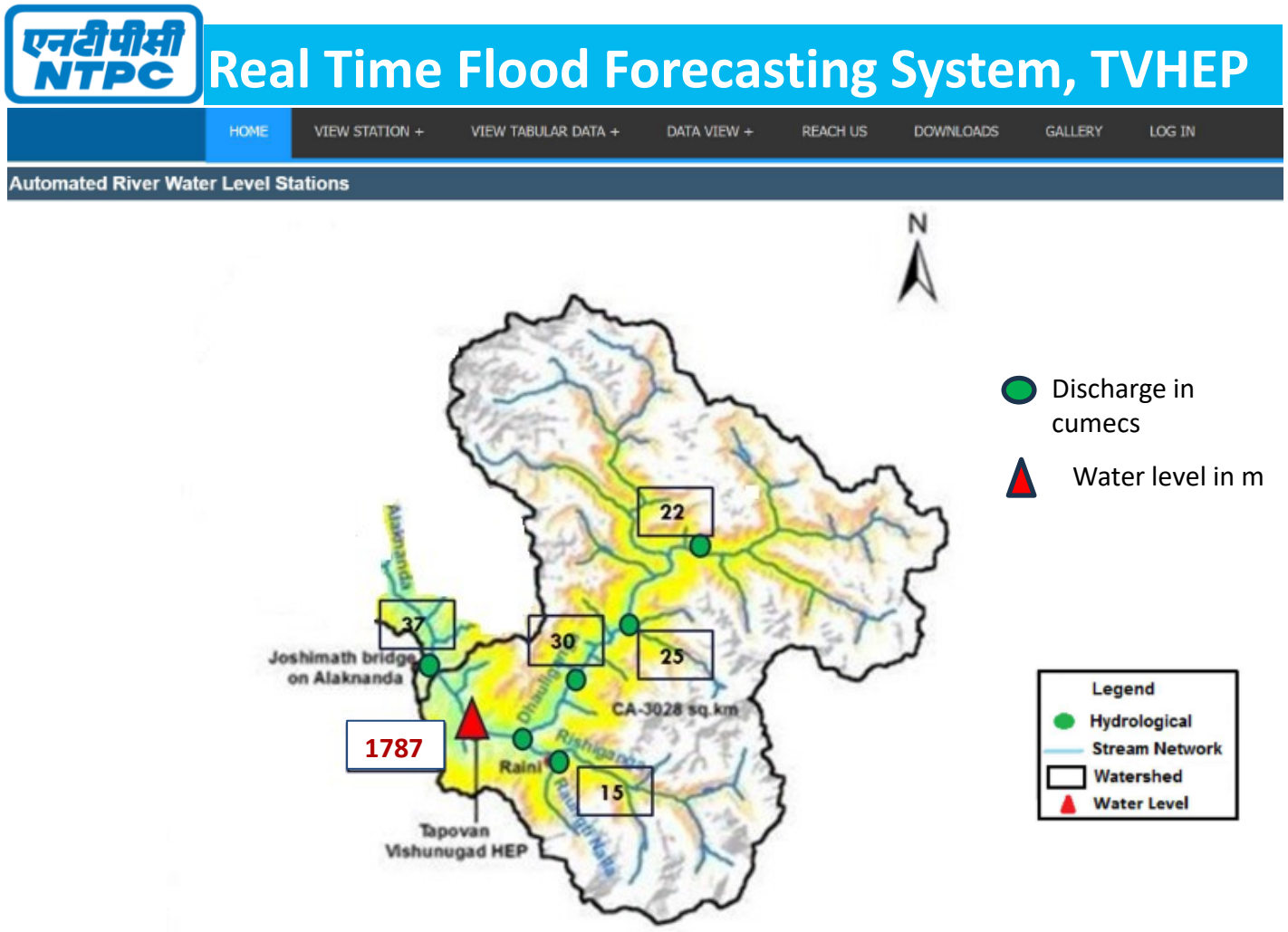
Vulnerable lake shall be further monitored using satellite imagery at a decided frequency.

Flood Forecasting System

- Network design of hydro-meteorological stations – Automatic Weather Stations
- Deterministic models based on unit hydrograph theory with channel routing and snowmelt runoff components for sub-catchments
- HEC- HMS/ HEC-RAS/MIKE and SWAT(Soil and Water Assessment Tool) models shall also be used for forecasting.
- This work is under development with IIT Roorkee.

The system shall be Integrated with the existing Flood warning system.

Real Time Flood Forecasting System

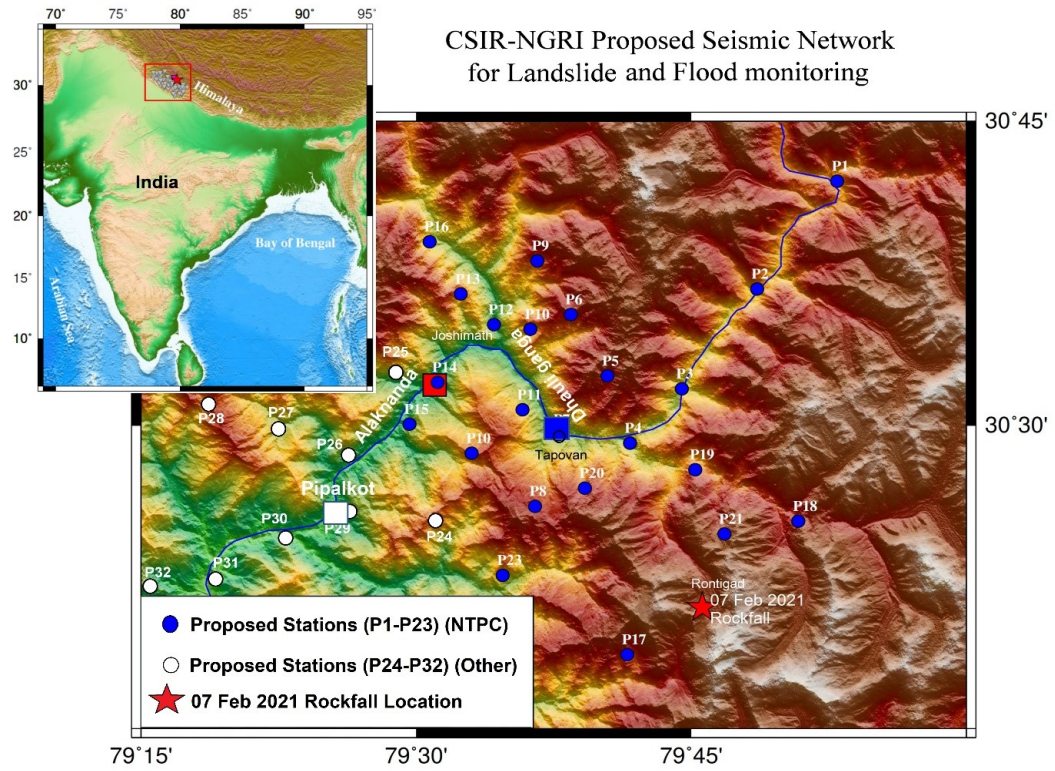


AWS (10 nos) data and IMD Forecasted data will be used to develop the Flood Forecasting model.

The Model shall be validated with the already installed sensor station data (level & discharge).

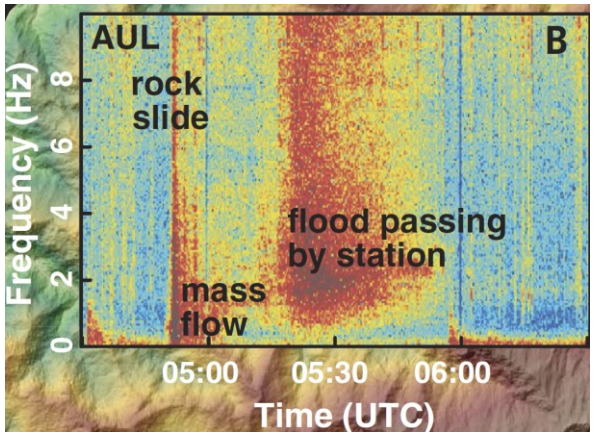
Based upon this, Forecast (Water level & Discharge) at Tapovan Barrage location shall be provided by this model.

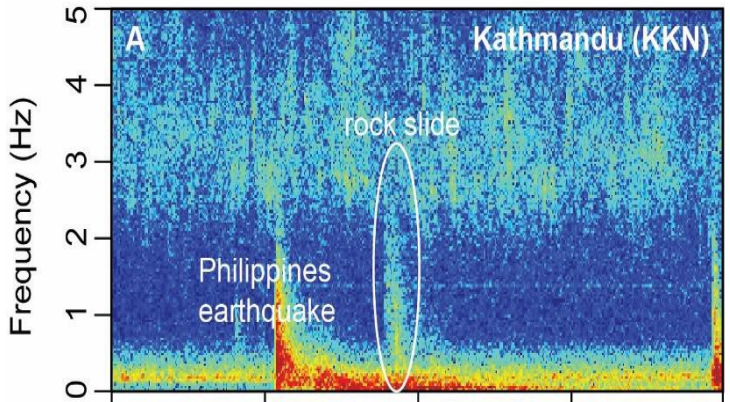
Seismic Monitoring of the Catchment for Early Warning of Geo-Hazard Incidents



- Establishing a dense seismic network (32 stations) surrounding the power plants
- VSAT connectivity for real-time data transmission.
- Collecting the seismic waveform data of **rock fall, landslides, glacial lake outbursts, and debris flow** to develop an automated event classification algorithm
- Testing and finalizing the data, analysis and classification using AI/ML algorithms in real-time.
- Time of completion of pilot project is about 3 years.

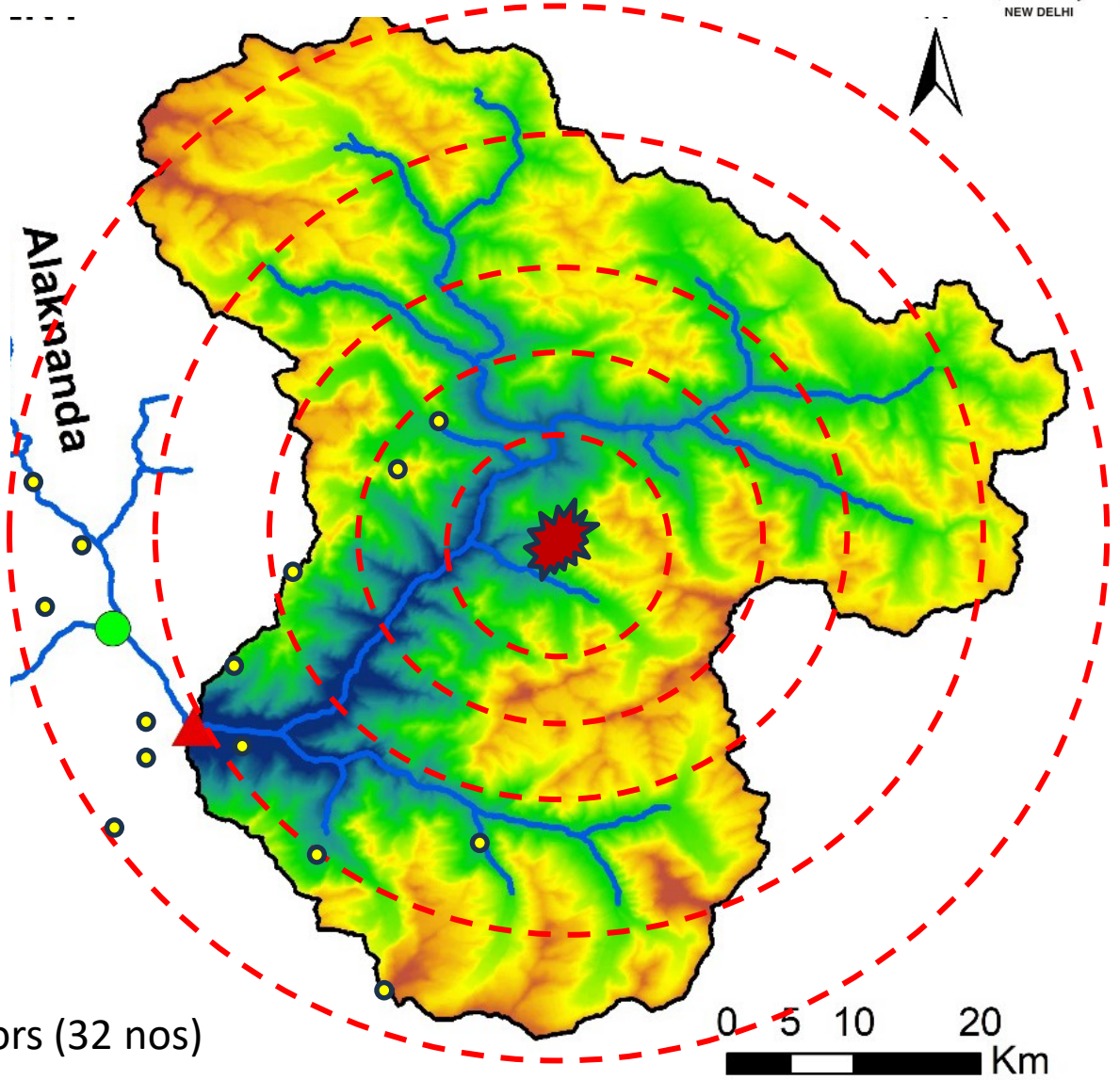
Seismic Monitoring for Early Warning





Cook et al. (2021)

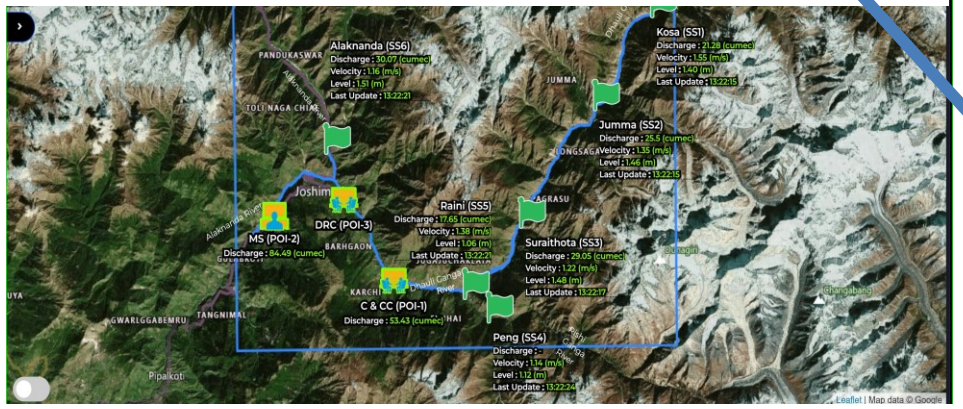
- A separate screen would be visible on the main EWS screen under a separate Tab.
- **Alarm will be generated based on the real-time monitoring.**
- Visible on the screen would be:
  - Catchment Area and Sensor Stations
  - Place and distance of Incident inside the catchment;
  - Time of Incident;
  - Type of Incident.



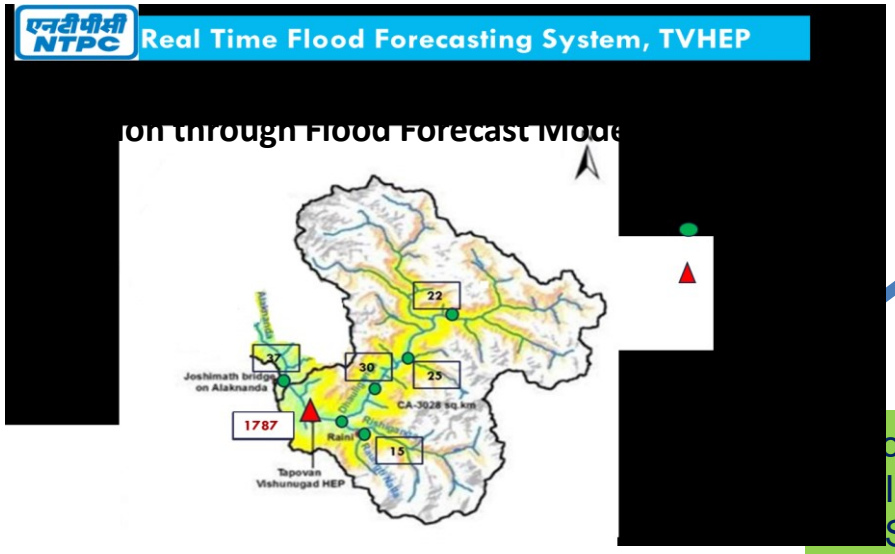
Integrated Comprehensive Early Warning System

Existing Flood warning

Warning generated wrt Water Level and Discharge transmitted from sensors at 6 locations



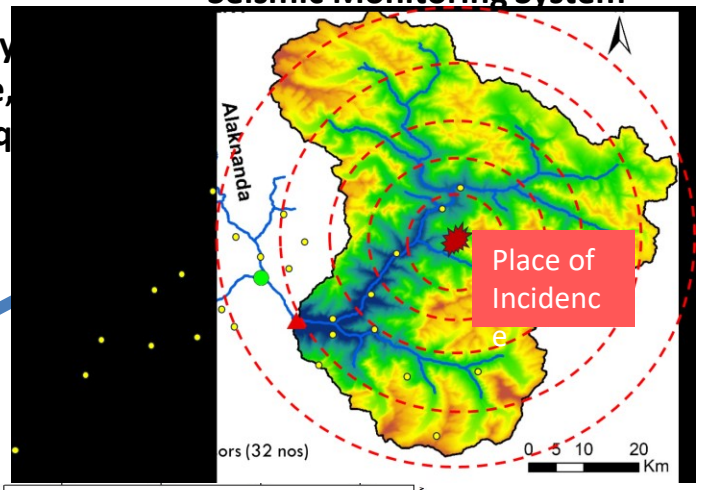
Real Time Flood Forecasting System, TVHEP

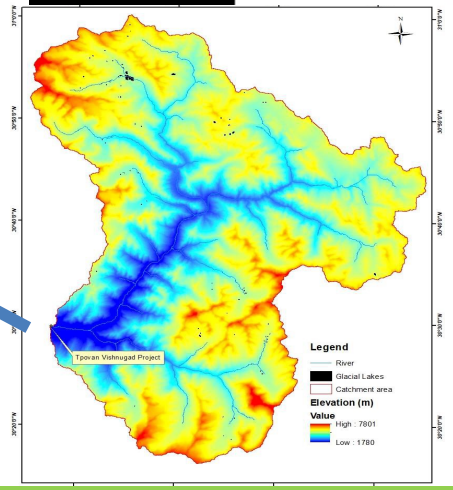


Central Control & Command System

Seismic Monitoring System

Place, time and ty hazard (Landslide, Debris flow, Earthq





Hazard Map for Glacial Lakes & Landslides

- omated Alarm would be generated;
- In case of any level and/or discharge rise in the river system through Automated Flood Warning System
- In case of any incident (Earthquake/landslide/ debris flow) through seismic monitoring system.

Benefits of Implementing CEWS

1. Hazard mapping and Monitoring of vulnerable locations/ lakes – This shall enable to provide us pre-alert by periodic monitoring of vulnerable locations/ lakes;

2. Flood Forecasting – This shall provide information of probable flood forecast for the next 10 days enabling preparedness at site accordingly;

3. Real-time information of any Geo-hazards in the catchment with seismic monitoring system – This shall provide real time alert about any incident occurred in the upstream, so that timely evacuation at site may be carried out;

As real time Information about any incident would be available, thereby increasing the lead time to react at site.


Thank You