QRA QUEENSLAND RECONSTRUCTION AUTHORITY

Alternative Flood Warning Infrastructure (Rain and Level Gauges): Guideline for Minimum Requirements

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Queensland Government

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Cover images
Top left: Radar water level sensor coupled with a battery-powered data logger and solar panel (Credits: Horizons Regional Council and Metasphere)
Top right: Radar water level sensor (Credit: Sunwater)
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Rainfall gauge (Credit: Lixia)

About this guideline

Introduction

Flooding is one of the most significant disaster risks in Queensland. Early flood warning systems are an important part of the flood risk management process, providing communities in flood prone areas with access to timely and accurate flood warnings.

Flood warning infrastructure forms part of the Total Flood Warning System, by detecting changes in the environment that lead to flooding and feeding data into systems used for prediction. Flood warning infrastructure comprises systems that measure and monitor flood conditions in near real-time. Rain and water height sensors and cameras relay critical data and camera imagery to agencies such as the Bureau of Meteorology and councils to be interpreted and formed into warnings which are communicated to potentially impacted people including through community-facing disaster dashboards and road signage. This data also feeds into response and recovery planning.

In recent years, there has been a significant increase in the availability and deployment of alternative flood warning infrastructure by various local governments, State government departments and other utilities. The high capital and operational investment involved in installing and maintaining Flood Warning Infrastructure Standard compliant gauges, coupled with an increase in demand for timely and accurate flood warning in flash flood environments, has led to a focus of innovation on low power protocols that enable battery or solar-operated devices to send small amounts of data for years at a time. This alternative flood warning infrastructure is readily deployable, demonstrates a high degree of accuracy and reliability, and can be installed for a fraction of the cost of Flood Warning Infrastructure Standard compliant gauges.

Alternative flood warning infrastructure has the potential to complement the existing Flood Warning Infrastructure Standard gauge network to deliver substantial benefits to not only the asset owner, but to all stakeholders within the flood risk management space, including the Bureau.

Purpose

The purpose of this guideline is to assist Queensland's local governments to understand the recommended minimum requirements for the supply, installation, operation and maintenance of alternative flood warning infrastructure (rain and level gauges).

Whilst non-mandatory, the minimum requirements set out in the guideline have been informed by a technical review which involved a detailed assessment of alternative flood warning infrastructure against the Bureau's Flood Warning Infrastructure Standard 2019 as well as extensive stakeholder engagement with asset owners (local governments and State agencies), suppliers of alternative flood warning infrastructure, the Bureau and providers of flood intelligence products. Organisations and practitioners are encouraged to consider these requirements when investing in alternate flood warning infrastructure. Future grant funding approvals for flood warning infrastructure may be conditional upon these requirements.

Audience

Representatives of Queensland local governments responsible for the installation and maintenance of the flood warning infrastructure network (gauges and supporting infrastructure), are encouraged to use this guideline to assist in the procurement supply and installation), operation and maintenance of alternative flood warning infrastructure (rain and level gauges).

Consultation and acknowledgements

This guideline has been developed in consultation with, and with contributions from, the following stakeholders:

- Aquamonix
- Bureau of Meteorology
- City of Gold Coast
- Department of Agriculture and Fisheries
- Department of Regional Development, Manufacturing and Water
- Department of Transport and Main Roads
- FloodMapp
- Gravelroad Group
- Hawk Measurement Systems
- IntelliDesign
- Lixia
- Logan City Council
- Metasphere
- Ontoto
- QIT Plus
- Qteq
- Reliant Systems
- Stantec
- Sunshine Coast Regional Council
- Sunwater
- Taggle
- Townsville Regional Council
- Virginia Innovation Partnership
- Tussock Innovation
- Water Technology

Queensland's flood warning infrastructure network

Policy context

The QRA is legislatively responsible for facilitating the development of a network of flood warning gauges that complies with best practice (*Queensland Reconstruction Authority Act 2011* s10 Authority's functions).

The Queensland Flood Risk Management Framework[1] (QFRMF) reinforces these roles and responsibilities, with primary responsibility for data collection and analysis at the local level, including the installation and maintenance of flood warning infrastructure, sitting with local governments. This includes rain and river height gauges as well as supporting infrastructure to support both the Bureau of Meteorology's Total Flood Warning System and a shared situational awareness for their communities.

The Queensland Strategic Flood Warning Infrastructure Plan[2] (QSFWIP) supports Queensland communities to better prepare and respond to flood events, and improve community resilience to flood events, through development of a best practice network of flood warning gauges.

Manual 21: Flood Warning[3], produced by the Australian Institute for Disaster Resilience, provides an overview of best practice flood warning and the development of Total Flood Warning Systems.

A best practice flood gauge network relies on all components of the flood warning system to be present and integrated for the system to operate effectively. This not only includes gauges, which support the monitoring of environmental and meteorological conditions which lead to flooding, but also supporting infrastructure such as cameras and signs, which enable other critical components of the total flood warning system to be undertaken. Supporting infrastructure such as cameras and signs are not within the scope of this guideline.

Key principles

Best practice flood warning infrastructure provides the right information, to the right people, at the right time.

This guideline and the Queensland Strategic Flood Warning Infrastructure Plan are both guided by the following six key principles to deliver best practice for Queensland's Flood Warning Gauge Network.

- Supports the Bureau of Meteorology's Total Flood Warning System
- Meets the national standard for flood warning infrastructure
- Provides real-time situational awareness and suitable data for flood forecasting models and timely early warnings
- Is reliable, accurate and fit for purpose
- Is continuously improved through ongoing review, endorsed governance structures and investment in upgrades
- Is managed collaboratively for shared benefits and cost effectiveness.

This guideline is intended for ongoing monitoring and review to ensure continual alignment with asset owner needs, developments in best practice and industry innovation.

Flood warning roles and responsibilities

The National Arrangements for Flood Forecasting and Warning (2018)[4], prepared by the Bureau of Meteorology, outlines the general roles and responsibilities of each level of government in providing and supporting an effective flood warning service.

The Flood Warning Infrastructure Standard (2019)[5], developed by the National Flood Warning Infrastructure Working Group of the Australia New Zealand Emergency Management Committee (ANZEMC) (administered and led by the Bureau of Meteorology), identifies the specific performance requirements for infrastructure, sensing, collecting and communicating data for flood forecasting and warning purposes. It is used to set the minimum performance requirements for the design, development and monitoring of fit-for-purpose flood warning infrastructure in Queensland delivered by the Bureau of Meteorology.

Whilst the Bureau is responsible for the provision of forecasting and warning services for riverine flooding and provides warnings for severe weather that may cause flash flooding, the responsibility for establishing and operating flash flood warning systems lies with States and Territories in partnership with local government.

The Bureau defines flash floods as floods of short duration with a relatively high peak discharge in which the time interval between the observable causative event and the flood is less than six hours[6]. Flood management in flash flood environments can be significantly more complex than in riverine environments due to the short run time of the catchments and the unpredictability of where the intense rain will fall that will cause a flash flood. For this reason, cost-effective solutions for monitoring fast rising and moving water in urbanised environments are in demand.

1 https://www.qra.qld.gov.au/QFRMF
2 https://www.qra.qld.gov.au/fwin/queensland-strategic-flood-warning-infrastructure-plan
3 https://knowledge.aidr.org.au/media/1964/manual-21-flood-warning.pdf
4 http://www.bom.gov.au/water/floods/document/National_Arrangements_V4.pdf
5 http://www.bom.gov.au/water/standards/documents/Flood_Warning_Infrastructure_Standard.pdf
6 National Arrangements for Flood Forecasting and Warning: http://www.bom.gov.au/water/floods/document/National_Arrangements_V4.pdf

Flood Warning Infrastructure Standard

In Queensland, there are more than 3300 rainfall and river gauges that inform statewide flood warnings and forecasts. These flood warning infrastructure assets conform to the Bureau of Meteorology's *Flood Warning Infrastructure Standard (2019)* and are owned and operated by more than 60 entities including state and local government, the private sector and the Bureau of Meteorology.

The most common type of rain gauge used in meteorological monitoring is the tipping bucket rain gauge, with many tipping buckets on the market able to comply with the applicable instrumentation performance requirements of the *Flood Warning Infrastructure Standard (2019)*.

Flood Warning Infrastructure Standard level gauges utilise a bubbler system to measure the water level which detects the pressure required to force air through a submerged tube. The tube is mounted with the end of the tube below the water surface being measured and the air emerges from the bottom of the tube as a stream of bubbles. The pressure required to push air through the tube is equal to the pressure at the tube's outlet which is proportional to the water depth above the bottom of the tube. The transducer (sensor) is located at the air source, inside a field cabinet, which is installed above the flood level to avoid potential submersion.

With regards to site reliability of both rain and level gauges, the *Flood Warning Infrastructure Standard (2019)* Cl. 3.9.1.1 states 'infrastructure shall be designed to withstand and operate when exposed to hazards of up to a severity of rare'. To meet this requirement, gauges are mounted on engineered elevated platforms designed to withstand such hazards, which contributes towards the high cost associated with their deployment.

Alternative Flood Warning Infrastructure

Alternative flood warning infrastructure level sensors are usually non-contact sensors that utilise technologies such as radar, ultrasonic and LiDAR to measure water level. These technologies work by measuring the distance from the sensor to the target object (water surface in this instance). Any fluctuations in the sensor's readings can then be accurately interpreted by establishing a reference point for the water depth at that location. Using a range of wireless technologies, data from the sensor is then transmitted to a cloud-based data platform where it can be processed, analysed and accessed by the data user/s.

Alternative flood warning infrastructure sensors are generally small, lightweight, waterproof units that can be deployed using a variety of installation methods including attached to posts installed in the ground or to mounting devices that are retrofitted to existing infrastructure.

Alternative flood warning infrastructure installations are generally not considered robust enough to meet the site reliability requirement of the Flood Warning Infrastructure Standard however due to their relative low cost and on the basis that they shouldn't be the sole asset for critical warning locations, the risk of losing them during an event is more readily accepted.

There is currently no standard which applies to alternative flood warning infrastructure. As such, the following guideline of minimum requirements has been developed for alternative flood warning infrastructure (rain and level gauges) in relation to communications; data; power; installation and reporting; and further considerations.

Rain gauge station (left) and rain and river level gauge station with a flood camera (right)

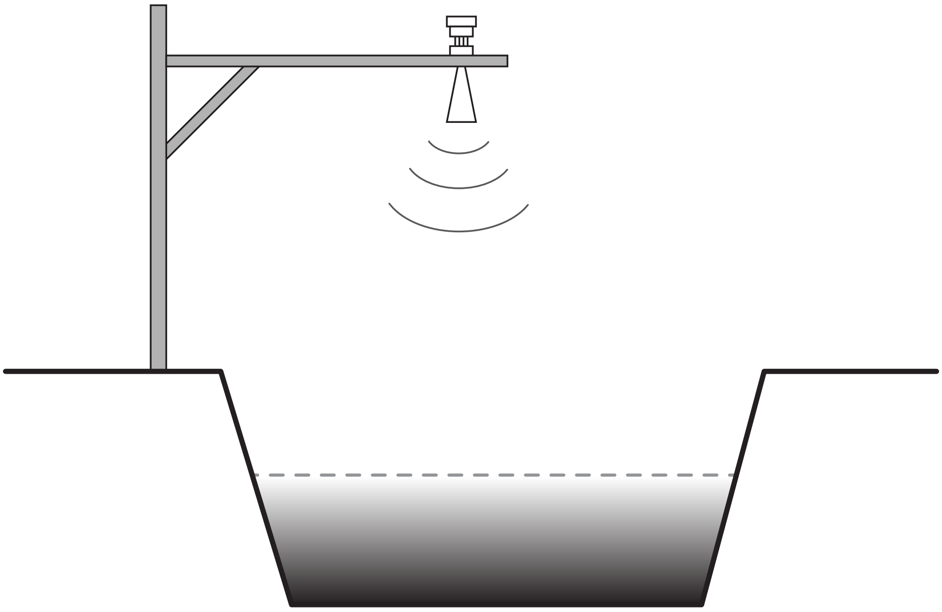


Diagram 1: A schematic description of a non-contact sensor for measuring water level (Credit: Rika Sensor)

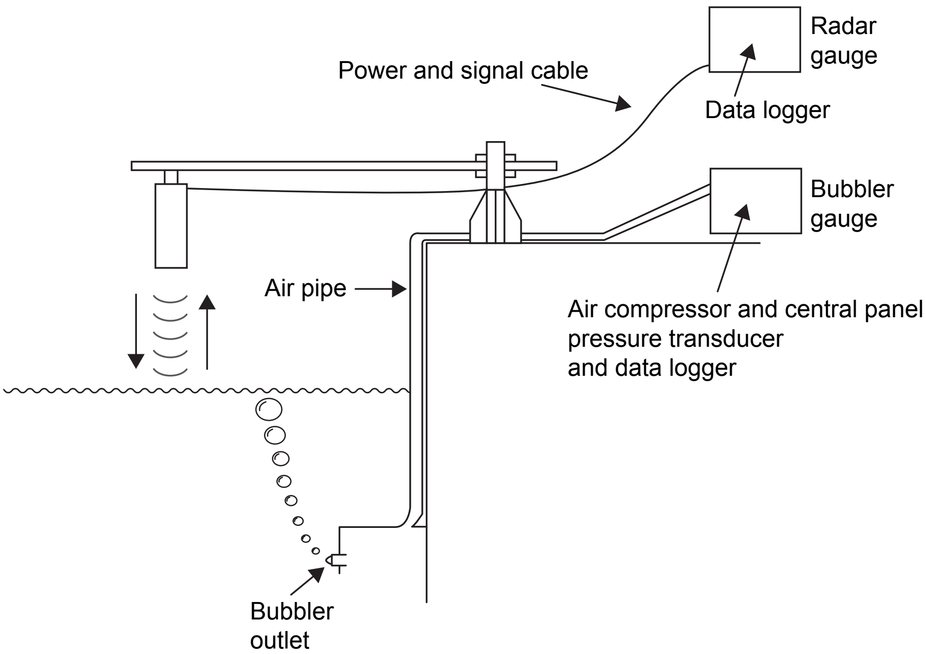
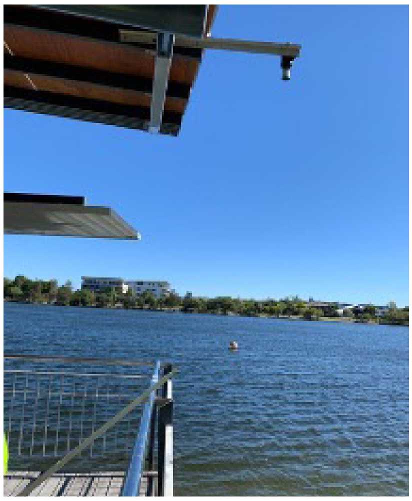


Diagram 2: A schematic description of a bubbler gauge system and example non-contact sensor system for measuring water level (Credit: Y.P.L Woodworth, David E. Smith 2003)

Radar water level sensor (Credit: Sunwater)


Radar water level sensor (Credit: Sunshine Coast Council and HiLo Level Monitoring)


Radar water level sensor (Credit: Sunshine Coast Council and HiLo Level Monitoring)


Radar water level sensor (Credit: Sunshine Coast Council and HiLo Level Monitoring)


Radar water level sensor coupled with a battery-powered data logger and solar panel (Credit: Horizons Regional Council and Metasphere)


LiDAR water level sensor (Credit: Lixia)


Rainfall gauge with pulse satellite data logger (Credit: Sunwater and Ontoto)


Radar water level sensor and data logger (Credit: Ontoto)

Minimum requirements for alternative flood warning infrastructure (rain and level gauges)

In addition to the performance-based requirements prescribed in the *Flood Warning Infrastructure Standard (2019)* (except for level accuracy and site reliability requirements), the supply, installation, operation and maintenance of alternative flood warning infrastructure will meet the following minimum requirements.

Communications

- The proposed communication modality and protocol is to comply with the rules and regulations set out by the Australian Communications and Media Authority (ACMA).
- End to end network performance is verified to ensure data is being successfully transmitted and received in accordance with the relevant performance requirements for latency, communications reliability and network reliability. For high priority sites, a wireless site survey (also known as a Radio Frequency (RF) site survey) will be beneficial to determine the most fit for purpose communications solution and redundancy options for the site.

Data

- Data is supplied to the Bureau of Meteorology in accordance with the Bureau's Administrative Instrument – Approved forms for provision of water information[7].
- Data is open and shareable with any third-party data-user agency (at no additional or ongoing cost to the asset owner) via File Transfer Protocol (FTP) or an easy to consume public Application Programming Interface (API) response format e.g. WaterML, developed by the supplier. In other words, all data shall be platform and technology agnostic.
- The asset continues to log rain/level data if communications are lost. Data is automatically transmitted or manually received from the logger when communications are re-established.
- End to end data management (sensor to data-user) is to comply with the *Information Privacy Act 2009*, Queensland Government Information Security Standard IS18 and the agency's data policies. Where a cloud provider or its hardware is in a country outside Australia, an agency's information may be subject to the law of that country. An agency planning to use a cloud provider located in another country should consider the impact of any such laws on their information.
- Data is to be continuously available and accessible to data users (i.e. 24/7/365).

Power

- The power system is capable of supplying enough power to reliably log and transmit data at the required frequency for a period of not less than two (2) years. This includes the minimum check-in heartbeat and reporting frequency during events.
- The asset supports discrete sampling. This provides confirmation to the asset owner that the instrumentation continues to operate well which is important for ingestion of data into flood intelligence products.
- The asset has a minimum IP67 rating. Instrumentation subject to potential immersion shall have a minimum IP68 rating.

Installation and reporting

- Where alternative flood warning infrastructure does not meet the level accuracy requirement of the *Flood Warning Infrastructure Standard (2019)*, at least one (1) of each asset brand/type is to be co-located with an existing Flood Warning Infrastructure Standard compliant gauge to verify sensor measurements and provide confidence in the asset's performance.
- A commissioning report containing the following information is to be provided to the asset owner upon handover:
  - » asset metadata (site and rain/level)
  - » asset details (product brand/model, serial number)
  - » asset location details (location description, GPS coordinates, measured or estimated datum)
  - » Site Acceptance Test (SAT) results
  - » transmission path test results (signal strength and data throughput)*
  - » construction and final installation photos (supplier-installed only).

  *Where applicable (desirable for high priority sites)
- A monitoring and evaluation plan is to be developed and implemented to assess the performance of the asset post-installation. Monitoring and evaluation plans should include, as a minimum:
  - » data accuracy, availability and latency
  - » site, power and communications reliability
  - » number of support requests logged with the supplier
  - » asset management (operation and maintenance) costs post-handover.

[7] http://www.bom.gov.au/water/regulations/dataFormat/document/Current_AI.pdf

Further considerations

The following should be considered and assessed on a case-by-case basis in terms of its applicability and value:

- The asset supports remote connectivity to enable adjustments to trigger levels and reporting frequencies.
- More than one communication modality for high priority or vulnerable sites (i.e. communications redundancy).
- A diversified approach to communication modality across the network wherever possible to improve overall network robustness.
- Data timestamp is in an industry-recognised format (e.g. Water Data Transfer Format or WaterML).
- Assets deployed to multiple locations within a catchment are synchronised to a single reporting timestamp.
- Data management platform service levels including descriptions, response and resolution times.
- Data security requirements including confidentiality, integrity, availability and redundancy.
- Careful consideration should be given to site selection. Factors to be considered include the feasibility for installation and maintenance, ensuring infrastructure presents no risk to public safety and the potential for vandalism. As a minimum, a risk assessment should be carried out and documented for each site to ensure risks are identified and managed appropriately.
- Consideration should be given to the physical environment in which the sensor will be required to operate in as this may influence the sensor technology best suited for the conditions. Factors affecting sensor performance may include atmospheric conditions, e.g. ambient temperature and humidity, interference from other transmitters and variability in the target surface medium, for example, grass and other vegetative sources.

Radar water level sensor coupled with a battery-powered data logger and solar panel (Credit: Horizons Regional Council and Metasphere) www.qra.qld.gov.au

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