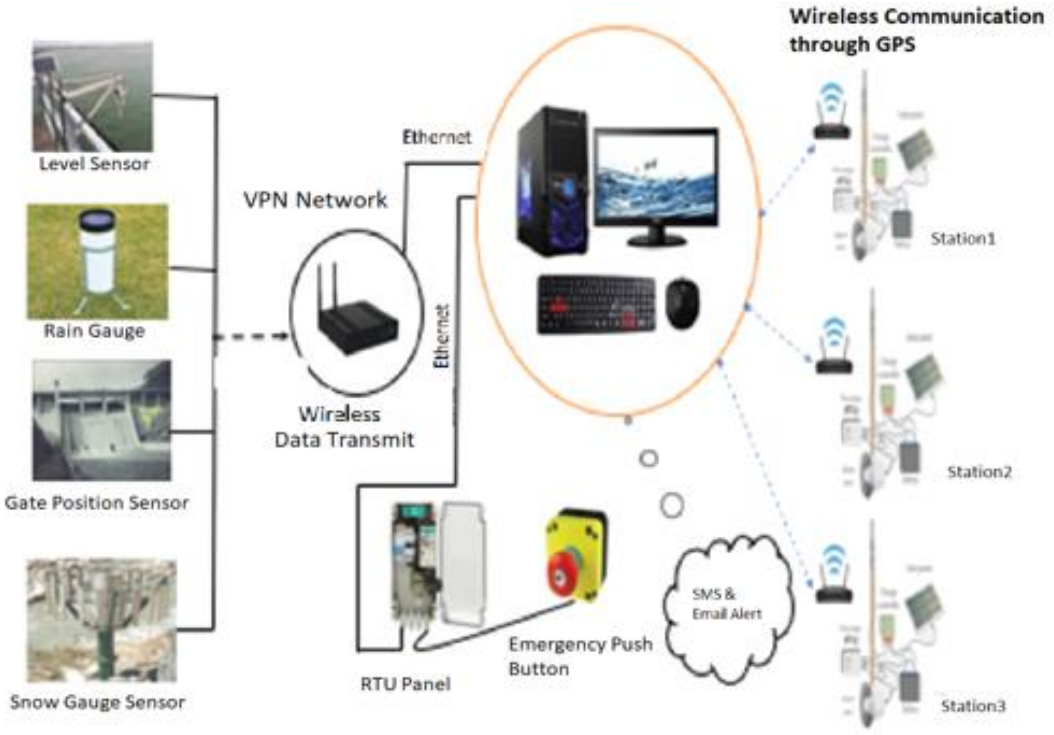
Standard Operating Procedure
for
Early Warning System
in Hydro Projects



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Central Electricity Authority

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STANDARD OPERATING PROCEDURE FOR EARLY WARNING SYSTEM IN HYDRO PROJECTS

1. BACKGROUND

Hydro projects, situated in upper reaches of Hilly regions are normally more vulnerable to occurrence of Cloud Burst, Flash Flood, GLOF, LLOF, Avalanche, Landslide, Snow Slide/ Rock Slide etc. Therefore, there is a need to establish an Early Warning System (EWS) for Hydro Projects in these Hilly Regions so that loss of human & animal lives and property, infrastructures, loss of biodiversity etc. could be minimized in case of occurrence of this kind of disaster.

Risk knowledge of hazards, data collection, processing, communication and relief operations are important elements of an Early Warning System (EWS). Such systems can be realized through modern technological advancements in majority of disaster monitoring applications, so that affected people may be warned in advance and precious lives could be saved.

A thorough risk identification and hazard classification of each dam needs to be identified/explored by Project Authority. The risks should include GLOF/LLOF, Cloud burst, Avalanche, PMF, Dam Break / failure etc. and the EWS should be capable to catering to the lead time for each risk identified for the Dam. Based on the type of risks and degree of hazard, the EWS shall be designed. The EWS design shall also keep into view other factors like type of dam, its storage, rule curve, spillway capacity and river channel capacity downstream of the dam, Dam Break Analysis (DBA) and inundation maps, population downstream, type of terrain, reliability of the network, distance from glacial lakes identified under risk identification and hazard classification, as applicable for the dam etc.

NEED OF SOP

Standard Operating Procedure (SOP) aims to provide broad guidelines for implementation of Early Warning System for Hydro Projects in case of occurrence of Cloud Burst, Flash Flood, GLOF, LLOF, Avalanche, Landslide, Snow Slide/ Rock Slide etc.

All Projects/ Power stations should have their own EWS. Till such EWS are established, Projects/ Power stations located in cascade may coordinate for information with the upstream Projects/ Power stations. The Project Authorities should have their own SOPs for Flood Warning Procedures prior to flood releases for effective disaster management.

Control Room should have proper coordination with downstream projects while releasing water from the dam both planned like during peaking operation, reservoir flushing operation, etc. as well as unplanned release of water ensuring blowing of Sirens/Hooters/announcements and operation of Beacon lights to give prior warning to the people before release of water from the dam. The upstream under construction projects will also share information in case any warning is generated by their flood warning system or if any event of concern is noticed by them with the downstream operational and under construction projects. Proper co-ordination with the upstream projects as well is required for timely forecast of the vulnerable situations at the site.

2. Hazard/ Risk Mapping and Vulnerability Analysis in Hydro Electric Project Catchment Area

The scope of work will include identification, inventory generation and mapping/monitoring the following geo-hazards of mountainous regions:

1. **Identification/ Inventory management in GIS environment**

- Digital database generation of the study area including Digital Elevation Model (DEM).

- Delineation of catchment area
- Generation of drainage, streams, river network etc.
- Road / routes, locations, permanent & temporary structures etc.
- Land Use Land Cover (LULC) map of study area
- Permanent Ice/ Glacier Boundary
- Glacier Lakes and their classification based on type and size
- Geological and geomorphological maps of study area
- Snow Cover Distributions (Max and Min.) and Snowline variations

2. **Mapping of following Geo-hazards**

a) **Avalanches**: Identify avalanche-prone slopes and assess the potential impact on infrastructure and communities. Mapping of avalanche prone areas as follows:

• Identification and demarcation of probable avalanche sites
• Identification and demarcation of potential release areas (PRA) for avalanches
• Estimation of fracture depth of snow for avalanche release
• Generation of avalanche occurrence scenarios
• Conducting avalanche flow simulation using high resolution Digital Elevation Model (DEM) data for different scenarios
• Estimation of avalanche velocity, run out distance, debris depth and impact pressure using avalanche flow simulation model based on varying PRA
• Mapping of avalanche hazard areas with respect to road/route and settlements and risk assessment.
• Generation of avalanche hazard maps over high resolution satellite images

b) **Landslides [Rockfall]**: Identify areas prone to slope instability and mass movements, including debris flows, rockfall and soil erosion along the major streams.

• Creation of landslide inventory map of the area
• Preparation of landslide susceptibility map
• Locate potential landslide/rockfall areas and assess the susceptibility of different slopes to landslide/rockfall events.
• Assessment of lead time and discharge in case LLOF forms near the potential sites and risk assessment.

c) **Glacial lake outburst floods (GLOF) Hazards**: Assess the risks associated with GLOFs.

• The mapping of permanent ice, glacier boundaries and glacier lakes are to be carried out by manual delineation on high resolution (HR) images.
• Inventory of Glacial lakes with an area of more than 1 hectare (0.01 sq. km) and their classification (such as supra glacier, moraine dammed etc.)
• Identification of potential GLOF susceptible lakes
• Six-month monitoring (**April - September**) of potential lakes on monthly basis using satellite data.
• GLOF simulation for selected hazardous lakes using hydrodynamic modelling and risk assessment.

Methods:

(i) **Identification and mapping/monitoring using Remote Sensing and GIS:**

• Inputs required are high resolution Digital Elevation Model (DEM) of resolution 5 m or better, high resolution satellite images of 0.5 m resolution or better.
• To assess the susceptibility mapping for different mountain geo-hazards in the study area, terrain parameters (elevation, slope, aspect, curvature etc.) and surface characteristics (snow

covered, glaciated, forested, barren, rocky etc.) are required and the same can be generated using high-resolution (HR) DEM and HR/Medium resolution satellite data.

• Demarcation of catchment/basin is required to estimate the amount of water accumulated due to the precipitation (Rain/Snow) and to understand the water discharge. The hydrological tools available in ArcGIS (web application) and QGIS (Quantum Geographic Information System-web application) etc. can be used for catchment/basin delineation using HR DEM along with HR satellite images.

• Drainage, stream, river network etc. are important to identify the water flow path and to understand the flow pattern in the catchment/basin and can be generated using the HR DEM.

• Mapping of Land Use Land Cover (LULC), Road/route, location, permanent and temporary structures etc. using HR satellite images and ancillary data.

• The temporal monitoring of Snow cover area (SCA) for minimum past 10 years is to be carried out using medium resolution optical satellite data of Indian Advanced Wide Field Sensor (AWiFS) and foreign (Sentinel 2, Landsat etc.) origin, to estimate the maximum and minimum snow cover and also to observe the variations in snow line. Estimation of seasonal snow line based on snow cover maps to understand the permanent snow-covered areas.

• Integration of different raster & vector data in Geographic Information System (GIS) platform for hazard maps generation and visualization.

(ii) **Field Investigations:**

• Conduct ground truthing/field validation to verify and supplement remote sensing data.

• Identify specific hazardous areas, such as unstable slopes, active landslide sites, or potential avalanche release zones.

• Collect additional data on ground conditions, such as soil properties, geological structures, and hydrological features.

(iii) **Hazard and vulnerability assessment:**

• Integrate spatial hazard/susceptibility maps and vulnerability assessment themes to develop multi-hazard risk maps.

• Analytical Hierarchy Process (AHP) based model or machine-learning techniques, such as Logistic regression, support vector machine, random forest based modelling approach may be used to generate these hazard/susceptibility maps.

• These maps will visualize the spatial distribution of risks, highlighting areas that require immediate attention for implementation of EWS and mitigation measures.

Deliverables in GIS ready Format:

• Various thematic maps generated using Remote Sensing (RS) data

• Multi-hazard vulnerability maps

• Vulnerability assessment and Field investigations report including recommendations for risk mitigation measures and initial inputs for implementation of EWS.

3. IMPACT ON HYDRO PROJECT

Hydro Power Projects are constructed for harnessing electricity, located in hilly terrain and are associated with natural hazards such as landslides, floods, and earthquakes etc. which are to be considered in design of the structures. Being young mountains, hydro projects in Himalayan region are more susceptible to these hazards. Considering above aspects, mitigation measures are to be adopted during development of such projects. However, many unpredicted incidents in the nature may also cause disasters.

As in the case of Glacial Lake Outburst Flood (GLOF), the velocity may vary from **10 to 15 m/sec**. The lead time for the GLOF to reach the Dam body will be very less causing significant impact on project components because of the flood water carrying large amount of sediment/ debris.

The hydro project in a basin shall be set up at a safe distance from the glacier, so that information regarding Lake Burst etc. is received in advance. **The first dam in every basin shall be a Concrete Dam based on a solid rock formation and shall be constructed at least 15-20 kms away from the glacial lake mouth** so as to have sufficient lead time for responding to the situation and for evacuation of peoples and shifting of important infrastructures/ equipments/ machineries in downstream area.

The project developers in a particular basin shall share their contribution towards costs incurred in installation of the Early Warning System/ Sensors (flow/ level) throughout the basin. The cost shall be shared rationally by all projects in the basin.

CEA shall also carry out physical inspections on half yearly basis to review the status of implementation of EWS in existing and under construction Hydro Power Projects.

4. SATELLITE BASED IMAGE PROCESSING AND ANALYSIS

Early information can be gathered through acquisition of satellite imagery from concerned agencies such as ISRO, IMD (Indian Meteorological Department) etc. by the project developers and interpreting the satellite imagery shall inform about the increase in size of lake and other activities so that necessary action can be taken. This would provide a broad overview of weather patterns and potential flood areas and may be useful for monitoring large geographical regions in inaccessible locations. However, they do not provide real-time data in short span of time (minutes/hours) and require highly skilled professionals. Further, satellite imageries are limited by weather conditions & visibility and their initial investment & operational costs can be significant.

Project Developers shall explore the possibilities of collaborating with various agencies such as ISRO/IMD for obtaining satellite imagery on daily basis during critical period in single licence and shared to others on common platforms to optimise the cost.

5. STRUCTURE OF EARLY WARNING SYSTEM (EWS) AT HYDRO POWER STATION

Strategic locations (G&D sites) on the river stream/ tributaries in the upstream of the dam/ barrage site be identified where suitable equipment/ sensors with reliable communication systems could be established with **a lead time of at least one to two hours**. The site should preferably be located at a bridge and near a straight reach avoiding bends/ confluences/ turbulent locations. Redundancy of the sensors may be included to ensure fail safe transmission of data from the sensor locations with auto switching facility i.e. in case of failure of one sensor, the second sensor should automatically take over. Healthiness check of the instruments, batteries, communication system shall also be available in real-time.

Sensors along with CCTV/ video cameras shall be deployed at potentially dangerous glacial lakes for continuous monitoring of the movement/ shift in glaciers/water bodies. The sensors should be deployed for monitoring the precipitation of snow, the snow carrying capacity (i.e. the max size of formation after which snow slides), depth measurement of lake, severity of snow at mouth of lakes etc. For the validation of the sensor data, the results should be occasionally compared with the traditional data obtained through manual gauges and systems. It is thus essential to establish manual gauge / weather sites for correct assessment of significant events.

The upstream most project shall be made responsible to monitor glacial lakes and pass on the information to the downstream projects. The cost may be shared rationally by all the developer in a particular basin.

A technologically advanced Early Warning System (EWS), which can be practically implemented, consists of:

i) Sensor and Equipment for Early Warning System for flood forecasting in Hydro Power Projects to be deployed at U/S G&D sites and D/S of Dam /Barrage.
ii) Site selection for automatic water level recorder (AWLR) / gauge and discharge (G&D) site.
iii) Mounting of sensors.
iv) Instruments/Arrangements/Establishments required for Data Transmission from Sensors
v) Un-interrupted/ continuous Power Supply Arrangements for sensors and communication system.
vi) Central Command and Control Station.

5.1 SENSOR/ EQUIPMENT FOR EARLY WARNING SYSTEMS FOR FLOOD FORECASTING IN HYDRO POWER PROJECTS TO BE DEPLOYED AT UPSTREAM G&D SITES AND DOWNSTREAM OF DAM/ BARRAGE

These equipment can be deployed standalone or in a combination at G&D / Dam / Barrage sites for Flood forecasting and calculating Lead Time for floods at Dam / Barrage Site:

a) Automatic Water Level Recorder with CCTV (if feasible).
b) Automatic Velocity Sensor with CCTV (if feasible).
c) Automatic Weather Station with CCTV (if feasible).
d) Hooter/ Siren.
e) Drone Scanning.
f) Manual gauge/discharge/weather/rain gauge sites etc.
g) Dam instrumentation for immediate feedback which is crucial for monitoring dam behaviour and responding quickly to any changes in the dam.

a) Automatic Water Level Recorder (AWLR)

The water level sensor is an equipment which is used universally for observing water levels automatically:

Pros:

- **Wide Application Range:** The radar-based sensor can be used for various fluids and solids, making it versatile for different applications.
- **Not Affected by Environmental Factors:** The sensor is not influenced by temperature, dust, or steam, making it suitable for challenging environmental conditions.
- **Unaffected by Narrow Beam Angle:** The radar system is not affected by a narrow beam angle, ensuring accurate measurements even in situations where a focused beam is required.
- **Accurate and Reliable:** The sensor provides accurate and reliable level measurements, with a large signal-to-noise ratio, even in Applications with rapidly changing levels.
- **Low Power Consumption:** The sensor has low power consumption, making it energy-efficient and potentially suitable for remote or off-grid locations.

Cons:

- **Accuracy Affected by Solids:** The accuracy of the sensor can be affected by the presence of solids in the measured material.

- **Continuous Power Requirement:** The sensor requires continuous power, which can be a limitation in areas with unreliable power sources. Additionally, the need for power backup increases the overall power consumption.

b) Automatic Velocity Sensor

The velocity sensor is an equipment, which is used universally for observing velocity of objects or fluids automatically:

Pros

- **Non-contact Measurement:** Radar-based velocity sensors allow for non-contact measurements, reducing wear and tear compared to contact-based sensors.
- **Wide Range of Applications:** Can be used in various Applications to measure the velocity of objects or fluids, providing versatility.
- **Accuracy:** Radar sensors can offer high accuracy in velocity measurements.
- **Remote Sensing:** Radar sensors can be deployed at a distance from the target, making them suitable for remote sensing applications.

Cons:

- **Complexity:** Radar-based velocity sensors may be more complex than some other types of velocity sensors, leading to potential challenges in installation and maintenance.
- **Erroneous results due to voltage fluctuations:** These sensors have been mentioned to give wrong results in case of voltage fluctuations. So, the results should be occasionally compared with traditional velocity data obtained through manual gauges.
- Expensive to maintain and install.
- May not give very accurate results during turbulent flows and when the river changes its course.
- Efficiency not yet proven in Himalayan Rivers owing to sediment laden water.

The General Technical Specification of sensors (a) Surface Velocity Sensor, (b) Water Level Sensors are given at **Appendix-1A & 1B**.

Acoustic Doppler Current Profiler (ADCP)

It is a type of velocity sensor, used to measure how fast water is moving i.e. velocity across an entire water column. An ADCP anchored to the bed can measure current speed not just at the bottom, but also at equal intervals all the way up to the surface. The instrument can also be mounted horizontally on bridge pilings in rivers and canals to measure the current profile from shore to shore. In very deep areas, they can be lowered on a cable from the surface.
Getting Automatic warning may be explored. This system can be used for calibrating gauge and discharge computed by AWLR and Velocity sensor.

Pros:

- In the past, measuring the current depth profile required the use of long strings of current meters. This is no longer needed.
- Measures small scale currents.
- ADCPs measure the absolute speed of the water, not just how fast one water mass is moving in relation to another.
- Measures a water column up to 1000m long.

Cons:

- High frequency pings yield more precise data, but low frequency pings travel farther in the water. So scientists must make a compromise between the distance that the profiler can measure and the precision of the measurements.
- ADCPs set to "ping" rapidly also run out of batteries rapidly.
- If the water is very clear, the pings may not hit enough particles to produce reliable data.
- Bubbles in turbulent water can cause the instrument to miscalculate the current.

- Users must take precautions to keep *'algae'* from growing on the transducers.
- May not give very accurate results during turbulent flows and when the river changes its course. In turbulent waters it may not possible to deploy the equipment.

c) Automatic Weather Station (AWS)

This equipment is used for automatically observing weather related data such as rainfall, evaporation, wind speed, wind direction, relative humidity, temperature etc.:

Pros:

- **Comprehensive Data Collection:** Weather stations can collect a wide range of meteorological data, including temperature, humidity, wind speed, rainfall, and atmospheric pressure.
- **Real-time Monitoring:** Weather stations can provide real-time data, enabling timely response to changing weather conditions.
- **Distributed Deployment:** Multiple weather stations can be deployed across a region, providing a comprehensive view of local weather variations.
- **Integration with Other Sensors:** Data from weather stations can be integrated with other environmental sensors to enhance the overall situational awareness.
- **Remote Sensing:** Weather stations can be installed in remote or hard-to-reach areas, improving coverage for monitoring and forecasting.

Cons:

- **Cost:** Weather stations can be expensive to install, maintain, and operate, especially when considering a network of stations across a large area.
- **Maintenance Requirements:** Regular maintenance is necessary to ensure the accuracy and reliability of the data collected.
- **Dependency on Power:** Weather stations typically require a continuous power supply, which can be a challenge in remote locations or during power outages.

Specifications of AWS sensors are given at **Appendix-2.**

d) Hooter and Siren Systems

The scope of the work of installation of Hooter and Alarm consists of designing, engineering, manufacturing, supply, installation & commissioning of Alert, Inform and Direct System (AI&D System) for before the release of water from dam of a Power House, during heavy rainfall or military operations through Phone, E-mail, SMS and Siren systems.

- This project is Alert, Inform and Direct (AI&D) equipped with Pre Alarm System which helps to alert and guide the people living nearby river banks when the water is planned to release from the Dam.
- This project consists of an AI & D system, Motorized Sirens, Strobe Light/Siren, GSM, Level Sensor, RTU, SCADA, Alarm Annunciator, Loud Speaker, Mobile, community based bulk SMS, Mobile vehicle and Amplifier to complete the project.
- An Early Warning System (EWS) can be defined as a set of capacities needed to generate and disseminate timely and meaningful warning information of the possible extreme or disasters (e.g. floods, dam failure, fire, earthquakes and tsunamis) that threatens people's lives.
- The very purpose of this information is to enable individuals, communities and organizations which are threatened, to prepare and act appropriately in due sufficient time to reduce the possibility of harm, loss and risk.

The General Technical Specification of Siren is given at **Appendix-3.**

e) Drone Scanning for potential Regions and Damage assessment after disaster

Pros:

- **Rapid Response:** Drones enable quick deployment and can provide immediate aerial imagery, facilitating rapid assessment of the extent of damage after an event such as an earthquake, flood, or landslide.
- **High-Resolution Imaging:** Drones equipped with high-resolution cameras can capture detailed images of the affected areas, allowing for a thorough analysis of the damage.
- **Integration with GIS:** The images are integrated into Geographic Information System (GIS) platforms for mapping and analysis, providing a spatial understanding of the impact.
- **Flexibility in Deployment:** Drones can be deployed in various terrains and environments, including remote or hard-to-reach areas, providing a comprehensive view of the affected region.
- **Cost-Effective:** Compared to traditional aerial surveys or satellite imagery, drones can be more cost-effective solution for obtaining high-quality images for damage assessment.
- **Real-time Monitoring:** Drones can transmit real-time images, enabling continuous monitoring of the situation and helping emergency responders make informed decisions.
- **Communication to Stakeholders:** Visualizations and assessments derived from drone imagery are communicated to relevant stakeholders, including CEA, rescue teams, and the public, aiding in transparency and coordination.

Cons:

- **Limited Flight Time:** Drones typically have limited battery life, restricting their flight time. This limitation can impact the coverage area and the duration of real-time monitoring.
- **Weather Dependency:** Adverse weather conditions, such as strong winds or heavy rain, can affect the drone's ability to fly and capture images.
- **Regulatory Constraints:** Drones are subject to aviation regulations, and obtaining necessary permits for deployment may be required. Regulatory constraints can vary by location and may impact the timely use of drones in emergency situations.
- **Continuous Power Requirement:** The sensor requires continuous power, which can be a limitation in areas with unreliable power sources. Additionally, the need for power backup increases the overall power consumption.
- **Skill Requirements:** Effective drone operation and image analysis require skilled operators and analysts, which may not always be readily available in emergency response situations.

5.2 SITE SELECTION FOR AUTOMATIC WATER LEVEL RECORDER (AWLR) / GAUGE AND DISCHARGE (G&D) SITE

For implementation of the Early warning System (EWS), location of the G&D site with Automatic Water Level Recorder (AWLR) and Telemetric communication at upstream location of dam are selected based on the catchment and river characteristics. Assuming flow velocity of 3-7 m/s (10-25 kmph) during floods as per site specific conditions, it is desirable that the AWLR/ G&D site be established at least at sufficiently upstream of concerned dam locations to provide at least 1 to 2 hour lead time to react, issue warning and for proper coordination among authorities. If a site is established for measuring Glacial Lake Outburst Flood (GLOF) then velocity of the range of 10-15 m/s need to be considered for deciding location of site for early warning.

If any major tributary is joining upstream of dam, a G&D site with AWLR and Telemetric communication shall also be established on it.

Measurement Range, Stability, Sensitivity, Scale Readability, Accessibility, flow conditions, network availability, Flood Protection etc. are criteria for the site selection for the establishment of a gauging station.

5.3 MOUNTING OF SENSORS

a) Location for installation of the sensors shall preferably be on a bridge at the centre of the river.
b) Sensors shall be installed on steel structure mounted on bridge, if required, with height as deemed to be suitable by the OEM/ Vendor considering highest flood level at that location.
c) If there is no bridge available for installation of the sensor, arrangement of GI cantilever beam shall be made at a suitable location at the river bank at a safe height. The GI cantilever beam shall be supported with Iron rope running from the top of the vertical pole to the far end of the cantilever beam to provide enough strength. This arrangement shall be within the scope of Vendor. Provision for extension shall be kept in the cantilever beam to take care of lean season/change in course of the river. Sensors should be mounted in such a robust way that in case of any disaster, the instrument does not get displaced or washed away.
d) Supply and transportation of GI pipes and other mounting arrangements till the project store shall be ensured.
e) Transportation of the mounting arrangements from the store to the G&D site shall be ensured Further, civil works including masonry, clearing of site etc. pertaining to installation of the poles and towers shall also be ensured.
f) Sensors should be properly protected from theft and vandalism.

5.4 INSTRUMENTS/ARRANGEMENTS/ESTABLISHMENTS REQUIRED FOR DATA TRANSMISSION FROM SENSORS

Effective data transmission in Early Warning System (EWS) for floods is important for several reasons:

- It enables the collection of real-time hydro-meteorological data from various sources, such as rain gauges, stream gauges, satellites, radars, and weather models.
- It facilitates the generation and dissemination of flood forecasts and warnings to the communities at risk, and the coordination of response and evacuation measures among different stakeholders, such as local authorities, emergency services, and media.

Internet connectivity shall be maintained at G&D site for communicating data from datalogger to the vendor's API server. Above connectivity shall be established using dual sim based **GPRS/3G/4G/5G upgraded modem**, if reliable mobile data network is available at the G&D Site. Facility for dual sim with auto switching of network is mandatory *(if two or more network available)* for ensuring continuous connectivity.

At sites where mobile data is not available or unreliable, the communication shall be established using VSAT. Separate battery bank also needs to be installed for providing continuous power to the VSAT system. The battery bank should be capable of providing backup power to the system continuously for not less than 15 days in case of non-availability of power. The battery bank shall be charged using regular power supply or through solar power to be decided by project authority.

Both GPRS and VSAT based communication system have chances of being destructed during extreme weather condition. VSAT systems consume a lot of power, making it a costly affair.

Another way of effective communication is satellite based (INSAT/INMARSAT) network, which is presently available to Government agencies. It requires licensing and has limited frequency range, therefore it needs government intervention to be used by other users too.

The General specifications for GPRS/3G/4G MODEM and VSAT are given at **Appendix-4.**

5.5 UN-INTERRUPTED/ CONTINUOUS POWER ARRANGEMENTS FOR SENSORS AND COMMUNICATION SYSTEM

a. The system shall run using Sealed Maintenance Free (SMF) Lithium batteries (12V) rechargeable through regular power supply (preferable, wherever available) or hybrid chargers (Solar+AC) or through solar panel wherever regular power supply is not available. The choice for this arrangement shall be made by the project/ power station for best results as per site conditions.
b. The battery shall be capable to run the system continuously for minimum period of one week and in case of locations that remain inaccessible for longer duration, 2 weeks on full load irrespective of power supply availability or cloudy/ foggy conditions.
c. A parameter for conveying the battery health status shall also be provided in the API.
d. The Battery bank shall also be equipped with a Battery Health Management System to monitor the health status of the battery. Further, current battery voltage level and battery health status like healthy/ unhealthy information shall also be passed in the API.
e. There shall be separate battery banks for
   - Datalogger and related devices
   - VSAT and related devices (if required)

The General Technical Specification for Datalogger and Solar panel & Battery are given at **Appendix-5A, 5B & 5C.**

5.6 CENTRAL COMMAND AND CONTROL STATION (CCCS)

a. Establishment of CCCS:

Central Command and Control Station (CCCS) shall be established at project/ power station for 24x7 monitoring. Establishment of CCCS shall be under the scope of the project authority. For the purpose of 24x7 monitoring of Early Warning System, Desktop PC with UPS and colour printer shall be installed at CCCS. 24x7 Internet connectivity shall be required at CCCS.

Following systems/ equipment shall be considered for Establishment of CCCS:

i. **Communication System**: Necessary equipment / system for communicating with all the Sensor Stations simultaneously through VSAT as well as Terrestrial (GSM/GPRS) mode for receiving water level, velocity/ flow & weather data along with others status / alarm signals on real-time basis. Necessary equipment/ system for communication of EWS Alarms to designated recipients through SMS / WhatsApp/ other means.
ii. **Data Centre**: All Hardware and Software including Servers and peripherals, Flow Modelling Software, inundation modelling, dam break modelling etc. for analyzing the received Sensor data to provide suitable Early Alert regarding anticipated flood conditions at Dam/ Barrage and Power House sites, Storage & Retrieval of Historical data.
iii. **HMI System**: All Hardware and Software including Operator Work Stations (OWS) with Full HD Screens of appropriate size, 2D Map application, HMI Software, etc. for Dynamic display of EWS data (both raw data from Sensor Stations and processed data from EWS software), Alarms & SOPs for Emergency conditions. All Hardware and Software for converting the alarm signals to formats suitable for dissemination like SMS, voice messages, Text to Speech (TTS), email, emergency sirens, etc.
iv. **Power Supply**: Reliable and redundant Power Supply system based on 415 V / 240 V AC Uninterrupted Power Supply (UPS) along with adequately sized Battery Bank, the input for which is to be tapped from projects AC Supply system.

v. **Electronic siren**: Electronic siren system for alarming purpose.
vi. **Miscellaneous**: Necessary mounting arrangement for the outdoor equipment/ systems mentioned above and other item as per the requirement of system.

b. Application Programming Interface (API) & API Server required to be connected to Master Control Room

Data from the sensors like water level, velocity, date time and battery voltage, battery status as per the API format given below shall be communicated through API in JSON format for integration with other systems.

{"Project Name": "ABC Project", "Location Name": "G&D Location 1", "date_time": "2024-01-01 12:45:00", "Water Level": "1276.044", "Battery Volt": "13.2V", "Battery Health": "healthy"}

*a key with 'velocity' may be included if velocity sensor is installed.

i. Server for hosting the API shall be maintained by the vendor. The physical location of the server shall be within the territory of India. If third party cloud services are hired for hosting the API/ Web portal, the service should be MeitY Approved.
ii. Data from datalogger shall be transmitted to the API server continuously for getting the latest data.
iii. 24x7 internet connectivity of the server shall be ensured.
iv. API/ Web portal shall be served over internet using secured https connection.
v. The corresponding data including rainfall may be provided to IMD in the form of API's which will further help in improving IMD forecast and warnings in the Numerical Weather Prediction (NWP) models.

The Manufacturers/ Suppliers of Sensor solutions for EWS and indicative list of vendors for EWS are given at **Appendix-6 & 7** respectively.

6. MEASURES TO BE TAKEN ON RECEIVING OF ALERT/ALARM IN CASE OF OCCURRENCE OF DISASTER

i. **Pre-Incident Actions:**
   a. Pre-incident actions for early warning systems at dams are crucial for ensuring the safety of downstream communities and infrastructure.
   b. As per Dam Safety Act, 2021, the pre-monsoon inspection of specified dam is done before monsoon that include inspection, maintenance and testing of the early warning system components including sensors, communication systems, alarm systems and other emergency equipment.
   c. A comprehensive risk assessment and analysis of historical data to identify potential hazards and vulnerabilities is critical which can help in anticipating probable incidents.
   d. The emergency response planning as per Emergency Action Plan/Disaster Management Plan is to be shared with stakeholders and local administration to create awareness among downstream communities for coordinated response in case of incident. Teams of divers and lifesaving material to be kept ready to co-ordinate with District Administration.
   e. Regular mock drills and exercises to test the effectiveness of the emergency response plan are undertaken to familiarize officers and other stakeholders with their roles and responsibilities during an emergency.
   f. The disaster information is being shared/ notified with systems at state and national level for effective rescue operations in case of incident.

ii. **Colour Coded Lighting System for Warning Purpose**

A colour coded warning scheme in the form of Red/ Amber/ Green lighting shall be devised based on the perceived risk assessment of the emerging abnormal emergency situation by the control room/ project authorities with Red indicating Severe Risk Category and the Green indicating Least Risk Category.

The personnel working at project site should be made aware of the impending emergency situation through the colour coded warning scheme. Project Authorities shall identify vulnerable locations where such lights scheme can be installed such as dam galleries, transformer gallery, machine floor area etc. of power house, enclosed areas or any other identified vulnerable locations at the project.

iii. **Automatic siren system**

There shall be an automatic siren system which could be programed to activate with the abrupt rise in water level in the river upstream of the hydroelectric project. Marking of danger levels at vulnerable places and setup of permanent warning posts (in English, Hindi and local language) along the river course in the upstream areas shall be made.

The Hooters/ Sirens System should be able to operate with just a touch of the button. On the lines of colour coding of the perceived risk, gradation of Hooters/ Sirens needs to be defined and blowing pattern of the Hooters/ Sirens could be distinguished based on the Red/ Amber alert. Loudness of the Hooter System have to be sufficiently high so as to be audible in case of occurrence of flash floods wherein the ambient decibel level rises significantly.

Apart from the installation of adequate number of sirens (both manual and electrically operated), marking of danger levels at vulnerable places and setup permanent warning posts (in English, Hindi and local language) along the river course in the downstream areas shall be made.

Whenever there is abrupt rise in the level or some releases are to be increased from turbines/spillway/ Barrage, all the sirens shall be operated to warn the people living nearby. A typical gradation scheme classified as Blue, Yellow, Orange, and Red alert according to their seriousness and severity as specified in Emergency Action Plan / Disaster Management Plan (EAP/DMP) shall be adopted. Accordingly, the gradation of hooter with no sound to gradual increase in number of repetitions of long tones (each of 45 seconds) of sound mode are being played corresponding to gravity of catastrophic situation. The gradation of hooters is typically accompanied by other available communication channels, such as public address systems, emergency contacts, WhatsApp or mobile SMS alerts, to ensure that all officers having responsibility for maintaining essential services and rescue/evacuation as well as residents receive timely warnings and instructions without panic.

iv. **Instantaneous/ automatic opening of gates**

All the Hydro Dams/ Barrages gates **should be capable to operate in auto mode in addition to manual mode**. Further, inter-connection between Dam/Barrage site Control Room and Power House Control Room shall be provided through redundant optical fiber cable to operate the gates in case of emergency in line with SOP of gate opening/closing of the individual project/Project Authority. Therefore, a Plant wise SOP needs to be prepared regarding opening sequence of gates according to severity of the Early Warning Alert e.g. the Red alert warrants opening of all the gates simultaneously and accordingly downstream population may be suitably informed.

Operational readiness of all Dams/ Barrages and intake gates, for its full opening/ closing in remote and local control needs to be ensured and accordingly their test operations should be carried out regularly

v. There shall be provision for an Un-gated spillway with crest at Full Reservoir Level (FRL) to regulate unprecedented inflow between FRL and Maximum Water Level (MWL) for the upcoming projects. This feature may serve as a crucial mechanism to mitigate potential risks posed by Glacial Lake Outburst Floods (GLOFs) or Flash Floods, particularly in scenarios where the opening of a gate may not be feasible due to the severity of the catastrophic situation at hand.

vi. Location of diversion / regulating structures shall not be close to a nallah/ stream / tributary in the upstream which may damage the structure/ regulating gates in the event of a cloud burst induced flash flood carrying large quantity of sediments.

vii. **Evacuation of manpower from tunnels**
Fluorescent direction indicators, EXIT lights in tunnels etc. shall be suitably provided for evacuation of manpower from tunnels in the Projects. During construction stage where tunnelling is involved, escape tunnels in the form of designated shafts may be kept as escape routes in the event of any catastrophe and the same are to be made operational from the initial construction stage of any large hydropower project. During construction stage, openings of adits/ tunnels could be equipped with gates, wherever feasible, which could be closed to avoid water ingress into the tunnels.

viii. The information in respect of early warning of any disaster/ emergency situation to upstream/ downstream hydro projects/ local population/ local civil & state administration shall be communicated on 24x7 basis in real time basis through hotline mechanism/ bulk messaging /bulk voice calling system to their mobile phone. This could be done by forming a Common User Group (CUG) among the hydro projects in the same river valley. The CUG should also include the officials from DDMA, SDMA and the District/ State administration of the region affected along with NDMA. This will help in early indication to project authorities in decision making to take advance step for disaster management.

ix. Dual mode of communication using VSAT (Extended C Band) and GSM/ GPRS (5G) shall solve the problem up to reasonable extent. In case of availability of 5G signals from more than one service provider, dual GSM/GPRS sim modems can be used discarding VSAT as it will greatly reduce the battery back-up requirement.

x. A detailed updated inventory of Glacial Lakes for a particular river basin shall be jointly prepared by all the developers in the river basin. The same may be got prepared through NRSC ISRO. The cost may be shared by all the developers.

xi. Project Authorities shall ensure that Emergency Action Plan (EAP), Crisis & Disaster Management Plan shall be in place even in under construction projects and should be well integrated with the SOP of EWS. Mock Drills shall be conducted on regular basis (e.g. quarterly/ half-yearly), to evacuate plant personnel in case of emergency situation in minimum time. An annual EAP review shall be conducted to ensure that contact names and numbers are current on the Notification Flowcharts.

xii. The instruments/ sensors deployed for early warning shall be able to communicate with control room in 24x7 real-time or near real-time basis & in fail proof manner automatically/ without human intervention.

xiii. The control room is to be equipped with Mobile phone/ satellite phone, internet connectivity, Wi-Fi Connection (with UPS) and emergency power supply (with DG backup) to operate efficiently in case of blackout during any emergency. Emergency Handling Items & equipment such as life Jackets, Helmets, Long Beam Torch are to be available in the Control Room. List of Contact Numbers of Project Head, key Personnel of the project and local administration, nearby Hospitals and other relevant agencies should be prominently displayed at suitable locations for early information of any impeding emergency situation to all concerned authorities in parallel for necessary action.

xiv. The control room shall also take feedback from other agencies/sources such as IMD, CWC, National Center for Seismology, DGRE, Weather reports, Forecasts, nowcast on different websites (mosdac.gov.in, ffc-india-water.gov.in, cwc.gov.in, city,imd.gov.in etc.) and register with them.

xv. Control room shall continuously monitor real time inputs i.e. Velocity, Level of sensor stations and healthiness of the system as per Check list for Automated Flood Warning System (AFWS).

xvi. The software regarding keeping the flow data history may also be developed and included in the existing EWS data logger. This will give necessary warning/indication when previous high floods value reach at any time and provide alert through automatic alarms signals accordingly.

xvii. A detailed inventory of rivers/ major tributaries etc. shall be prepared by the Project authority and be made available in the Control Room.

xviii. **Level of In-charge & manpower deployment**

Control room shall be manned by executives of project authorities on 24x7 basis and electronic recording of activities being monitored shall be ensured. The in-charge of Control Room at project site shall be senior most with adequate manpower for 3 shifts of 8 hours each. The control Room shall also maintain a Log Register wherein activities being monitored round the clock shall also be physically recorded. The Control room shall not be left unmanned at any point of time.

Chief Engineer/equivalent to Chief Engineer shall be designated overall in-charge responsible for the management of Emergency Action Plan/ Disaster Management Plan. Alternatively, the choice for the manpower arrangement shall be made by the Project Authority for best results as per site conditions. The Notification Flow Chart and emergency control rooms have been made an integral part of EAP/DMP to pass on the information about the developing situation to all responsible and concerned project officers and other support staff for undertaking evacuation, rescue, and relief operations in coordination with District Administration. The teams for rescue, relief and evacuation operations at Dam and Township area, Technical Teams for electricity and transportation, communication team and medical assistance teams are well specified in EAP/DMP. Project Authorities shall also remain in close contact for coordination with the civil administration including Deputy Commissioner, SDMs, Tehsildars, and District/State Disaster Management Authorities etc. to mitigate the effect of disaster.

xix. A dedicated vehicle shall be provided to the Control Room Personnel for movements within the Project site and Manual Observation Posts.

xx. At least two Cellular Smart Phone with mobile connectivity, one Wi-Fi Connection with adequate Data plan, Search Light/ Long Beam Torch and PA System shall be provided in the Control Room. The Satellite phone, unless prohibited by Defence Forces for the plants located at sensitive locations from National Defence aspect, shall also be provided in the Control Room.

xxi. Depending on analysis of the feedback from Manual Observation Guard posts/ Automated Flood Warning System or any other source, Control room shall initiate alarm to disseminate information about any emergency at Site to Project authorities and other concerned as per the Emergency Communication Flow chart attached to take appropriate action for evacuation of people from site (s).

xxii. The Control Room Shall use Siren/ Public Address system for alerting the people working at Sites depending upon the nature of Emergencies as per the existing approved Disaster Management Plan (DMP).

xxiii. The routine dam maintenance, such as annual weed control, conducting dam integrity inspections and notifying the nominated Nodal Officer for Dam Safety of any potential emergency situations shall be ensured. Pre-monsoon and post-monsoon inspections of the dam shall be made to evaluate its structural safety, stability, and operational adequacy.

xxiv. The availability of equipment, supplies, or personnel shall be ensured which may be necessary for use during a dam emergency.

xxv. All people involved in the EAP shall be trained to ensure that they are thoroughly familiar with its elements, the availability of equipment, and their responsibilities and duties under the plan. Personnel shall be trained in problem detection, evaluation, and appropriate corrective measures. This training is essential for proper evaluation of developing situations at all levels of responsibility.

xxvi. Synchronization with upstream projects, if available, may also be helpful in providing real-time data and detailed information regarding the EWS parameters. Further, the synchronization with inter-projects in a particular area may also help to obtain more detailed parameters of the projects and enhance the functioning of EWS in a better way.

xxvii. A stakeholders' consultative meeting shall be held periodically with a view to assess the performance of the EWS and explore upgradation of the warning system based on the past experiences and advancement of technology.

xxviii. There shall be documentation and record-keeping during and after an event by the Project Authority. Accurate records are crucial for post-event analysis, compliance with regulatory requirements, and transparency.

xxix. There shall be a provision of dedicated Nodal officer along with the team for Early Warning System in each project. Further, the nodal officers of EWS of all the hydro projects in a basin shall regularly have a meeting for better coordination and shall remain in touch on hot-line.

xxx. The upstream most hydro project of the particular basin shall have regular meetings with SDMA, DDMA and local administration for strong coordination and communication to mitigate all the probable losses with the help of Early Warning System.

General Technical Specifications of Sensors

a. Surface Velocity Sensor

Parameter	**Requirement**
Technology	Radar
Measurement range	0.1 -15 m/sec
Flow velocity Resolution	0.01 m/sec
Flow Accuracy	1% or better
Installation height above water level	As per site condition
Power supply voltage	9-27 VDC
Operating temperature	-40 to 70°C
Sample rate	10 sps
IP rating	IP 67 or Higher
Communication protocol	MODBUS RTU
Communication interface	2-Wire RS-485

b. Water Level Sensor

Parameter	**Requirement**
Technology	Radar
Process fitting & Beam Angle	Thread G2, Flange from DN 80; Beam Angle 5^0 or better. Fitting as per suitability of site.
Measurement range	0-30 m (may be increased depending upon site condition)
Resolution	5mm
Accuracy	±3mm-4mm
Power supply voltage	9-27 VDC
Operating temperature	-40 to 70°C
Signal Output	4-20 mA/HART (2-Wire/4-Wire)
IP rating	IP67 or higher
Communication protocol	MODBUS RTU/ OEM specific to meet application requirement
Communication interface	2-Wire RS-485

c. Automatic Gauge & Discharge Stations (Imagery Based)

Automatic Gauge & Discharge Stations having non-contact imagery based water level and velocity sensors.

Width of River /River Span	≤ 120 m
Resolution of sensor	3 MP Full HD 1080p PoE IR
Protection Class	IP 66
Measuring Range	0.2 - 15 m/s
Frame Rate	30 FPS
Operating system	Linux/Windows
Accuracy	Flow velocity: < 5% of measure value*
	Water level: < 1 cm*
	Discharge: < 10% of measured value*
Data Output	MODBUS/4-20 mA / RS 485 / SDI - 12
External water level output	4 -20 mA/RS485/RS232/SDI -12
Operating temperature camera	: -40° C to + 50° C
Power supply	230 V/12 V, grid or solar power
Measurement Principle	Image Velocimetry

Appendix-2

1. SPECIFICATIONS OF AWS SENSORS-

- For all sensors offered, it should be rugged, well proven sensors and used for operational purpose.
- Cables used for sensors to connect Data logger should be Teflon insulated multi strand and silver coated.
- **For sensors, valid Certification from reputed International/ Indian institute is to be submitted.**
- **Detailed Technical Specifications of Sensors are mentioned below:**

Temperature and Relative Humidity Sensor with Radiation Shield	
Air Temperature	
a) Sensor type	Pt 100 RTD
b) Measurement Range	-40 °C to +60 °C
c) Accuracy (with radiation shield)	± 0.20 °C or better for +10°C to +60 °C ± 0.35 °C or better for -40°C to +10 °C
d) Resolution	0.1 °C
e) Output	Analog/ Digital
Relative Humidity	
a) Measurement	Range 0% to 100%
b) Accuracy (including nonlinearity, hysteresis and repeatability)	± 3% RH or better with membrane filter (In the Range 10% to 100%)
c) Output	Analog / Digital
d) Resolution	1% or better
e) Sensor type	Capacitive / solid state
Radiation Shield	
a) Type	Thermoplastic
b) Louvered	Minimum 9
c) Ventilation	Natural
d) Mounting Accessories	Aluminium Mounting bracket and Stainless-steel U Bolt clamp.
Wind Sensor (Ultrasonic 2 Dimensional)	
Wind Speed	
a) Range (Operation)	0 to 60m/s or better
b) Sustainability	Up to 60 m/sec
c) Accuracy	± 0.5 m/s or better
d) Resolution	0.1 m/s
e) Threshold	0.5 m/s
f) Response time	1 sec or better
g) Output	Digital
Wind Direction	

a) Range	0 to 359 Degrees
b) Accuracy	±5 degrees or better
c) Resolution	1 deg. or better
d) Response time	1 sec or better
e) Output	Analog/ Digital
Tipping Bucket Rain Gauge sensor or with better technology	
a) Collector Area	Specified Collector Area should be between 200 cm^2 to 325 cm^2
b) Height above funnel	Height above funnel should be sufficient to accumulate rain during heavy rainfall as per WMO guidelines.
c) Switch	Rugged Magnetic Proximity
d) Resolution	0.5 mm per tip
e) Output	0.1 sec switch closure
f) Accuracy	±2% or better, for rain rate up to 25 mm/hr ±3% or better, for rain rate between 25mm/hr to 50 mm/hr ±4% or better, for rain rate between 50mm/hr to 100 mm/hr ±5% or better, for rain rate>100 mm/hr
g) Material of Outer Body/housing (Base/Collector)	Rust Proof Housing.
h) Levelling	Suitable levelling adjustment screws and circular spirit level must be provided on the base of TBRG for levelling the Tipping bucket Mechanism.
i) Debris protection filter	Suitable (Wire mesh) debris protection filter should be provided inside the collector.
Pressure sensor	
a) Range	600 to 1100 hPa
b) Accuracy	± 0.2hPa or better for complete range (600 to 1100 hPa)
c) Resolution	0.1 or better
d) Output	Digital

2. 2. SPECIFICATIONS FOR POWER SUPPLY

- The complete AWS station shall have capability for unattended operation at **remote place** using Sealed Maintenance Free (SMF) battery, Electrical charger, Solar charge controller and rechargeable through a Solar panel.
  (i) **Battery**: Single 12 V chargeable SMF batteries 65 AH capacity or better.
  (ii) **The switch with fuse is required for power supply to the Data logger.**

(iii) **Solar Charge controller (MPPT)**: It should charge the 12 V, 65 AH SMF battery through 75 W Solar panel and also Over-load protection, Short circuit protection, Protection from the lightning strike and Under-voltage protection. It should have provision to controlled power supply to the Datalogger.

(iv) **Solar Panel (Mono Crystalline)**: Rated capacity 75 W or better,

- AWS should run for 20 days during cloudy day or without charging the battery.

4. 3. SPECIFICATIONS FOR WEATHER PROOF FRP ENCLOSURE FOR AWS

- Two separate enclosures are required for AWS.
- Weather proof Enclosure of AWS should be FRP Enclosure (IP 66) and for outdoor use to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water.
- **One enclosure** FRP Enclosure (IP 66) is suitable to keep Data logger, solar charge Controller, Pressure sensors, switch with suitable fuse for power supply to Data logger and GPRS modem.
- **Another separate** FRP Enclosure (IP 66) for 12 V, 65 AH SMF batteries
- Silicone gasket is used for both Enclosures for harsh environments and extreme temperatures.
- FRP Enclosure (IP 66) enclosures should be designed for outdoor applications that require corrosion protection against chemicals and water. From humble to harsh environments, it safeguards vital electrical and electronic components with enclosures, climate control and accessories to help keep operations up and running smoothly.
- Enclosure with hinged door and locking facility.
- Data Pockets provide convenient storage for wiring diagrams, operation manuals and other documentation inside an enclosure.

5. 4. MAST FOR AWS (Tiltable type / Foldable/Sliding up and down)

- Mast shall be 10-meter (**Tiltable type / Foldable/Sliding up and down)** mast. The mast is designed to withstand high wind conditions, up to 60 m/s of maximum wind speed, with a standard set of guy wires.
- It shall be corrosion resistant and salt water resistant.
- The Mast can be lowered down any time to remove for maintenance and reinstallation of the wind sensors.
- Instrument booms suitable for mounting on the Mast need to be designed on the basis of the mounting requirements of the sensors.
- The bidder shall be responsible for installation of sensors at various levels, fixing and laying of the signal cables from all the sensors up to the ground level along with fixing the cable identification tags. The signal cables should be laid out properly on the mast and tied to the structure elements with cable ties of appropriate lengths.
- Tension in the guy wires shall be adjusted by means of tension meters or any standard method for adjusting the tension in the guy wires may be followed and tension should be adjusted in the presence of representative of developer.
- The overall specifications of Mast are given in table below:

1	Height	10 m
2	Wind	60 m/s
3	Guy levels	At 6 m
4	Lightning Arrestor	A lightening arrestor with spiked copper rod of atleast 10 meter height should be installed at the top of the mast and connected to an earth pit with copper bars and suitable copper cable. Separate maintenance free type earth pit conforming to the relevant IS specifications should be provided for this purpose.

5	Cable routing	Provision for cable routing from instrument booms / junction boxes to the bottom of the mast will be provided. The cable bunch has to run in a flexible PVC pipe / with equivalent arrangement from top to the lower end of the tower and into the instrument enclosure

Appendix-3

General Technical Specification of Siren

Serial No.	DESCRIPTION OF EQUIPMENT FOR LOCAL STATIONS	Specifications
C1.	**Local station for Alert, Information and Direct system comprising of the following hardware/software:** • Panel/Housing with power supply module • Dual SIM 3G/4G communication Router • Intelligent Remote Terminal Unit (RTU) or Programmable Logic Controller • Electronic Siren •Starter with feedback arrangement for siren • Strobe Light with three color •Mounting hardware and cable connectors etc. • Set of applications and system software	**Panels for Mounting Hardware:** The panel should be duly wired and sufficiently spaced to accommodate all the equipment with IP65 protection, CRCA sheet metal. Earthing bolts available at single sides. The enclosure should have single door. The panel should have lock arrangement and wall mounting arrangement. The system should run-on single-phase power 230V AC, operating in the range 170-250V /50Hz and should be rugged enough to withstand voltage fluctuations without damage. **Power and Backup:** All the stations equipment (i.e. Electronic Siren, strobe lights, PLCs etc.) must be powered and activated by single phase power. The status of Power Supply must be available in the Central Control Room. **Siren System:** • Must have provision of Pre-recorded/programmed electronic warning tone. **Strobe Light:** • Light Color: Red, Amber, Green • Operating Voltage: 24/12V DC • Flash pattern: Double Flash • Mounting: Permanent Mount • Flashes per minute -75 Double Strobe Light should be installed in Local Stations in a manner that it is visible. **Controller/PLC/RTU:** The Controller shall be designed to have communication compatibility for any wireless mode like GSM, GPRS, Radio, Satellite or Wired mode like Internet, Broadband to transmit data and receive commands remotely. **Cyber security on Hardware:** 1. Access to the controller shall be password-protected. Additionally, only selected devices are allowed to connect to controller. 2. Memory protection mode is available via

		physical inputs or software configuration. The application and user data are protected in this mode 3. Run/Stop protection mode is available via physical inputs or software configuration
C2.	**Electronic Siren up to 50db**	• Considering ambient noise, system audio output must be at least 3 dB above the ambient noise conditions. • High Power Electronic Siren System each with a minimum acoustic power of 50dB @ 1M (Lab Tested). • Siren Controller box must be IP55 compliant (or better). • Operating Temperature: -20 to +60deg C • The system must have a capability to run continuously for 10 minutes without overheating/failure. • The system must adhere to EN 60065 certification for compliance to highest European Safety Standards and ISO 9001:2008 certification of product design and manufacturing. Equivalent International i.e., UL, FEMA and Indian Certifications are also acceptable. • Standby mode current should not exceed 40mA. • Dual feature of Control – Remotely from Control Room and Locally at the Siren Controller box for authorized user.
C3.	**Feedback Unit for status of Local Stations at Control Room**	All feedbacks (on, off, trip, faults etc.) of the equipment installed for Alert, Information and Direct system should communicated to main Control room SCADA/MCR/CCCS.
C4.	**Interface system for Radio and 3G/4G link on wireless communication through dual SIM and associated software at control room**	A suitable interface/communication system of reputed make should be installed in the Local Station with the capability of operating over 3G/4G Link through Dual SIM and should be accordingly interfaced with main Control Room SCADA.

C5.	**Cable and required mounting accessories**	Power Cables and Accessories: All required power cables and accessories to make the system functional will be supplied by the vendor. Cables should comply with IS-694, IS-3961, IS-8130 and IS-5831. MAKE: Polycab / Finolex or reputed.
C6.	**Mandatory Spares (one set)**	**I)** Electronic Siren- 1 Nos **II)** RTU/PLC – 1 Nos **III)** Modem – 1 Nos **IV)** Strobe Light – 3 Nos (Red, Amber, Green)
C7.	**Siren type**	**Required Technical Specification**
	Acoustic power	50 dB(A) / 1 m
	Number of alarm messages	Min. 5 x 6 min.
	Operating power	230 VAC/ 24 VDC
	Load impedance	4 Ohm / 8 Ohm
	Number of warning voice messages	100 Nos. with USB
	Overall records length /1GMB Flash memory/	Min. 16 hours
	Voltage	110 – 250 V / 24 VDC/50 Hz
	Stand-by mode current	40 mA / 230 V
	Max. input /stand-by input (Pi/Pp) / 230V	150 VA / 11 VA
	Control circuits voltage	24V/12V
	Battery	2 x 12V, Ah capacity based on Design/requirement.
	Service temperature	-10°C to +60°C
	Service temperature of local control module	-10°C to +60°C
	Weight of 1 horn	<=5 kg
	Dimensions of siren box / L x H x W / mm	As per design
	Siren box cover	IP55 for Panel Mount
	Interfaces	
	USB device	Inbuilt Tone
	Tone	2 Tone
	Selection of Tone	By Toggle Switch
	Wireless	Wired
	LAN	10/100Mbit Ethernet link
	8x Binary input 2x Binary output	User programmable I/O lines

	Power amplifier	As per Design. Full diagnostics, including speaker impedance.
	Real time clock	RTC circuit with battery backup, GPS time Synchronization
	Authorization	For authorized Users only

A. General Technical Specification for GPRS/ 3G/ 4G/ 5G MODEM

4G based GPRS Modem (compatible with 3G) with dual SIM facility and also have provision of fast and reliable wireless data communications along with support for IP based access to the central server IP. The GPRS Modem shall be compatible to all SIM. The following technical specifications are indicative.

(i) GPRS facility with fast and reliable wireless data communications.
(ii) Remote dial-up facility.
(iii) Shall support SMS, Email and FTP.
(iv) Accept dual standard SIM card.
(v) Ethernet/RS 232/485/USB interface with DATALOGGER.
(vi) Indication of network availability (signal strength).
(vii) Suitable High gain GPRS Antenna for reliable communication.

In order to provide redundancy in Connectivity for facilitating Data transfer from AWS to Master Control Room, VSAT services (Ku / Ka / Extended C) with Internet facility can provided for which minimum specifications are as follows:

Indoor Unit (IDU)

Forward Channel

1. DVB-S2X with Adaptive Coding and Modulation (ACM)
2. Frequency: C-band, Ku-band and Ka-band
3. Modulation: QPSK, 8PSK, 16APSK, 32APSK, 64APSK
4. Encapsulation: GSE
5. Symbol rate: Up to 235 Msps

Return Channel

1. MF-TDMA
2. LDPC FEC with efficient variable block/burst sizes
3. OQPSK, QPSK, 8PSK, or 16APSK
4. Symbol rate from 256 Ksps to 12Msps
5. Adaptive Coding and Modulation (ACM) capability

Network Interfaces

1. 2/4 GigE LAN ports
2. USB

ODU

1. Radio interface: Operates in Extended C-, Ku- , or Ka-Band Networks
2. Antennas: 74 cm, 98 cm, 120 cm, or 180 cm.
3. IFL cable type and length: Dual RG-6, 75-ohm, F – type connector up to 150’

IP Features

1. Dual stack IPv4/IPv6
2. Static and Dynamic addressing
3. BGP Routing Support
4. Policy Based Routing
5. DHCP
6. VRRP
7. Access Control List (ACL)
8. DNS Caching
9. SIP Call Proxy
10. Advanced Web Acceleration
11. Layer 2 transport with acceleration and compression

GPRS Network Service

There should be provision for SMS and IP based communication with DATALOGGER remotely to access and configure the DATALOGGER through GPRS / VSAT modem.

- **GSM & GPRS MODEM**
  a. Shall have embedded HTTP/FTP/TCP/UDP Protocol.
  b. Shall be compatible with standard 3G and 4G GSM network of all reputed national operator.
  c. Shall be compatible with the data logger proposed by the vendor.
  d. Shall have ISO 16759 qualification.
  e. Standby current: < 0.90 mA
  f. Shall have GSM/GPRS functionality scalable to customer needs.
  g. The modem/software in the data logger shall be configurable to send SMS/GPRS packets to the central reception facility at a user defined interval ranging from 1 minutes to 24 hours.
  h. The modem configuration shall ensure that no data is missed. The modem or the data logger should send data in packets (GPRS) at pre-defined interval. In case of non-availability of mobile network during its schedule transmission time, the data will be transmitted as and when mobile network is available. In such cases, all the data that has not been transmitted till any particular time, shall be transmitted once mobile network is available.

B. General Technical Specification for VSAT

a. Dedicated 256Kbps Bandwidth
b. Ku/ Extended C band VSAT
c. Antenna size: 1.2m
d. Separate battery bank for VSAT to provide power backup for minimum 15 days.
e. Other Standard IDU and ODU features.
f. Smooth operation during rainy or cloudy conditions.

Appendix-5A

A. General Technical Specification of Data Logger

a) The DATALOGGER shall have facility to sample the output of the attached sensors with user selectable sampling interval. The process of the samples collected is to obtain instantaneous, average, maximum and minimum values along with their time stamp for the selected measurement interval for transmission.
b) There should be provision of Maximum wind observation (Gust and squall) for both wind sensors along with their time stamp.
c) All DATALOGGER should have suitable port to interface with any external display unit.
d) The sampling and measurement interval for individual parameters shall also be user selectable.
e) The DATALOGGER should have capability to store the data for specified parameter at user defined intervals in distinct multiple log files for each sensor and other related parameters (data volume 1GB or more).
f) Stored data shall be retrievable via Telemetry/serial port/ USB port/Ethernet port to a PC/laptop and a pen drive or any other compact and commercially available solid-state memory device in standard text file format without requirement of specific software to retrieve the data.
g) DATALOGGER should have menu driven keypad and backlit LCD/LED display (internal/external unit) and facility to display the command, data characters.
h) All the Analog and Digital channels in the DATALOGGER must be compatible to the sensors supplied and integrated with the system.
i) The DATALOGGER should have a built-in high-performance analog channels, adequate number of built-in digital channels to accommodate digital output of the sensors, Counter channels for rainfall measurement.
j) The DATALOGGER shall have suitable interface for 4G dual SIM GPRS modem.
k) DATALOGGER should have provision to accept SMS command from remote mobile for Remote configuring DATALOGGER for communicating
   i) Changing time interval of server communication from 1min to 15min.
   ii) Display current data.
   iii) Monitoring the signal strength of mobile network.
l) Provision to access to the DATALOGGER through GPRS modem shall also be made with password protection.
m) In order to facilitate data processing, the DATALOGGER shall have a provision for 24-hour Real-Time Clock (RTC) powered by a battery (with min. one-year lifetime) to ensure that time is maintained even during power outages. The DATALOGGER shall have provision to easily include and change the “Unique station identification code”, “Station Name”, “Time of observation and transmission”, “Measurement schedule” and “Sensor identification information”, for all parameters, as mandatory requirements. Any change in the DATALOGGER should be properly logged along with user, date and time details.
n) The DATALOGGER should transmit the AWS data as per specified data format to receiving server.

B. Solar Panel and Battery

a. Mono crystalline Solar panel of rated capacity 50W or better, Open Circuit voltage: 21 V or better, Short circuit current: 2.5A or better and a sealed maintenance free (SMF) battery of minimum 65 AH (12 V) of reputed national brand shall be used to power the system. In no sun condition the AWS should operate for at least 15 days. The vendor shall provide a calculation sheet to demonstrate the same.
b. The system shall have a battery charger of proper rating to charge the battery through the solar panel.

c. The system shall have photovoltaic battery charge controller for protection of battery from over charging, Under-voltage protection. Short circuit protection and Protection from the lightning strike.
d. All fixing devices required to fix the solar panel to the tower/mast shall be provided by the vendor.

Data Logger for Automatic Weather Station

i. It should have menu-driven status monitoring and settings to enable.
ii. View connected sensor data onsite.
iii. View real-time data.
iv. Take data backup in USB drives onsite.
v. View station ID System Health, etc. View system clock onsite.
vi. Sensor Measurement/Auto Transmission as scheduled by the User.
vii. The data logger should support a minimum of 8 uni-polar channels or 4 bi-polar channels (passive transducers) or mixed-up.
viii. It should have multiple communication facilities including RS 232, SDI–12, Ethernet (Compact flash), USB, etc.
ix. Two or more numbers of SDI-12 Interface ports.
x. 24-bit or better Analog to Digital converter.
xi. Conversion Accuracy ± 1 LSB.
xii. Maximum scan rate of data logger 1000 Hz.
xiii. Should support individual recording intervals for different sensors/parameters connected.
xiv. Firmware Operating System: Multi-tasking operating system - must log data and transmit at the same time.
xv. Internal memory of the data logger should be sufficient to store a minimum of 10,00,000 readings, expandable to 100,00,00,000 readings (16 GB) via an internal SDHC card.
xvi. If internal memory is full, it should overwrite the data. While overwriting, it should delete the oldest data and store the current data.
xvii. Power supply: 12V DC, low current drain (quiescent ≤10.0mA).
xviii. Internal battery backup for clock: Lithium-ion Battery with storage: 3 years.
xix. Charge Controller: Internal or External.
xx. User Permissions: System of user rights/passwords, access restricted to authorized personnel.
xxi. Shall receive time synchronization with NAVIC/GPS time (UTC/GMT) through a NAVIC/GPS receiver connected to the data logger. The time synchronization should be automatic, at least once in 6 hours.
xxii. Should have an LED Display with a Graphical dot matrix of minimum 122 × 32 pixels or LCD Display of minimum 16 x 2 alphanumeric display.
xxiii. Should have a separate key for navigation of the menu and other functions.
xxiv. Should have at least one USB 3.0 Compatible host for data backup in a USB Memory Stick.
xxv. Sensor Interface: 8 × Sensor Channels, 4 × Sensor Power Control.
xxvi. Operating Temperature Range: -5° C to +60° C.
xxvii. Battery-Backed SRAM: Minimum 4 MB.
xxviii. The data logger software shall be compatible with the Microsoft Windows 10 operating system or an updated version with all required licenses.
xxix. Necessary accessories: Serial cable + adaptor for notebook connection. All accessories (fixing units, etc.) as required.
xxx. Tools: complete tool kit for installation and routine maintenance giving full detail (number of pieces and type).
xxxi. Manuals: Full documentation and maintenance instructions in English (1 copy per station).

Data Logger Specifications for Automatic G&D and AWLR

a. Four analog/digital input channels
b. Input range: The data logger should have multiple input ranges to measure the sensors accurately without any loss of accuracy. The data logger should have at least these input ranges: ±5000mV, ±2500mV, ±78mV
c. SDI-12 Input: at least 1 Channel
d. RS485 Input: at least 1 Channel (Programmable as Master or Slave Modbus)

Analog to Digital Conversion

a. Resolution: (16 Bit) or more
b. Conversion Accuracy +/-1 LSB
c. The DCP should have watchdog timer to reset the system and restore the previous set-up case of microprocessor resets and power glitch.
d. Visual Display and Keypad type numeric or alphanumeric or touch with the keypad and display it should be possible to program the data logger, manually initiate data transfer, and display data.
e. The display should be 2 lines x 20 characters and should have soft keypad for configuration.
f. The display should have a time-out feature to conserve the power.

Real Time Clock

In addition, the system should also have battery backed real time clock so that the time is updated even during power failure. The accuracy of this clock should be better than 6 seconds per month.

RS 232- Port

The DCP should have multiple RS 232 port capable of having communication with external devices like GSM/GPRS Modem, VSAT, LOS Radio modem and INSAT Satellite Transmitter. Also, it should be possible to configure the port through software. It should support MODBUS communication.

Ethernet Port

The DCP should have an Ethernet port for interfacing with VSAT Terminal for data transmission where there is no cellular network. Should also support Modbus communication.

Data Storage

The data logger shall have the capacity to store 1 year data at 15 seconds sampling and 15 minutes of averaging.

Power Requirements

Measurement Interval	1.0 Second to 24 hours (Programmable)
Number of Measurements Supported	Unlimited
Accuracy	0.002% of 5V
Expandable	Option for future channel expansion
Functions Supported	frequency inputs, quadrature input, Status inputs, counter inputs,
Output Type	Open collector with 100-ohm current limiting resistor, 100 mA max, 15V max

Excitation Channels	5 Channels
Communication Ports	RS232 for communications
Telemetry	INSAT Satellite Transmitter, Radio, Direct Connect, GPRS, MODBUS, and custom devices via BASIC/Python
Number of Simultaneous Communications	4
Operating Temperature	-40°C to +60°C
Display Operating Temperature	LED operates to -20°C
Programming	Menu driven setup, Expanded complexity via BASIC/Python Custom capability via C++/Python
ADC Resolution	16 bit or better

Appendix-6

Indicative list of Manufacturers/ Suppliers of Sensor solutions for EWS

Sensor System	Description	Make
Datalogger for Hydro Met and geotechnical Stations	Datalogger AWS - Meteorology	HyQuest Solution
	Datalogger AWS - Level and Velocity Monitoring	HyQuest Solution
	Datalogger AWS - Level Monitoring	HyQuest Solution
	Datalogger AWS - Distrometer	HyQuest Solution
	Datalogger AWS - Hail	HyQuest Solution
	Datalogger - Seismic sensors and seismographs	HyQuest Solution
	Datalogger - Geotechnical & Geodetic	HyQuest Solution
	Datalogger - Snowmelt and Glacial melt.	HyQuest Solution
Monitoring of rivers and streams for level, velocity, and discharge.	Velocity Monitoring (Non-Contact)	SOMMER
	Level and Velocity Monitoring (Non-Contact)	
	Level Monitoring (Non- Contact)	VEGA
	Level Monitoring (Non- Contact)	Geolux
	Level and Velocity Monitoring (Non-Contact)	HyQuest Solution
	Level Monitoring	OEM / TerraTransfer
	Level Monitoring	3rd Party / Keller
Monitoring of meteorological parameters in the atmospheric pressure, temperature, wind precipitation	Air Temperature	OEM / Theta
	Barometric Pressure	
	Air Humidity	
	Wind Speed	
	Wind direction	
	Global Radiation	
	Air Temperature	3rd Party / Lambrecht
	Barometric Pressure	
	Air Humidity	
	Wind Speed	
	Wind direction	
	Global Radiation	
	Precipitation: Weighing Principle Precipitation Gauge	HyQuest Solutions
	Precipitation: Tipping Bucket	HyQuest Solutions
Monitoring of meteorological snowfall	Snow Fall - Distrometer	HyQuest Solution
	Hail Monitoring	HyQuest Solutions
Monitoring of seismic activities	Seismic sensors and seismographs	3rd Party / Woelfel
Geotechnical and Geodetic sensors for monitoring of Landslide Lake Outburst Flood, Avalanche, Landslides, Subsidence, Rockfall, Debris flow, Monitoring of Snowmelt	Extensometers	3rd Party / RST
	Piezometers	
	Inclinometers	
	Tiltmeters	
	Crack Meters & Joint Meters	
	Load-Cells	

and Glacial melt, Avalanche, Landslides, subsidence, rockfall, debris flow	Pressure Cells	
Monitoring of Snowmelt and Glacial melt.	Snow Depth Sensor	3rd Party / SOMMER
	Snow Pack Sensor	
	Snow Melt Sensor	
	Snow Temperature Sensor	
Others	Air Flow Wireless Sensor	3rd Party / E+E
	Portable DC Voltage Measurement Wireless Sensors & Transmitters (0-50V DC)	3rd Party / Fluke
	Portable DC Current Measurement Wireless Sensors & Transmitter including dismountable current transformer, as applicable (0-300 amp)	3rd Party / Fluke
	CCTV	3rd Party / Paessler
	Thermal Cameras & Infrared cameras	3rd Party / Fluke
	Professional experts for interpreting satellite imageries for advance information on forthcoming situations	3rd Party

1. List of probable Vendors for EWS (Suggestive Only)

a) M/s. Intergraph SG&I
b) M/s. Fluent Grid
c) M/s. Everbridge
d) M/s. DHI
e) M/s. Cyber Swift
f) M/s. Consol Geotech
g) M/s. CMS
h) M/s. Blue Ocean
i) M/s. BECIL
j) M/s. AIT
k) M/s. Telecon
l) M/s. TCIL
m) M/s. Sterlite
n) M/s. Satpalda Geospatial Services
o) M/s. Oberoi Thermit
p) M/s. NEC
q) M/s. Lotus Wireless
r) M/s. Kisters AG
s) M/s. iSenses
t) M/s. CROPC
u) M/S AIMIL
v) M/S Virtual
w) M/s Alpha pacific
x) M/S M2M logger
y) M/s BIPS
z) M/s Srijon Microsystems

2. Preferred Brand Name for Different Hydro meteorological Instruments (Suggestive Only)

S.No.	AWS	AG&D (Radar Based)	Data Logger	AWLR	Automatic Imagery based G&D
1	Campbell Scientific	OTT	OTT (Sutron)	Campbell	SEBA Hydrometrie
2	GILL Instruments	Sommer	Campbell Scientific	Vega	
3	OTT	Geolux	Data Taker	Sommer	
4	RM Young	Vega	National Instruments	OTT	
5	Virtual Hydromet	Campbell Scientific	Kinemetrics	Geolux	
6	Vaisala	Hyquest	Optima	Siemens	
7	Microstep		Hyquest	EIP	
8			Vaisala Siemens		