# SWARM Buoys - Real-Time Water Quality Monitoring in Reservoirs

Internet of Things Alliance Australia – Water Workstream
In partnership with Water Services Association of Australia

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**Background**

Water quality in Australian reservoirs, lakes and rivers is impacted by multiple events such as floods and algal blooms. These water quality variations can be exacerbated in Summer due to intense biological activity in Australian water bodies. The overall effect of these events could put a greater pressure on downstream water treatment plants and have an impact on public health and safety when water bodies are opened for recreational purposes.

It is therefore critical to monitor the water quality of these water storages, preferably in real time even if they are difficult to access and remotely located. In this context, Veolia designed and developed the 'SWARM buoy', a device that monitors water quality in real-time while requiring a minimal amount of maintenance.

**Challenge**

Continuously monitoring water quality in remote locations can be challenging in practice and costly if performed manually. When designing the SWARM buoy, it was therefore necessary to address the following aspects:

- **Energy self-sufficiency**: Considering the high energy needs for data collection and transmission, relying on a battery without recharging ability would have led to high maintenance needs. The device therefore had to be energy self-sufficient.
- **Low maintenance needs**: The different sensors must be operational without any manual cleaning for several months to minimise the frequency of maintenance operations. This was particularly challenging for UV and turbidity which can only be measured by optical sensors.
- **Real-time data communication**: Lakes and reservoirs of interest are typically in remote areas where communication networks are generally weak.
- **Rough conditions:** The device is exposed to difficult weather conditions (storms, floods, etc.) and continuously in a water environment.
- **Maintenance from a boat:** As the buoys often need to be positioned in the middle of large water bodies, maintenance operations are usually performed from a boat. The device needed to be adjusted to these challenging practical conditions.
- **Degradation:** Because lakes and reservoirs are often used for recreational purposes, the device is in direct contact with populations and this can lead to interference.

**Drivers and Enablers**

The ability to determine changes in the quality of raw water sources in a timely manner can be critical for maintaining and optimising downstream water treatment. Veolia came across multiple challenges regarding water quality monitoring, often undertaken manually at a frequency of a few times per week or less, and costly to build and operate. Today, the ability to determine changes in water quality soon after they have occurred allows water treatment processes to be adjusted in advance if water quality deteriorates and avoid critical situations.

In some locations within Australia, fixed measurement upstream of water treatment plants can provide a level of 'automated' monitoring on specific locations even if it does not monitor the entire catchment. The SWARM buoy was designed to replace manual catchment monitoring and fixed location monitoring stations to make significant financial savings.

Multiple technical innovations enabled the development of the SWARM buoy device:
- The general extension of the 3G/4G network coverage;
- The appearance of reliable sensor technologies on the market: optical dissolved oxygen, Chlorophyll, etc;
- The development of the Veolia R&D department of optical probes through Neroxis, its dedicated business unit.

The SWARM buoy installed in the Malmsbury Reservoir (managed by Coliban Water, Victoria) in May 2018 was the first device installed outside of France. This partnership with Coliban Water was a great opportunity to test the device in Australia.

**Solution**

The SWARM buoy has 4 main components:
- An energy module composed of solar panels and a windmill connected to a battery to ensure energy self-sufficiency;
- Up to 6 low-maintenance water quality sensors of different types;
- A communication module which continuously transmits collected data through the 3G/4G network; and
- A mechanical structure able to resist outdoor conditions and ensuring buoy floatation.
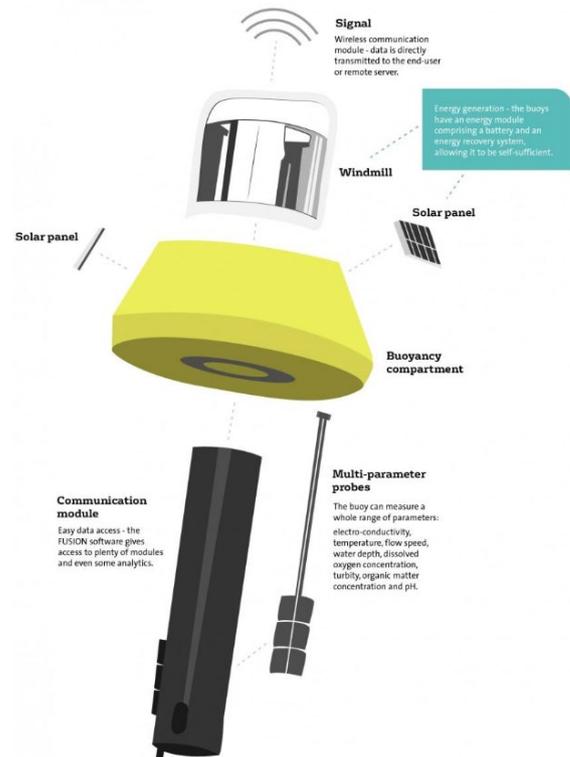
The collected data is accessible in real-time through the SWARM buoy web portal. The device also includes an anchor to maintain the buoy at the same location. The purpose of the SWARM buoy is to measure the water quality in remote locations (i.e. which cannot be easily accessed), so the device was designed for a low level of maintenance. In practice, only 3-4 maintenance operations are required per year.



The SWARM buoy was designed to ensure that most maintenance operations can be done from a boat or river/reservoir banks, in particular:
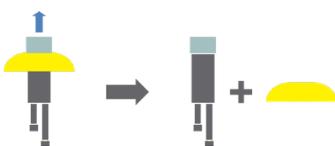


**Dismounting the core**
The core of the buoy (containing the communication module, the battery and the sensors) can easily be dismounted from the buoyancy compartment, which facilitates the sensor maintenance/replacement.
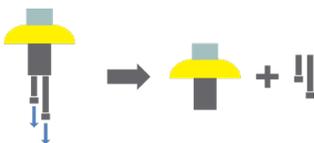


**Connecting the sensors**
All the water quality sensors were designed in house as "plug-and-play" devices: connecting them on and off the buoy core is easily done manually.

The data collected by the SWARM buoy is used for two applications:
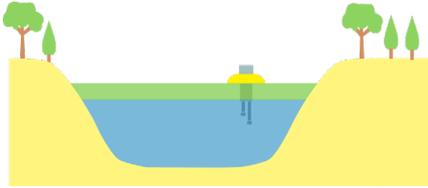
**Algal bloom early-warning**: The SWARM buoy can be used to track daily fluctuations of dissolved oxygen which can be an accurate proxy of the algal concentration. This early warning device can therefore also be used as an autonomous, connected and communicating water quality monitoring station to inform citizens on the quality of bathing water provided when reservoirs are used for recreational use. This capacity to monitor algal blooms in real time will be further strengthened with the additional Chlorophyll-Phycocyanin probe (currently being tested with Goulburn-Valley Water in the Waranga Channel).
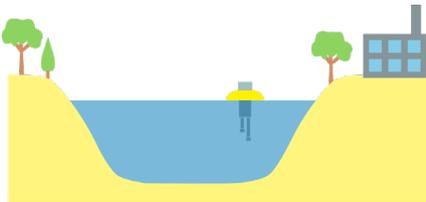
**Downstream water treatment optimization**: The measurements collected by the SWARM buoy can be used as an early-warning system to predict future water quality at downstream water treatment plants. For example, predictive models can use the real-time measurement of turbidity from the buoy combined with weather conditions and turbidity at the plant to predict how the turbidity at the plant will evolve in the coming days. Such information can be used to optimise water resource management.

## Benefits (to utility and customers)

**Public health**
The continuous monitoring of water quality helps ensure waterways across Australia are safe for people to use, whether for swimming or as a raw water source.

**Process efficiency**
The real-time collection of water quality data allows adjusting water treatment processes, hence smoother operations, by tracking pollutant emissions in waterways to inform run of river water treatment plants of when to stop pumping water due to contamination, or to optimise the running of treatment plants downstream of reservoirs.

**Reduce costs**
The anticipation of algae blooms upstream of a water treatment plant can be used as an early-warning system, assisting with early intervention and potentially reducing the amount of chemicals used for the water treatment process, resulting in financial savings.

**Learnings**

**Technical learnings**

Following the first implementation of the SWARM Buoy device in Australia, several learnings have arisen in terms of data transmission, device reliability in local conditions, maintenance requirements and technology dependency.

**98% of data collected**

The rate of successful receipt of transmitted data was 98% since the installation of the device in May 2018 to present. This met the project requirements and demonstrated compatibility between the transmission module and the Australian 3G/4G network.

**Material resistance**

One optical sensor (UV/Turbidity probe) initially installed on the buoy was not reliable enough to meet Australian lakes local conditions. Additionally, the plastic material used for the windmill did not resist the high strength of UV light in Australia. Hence, both materials were upgraded accordingly.

**5 Operations of maintenance in 18 months**

Maintenance operations proved to be required more often during Summer in Australia due to intense biological activity in Australian open water bodies. Based on this, the following schedule of maintenance was put in place: November, January, March, June and September. These 5 maintenance operations per year prove that maintenance requirements were lower than alternative solutions. In practice, these maintenance operations were completed in less than 2 hours and did not cause any major practical challenge.

**3 Software updates… by SMS!**

The data collection and transmission software system installed on the buoy was proven to be easily manageable. Software packages updates were easily made remotely by the SWARM Team in France.

**Data analysis applications**

Two applications have been developed:

**1. Real-time detection of algal blooms**

The Chlorophyll/Phycocyanin probe is still being trialled, so the dissolved oxygen probe was used as a proxy to detect the presence of blue-green algae in water. Blue-green algae produce oxygen through photosynthesis when exposed to sunlight and this results in diurnal dissolved oxygen concentration fluctuations. Typically, the higher the magnitude of these fluctuations, the higher the algal concentration (see Appendix A).

Veolia partnered with Massey University (Palmerston North, New Zealand) to build a mathematical model to convert these dissolved oxygen fluctuations into algal concentration. The model is currently being validated with the support of several water utilities in Victoria.

## 2. Downstream water treatment optimisation

Veolia operates the Castlemaine water treatment plant at the McCay Reservoir, which is fed from the Malmsbury Reservoir.

Turbidity in the McCay Reservoir significantly varies with time, with regular peaks above 15 NTU (see Appendix B). Chemical dosing must be increased during these peaks to ensure good flocculation conditions. This can in turn significantly increase operational costs.

The turbidity in the Malmsbury Reservoir is one of the main factors impacting the downstream turbidity in the McCay Reservoir. Other factors were found to have a significant impact including the McCay Reservoir water level, wind speed and rainfall.

Given the complex mechanisms involved in the fluctuations of turbidity in the McCay Reservoir, an artificial intelligence model was built to predict how the turbidity in the reservoir varies as a function of other parameters. The model is relatively accurate and could be used to operate the connection channel between the two reservoirs (see Appendix C).

## Next steps

The SWARM buoy was shown to be reliable and the collected data can be used to address the needs of Australian water utilities. Based on this, a wider deployment of SWARM buoys is proposed at key locations across Victoria, with the objectives:
- To fully validate the mathematical model converting the dissolved oxygen measurements into a real-time estimation of the algal concentration;
- To investigate how water treatment of downstream plants can be optimised by combining the real-time data collected by the buoy and modelling/artificial intelligence approaches.
- To evaluate a new pH probe currently in development by Veolia R&D team.

## Partners

**Veolia**: World's largest supplier of water, waste and energy services for municipal and industrial clients.
**Coliban Water**: Regional water corporation operating across North-Central Victoria.
**Goulburn Valley Water**: Urban water corporation operating in Victoria's Hume Region.

**References**

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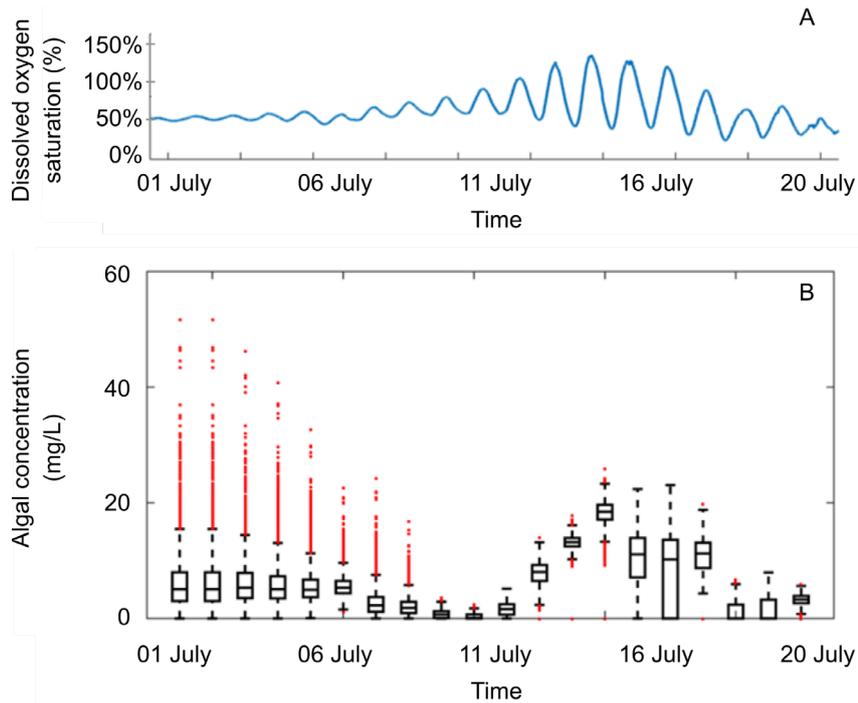www.veolia.com



www.iot.org.au



www.wsaa.asn.au

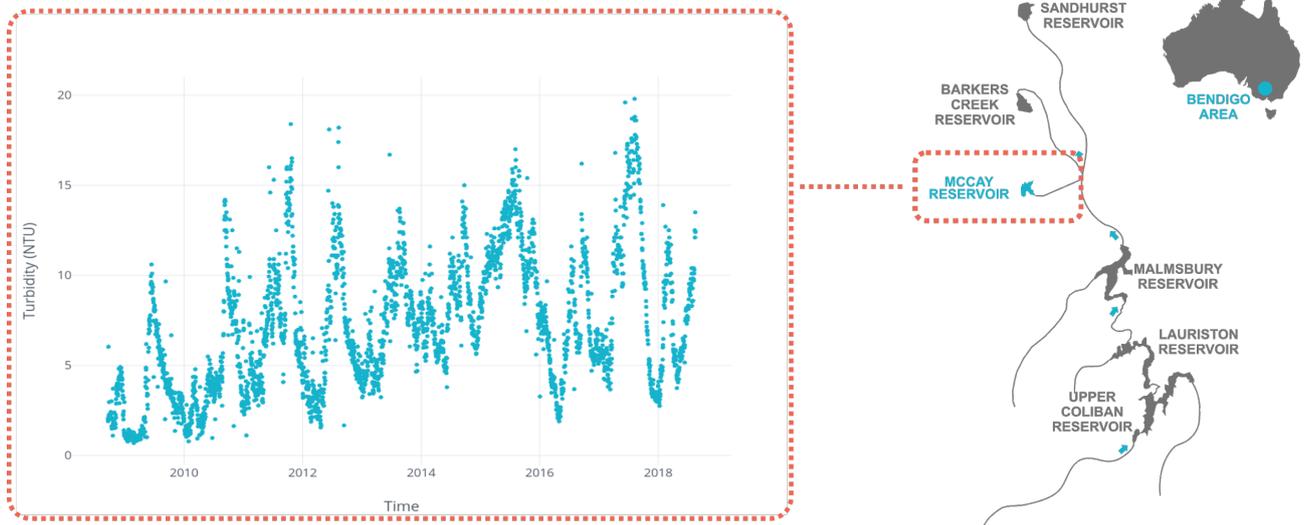

www.coliban.com.au



www.gvwater.vic.gov.au

**Appendices**

**Appendix A – Real-time Detection of Algal Blooms**



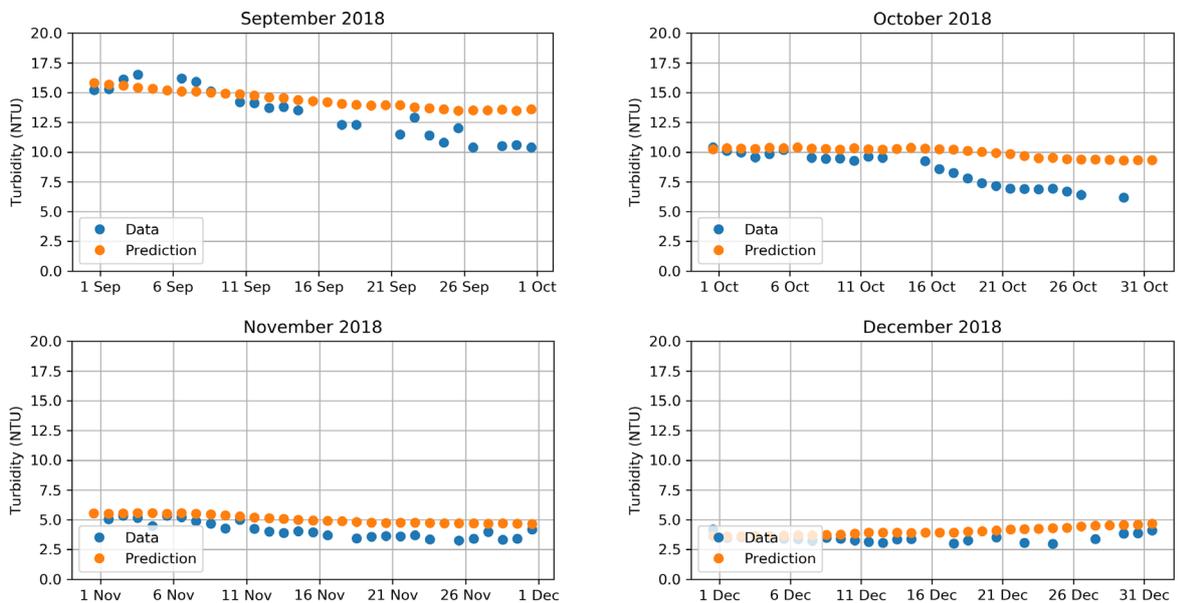Results of the mathematical model implemented to convert oxygen fluctuations measured by the SWARM buoy (top) into an algal concentration (bottom).

## Appendix B – Turbidity in the MaCay Reservoir



Evolution of the Turbidity in the McCay Reservoir, located downstream of the Malmsbury Reservoir

## Appendix C – Predicted and Actual Turbidity in the McCay Reservoir



Comparison between the predicted (Orange) and the measured (Blue) turbidity in the McCay Reservoir over in late 2018.