SIYTE for Remote Flood Monitoring

Impact of Extreme Weather

Extreme weather is a growing issue, causing flooding, instability and delays in operations at a growing frequency. Many organisations have a requirement to develop long term strategies to adapt to extreme weather conditions.

A significant challenge with sensing and camera systems is the ability to record and visualise data remotely and in real time, given the challenges of connectivity and power at remote locations and frequently siloed monitoring solutions. Assessing conditions as a 'whole system' often means people going to site, which has safety, financial and carbon impact.

Given the breadth of effects of extreme weather, there is no one single detection system. The disparate sensing systems in use provide dashboards and produce alerts in different formats, often requiring technical knowledge. This complexity hampers response, with data often inaccessible or hard to understand for extended teams and mobile responders.

Contents

Solution Overview: SIYTE for Extreme Weather Insights & Alerts

SIYTE Data Aggregation

SIYTE combines analytics from cameras, sensors, process control equipment and third-party data via APIs to allow for full situational awareness of remote locations that are liable to flooding.

Cameras provide situational awareness, which can be further enhanced with machine vision for water level, blockage and water flow detection. SIYTE integrates with almost all manufacturers, using standard protocols such as ONVIF and RTSP, consolidating all existing security CCTV cameras into the SIYTE dashboard. Where CCTV cameras are not correctly oriented, specific flood detection infill cameras can be recommended.

IoT Sensors use low power, long-range wireless technology for easy deployment in hard to access locations. Battery-powered sensors can last up to 10 years and provide readings hourly or even more frequently. There is a wide variety of sensors on the market, covering a wide range of use cases. For flood monitoring, typically water level, water detection, water flow, weather monitoring and power usage sensors are used. SIYTE is extremely scalable and after deployment, it is easy to add sensors for additional use cases, maximising the investment in the infrastructure.

Another source of data that is often overlooked, is the data that resides in process control systems and PLC devices, used to control pumps and sluice gates. SIYTE can support a read-only integration into these to visualise this data that is generally not available – enabling it to be correlated with data from other systems.

As well as integrating newly deployed IoT sensors, SIYTE can also integrate with existing sensor deployments. One example is BlueSiren, who provide integrated wireless environmental monitoring solutions that include snapshot images.

Finally, SIYTE can extract data from 3rd party and public data sources such a weather forecasts, rain fall, train times or other publicly available data.

SIYTE Data Visualisation

All data sources are combined into a single platform that reduces complexity for stakeholders, from asset engineers to Route Control, by providing:

- Consolidation of camera, sensors and other data sources into single “whole system” dashboard views, adapted to different stakeholder needs.
- Situational awareness for remote sites, accessible both on desktop and mobile devices, providing information as disperse as pumps, water levels, gate status and air quality.
- Insights across multiple data sets, combining analysis of data from sensors, APIs or machine vision – to enable better insights and predications for flooding events.
- Historical baselining of data so that normal operations can be distinguished from anomalous events.

SIYTE Data Alerting

SIYTE is also a real time, multi-channel alerting platform that can alert staff to events requiring action. Using SIYTE’s in-built workflow engine, alerts can be based on any combination of sensor, API or machine vision criteria, and be sent via email, SMS, mobile app or into another monitoring system, such as MICA:

- Reduce complexity for responders: Aggregate alerts into one simple format.

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- Provide context with alerts: Provide camera images and public data (e.g. tide levels or weather predictions) alongside sensor data with alerts.

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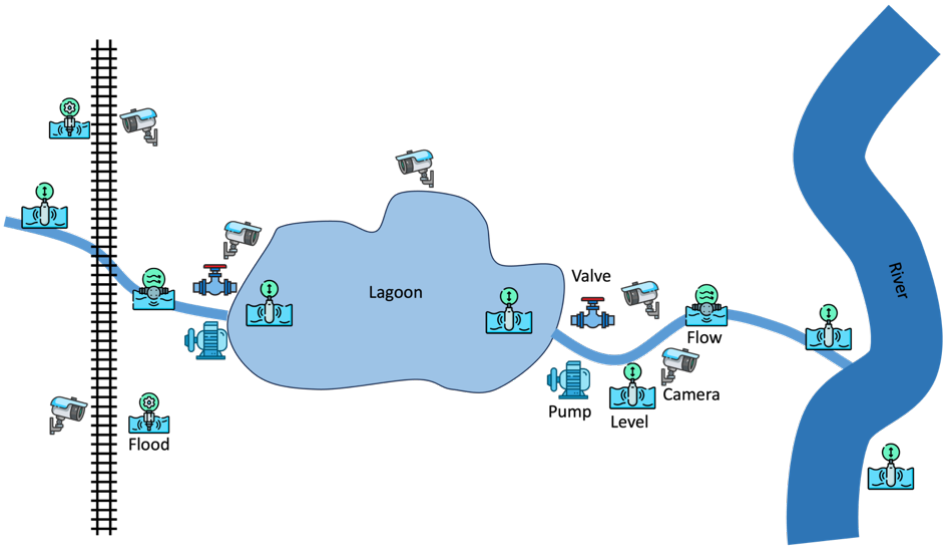
SIYTE Case Study

A typical example of a deployment is the Network Rail Chipping Sodbury case study published here.

Water is pumped into the lagoon, the catchment area for water that would flood the tracks. This is then pumped into the local water course, when the river level is below a threshold.

As illustrated in the diagram, IoT sensors monitor the water level of the lagoon, tributaries and river at



multiple points. Water levels relative to the rail head are also measured at multiple places to indicate if there is potential track flooding. Sensors and PLC integrations also monitor pump activity, duty cycle and flow rate.

Snapshot cameras give situational awareness with an image retrieved every hour - and real time CCTV cameras are used for the critical locations such as the pumps.

All camera and sensor data are aggregated into a single view on the SIYTE dashboard, enabling asset teams and operators to gain a "whole system" view.

Camera views can be refreshed on demand on the dashboard, with SIYTE rate limiting access to solar powered cameras to preserve battery life.

All of this has enabled asset teams to gain a "whole systems" view for the first time to better understand the operation of the system. After 4 months of deployment, this has already been estimated to have enable asset teams to avoid 11,000 in delay minutes.

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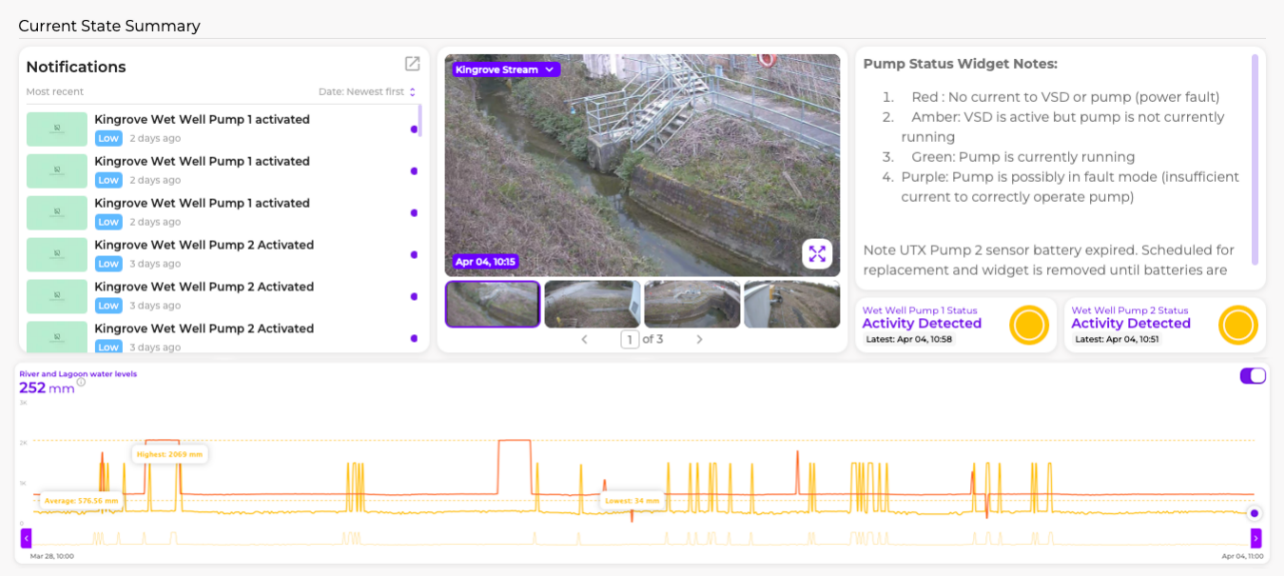


Solution Detail

LoRaWAN for Low-Cost Sensor Connectivity

Achieving complete situational awareness requires both sensors and cameras. In many locations, deploying cables, networks and power access can be a challenge, so we use long range, low power radio technology extensively for sensor deployments. These sensors have very long battery lives and can be essentially “fit and forget” devices.

The radio technology being used is LoRaWAN, a low-power, wide-area networking (LPWAN) protocol based on LoRa modulation, designed for long-range, low-bandwidth communication over large distances. It enables devices to transmit data efficiently with minimal power consumption, making it suitable for applications like IoT sensors and smart city infrastructure.

Key LoRaWAN Features and Components:

Long Range & Low Power: LoRaWAN uses a low frequency (863–873 MHz) wireless network that enables communication over several kilometres while minimizing energy consumption, allowing devices to operate for extended periods on battery power.

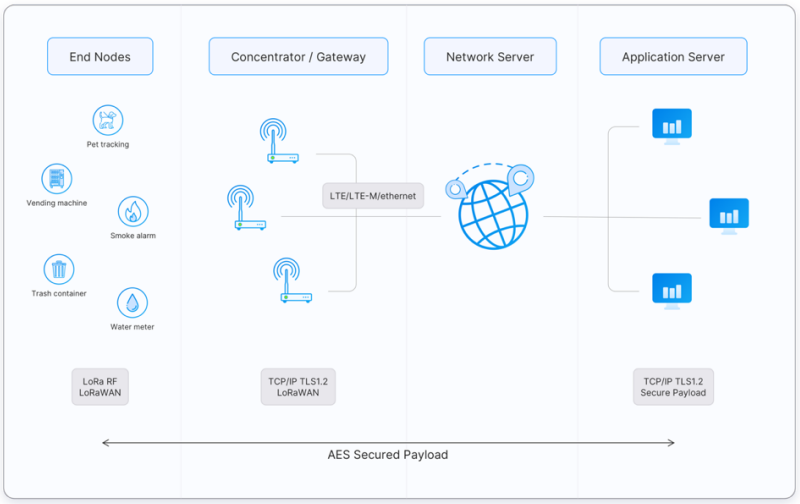
LoRa is a physical layer technology that allows for long-range, low-power communication using a spread spectrum technique. The network protocol builds on top of LoRa, defining how devices communicate and access the network.

End Devices (LoRa or LoRaWAN IoT Sensors): These devices transmit data to gateways, typically collecting data from sensors.

LoRaWAN Gateways: Gateways receive data from end devices and relay it to a central network server.

LoRaWAN Network Server (LNS): The network server manages the network, handles authentication, and forwards data to application servers.

Application Server: This processes and analyses the data received from the network server.



In this architecture, SIYTE acts as an Application Server, processing the data received from sensors. Purple Transform can also manage both the LoRaWAN Network Server and LoRaWAN Gateways for our clients as required.

Environmental Sensors

If there are no existing sensors or the existing sensor network needs expanding, the following sensors are typically used for flood and water management:

1. Water Level Monitoring using Ultrasonic sensors

We use various ultrasonic and submersible level sensors depending on requirements. These are designed for distance or level detection in harsh environments and are ideal for use in outdoor applications like flood monitoring, tank monitoring, manhole cover monitoring, etc. They feature:

- Accurate Non-Contact Detection with Ultrasonic Waves
- Wide Measuring Range and Multiple Probing Options
- Exceptional IP67 Rated Performance and UV Resistant
- 10 Years Long Battery Life

2. Water Flow Monitoring sensors

We use a compact, easy-to-use system for measuring the velocity and depth of water in drainage channels, large pipes, in rivers and streams.

It is suitable for use in a wide range of water qualities, from sewerage and wastewater to clean streams, potable water and even sea water.

The instrument can measure forward and reverse flow conditions and may be programmed to compute Flow Rate and Total Flow in pipes and open channels.

The device combines an ultrasonic transducer assembly (profiled to reduce flow disturbance) with signal processing electronics. It is designed to be placed at (or near) the bottom of a water channel for "upward looking" measurement. A single cable connects the instrument to the power and LoRaWAN communication device

Water velocity is measured by suspended particles or small air bubbles in the water to reflect the ultrasonic detector signal. Water depth is gauged by a hydrostatic pressure sensor, referenced to atmospheric pressure through the vented power and signal cable.

Water temperature is also measured so the instrument can adjust for the change in velocity. Water temperature can also be logged.

3. Pump Power usage using Current Sensors

The wireless single-phase current detector is used to detect the input current to the motor or variable speed drive. This gives both the idle and active current for these drives.

Three phase sensors can also be used but a single phase allows for the detection of motor activity and increases battery life. The device uses a split core current clamp meaning installation is not invasive.

4. Solar-powered Weather Stations

The all-in-one wireless weather monitoring system is used for various atmospheric conditions, such as temperature, humidity, wind speed, wind direction, barometric pressure and rainfall. The device is solar powered with an internal battery.

The weather station is designed to withstand the most challenging weather conditions and is easy to install in different scenarios to be widely used in meteorology, environmental monitoring, smart building, etc.

5. Connectivity to Industrial control PLCs

For PLC connectivity we can support various connectivity methods using Modbus. Due to PLC locations normally having power, we use powered sensors to connect to these PLCs.

However, for these remote locations there may not be a communications network available. As such we can use a LoRaWAN IOT controller to connect to the Modbus PLC via a serial port. This enables connectivity for hard-to-reach assets without any significant increase in power budget.

We can also use 4G devices to connect directly to the Modbus PLC, either via serial or TCP.

To preserve the integrity and security of the process control system, the devices are only capable of reading the registers and exporting the data as metadata. No control is possible.

The device will typically sit alongside the PLC in the control cabinet and be powered by 24 Volt DC.

The integration into this process control system allows visibility into the pump management, the duty cycle of the pumps and the sensor data that is driving the pump decisions (such a level).

This enables better situational awareness and can allow better planning of pumping scheme based on a wider data set.


```
{
  "payloadType": "Telemetry",
  "device": "PLC1",
  "timestamp": "2025-04-15 11:30:03.931437",
  "cabinet": false,
  "button1": false,
  "emergency": true,
  "interlock1": false,
  "Button2": false,
  "Button3": false,
  "Level": 458754
}
```


Cameras

The use of cameras for situational awareness is very beneficial and can be used to support decisions, give context to sensor location and readings. These can also be used for machine vision - object detection and image analysis.

There are three types of cameras typically used.

- Existing cameras that are deployed at these sites for security
- Solar, situational awareness snapshot cameras
- Dedicated CCTV for condition monitoring

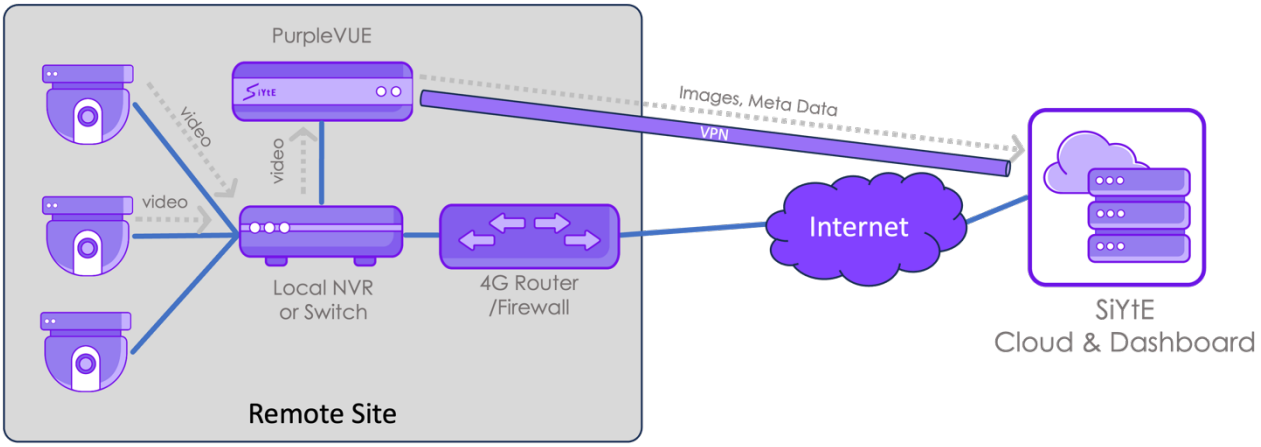
1. Existing Cameras

These are typically existing CCTV cameras used for security that have already been deployed at the site. They are often not smart cameras and may even be analogue. The position may be for trespass and intruders rather than for monitoring the environmental conditions or flood detection.

However, they can still be valuable for situational awareness and general location monitoring or visibility, if integrated into the SIYTE dashboard.

They may also not have any network connectivity and may also run as a closed system with an NVR (Network video recorder) to record the manage the cameras.

As such we integrate into existing CCTV systems using the PurpleVUE (Purple Virtual Unified Edge) which allows metadata and snapshot images to be extracted and displayed as part of the monitoring dashboard alongside sensor data.



The PurpleVUE device is a lightweight node that can communicate on both the LAN and WAN and has built in security and VPN technology to ensure data is not compromised.

It should be noted that camera access in SIYTE is via snapshot images, each one of which is redacted to remove any personally identifiable information of people in the image. Snapshots can be requested through the SIYTE dashboard and these requests can be rate limited for solar cameras.

2. Remote Solar Situational Awareness Snapshot Cameras

These cameras are used for visibility into specific areas, such as drains, aquifers, pumping sites or overflows. They are typically in hard-to-reach areas and have no power or connectivity to the local communications network.

As such these are low powered cameras using batteries and solar power. These cameras take snapshot images, taking an image at a set interval, when triggered or when requested by the SIYTE platform.

They do not take continuous video footage due to the low power requirements. Whilst solar video cameras are available and can be used, they are more expensive and require larger solar panels and batteries and are thus also more expensive to install and maintain.

These snapshot cameras have become more sophisticated in recent years and come equipped with a highly advanced image sensor that can deliver high-quality images for a range of scenarios. They have embedded low-consumption radar, PIR sensors and noise sensors which provide greater sensitivity for object detection.

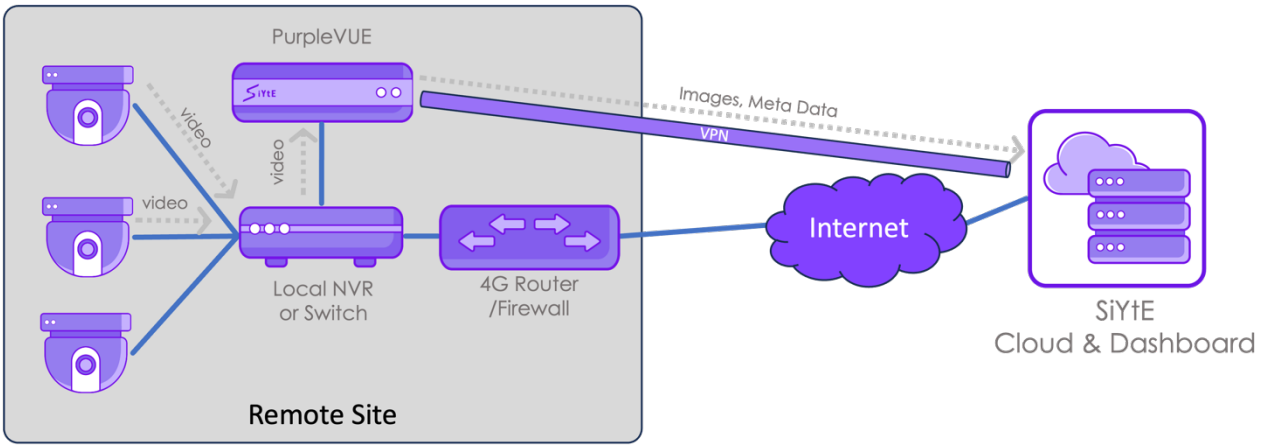
The device is connected via the 4G network and transmits data using MQTT(S) publish subscribe mechanism.

3. Dedicated CCTV for condition monitoring

Where enhanced visibility or real time analytics is needed, SIYTE supports the use of dedicated CCTV cameras. These are likely to be high resolution, and/or high frame rate cameras that are used to monitor the site in real time. Due to their capabilities, it is also possible to run enhanced computer vision capabilities at the edge using PurpleMV (Purple Machine Vision). This can provide real time video analysis using dedicated models for situations such as flooding, overtopping, flow detection, blockages as well security use cases such as trespass and vandalism.

SIYTE can utilise both the Smart Cameras object detection capability as well as the additional machine vision capabilities that PurpleMV is providing to give a complete real time view of the location. As the protocols used are standards such as RTSP and ONVIF the solution supports multiple camera

manufactures. Purple can also recommend cameras that we have worked with and used for similar solutions in the past.



Water Flow monitoring using Optical Flow Analysis (Roadmap)

An upcoming capability is to use these smart cameras with high resolution sensors for non-invasive water flow analysis using machine vision.

Using this technology, using CCTV cameras deployed for situational awareness, SIYTE can infer the water flow based on the pixel movement of the water. Combining this with water level data and an understanding of the water course enables SIYTE to infer the water volume flow rate. This is easier to deploy than traditional in-river sensors and also gives additional data points.

3rd Party Monitoring

Many at-risk sites have existing sensors and cameras deployed. However, these are often on different silo'd dashboards that do not offer a simple user experience or combined views of data, thus making it harder to make the appropriate decisions.

The SIYTE platform can integrate with many different systems. If sensors and devices are connected locally, this can be supported using the PurpleVUE edge platform by integrating the data at the remote site.

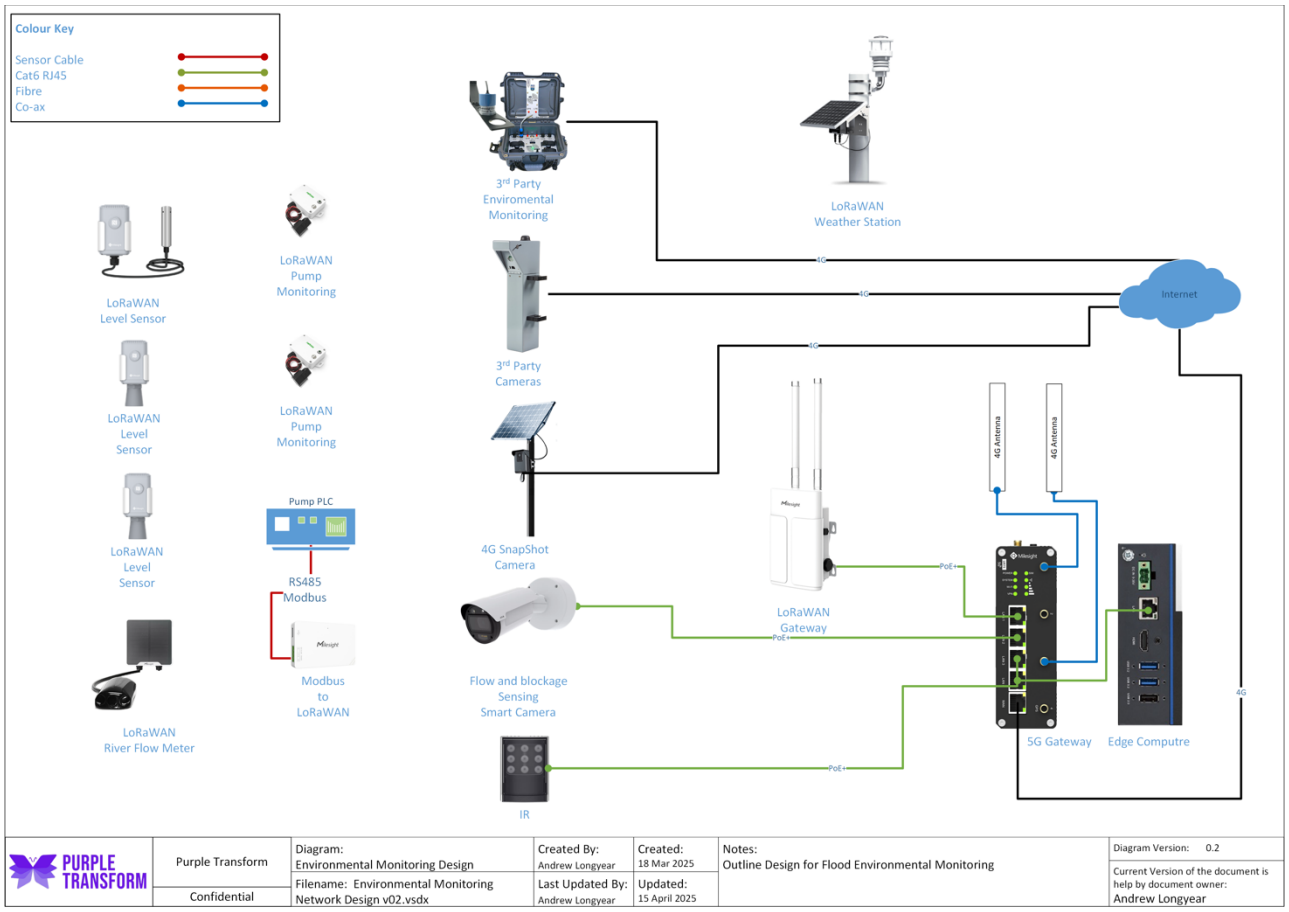
SIYTE can also integrate with cloud-based platforms with APIs, giving a single comprehensive view across multiple sensors, cameras and process control systems from multiple providers.

The following are example integrations

- Meteor Communications Cameras (including partners such as Aquasition)
- BlueSiren Cameras (both their multiple sensor types and cameras)
- Senceive Environmental Monitoring

Architecture Overview

The architectural overview can be seen in the diagram below. This shows the components discussed in this document and where they sit in the solution architecture.

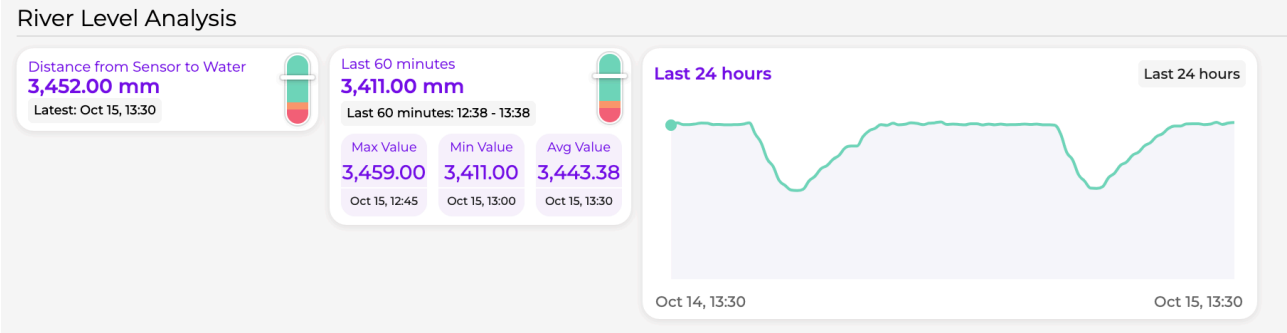


As well as the components already detained in this document, local network components and 4G/5G gateways may be needed for a complete solution. Also, note that the 3rd party monitoring and camera systems typically use their own 4G gateway.

Additional Example Use cases

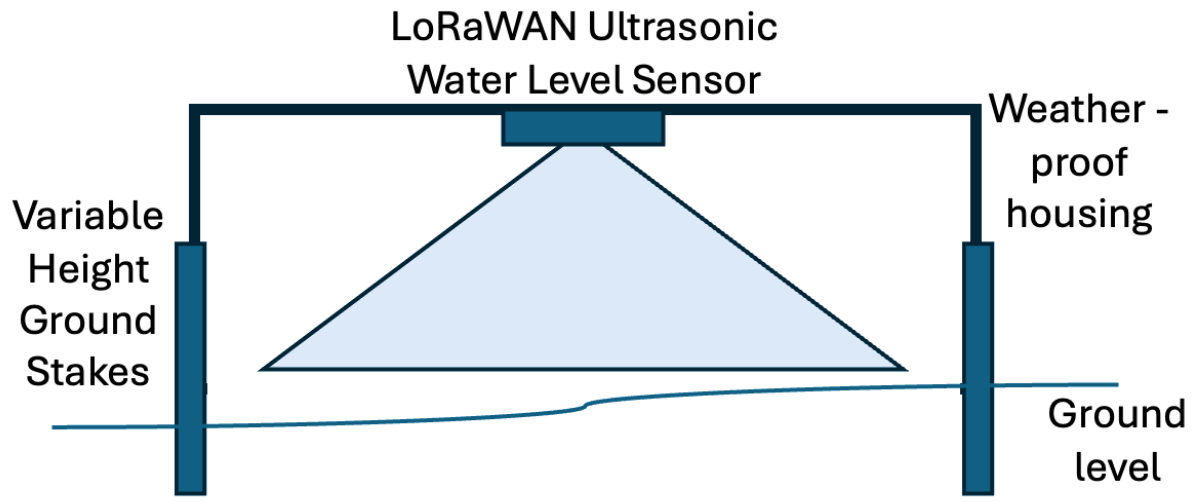
SIYTE for Under Bridge Flooding Detection

PT have utilised LoRaWAN connected sensors for under bridge flooding which can be used to monitor and alert of water levels, alerting when thresholds are reached – providing responders with an ability to monitor water levels, access camera images and also receive information on tidal levels in a single dashboard, in the office or at site.



SIYTE for Surface Water Flooding Detection

PT's LoRaWAN surface water flooding sensor is housed in a weather-proof housing which is staked to the ground and provides water level measurements using an ultrasonic sensor.
This can be positioned wherever appropriate and raised or lowered to ensure measurements calibrated to the appropriate height (such as relative to the railhead). If the sensor is moved or becomes misaligned in any way, the in-built tilt sensor will also alert operators.
As this sensor is not just measuring the presence of water, it can highlight the rate water is rising, predicting if, and when, it will reach the safety impacting heights.



It can also be mounted on existing infrastructure such a masts, cabinets or fences and calibrated to account for the additional height of these assets.
PT will combine this with camera analytics (using existing or new cameras) to detect flooding, subsidence and rockfall detection.

Ordering Information

Package 1: New Flood Risk Site

Deploying a new site one specific monitoring location such as a drain grate or overflow. Level sensors used to monitoring drain as well as upstream and downstream points.

1) LoRaWAN Gateway – Milesight UG67 x 1
2) Ultransonic Level Sensors – Milesight EM500-UDL x 5
3) SnapShot Cameras – Milesight X5 x 1
4) SIYTE LoRaWAN Network Server and Gateway Management x 1
5) SIYTE Sensor license x 5
6) SIYTE Camera License x 1
7) Solar Option is not power available

Package 2: New Pumping station Flood Risk Site

Deploying a new site one specific monitoring location such as a PLC pumping site with dual pumps. Level sensors used to wet well as well as upstream and downstream points.

1) LoRaWAN Gateway – Milesight UG67 x 1
2) Ultransonic Level Sensors – Milesight EM500-UDL x 6
3) Current Sensors – Netvox R718N17 x 2 (None PLC)
4) Modbus Sensor – Milesight UC100 x 1 (PLC Option)
5) SnapShot Cameras – Milesight X5 x 2
6) SIYTE LoRaWAN Network Server and Gateway Management x 1
7) SIYTE Sensor license x 8
8) SIYTE Camera License x 2

Package 3: Existing Flood Monitoring Site using 3rd Party Sensors

Monitoring cameras and sensors from multiple vendors across one site. This assumes that the 3rd party devices have connectivity

1) SIYTE 3rd Party Integration License x 1
2) SIYTE Sensor license x 10
3) SIYTE Camera License x 2

Package 4: Situational Awareness CCTV Integration

Deploying a site with existing CCTV to monitoring location such as a drain grate or overflow. Level sensors used to monitoring drain as well as upstream and downstream points. This assume that there is network and WAN connectivity at the remote site.

1) LoRaWAN Gateway – Milesight UG67 x 1
2) Ultransonic Level Sensors – Milesight EM500-UDL x 5
3) PurpleVUE Edge Node x 1
4) SIYTE LoRaWAN Network Server and Gateway Management x 1
5) SIYTE Sensor license x 5
6) SIYTE Camera License x 2

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