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SLUDGE SENSING AT KENILWORTH STP

Winner of the Best Paper Overall at the 2019 WIOA Queensland Operations Conference

Cale Maclean, Anthony Smith and Ramraj Kulkarni

Operators of Waste Stabilisation Ponds (WSPs) often find themselves in a "blindspot" regarding sludge formation in the ponds. Sludge formation is invisible since it occurs well below the pond water surface. While the accumulation of sludge is a slow process, its removal is time consuming, messy and can be very expensive. It can also lead to lengthy disruptions of the treatment process. The rate of sludge accumulation and volumetric measurements are therefore essential from a maintenance and budget perspective.

The Kenilworth STP is a small (350 equivalent persons) plant located in the Sunshine Coast Hinterland consisting of two facultative ponds followed by a maturation pond. The ponds were de-sludged and re-lined in October 2010 at a cost of $460,000. A total of approximately 6,600 m^3 of sludge was removed from the three ponds. There was a significant discrepancy between the surveyed sludge volume and actual volume removed (38% increase). Unitywater needed to improve the efficiency and accuracy of sludge measurements to better assist in the decision-making process on when sludge removal should be conducted and to more accurately budget for the work.

In an attempt to obtain better data for future management, a sludge survey was undertaken in the maturation pond in October 2018, trialling the Cerlic Multitracker and Blanko Sensor (Figure 1).

The optical sensor is designed to measure suspended solids, temperature and sludge blanket level, while the Multitracker logs a profile of Mixed Liquor Suspended Solids (MLSS) versus pond depth as the sensor is lowered down through the water column into the pond.

The specific purpose of the trial was to:

- Measure the "fluff" layer on top of the settled sludge and the higher suspended solids concentrations below.
- Produce a profile of pond depth and sludge depth.
- Estimate the sludge blanket level, including its depth.

In the trial, two MLSS set points were adopted: the first representing the "fluff layer" and the second representing the top of the "sludge blanket". The threshold concentrations were set at 500 mg/L for the "fluff layer" and 5,000 mg/L for the "sludge blanket". For the purpose of the survey, the sludge blanket threshold concentration was considered most important, as it represented the top of the sludge layer that was of interest.

The Multitracker has built-in audio and vibration alerts when each of these thresholds are met. The unit also logs the

Figure 1. Cerlic's Multitracker and Blanko Sensor.

OUR COVER

A water storage reservoir in South East Queensland covered with telecommunications equipment. Very difficult for operators to access the top of this reservoir safely.

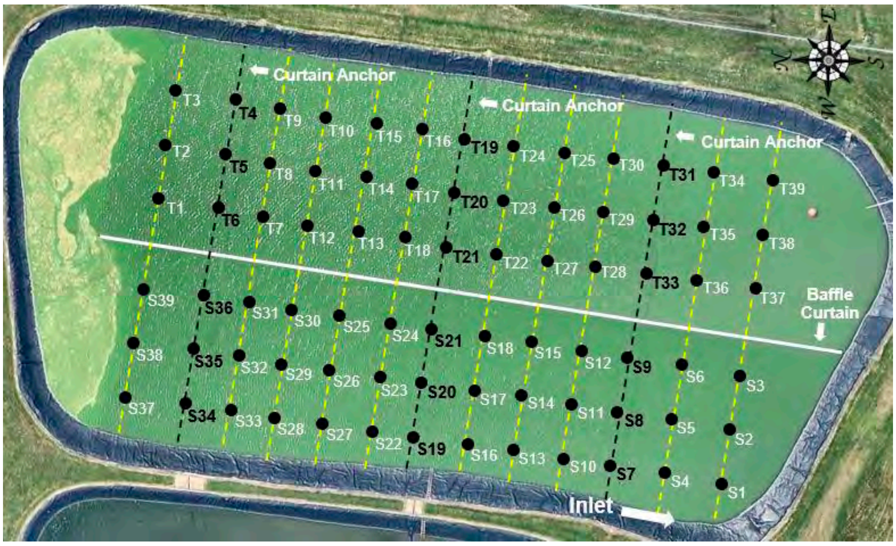

Figure 2. Sludge survey grid locations.

Figure 3. Typical "Sludge Judge" For Sludge Measurements.

depth and actual concentration when the set points are reached.

It is also necessary to set the maximum depth as this will determine the resolution of concentration data. A maximum of 64 data points were recorded as the sensor was lowered through the water column split evenly over the depth. It is also important that the depth set point is greater than or equal to the maximum depth of the pond. The sensor will not record any data past the maximum depth set point. The depth for this survey was set to 2 m to ensure that all the data was captured.

Survey Methodology and Safety

The aim of the survey was to take measurements at approximately even intervals spanning the pond surface. This resulted in 78 measurement locations covering approximately 70% across the pond surface area of 5,400 m^2. While it would have been ideal to cover the entirety of the lagoon, it was not possible due to time constraints and availability of the equipment. It is important to keep in mind that adding additional sample locations exponentially increases the number of measurements that need to be taken.

While the distance between survey points was not exact, this was acceptable because the curtain anchors (black dotted lines in Figure 2) provided a way to georeference the survey results without using GPS coordinates. The curtain anchors are essentially guide-wires that hold an HDPE baffle curtain in place and keep it taut. Taking measurements along these visible anchors was the only way to correlate onsite measurements with a digital map in the "ArcGIS" software package.

Each "zone" between curtain anchors was split up evenly, resulting in grid intervals that were ~6-7 metres, both ways.

Wooden pegs were set up along the sides of the maturation pond to mark the intervals at which the measurements were taken. Additional staff assisted with making sure that each measurement location was aligned with the survey plan. Each sludge measurement was taken from a small dinghy (with oars). The dinghy was carefully rowed to each survey location with minimal turbulence on the pond water surface to avoid disturbing the underlying sludge.

Prior to commencing work, a risk assessment was carried out. The major considerations were around the risk posed by the water – for example falling in and drowning – and also contact with partially treated wastewater. The other major risk was falling when entering or exiting the boat on the bank of the lagoon. In terms of the risk of falling in, it was ensured that both operators remained seated at all times so as to not unbalance the boat and cause any risk of the boat leaning significantly or tipping. In addition to this, both boat operators were wearing Personal Flotation Devices (PFDs) at all times during the sampling. Finally, there were numerous staff tracking the boat around the lagoon at all times, equipped with guide ropes as well as life buoys for land rescue in the event that an operator fell into the lagoon. In terms of contact with semi-treated wastewater, it was ensured that gloves were worn at all times and minimal contact was made with the wastewater. Finally, in terms of embarking and disembarking, a ladder and guide ropes were used to ensure solid footholds and that a rescue system was in place in case an operator were to slip. PFDs and full PPE (including gloves) were worn prior to embarking on the boat.

At each survey location, the sensor was steadily lowered through the water column until it reached the pond bottom. The end point was evident through both "feel" and a "profile graph" that was generated on the Multitracker. The time of each reading was recorded to correlate saved data with the correct location.

The sensor readings were periodically checked visually against physical readings from a "Sludge Judge" to verify the depth of sludge accumulation. A "Sludge Judge" (Figure 3) is a long measuring tube that is lowered down through the water column. The tube has a check valve on the bottom that closes when the tube reaches the bottom of the pond; trapping a core sample of the sludge layer in the tube that can then be physically examined once the tube is removed from the water.

The results from the Multitracker and Blanko sensor were downloaded as a CSV file and a real-time bar graph of the sludge profile was created (Figure 4). Two threshold depths for "fluff" and "sludge blanket level", as well as a temperature measurement and time of reading was also recorded.

Results

The average sludge accumulation across the survey grid was 340 mm, with the maximum depth of sludge at a single point being recorded at 520 mm. These depths represent sludge with an MLSS concentration above 5,000 mg/L as previously discussed.

The average depth of sludge was much higher on the eastern side (avg. 428 mm) versus western side (avg. 255 mm) of the pond, which followed the slope of the pond bottom (deeper on the eastern side).

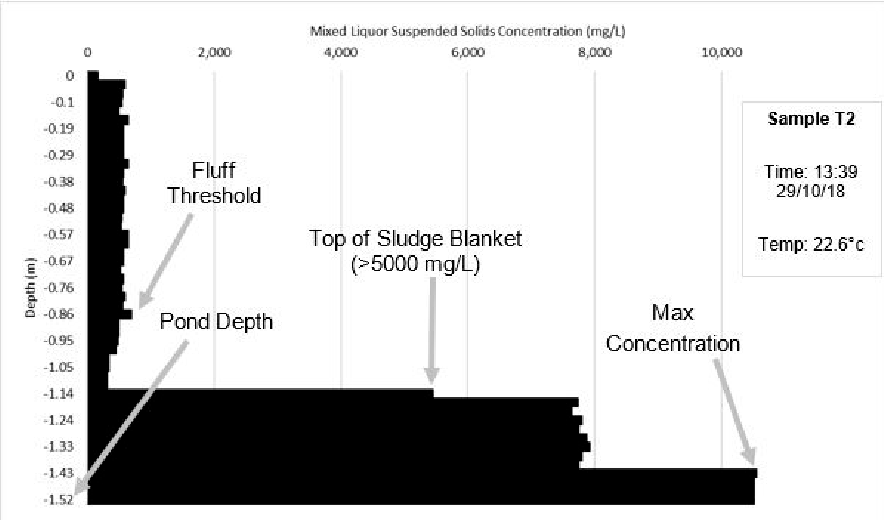

Figure 4. An example of output from the Multitracker.

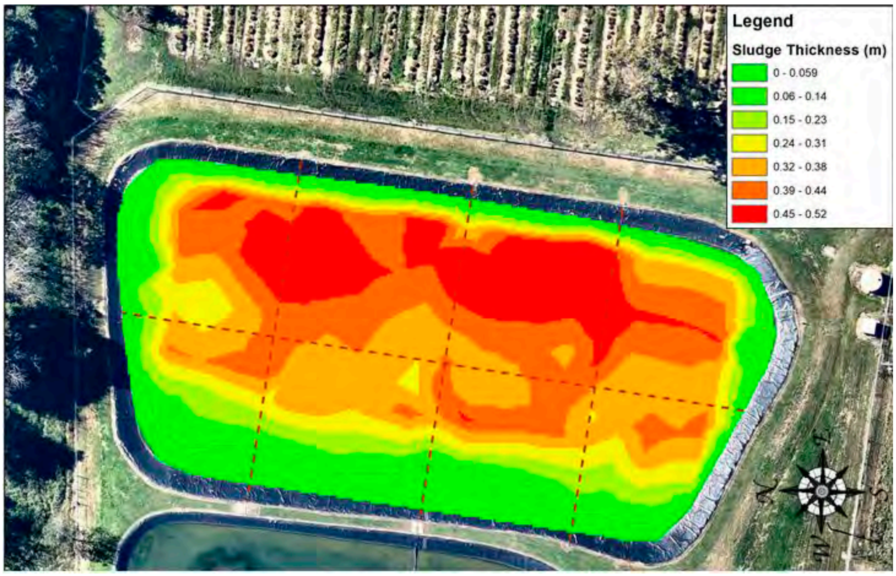

Figure 5. The "heat map" of sludge accumulation in the maturation pond. The darker colours represent the greater depths of sludge.

The sludge deposition followed a centrifugal pattern as it flows out of the inlet (see Figure 2 above), skirts the edge of the baffle curtain, and slows down as it moves around the northern corner and deposits on the far eastern side. It is likely a combination of the sloped bottom, short-circuiting and reduced velocity around the corner, which results in a greater sludge volume accumulation on the eastern side.

The depth of sludge was equivalent to 26% of the total water column depth on average with a maximum of 32% at a single point. This means that the pond is currently at approximately 75% of its hydraulic capacity; a significant reduction in operating/working volume.

The total volume of sludge in the pond was estimated using two different methods. The first method was by using "ArcGIS" and geographically referencing the survey locations against the baffle curtain anchors. This, in effect, gives all the surveyed locations positions that are geographically correct. By doing so, it was then possible to extrapolate across the entire surface of the lagoon to estimate sludge depth at any given point. Results were then converted into a "heat map" as displayed in Figure 4. Knowing the depth at all points and the surface area, "ArcGIS" was then used to estimate the in-situ sludge volume in the maturation pond.

The second method was to estimate the sludge volume using the "Trapezoidal Rule", a numerical technique that uses mathematical calculations. This technique was used as a spot check to validate the results produced using "ArcGIS".

The two methods resulted in two different sludge volumes, 1,600 m^3 from "ArcGIS" and 1,360 m^3 from the "Trapezoidal Rule". The discrepancy between the two is likely because the latter method does not take into account extrapolation of data points outside of the survey grid such as pond embankments and its slope, which resulted in the estimated sludge volume being "lower".

Finally, the rate of sludge accumulation, since late 2010, was estimated ranging between 31 to 37 mm per year averaged across the pond surface area.

Conclusions

The results show that there is a roughly 25% reduction in the operational capacity of the maturation pond, due to sludge accumulation in the last eight years.

There was considerable variation in the sludge distribution pattern largely attributable to the improper pond geometry. This was unexpected.

It was easy to identify the "fluff layer" and "sludge blanket layer" effectively and also the MLSS concentrations at different levels.

The Multitracker and Blanko sensor provided less opportunity for errors, ease of data storage, reduced reliance, time and labour. Taking 78 samples with high-resolution data in an eight-hour period would not be feasible with other methods.

One foreseeable challenge, however, is determining the necessary resolution of data required to obtain the desired results. This is especially a challenge to STPs with significantly greater pond surface area to cover. The other challenge is to develop remote-controlled equipment for ease of operation and ongoing monitoring.

Acknowledgements

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THARGOMINDAH'S HOT COLD WATER

Wayne Mills

The town is Thargomindah, "Thargo" to the locals, and it is the main township for the Bulloo Shire Council. Where is Bulloo Shire, you ask? It is the third largest shire in Queensland, with an area of 73,807.6 km^2, or 4.15% of Queensland, and is located in the far south-west corner of Queensland. Cameron's Corner makes up the south-west corner fence post (Figure 1). Bulloo Shire Council is 7.9% larger than Tasmania, and according to the 2016 Census, has a population of 353.

Thargomindah is situated on the banks of the Bulloo River. It was first settled in 1860. The town prospered in the 1890s as the service and administrative centre of a vast grazing district. The first bore was sunk in 1893 and as well as supplying water, it was also a source of hydroelectric power. The natural pressure was used to power a turbine that supplied electricity for street lighting.

The current bore (Figure 2), constructed in 1999 to a depth of 820 m, supplies the town directly from the Great Artesian Basin, under pressure and without any treatment other than cooling. The water is of a high quality; however, natural fluoride levels of between 1.6 and 1.9 mg/L exceed the ADWG health limit of 1.5 mg/L. The main issue is managing the high pressure and temperature of the water as it leaves the bore.

Figure 2. The "Thargo" town bore.

Figure 1. Thargomindah is located in the far south-west of Queensland.

Figure 3. Cooling ponds and one of the cooling towers.

Figure 4. One of the old cooling ponds revealing the original cooling manifold.

The water supply from the bore requires the pressure to be reduced from the 1,000 kpa prior to delivery into town, and as the supply temperature during the summer months is around 72°C, cooling of the supply is required to prevent the likelihood of scalding due to the elevated temperature.

So what is the solution to provide the residents of Thargomindah with a town water supply that is cooler than the water that is supplied to them from their hot water systems?

Initially, the residents of the town had sealed rainwater tanks and a pump system that allowed cooler water to be provided to the homes. Following a successful funding application, the Bulloo Shire was able to construct cooling ponds, including cooling towers (Figure 3).

Each of the original cooling ponds was approximately 60 m long and 15 m wide. The cooling manifold constructed in the base of each pond consisted of 8 by 50 mm copper tubes connected in a configuration so that the water travelled up, down and then back up to the outlet manifold, prior to connecting into the town reticulation system (Figure 4).

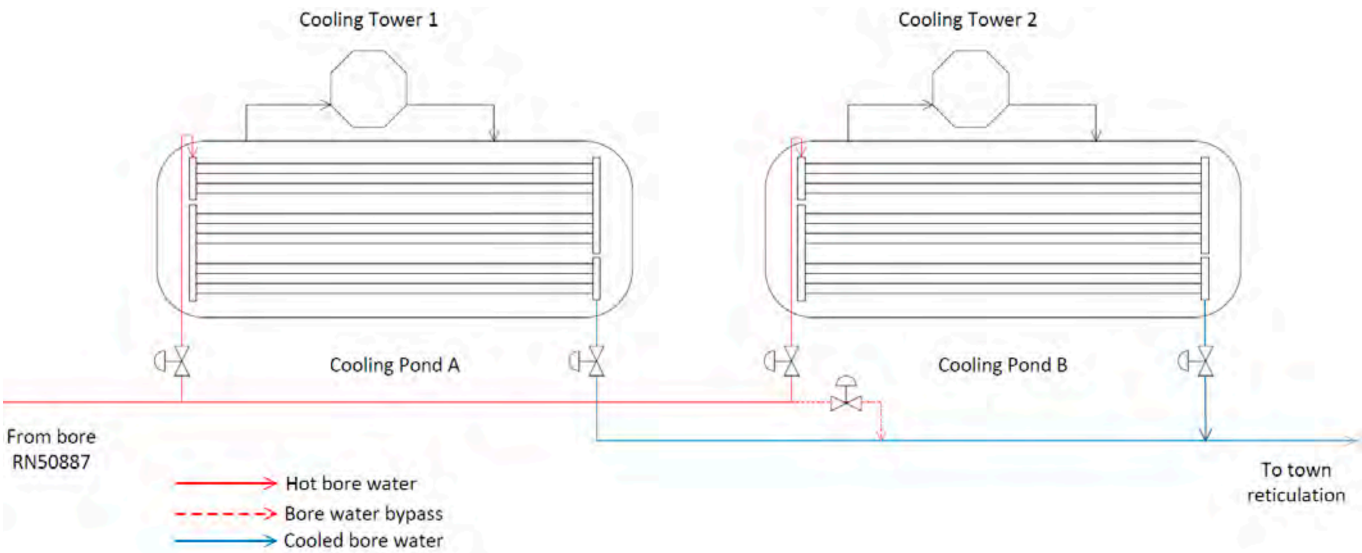

Figure 5. Cooling towers schematic.

Figure 6. Thargomindah Cooling Manifold.

Figure 7. Expansion loops.

Figure 8. Music festival.

Due to the original pipe size, the cooling ponds could only be operated in parallel (Figure 5). They could not be connected in series, which would have allowed extended detention time to further reduce the water temperature. This meant that during summer, water supplied to the town varied between 36°C and 58°C, and in winter was typically around 32°C.

Water consumption during summer, produces high water velocity throughout the system. This reduces the detention time of the water passing through the cooling ponds, increasing the friction losses within the system, and results in reduced pressure and high temperatures in the water being supplied to town.

A recent upgrade has allowed the ponds to be connected in series, and the detention time in each of the ponds has been increased by the increase in pipe numbers and size (Figures 6 and 7).

This has resulted in a dramatic decrease in the temperature of the water being provided to the inhabitants of the town. Although the figures are only available for winter at this stage, the decrease in water temperature has been in excess of 50°C. Water leaving the town bore is 72°C and after passing through the cooling ponds, is reduced to around 19°C. A much more tolerable outcome for the residents. The lower temperature also reduces the risk of *Legionella* and *Naegleria* becoming established in the water supply system.

The upgrade and capacity of the cooling system were recently tested, when Thargomindah held its inaugural Music Festival. Over 250 caravans and motorhomes arrived in town (Figure 8), testing the ability of the system to continually supply a safe water supply to the community when its population is increased by more than 100% for the week of the Festival.

The Author

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IMPROVED DISINFECTION AT MT KYNOCH

Runner-up for the Best Paper by an Operator at the 2019 WIOA Queensland Operations Conference

Marcus Boyd and Terry Heness

The Mt Kynoch Water Treatment Plant (WTP) provides drinking water to consumers in Toowoomba and surrounding areas. Treated water is pumped into three bulk water reservoirs located adjacent to the WTP (Figure 1), prior to supplying reservoir and reticulation networks. The reservoir system has a total capacity of 30.7 ML.

Prior to entering the reservoir system, water entering the WTP clear water tank is dosed with chlorine gas to achieve a residual of 3.4 to 4.0 mg/L. An ideal chlorine residual range of 1.9 and 2.1 mg/L is required in water leaving the reservoirs for consumption. From entry to exit point of the reservoir system, chlorine decay is evident, with approximately 50% of the chlorine thought to be used in storage. This is, however, a large unknown as there is only a single chlorine analyser on Reservoir 3 measuring chlorine residual as water leaves the Mt Kynoch reservoirs. Reservoirs 1 and 2 have no online instrumentation and daily grab samples are required to monitor chlorine residual, providing a snapshot of water quality leaving the reservoirs. Overall, there is a large uncertainty of chlorine levels exiting the system.

The flow of water from the WTP into each reservoir is uncontrolled, likewise the flow from each reservoir into the distribution system is uncontrolled. Each reservoir has an inlet receiving flow from the WTP and an outlet pipe feeding the reticulation system, and there are interconnecting pipes between each reservoir (Figure 1). This configuration maintains one large body of water, capable of supplying the distribution system with a free-flowing supply. Unfortunately, the configuration proves difficult to maintain a homogeneous body of water maintaining a constant chlorine residual.

Due to the reservoir arrangement and flow configuration, stored water is not a homogeneous body with a constant chlorine residual. The chlorine residual of stored water varies depending on the depth and location, resulting in pockets of low chlorine residuals compromising the system when eventually drawn from the reservoir. Online chlorine results show that the required ideal chlorine residual of 1.9–2.1 mg/L is not achieved in water leaving the reservoir system. In short, Council cannot guarantee the quality of the water leaving the Mt Kynoch bulk water reservoirs.

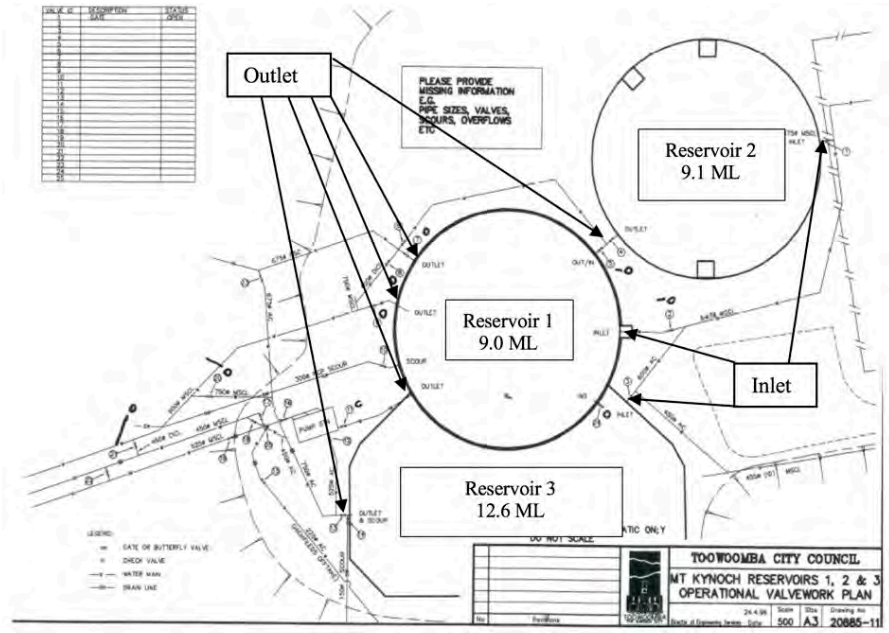

Figure 1. Mt Kynoch reservoir configuration.

In order to remove dead spots and short-circuiting while ensuring all water stored in the reservoir is maintained in one homogeneous state, a mixer was installed in Reservoir 3. The mixer is an integrated floating pontoon anchored to the reservoirs internal columns (Figure 2), a cable and pulley system allows the mixer to rise and fall with the water level in the reservoir.

The mixer is powered by a 0.5 kW motor and gearbox arrangement using food grade oil in the gear motor. Water is drawn from the surface into the mixer and pumped vertically down creating a large and effective mixing pattern throughout the entire reservoir. The continual mixing action in the reservoir removed the previously identified dead spots and short-circuiting problems, reducing low chorine residual issues with water quality leaving the reservoir, while also improving the chlorine residual. Prior to mixing, the reservoir discharge water quality was determined by the flow configuration of the system. Modelling indicated water could short-circuit the reservoir, meaning a direct path was taken from the inlet to the outlet, with high levels of chlorine entering the distribution. During this flow arrangement, water stored outside this flow

Figure 2a. mixer being lowered.

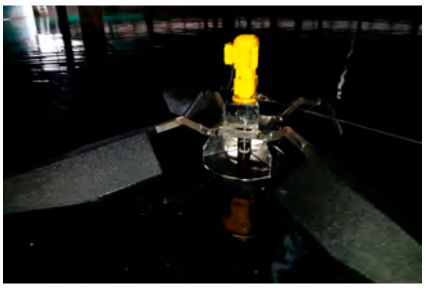

Figure 2b. Mixer in place.

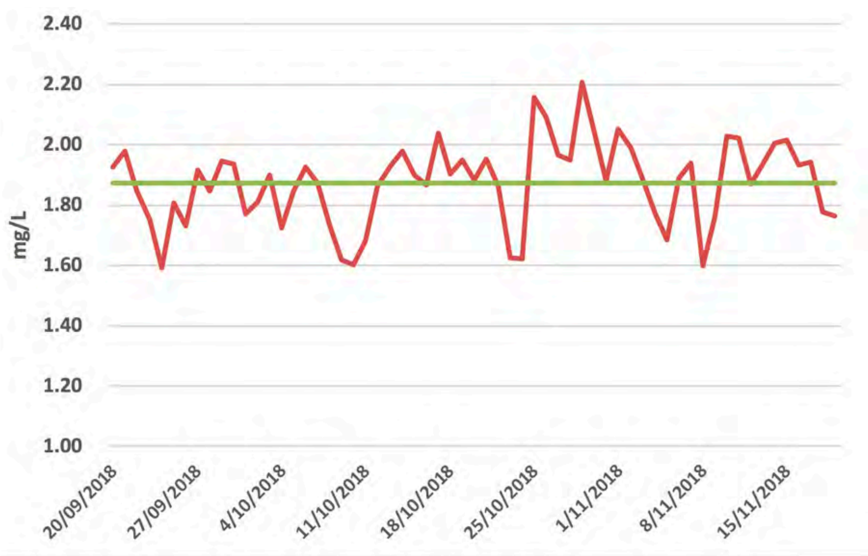

Figure 3. A 2 month trend of the free chlorine residual leaving Reservoir 3 prior to installation of the mixer.

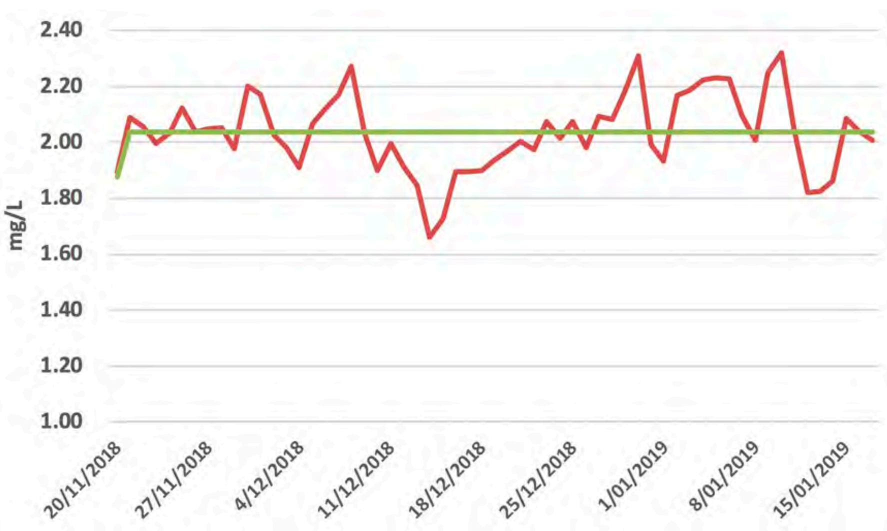

Figure 4. A 2 month trend of the free chlorine residual leaving Reservoir 3 after installation of the mixer.

path experienced chlorine decay as the residual declined. This water sitting outside the short-circuit path eventually finds its way to the outlet depending on flow conditions, resulting in low levels of chlorine entering the distribution system. The Mt Kynoch reservoir system supplies water to a large distribution area with kilometres of water mains between reservoirs. When low chlorine residuals leave the Mt Kynoch system, Operators find manually re-dosing storage reservoirs necessary to maintain chlorine residual in the distribution system. Manually re-dosing reservoirs with chlorine involves unnecessary OHS risk, as well as the unwanted ability to generate THMs in the system. While mixing the water in the reservoir, Operators noticed a reduction in chlorine decay, chlorine dose rates at the WTP were reduced while improved residuals leaving the reservoir were recorded.

Figure 3 shows a 2 month trend of the free chlorine residual leaving Reservoir 3 prior to installation of the mixer. The graph indicates the required range of chlorine residual is achieved 30% of the time during the sample period, which was not acceptable.

A 2 month trend of the free chlorine residual leaving Reservoir 3 after installation of the mixer is shown in Figure 4. The target levels were achieved 62% of the time and there was less variation. Further chlorine residual improvements are expected if all three reservoirs at Mt Kynoch have mixers installed.

At the time of installation of the mixer, chlorine sensing probes were installed and it was an additional 2–3 days until the mixer was operating. Data collected during this period identifies the chlorine residual at a "dead spot" in the reservoir where the sensors were located, after turning the mixer on, instant improvements were observed (Figure 5).

A summary of water quality before and after the trial installation of the mixer is provided in Table 1.

In order to gain a balanced view of the performance of the reservoir mixer, Council requested the unit be "turned off" for 1 week during the demonstration period. Within 2 days of shutting down the mixer, there was a significant reduction in the chlorine residual measured at the Reservoir 3 analyser requiring the chlorine dose rate to be increased at the WTP. Once the mixer was switched back on four days later, the chlorine residuals restabilised.

Once the mixer trial was completed and the data reviewed, it was evident that permanently installing a mixer would allow a reduction in the amount of chlorine dosed at the WTP while still

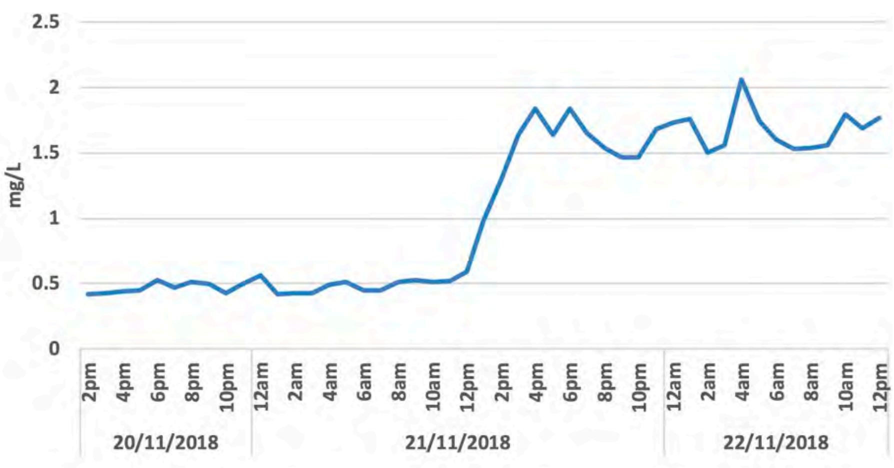

Figure 5. Chlorine residual in Reservoir 3 pre and post mixer over a 3-day period.

Prior to Mixer Installation	After Mixer Installation
30 % of readings within range	62% of readings within range
62% of readings <1.9 mg/L	12% of readings <1.9 mg/L
36% of readings <1.8 mg/L	3% of readings <1.8 mg/L
22% of readings <1.7 mg/L	0.5% of readings <1.7 mg/L
8% of readings >2.1 mg/L	27% of readings >2.1 mg/L
3%of readings >2.15 mg/L	8% of readings >2.15 mg/L

Table 1. Chlorine residuals analysed before and after installation of the mixer.

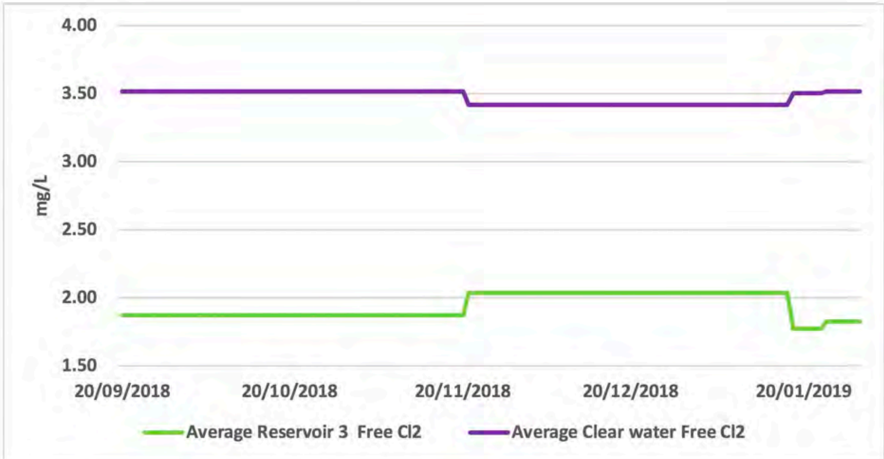

Figure 6. Free-chlorine residuals for Reservoir 3 and the WTP Clear Water Tank before, during and after the trial.

achieving an improved chlorine residual in Reservoir 3 (Figure 6). Additionally, re-dosing chlorine in the distribution reservoirs was largely reduced, and THM results declined.

Addition of the mixer improved water quality by maintaining a fully mixed reservoir and maintaining adequate chlorine residuals throughout the distribution system. At the same time, the reduction in chlorine dosing would achieve approximate savings of $8,000/year.

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Editor's Note

Addition of a mixer to a water storage can improve the overall chlorine residual throughout the storage and help to eliminate dead spots as demonstrated in this paper. However, care is needed where the Ct is marginal. In the absence of baffles in the tank, addition of a mixer could effectively reduce the Ct by reducing the T10 (the time taken for first 10% of the water to leave the tank).

THE VALUE OF WATER INDUSTRY OPERATOR COMPETENCY: THE WHAT, WHY AND HOW

Sallyanne Bartlett and Kathy Northcott

Two separate but complementary projects have recently been completed relating to competency in the water industry.

The "Value of Operator Competency" project is a Water Research Australia (WaterRA) member-funded project intended to investigate and communicate the importance of frontline operator technical competency to ensure the protection of public health and the environment.

The "Technical Competency Project" was undertaken by the Water Industry Operators Association of Australia (WIOA) in conjunction with South East Water, VicWater, ***qldwater*** and the NSW Water Directorate. It aimed to develop guidance material on the development of a consistent and effective technical competency framework for the water industry (the Technical Competency Handbook).

Why Undertake These Projects?

In Australia, there are many other industries tasked with the protection of public health and safety. These include, but are not limited to: aviation, nursing, electrical and engineering. In each of these industries, mandatory licensing and registration schemes provide a nationally consistent approach to workforce competency. These industry credentials offer transparent assurance to regulators, customers and communities that service delivery obligations are met by an appropriately trained and proficient workforce.

The Australian water industry has invested considerable effort over the past decade to develop and implement a similar nationally consistent approach to frontline operator competency. This has been through the establishment of a voluntary national water industry credentialing scheme firstly in Victoira and now nationally in the Water Industry Operators Certification Framework (WIOCF). Despite the WIOCF offering an industry consistent and effective best practice approach to frontline operator competency management, less than 10% of water utilities currently employ operators certified under the scheme.

What Defines Minimum Frontline Operator Competency?

In Australia, at a regulatory level, the definition of water industry frontline operator competency varies across states and territories. The legislative terminology used does not define the specific knowledge, skills and experience required to fulfil frontline operator roles, and regulator recommendations are not clear. To meet legislative compliance, the structure, content and extent of frontline operator learning and devolvement programs is largely at the discretion of individual water utilities.

The Australian Drinking Water Guidelines (ADWG) and the Australian Guidelines for Water Recycling (AGWR), set out in the respective frameworks (element 7) employee awareness and involvement, along with employee training recommendations. The ADWG and AGWR describe broadly the type of knowledge and skills an operator may require to competently perform duties and how this knowledge may be acquired. They are not mandatory standards. Instead, each framework represents an authoritative reference that can be used by the Australian water industry and regulators to achieve good safe drinking water or recycled water outcomes.

The WIOCF (WIOCT, 2018) is the water industry credential that does define frontline operator competency. A certified operator is recognised as having demonstrated the minimum competency requirements to capably and competently manage a water supply system. The requirements included an independently verified "fit for purpose" skill set, relevant on-the-job operational experience, an employer capability statement and a commitment to continual professional development (CPD). Currently, the

Figure 1. Water Industry Operator Certification Framework (WIOCT, 2018).

WIOCF is a voluntary initiative for Australian water utilities. In contrast to other industries, the WIOCF lacks the regulatory commitment to drive its widespread uptake.

Hence, the governance approach to technical competency in the Australian water industry lacks a nationally consistent benchmark to define frontline operator competency. The industry would benefit from a benchmark to underpin the minimum knowledge, skills and experience required for frontline operator roles. It would facilitate a move toward a nationally consistent approach to frontline operator competency provision. In doing so, it would offer assurance to regulators, water utilities, customers and communities that the frontline operator workforce is capable and competent to deliver water service obligations.

Why is Frontline Operator Competency Assurance Important?

A frontline operator with the right level of knowledge, skills and experience has

Figure 2. The link between competency provision, human error and water quality safety incidents.

a strong foundation to exercise good judgement for sound and informed decision-making. The capability of frontline operators to make the right decision at the right time is extremely important to public health and safety, and positive environmental outcomes.

A literature review conducted as part of the "Value of Operator Competency" project demonstrated the significant consequences experienced by customers and communities when a water quality safety incident occurs. There is a multitude of contributing factors involved in these incidents. However, in a number of the reported cases of international water quality incidents, a common causal factor was inappropriate training and competency provision. This identified lack of frontline operator competency led to poor decision-making, human error and ultimately harm to the community.

A study by Wu, et al. in 2009 demonstrated just how significant the role human error plays in water quality safety incidents. This study reviewed 62 cases from Hrudey and Hrudey (2004) and reported that 78% of the errors that occurred were human-related. A lack of training and competency provision can reside as a vulnerability within an organisation's system, waiting for the right circumstances to present and test frontline operator competency. The literature review highlighted that, when competency is tested and found to be lacking, human errors occur that compromise the ability to adequately manage water quality safety risks. Walkerton, North Battleford, Flint and Havelock North are high-profile examples of overseas incidents where this has been the case.

Closer to home, Seqwater, a major water utility in Queensland, were able to identify potential vulnerabilities in the technical capability of their frontline operator workforce in the wake of flood events in 2011 and 2013, which placed stress upon the water supply system. The Seqwater experience identified a need to ensure the organisation had adequately trained operators with the capability to deal with such severe events. In response, over the past 8 years, Seqwater has established and implemented the Operations Development Program (ODP). The Seqwater ODP is described in more detail later in this article and highlights the importance of understanding workforce capability and aligning competency management to ensure the workforce can reliably meet business objectives to protect the public and the environment.

A national and international survey conducted by WSAA for the report "Workforce Skills of the Future" indicated "alignment of workforce planning to business needs" as an area which is currently lacking (WSAA, KPMG 2017). A suggestion that many more water industry organisations may be vulnerable to a lack of workforce capability to meet future water industry challenges.

How Can We Assure Frontline Operator Competency?

In May 2019, the Water Industry Operators Association of Australia (WIOA) released the *"Technical Competency Handbook – knowledge, skills and competency development for water industry staff"*.

Project-managed by WIOA and South East Water and supported by three state-based advisory and advocacy bodies (VicWater, ***qldwater***, NSW Water Directorate), the Technical Competency Project aimed to develop guidance material on industry best practice in the development of technical competency frameworks for the water industry (the Technical Competency Handbook).

Freely available from the WIOA website, the Technical Competency Handbook is intended to be used by Human Resources (HR), learning and development (L&D) practitioners, and direct line managers who are tasked with the creation and implementation of L&D programs for staff in water industry operations.

The project also developed examples (Case Studies) of good practice in developing technical competency in

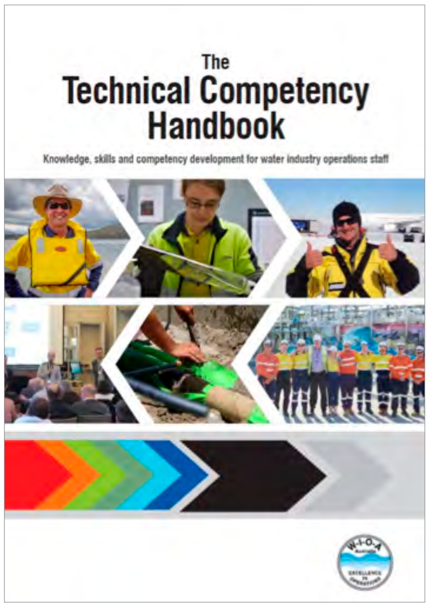

Figure 3. The Technical Competency Handbook.

the water industry context. The Case Studies produced demonstrate approaches for planning and delivery of skills development programs to achieve technical competency, as well as manage ongoing professional development.

The Handbook provides direction on important aspects of developing technical competency across an organisation, including:

- Principles of technical capability framework design.
- Identifying and articulating technical roles and responsibilities.
- Adopting an annual cycle of L&D planning.
- Identifying and evaluating the L&D needs of technical staff.
- Recognising and maintaining technical competency.

Technical Capability Framework Design

The Technical Competency Handbook provides a matrix that water businesses can use to self-assess their organisational preparedness for the creation of a technical capability system and competency framework.

Identify and Articulate Technical Roles

The Technical Competency Handbook describes the first step in developing technical competency frameworks, which is identifying the roles that are relevant. For each role identified, there should be a position description that outlines:

- Key Responsibilities.
- Key Performance Indicators.
- Skills set (required and desirable).
- Qualifications/accreditations (required and desirable).
- Previous experience.
- Employability and team skills.
- Other relevant skills (e.g. driver's licence, first aid etc.).

Based on each position description, it should be possible to create a list of technical roles and competency sets for an organisation. Technical competencies reflect the skills, know-how and processes needed to deliver an organisation's core business operations and services. Based on the position description and knowledge of the products/services that an organisation or department delivers, it should be possible to create a technical skills matrix specific to each operational role. The skills matrix contains all of the required training and competencies an individual would require to carry out their duties.

The L&D Planning Cycle

The Handbook describes L&D planning as an activity that typically occurs on an annual cycle. The recommended planning process is as follows:

1. Link L&D to organisational core values.
2. Regular review of L&D options and offerings.
3. L&D needs analysis. This is typically carried out as part of the annual performance appraisal process.
4. Rollout of L&D activities. The activities on offer are based on the job roles and needs analyses.
5. Evaluation and improvement. Feedback is sought from employees on the effectiveness of L&D on offer, and improvements are made for the following year.

The Handbook provides some simple tools for staff and managers to conduct a performance evaluation of skills and competence against the skills set required to perform specific technical roles within an organisation.

Learning and Development Models

Studies of organisational learning programs make reference to the fact that a significant proportion of professional learning is informal. Hence, the creation of the 70:20:10 L&D model, which states that:

- 70% of our learning comes from challenging assignments and on-the-job experiences.
- 20% of our learning is developed from our relationships with other people, our networks and the feedback we receive.
- 10% of our learning comes from formal training, such as courses, workshops and programs.
- To help make sense of what 70:20:10 looks like in practice, it is useful to look at each technical role and consider the appropriate activities that can support learning.

Recognition and Maintenance of Technical Competency

It is one thing for technical staff to achieve the minimum technical competencies, qualifications and experience to perform their role. Maintaining currency of skills and knowledge, and keeping up with industry trends and technologies is another matter entirely. Hence, the importance of a continuing professional development framework for technical staff.

However, it should not be necessary to reinvent the wheel when it comes to professional development. In fact, it is a good idea to look to other well-established continuing professional development (CPD) schemes for guidance. Chapter 6 of the Handbook provides details on the WIOCF and the WIOA Water Industry Operator Certification Scheme.

Seqwater Case Study

The Seqwater ODP is presented as a Case Study in both the WaterRA Value of Operator Competency Project Report and the WIOA Technical Competency Handbook. The Case Study provides an example of how an Australian water business is managing frontline operator competency. The key features of the Seqwater ODP are knowledge, skills and experience aligned with job roles, the use of a site-based competency assessment to demonstrate on the job capability, and a commitment to support ongoing and further development of competency.

The ODP program prepares the Seqwater workforce to capably and competently deliver water services into the future. It sets a career pathway to attract a younger demographic of operators (succession planning), a commitment to updating/refreshing knowledge and skills (growth opportunities), and a structured method to ensure knowledge transfer from the more experienced operators to operators in training (knowledge retention). Some of the value and benefits to the business are consistent knowledge and skills base, reduced organisational risk, evidence of workforce competency (for the Board and executive management), increased workforce engagement and assurance of the technical capability of the business to deliver service obligations.

Figure 4. Overview of the Seqwater Operations Development Program.

The structure of the OPD program offers Seqwater operators with the opportunity to pursue WIOCF certification. In fact, Seqwater encourages operators to become certified as formal recognition of the level of training, experience and competency of the frontline workforce.

Conclusion

To ensure the future technical capability of the Australian water industry frontline operator workforce, a move toward a nationally consistent learning and development approach is essential. The value and benefits derived include that it:

- Sets a benchmark for operator training and competency requirements.
- Establishes a foundation to inform and build technical capacity, capability and consistency across the industry.
- Assures the workforce is prepared to deliver and maintain service standards.
- Fosters a high level of customer and community trust and confidence.
- Facilitates portability of skill within the industry
- Increases staff confidence, engagement and innovation.
- Establishes an industry career pathway from entry-level through to career progression.
- Promotes a water industry-specific credential to demonstrate workforce competency to perform duties.

These are all key aspects relevant to securing a robust and resilient frontline operator workforce that is well equipped and prepared to deliver safe, reliable water service outcomes into the future.

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REDUCING THMS DURING HIGH SOURCE WATER BROMIDE AND SALT EVENTS

Duncan Shillito

Seqwater's Mt Crosby East Bank and West Bank Water Treatment Plants (WTPs) produce up to 800 ML/d to supply the majority of drinking water for the South East Queensland (SEQ) region. Disinfection of the treated water varies across the SEQ grid. Brisbane, Ipswich and Logan use chloramine disinfection, whereas the Gold Coast, Redland and Sunshine Coast regions use free-chlorine. In a chloramine environment, trihalomethanes (THMs) are considered a low risk with the THM formation post treatment remaining low. In a free-chlorine environment, THMs continue to increase depending on bromide and organic levels post treatment, free-chlorine residual, the water age and number of doses of free-chlorine. Although THMs can leave the WTPs at low levels, the ADWG guideline value of 250 µg/L can still be exceeded in free-chlorine systems, especially with organics >3.5 mg/L Total Organic Carbon and elevated bromide. Seqwater has adopted an internal specification of <150 µg/L, leaving the treatment plant to allow for the increase in THMs in downstream networks.

The raw water source for the 2 treatment plants is the Mid Brisbane River (MBR), with the predominant supply coming from releases through Wivenhoe Dam. The water quality is typically good and stable. However, in periods of rainfall in the MBR catchment, a few problematic tributaries contribute high levels of salt and bromide, sometimes without increases in turbidity and colour.

Following an investigation into a 2015 incident where high THM levels (290 µg/L) were detected in the drinking water, a link was established between increased salt and bromide levels in the MBR and the potential for high levels of THMs. A Bromide Management Plan was developed with the aim to reduce organic levels in the drinking water when elevated levels of bromide and/or organics are recorded in Mt Crosby WTPs raw water.

In 2018, raw water conductivity (>450 uS/cm) and bromide (0.18 mg/L) triggered an incident that lasted from 22nd October to 5th November.

Where Does the Bromide and Salt Come From?

In dry weather periods, raw water supplied to the Mt Crosby East and West Bank plants comes mainly from Lake Wivenhoe (typically 90–100%). Water released from Wivenhoe then travels along 60 km of the Mid Brisbane River to the plants. Water quality during these periods is stable with turbidity <10 NTU, colour <5 HU and conductivity 400 µS/cm. The system is also subject to flooding as seen recently in 2011 and 2013, where the Lockyer Creek can contribute significantly in volume and sediment and organic loads. However, in periods of localised rainfall, the MBR catchment can also contribute to flows, with one tributary in particular (Black Snake Creek) also introducing high levels of salt and bromide.

Since the 2011 floods, Mt Crosby WTPs have periodically been impacted by salt levels from the Black Snake Creek with conductivity in the drinking water exceeding 1,000 µS/cm. This event in October 2018 saw 2 separate injections of water from Black Snake Creek into the MBR of approximately 12,000 µS/cm (Figure 1). The volume was unquantified; however, the effects of these injections raised the background levels of conductivity from 450 µS/cm to approximately 1,200 µS/cm in the upper sections, which indicates a potential large increase at Mt Crosby.

Laboratory testing established that the correlation of conductivity to bromide was strong.

Figure 1. Black Snake Creek salinity measured as conductivity.

Treatment Responses

Both the East and West Bank WTPs have conventional treatment processes, which include: aluminium sulphate (alum) coagulation, sedimentation via longitudinal basins, rapid gravity filtration with free-chlorine disinfection followed by chloramine for secondary disinfection, as the agreed regime for the broader parts of Brisbane. The normal operating objective for coagulation and sedimentation processes is to reduce turbidity and colour.

Neither salt nor bromide can be removed by the existing processes; therefore, the Bromide Management Plan's strategy is to reduce THM precursors such as Natural Organic Matter (NOM) using higher alum doses, thereby reducing the THM formation potential of higher bromide concentrations. Thus the operational objectives change from focusing on turbidity and colour levels to reducing settled water organics levels. The operational treatment target derived for organics reduction under the Plan is a Bromide Factor Value of <1.3 (based on raw water bromide mg/L x settled water UV245 cm^{-1} x 100) to minimise THM production. This value was established using jar tests to maintain THMs of <250 µg/L in THM formation potential tests.

The lowest dosed water pH and settled water UV245 achievable at both WTPs was 5.8 and 0.036 cm^{-1} respectively. A coagulation pH of 5.8 was adopted as the lower target, since at pH <5.8, the aluminium levels in the treated water can exceed the internal specification of 0.05 mg/L.

Raw Water Conductivity (µS/cm)	Estimated Raw Water Bromide (mg/L)	Target Settled Water UV254 (cm^{-1})
450	0.21	0.063
500	0.23	0.055
600	0.29	0.045
700	0.34	0.038
800	0.40	0.033
900	0.45	0.029

Table 1. Operational targets based on raw water changes using the Bromide Factor value of 1.3. Bromide values were estimated based on the relationship to conductivity. For this particular event, the R2 value was 0.97.

THMs	Min (Plant)	Max (Plant)	Average (Plant)	Formation Potential (end of system)
Chloroform µg/L	8	13	11	41
Bromodichloromethane µg/L	23	26	25	76
Dibromochloromethane µg/L	31	48	35	69
Bromoform µg/L	9	26	14	33
Total THMs µg/L	71	117	86	219

Table 2. Mt Crosby WTPs THM results during the high salt, high bromide event.

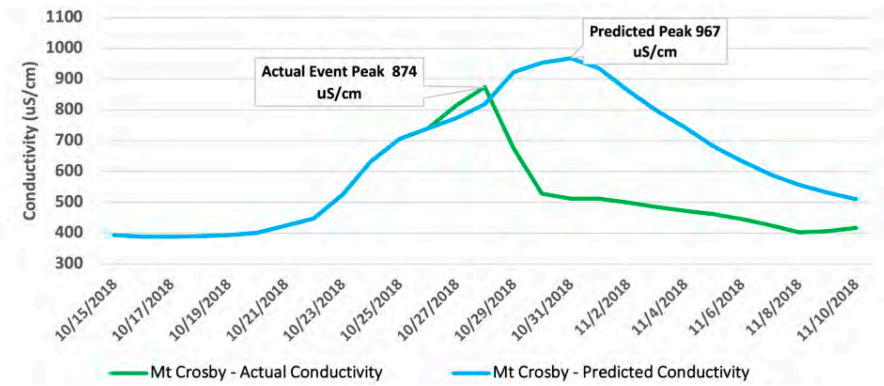

Figure 2. Conductivity at Mt Crosby. The thick green line is the actual measured conductivity and the blue line is the predicted conductivity with increased release from Wivenhoe.

A series of jar tests from various sections of Mid Brisbane River were undertaken to establish target criteria for settled water organics. The operators undertook flocculated and settled water UV254 tests at least twice per 8-hour shift and adjusted alum doses in 1 mg/L increments until the desired targets were met (Table 1).

Application of the target Bromide Factor resulted in higher alum doses from a background of 8 mg/L Al_2O_3 to 27 mg/L Al_2O_3. This had several operational challenges:

- Maintaining sufficient stock of alum and the associated increased cost.
- Addition of higher lime doses and sodium hydroxide to offset low coagulation pH.
- The floc was observed to be very light and excess carryover from settling basins was evident. At this point, filtered water quality was unstable (although within specification). Any further efforts to reduce organics without compromising filtration was considered a high risk.
- Increased sludge production resulting in increased handling costs.
- Increased monitoring and jar testing.

During the event, treated water from both WTPs was analysed for THMs (total and individual), as well as testing the THM formation potential. The background THM levels under normal raw water quality and operations ranged from 80-120 µg/L. During the event, the THM levels remained unchanged and probably at the lowest achievable based on the organic fractions. They were also observed to be roughly half of the maximum THM formation potential mostly due to low water age at the plant (Table 2), which was shorter than the incubation time for the THM formation potential test.

River Flushing

Although not explicitly referred to in the Plan, an option exists to reduce and dilute the salt and bromide levels in the Mid Brisbane River by additional releases from Lake Wivenhoe. Seqwater has used this option in recent similar events. For this event, it was determined that the levels of salt and bromide would exceed the capabilities of the plants to manage the problem. Additional releases from Lake Wivenhoe were approved by senior management. Background release rates of 540 ML/d were increased to 1,150 ML/d for a period of 3.5 days. This action was very effective and reduced the peak and duration of the event significantly (Figure 2).

Outcomes

Seqwater's most likely supply system to have high levels of THMs is the supply from the Southern Regional Pipeline. The Chambers Flat water quality management facility converts chloramine to free-chlorine and further chlorine doses are applied at Stapylton Reservoir. This system represents the highest water age in Seqwater's supply. Throughout this event, the highest level of THMs observed in this system was 160 µg/L.

Reports from Queensland Urban Utilities and Logan City Council indicated that all results for THM were <250 µg/L, which was a vast improvement on the last high salt and bromide event in 2017. During the event, no water quality complaints of this nature were reported to Queensland Urban Utilities or Logan City Council.

So, what of the future? The overwhelming improvement required to manage this situation is the remediation of the Black Snake Creek catchment. This is a significant issue for Seqwater and the local region; however, any improvements will take many years or decades to be realised.

In the meantime, the Bromide Management Plan has the potential to effectively manage any future events.

Further bromide events will need to consider adding river flushes into the management plan.

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CHOOSING THE RIGHT PAC

Adrian Knight, Peta Thiel and Peter Cullum

When selecting a powdered activated carbon (PAC) product for a given application, a wide range of material properties are presented, which can complicate the selection process. It is strongly recommended that all PACs are performance tested via jar testing in the water that is to be treated before commencing full-scale treatment. To help with choosing a PAC, an understanding of what each material property means and how each may be used to predict PAC performance is a helpful tool.

A wide range of PACs with different material properties have been tested in a number of raw waters with differing organic content. This data has been analysed to assess which material properties correlate best with PAC performance for removal of colour, dissolved organic carbon (DOC), UV254 reduction, and the removal of the taste and odour compounds MIB and geosmin.

PAC Material Properties

1. Adsorption

Iodine Number, Methylene Blue Adsorption and Tannin Value

All activated carbons are characterised using adsorptive tests, with the carbons ranked according to how much of a given compound they remove from the test solution. Commonly used molecules and compounds in adsorptive testing are iodine, tannic acid and methylene blue (MB) dye. The amount of target compound removed during the test is used to rank activated carbons in order of their adsorptive capacity.

For iodine number (mg iodine adsorbed per g of PAC) and methylene blue adsorption (g dye adsorbed per 100 g of PAC), a higher number indicates a more adsorptive PAC. For tannin value, which is defined as the concentration of PAC (mg/L) required to remove a given amount of tannic acid from a test solution, an inverse relationship exists and PACs with a lower tannin value are considered more adsorptive.

Of particular interest to water treatment plant operators is the question of whether any of these adsorptive properties may be used to better predict PAC performance for the removal of colour, DOC and UV254, as well as MIB and geosmin.

1. Particle Size Distribution

The particle size distribution (PSD) of a PAC is generally defined by the median particle size, d50. A finer PAC will have more surface area available for adsorptive processes and hence may have faster reaction times for the adsorption of certain contaminants, improving performance for a given contact/mixing time.

PAC Characterisation

A range of PACs were sourced and were characterised for iodine number (ASTM D4607), tannin value (AWWA B604) and methylene blue adsorption (CEFIC) using approved testing methods. Particle sizing was conducted using a laser diffractometer.

PAC Performance in Low and High DOC Waters

This study aimed at assessing the ability of a range of PACs to continue to remove MIB and geosmin in high DOC waters. Often, PAC datasheets may include MIB and geosmin removal performance data; these values may be misleading if the testing has been conducted in a low DOC (potable and deionised) water as they fail to account for interference effects, which occur in real-world applications.

Interference effects refer to the preferential adsorption of compounds other than the target compound onto a PAC, or a reduction in target compound removal due to other physical effects. Interference is likely to be experienced in high DOC waters or in situations where raw water quality changes seasonally or due to rainfall events. Understanding these effects and how PAC performance is affected is a key part of successfully managing variable raw water quality risks.

By assessing PACs of varying material properties, it can be determined which properties, if any, are the most useful for gauging PAC performance in both low and high DOC waters. The PACs investigated in this study are given in Table 1.

The PACs were used in jar testing studies with both low (2.8 mg/L) and high (10.8 mg/L) DOC water, to which MIB and geosmin were spiked at concentrations of 100 ng/L each. The dose rate used was 30 mg/L and contact time 60 minutes.

Performance data for MIB and geosmin removal are given in Table 2.

The data in Table 2 shows the following:

- In low DOC water, MIB reduction increases with increasing iodine number and Methylene Blue adsorption, and with decreasing tannin value. Geosmin reduction was not affected by any of these material properties.

PAC ID	Type	Iodine Number (mg/g)	Tannin Value (-)	Methylene Blue Adsorption (g/100 g)	PAC d50 (µm)
PAC1	Steam activated, Coal based	888	260	17.9	17.5
PAC2	Steam activated, Coal based	1006	259	19.6	18.6
PAC3	Steam activated, Coal based	1012	217	22.7	13.5
PAC4	Steam activated, Coal based	1214	128	24.3	13.8
PAC5	Chemically activated, Wood based	993	367	16.5	20.4

Table 1. PACs used in interference study.

PAC ID	Low DOC Water		High DOC Water		% Performance Reduction	
	% MIB Reduction	% Geosmin Reduction	% MIB Reduction	% Geosmin Reduction	MIB Reduction	Geosmin Reduction
PAC1	90.8	96.6	74.2	91.8	18.3	5.0
PAC2	93.1	96.6	78.5	93.6	15.7	3.1
PAC3	94.3	96.6	86.0	94.5	8.7	2.1
PAC4	95.4	96.6	87.1	96.4	8.7	0.3
PAC5			70.1	92.0		

Table 2. PAC performance data, DOC interference study.

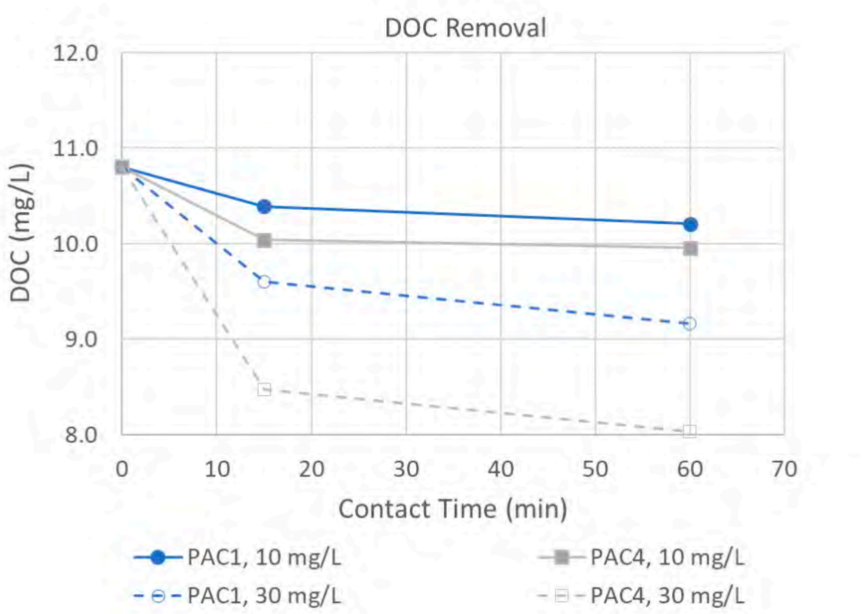

Figure 1. Effect of increasing concentration of PAC on the removal of DOC.

- In high DOC water, the same trends in MIB reduction applied as for low DOC water, although geosmin reduction now followed the same trend as MIB reduction.
- In spite of the large concentration differences between DOC (mg/L) and MIB/geosmin (ng/L) (ratio of DOC to MIB/geosmin are 1,000,000:1), the latter compounds were still removed in high DOC waters, suggesting that they adsorb onto different adsorptive sites than the DOC in the waters tested.
- PAC5 (chemically activated wood-based PAC) was an outlier, indicating raw material (wood based) and activation process (chemically activated) affect PAC performance. PAC5 removed less MIB and geosmin than a comparable coal based PAC (PAC2).
- The extent of PAC performance reduction due to interference effects between low and high DOC waters decreased with increasing iodine number and Methylene Blue adsorption or decreasing tannin.
- Particle Size Distribution played a significant role in PAC performance. PAC2 (d50 18.6 µm) and PAC3 (d50 13.5 µm) have similar iodine numbers, but the finer PAC has lower tannin value and higher Methylene Blue adsorption. This did not affect PAC performance greatly in low DOC waters but was evident in high DOC waters, where PAC3 reduced MIB by almost 9% more than PAC2. This is also indicative of adsorption processes, where the finer PAC has a much greater surface area and access to adsorptive sites for MIB/geosmin removal.
- In general, DOC interference effects were less significant for PACs with better adsorptive material properties.

This is an important outcome for selection of PACs for use in applications where raw water quality can vary significantly. While all PACs would appear to remove in excess of 90% of MIB and 95% of geosmin in a low DOC water, once the water quality deteriorates and DOC levels increase, higher iodine number PACs are required to maintain MIB removal. This outcome stresses the importance of conducting jar tests using the actual water to be tested.

It is important to note that an existing PAC, when applied at a higher dose rate, can still be used for removal of organics as DOC increases. Figure 1 shows DOC removal as a function of contact time and dose rate for the least (PAC1) and most (PAC4) adsorptive PACs. It can be seen that increasing the dose rate of PAC1 achieves a higher DOC removal than using PAC4 at a lower dose rate. However, with higher dose rates comes increased handling costs and sludge generation/handling/disposal costs, so a thorough analysis needs to be conducted to assess whether it is best to use more of a cheaper PAC or less of a more expensive PAC to achieve the desired outcome.

The DOC interference study highlights the interconnectivity of PAC material properties and performance. Given the apparent relationship between PSD, tannin value and Methylene Blue adsorption, it was difficult to isolate the effects of particle size using this data set. A second set of jar tests were conducted using 6 PACs, all coal-based steam activated PACs, which had comparable particle size.

Iodine, Tannin, Methylene Blue and PAC Performance

The PACs used in this study are given in Table 3. The aim of this study was to keep particle sizes consistent across all PACs, and investigate which of the adsorptive properties best predicted PAC performance.

PAC ID	Iodine Number (mg/g)	Tannin Value (-)	Methylene Blue Adsorption (g/100 g)	PAC d50 (µm)
PAC6	957	214	21.0	12.6
PAC7	958	240	22.7	12.7
PAC8	1022	167	24.3	12.9
PAC9	1015	260	22.6	13.1
PAC10	887	333	21.3	13.1
PAC11	857	340	21.3	12.6

Table 3. PACs used in adsorptive property investigation.

Material Property	MIB Reduction R^2 (-)	Geosmin Reduction R^2 (-)	Colour Reduction R^2 (-)	DOC Reduction R^2 (-)	UV254 Reduction R^2 (-)
Iodine Number	0.5981	0.8315	0.6469	0.7367	0.6929
Tannin Value	0.8796	0.9601	0.9800	0.5857	0.9583
Methylene Blue (g/100 g)	0.3543	0.4123	0.3473	0.3560	0.5722

Table 4. Coefficients of determination for linear regression analysis of PAC performance as a function of adsorptive material properties.

It can be seen that the PACs investigated are grouped into sets of 2 where iodine number is comparable but tannin number and Methylene Blue adsorption differ.

A high DOC (7.8 mg/L, true colour 17 CPU, UV254 0.21 abs/cm) water was used as the feed water for this study, and dose rates of 30 mg/L and contact times of 60 minutes used for all PACs. MIB and geosmin were spiked into the matrix at concentrations of 100 ng/L each.

Trends in organics, MIB and geosmin reduction are given in Figures 2 and 3. All data was curve fitted using linear regression, with the coefficients of determination (R2) for each curve fit given in Table 4.

Removing the particle size effects allows for a stronger comparison of adsorptive material properties and PAC performance.

The correlation study shows that:

- Where two PACs had a similar iodine number and differing tannin numbers, the PAC with the lowest tannin number generally removed more MIB, geosmin and organics.
- Linear regression analysis shows that, for these PACs, the tannin value is an excellent indicator of MIB, geosmin, and colour reduction, with coefficients of determination above 0.85 for correlations between tannin value and these performance indicators.
- Methylene Blue adsorption did not correlate well enough to be used as a performance predictor in this application, while iodine number was the most accurate at predicting DOC reduction.

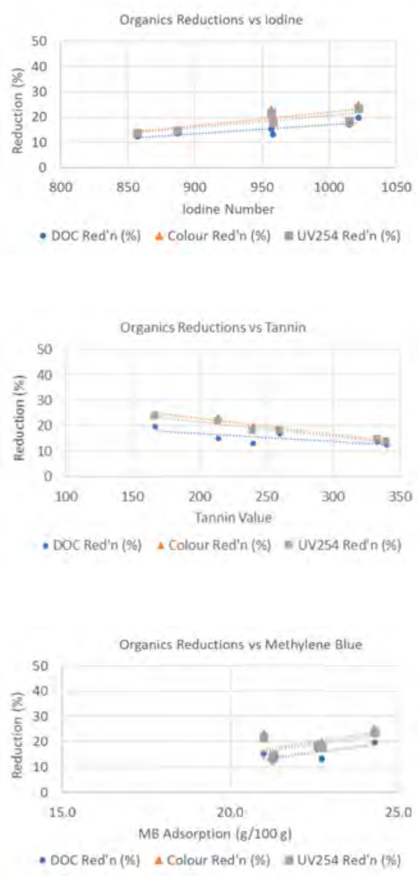

Figure 2. Organics reductions vs adsorptive properties.

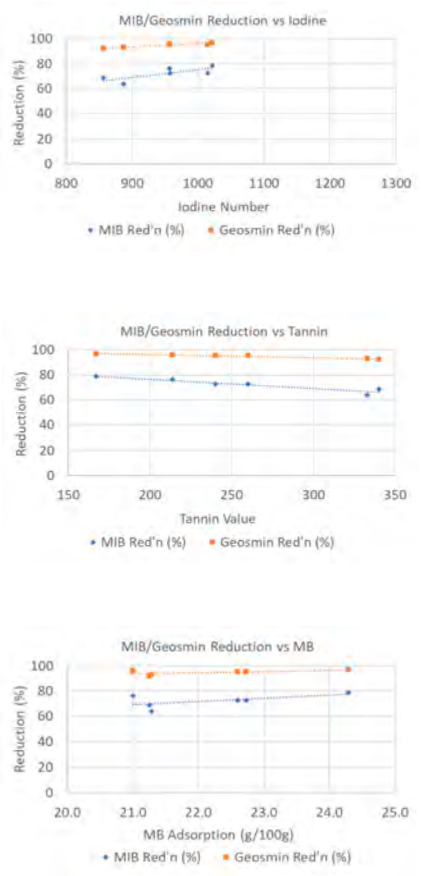

Figure 3. MIB/geosmin reductions vs adsorptive properties.

Conclusion

The outcomes of this study showed that a range of factors need to be considered when selecting PAC for a given application. The importance of a comprehensive jar testing program tailored to replicate operational conditions and considering variations in raw water quality cannot be overstated; indeed, the correlations observed in this study are unlikely to be reproducible for raw waters with differing DOC constituents. However, the wider trends observed suggest:

- The tannin value of PACs correlated strongly with MIB/geosmin removal, and if available is a useful material property for selecting PACs for jar testing studies. All else (iodine number and particle size, especially) being equal, the PAC with the lower tannin value is likely to remove more MIB/geosmin.
- While MB adsorption did not correlate with MIB/geosmin removal as strongly as tannin value, it may do so with other contaminants or in other industry applications.
- Variability of raw waters must be considered, and PACs chosen and performance tested appropriately. PAC performance in low DOC waters is no guarantee of real-world performance, and a higher dose rate or longer contact time, or switching to either finer PACs or higher iodine/lower tannin value PACs may be needed to ensure PAC performance is not overly compromised by DOC interference effects.

But remember test the PACs in your water for your problems!

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IMPORTANCE OF PRESCREENING FOR FAIRFIELD MEMRANE BIOREACTOR

Bill Collie

Queensland Urban Utilities delivers drinking water and sewerage services to 1.5 million customers in South East Queensland. As part of its vast network, the utility operates 29 sewage treatment plants including the Fairfield Membrane Bioreactor (MBR) Sewage Treatment Plant.

The Fairfield treatment plant (15,000 EP) services suburbs on the fringes of Brisbane and is located on a small foot print in Yeronga, surrounded by sporting fields and houses.

More than 90% of the flows received at the plant are from domestic sources, with minimal commercial or industrial flows. Approximately 40% of the plant's effluent is supplied as recycled water.

The plant was built in 2010, with commissioning completed in February 2011. The MBR replaced an activated sludge plant and clarifiers. Once the transfer to the new plant was complete, the primary sedimentation tank was converted to a wet weather overflow, and the clarifiers were demolished leaving behind the chlorine contact tanks and aerated digesters to be integrated into the MBR process.

The MBR treats up to three times average dry weather flows of 135 L/s. Excess flows from wet weather are diverted to the old primary tank, where it is stored and returned to the process when the event has passed. Fairfield receives all flows via gravity to an internal pump station, which then lifts the influent to the inlet works, setting the hydraulic gradient for the treatment plant.

The inlet works contain the prescreening, which consists of 3 mm Inclined Rotary Drum Screens for both the process and the bypass weir system for when flows exceed the plant capacity. All flows are then delivered to the bioreactor for biological processing.

From there, the mixed liquor is distributed to the four membrane chambers continuously. The membranes run in a cycle of Production, Backwash, Air Scour and Deaeration, and results in the production of high-quality effluent for discharge to the environment and recycling.

Figure 1. Membrane Cassette removal.

Figure 2. Contaminated Membrane Cassette when first removed from its chamber.

Figure 3. Contaminated Membranes being stripped for disposal.

The membranes are air scoured and backwashed every cycle, and every night there is an automatic clean with sodium hypochlorite. Once a month, operational staff manually complete a citric acid backwash, and once a year the membranes are taken offline one at a time for up to 24 hours to soak in a solution of sodium hypochlorite and caustic soda (for pH correction).

In early 2017, the Planning Team reviewed the performance of the membranes as part of plans to replace them at the end of their service life. At the time, Operations highlighted that the transmembrane pressure (TMP) had seen a significant drop. Inspection of the membranes during the yearly clean (Figures 1 and 2) revealed that the membrane cassettes were severely fouled with rag (Figure 3).

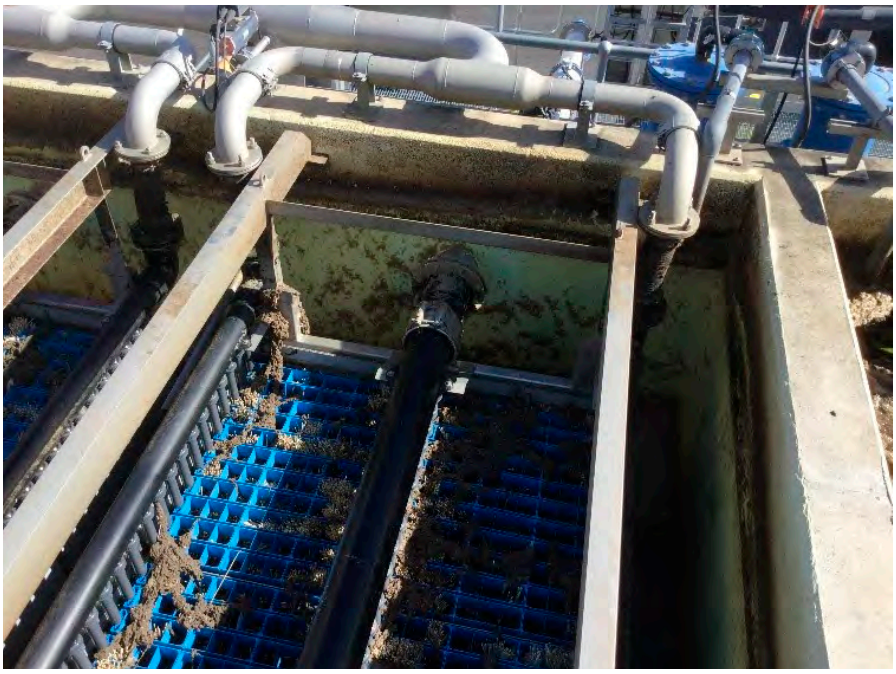

Figure 4. Membrane Cassette in chamber before removal Note No Membrane straws protruding above the cassette.

Figure 5. New Membranes prior installation into the Cassette.

In response, the Planning and Operations Teams immediately set the procurement process in motion to replace the membranes. The team also commenced an investigation into the contamination of the cassettes to determine the source and fix the problem before the new membranes were delivered.

The investigations led to the inlet works and the screening methods that protect the process. Ultimately, the issue was that temporary drum screen skirts, which had been installed around the drums some time previously, had failed. This meant contaminants had bypassed the screens undetected and made it through to the membrane chamber, contributing to the deterioration of the membranes.

Once the correct skirts were installed on the drums, the problem ceased. However, the membranes still needed to be replaced.

The weight of the contaminants has pulled the membrane straws down in their guides (Figure 4) and some were bent, kinked and distorted, which reduced their effective permeability to produce product water from the process.

While new membranes were being procured and delivered, the MBR plant was continuing to operate and meet demand.

However, deterioration of the membranes in April 2018 meant the plant could no longer operate at its design capacity. Operations increased from day work to 24/7, and temporary arrangements were made to tanker a portion of the influent to another treatment plant nearby, while waiting for the membranes and the installation team to arrive.

The installation of the new membranes (Figure 5) presented some additional challenges. The compaction within the cassettes caused structural cracking of the cassette framework, which added to the refurbishment times.

Jump forward 12 months from the installation of the new membranes and we have just completed the yearly soaks for each membrane chamber and inspected the fibres. They are in excellent condition with very little or no contamination in the chambers.

They are producing excellent effluent for discharge to the environment and our recycled water customers.

As a result of this event and the lessons learnt, there's been a number of operational changes, including:

- Increased inspections on the skirts and their associated drum screen.
- Better maintenance management of the critical assets protecting the membranes.
- Improved procurement in resourcing and holding of appropriate stock.

The key lesson is: effective screens are everything when operating an MBR STP.

The Author

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COEXISTING WITH TELCOS

Jason Ip

There are documented horror stories where the balance between the requirements of a Telecommunications Provider (Telco) and the responsibility of a water utility falls in favour of the Telcos. Documented impacts to water utility reservoirs have included:

- Compromised site security.
- Compromised worker health and safety of workers.
- Restricted access/egress to reservoirs.
- Difficulties to water supply operations and asset management.
- Increased risk to water quality and public health.

One of the major consequences is that water utility staff are no longer allowed to access some structures, and in particular the roof because of the level of radiation and, in some cases, simply a lack of space (Figure 1).

Perhaps our water industry has unknowingly made things too easy for Telcos by simply (albeit sometimes grudgingly) allowing them to dictate how they install and operate their communications equipment on our water assets.

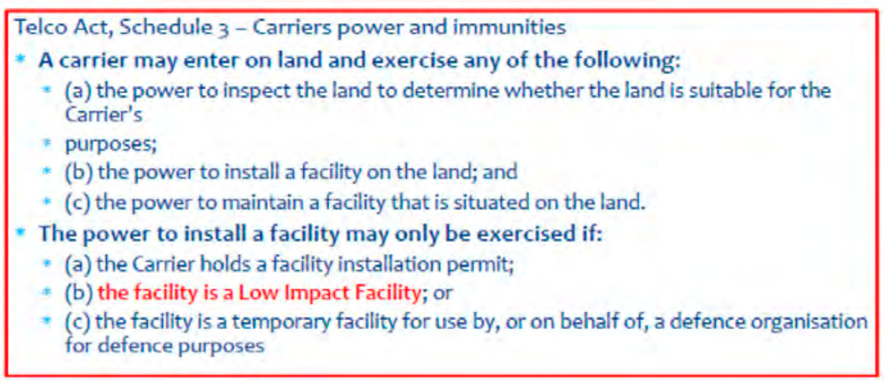
There is now a stronger need for us to understand and exercise our legislative rights so we can meet operational and governance requirements, reduce business costs imposed by Telco facilities, and to highlight any legislative deficiencies so things can be fixed. For example, the

Figure 1. Access to the roof of this storage is all but impossible.

Figure 2. Daisy chain of (whose) locks.

Figure 3. A crane is the only way to access some reservoir due Telco impacts.

Figure 4. "Swiss Cheese" effect from Telco roof penetrations.



Telco Act, Schedule 3 – Carriers power and immunities

- A carrier may enter on land and exercise any of the following:
  - (a) the power to inspect the land to determine whether the land is suitable for the Carrier's
  - purposes;
  - (b) the power to install a facility on the land; and
  - (c) the power to maintain a facility that is situated on the land.
- The power to install a facility may only be exercised if:
  - (a) the Carrier holds a facility installation permit;
  - (b) the facility is a Low Impact Facility; or
  - (c) the facility is a temporary facility for use by, or on behalf of, a defence organisation for defence purposes

Figure 5. Schedule 3 of the Telco Act.

rollout of 5G into the communities.

This article focuses on Telcos accessing water utilities assets using the telecommunications legislation, outside commercial arrangements.

Legislative Framework

The current Commonwealth telecommunication legislation was introduced when Telstra was privatised in the late 1990s. This was at a time when other various state and national water legislation for public health, water quality and workers safety was not as developed as it is now.

The *Telecommunication Act 1997 Cth* (Telco Act) provides substantial powers and immunities allowing Telcos to access, install and operate communication facilities on private property, especially if the facility is categorised as "Low Impact".

If the facility cannot be categorised as "Low Impact", the Telco must obtain development approval through state and local government planning processes. This gives water utilities an opportunity to stipulate conditions to ensure the Telco's facility is compatible with the water utility's essential operations and governance requirements. Some of these include:

1. Site access protocols.
2. Installation and maintenance activities.
3. Water quality contamination.
4. Work health and safety.
5. Lease/licence agreements.

However, if the facility is categorised as "Low Impact", then there is no need for the Telco to obtain approval. This is the area of greatest concern for the water industry because many of its reservoirs, towers and tanks are considered candidates to host Low Impact communication facilities.

This part of the legislation is best outlined in Schedule 3 of the Telco Act with an excerpt shown in Figure 5.

What are Low Impact Facilities?

Low Impact facilities are facilities that are considered to have a low visual impact because of their size and location. At the time the Telco Act was drafted, they were considered to be less likely to raise significant planning, heritage, or environmental concerns. Water supply reservoirs may be considered as a Low Impact facility more often than not.

The telecommunication industry has since significantly changed, with many other Telco Carriers competing for their own competitive advantage.

Land Access and Activity Notice and Objection Processes for Low Impact Facilities

Before a Telco can utilise this part of legislation to install equipment onto reservoirs, they must follow stringent processes that often begins with issuing a Land Access and Activity Notice (LAAN) 10 days before commencing works.

It's very important for water utilities to immediately review a Telco's proposal and be prepared to lodge an objection on legitimate grounds at least 5 days before commencement of works… that's only 5 days after receiving the notice!

The onus is on the water utility to identify noncompliance and lodge an objection, and failure to do this is interpreted as accepting the Telco's proposal on prima facie. This enables the Telco to carry out activities as stipulated in the LAAN.

It's vital for organisations to have adequate correspondence systems that gives the best opportunity to review the LAAN, and immediately submit an objection on legitimate grounds. Ironically, submitting an objection allows the first opportunity to commence proper consultation.

It's recommended that water utilities get familiar with other elements to this process, including referral to the Telecommunications Industry Ombudsman (TIO).

Valid Grounds for an Objection

Fortunately, Telcos must comply with a number of conditions that are contained within Division 5 of Schedule 3 to the Telco Act, and the Telco Code. Water utilities could use the objection process as a powerful mechanism to negotiate with Telcos, rather than accepting a notification of their planned installation or maintenance of facilities under the Telco Act. Exercising the objection process could (perhaps) even encourage Telcos to enter into a mutually agreed commercial arrangement, or even go elsewhere.

Some legitimate grounds to object are summarised in Figure 6.

Where to Next?

Since the proposed amendments to the telecommunications powers and immunities legislation was raised in June–July 2017, the water industry representatives have established a working group comprising WSAA, NSW and Queensland Water Directorates and other key water industry organisations (such as SEQ Water). The concerns of the group included potential legislation changes that would increase the burden onto water utilities for the establishment and operation of Telco facilities on reservoirs.

Department of Communication and the Arts (DoCA) has established a stakeholder representative community, Powers and Immunities Reference Group (PIRG), that includes representation from the water industry, road and railways authorites, affiliated Telco associations, and other federal agencies, such as Australian Communications Media Authority (ACMA) and DoCA.

The PIRG meets regularly and is now part of the formal consultation process to discuss current Telco impacts to water utilities (as described in this paper), and negotiating better ways to coexist with respect to current and future changes to Telco legislation.

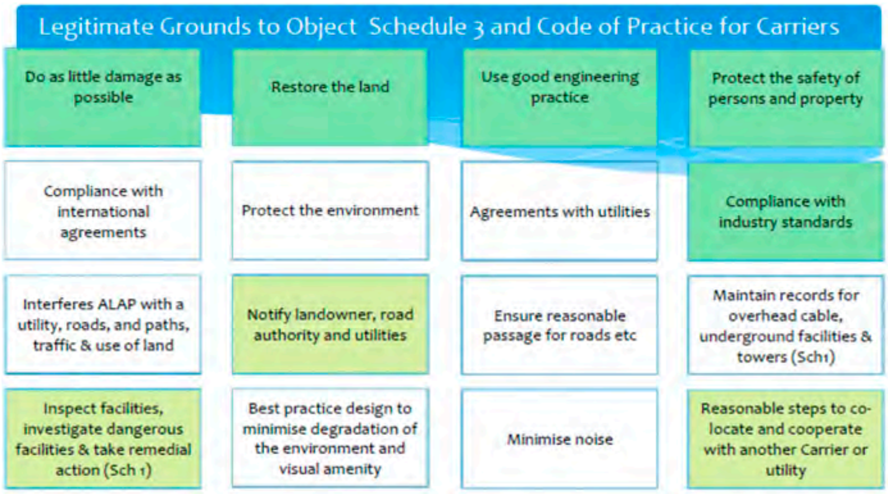


Figure 6. Some Legitimate grounds to object to Land Activity Access Notices (LAANs).

The Author

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Figure 7. Promotion of bird roosting habitats and blocking roof runoff.

IMPACT OF TELCO STRUCTURES ON WATER STORAGE RESERVOIRS

Carmel Serratore and Jill Busch

The installation of telecommunications equipment on drinking water reservoirs can present additional operational challenges and increase risks to water quality, worker safety and the ability of the owners to meet their statutory obligations and maintain assets. Some of these risks are presented below.

Electro-magnetic Energy (EME) Emission Zones and Access Areas

All reservoir sites that have telecommunications fixtures are to be registered with the Radio Frequency National Site Archive (RFNSA, see website www.rfnsa.com.au), and prepare and maintain an EME Guide for Site Safety report (previously known as a Radio Communications Site Management Handbook). EME guides are meant to list all carrier equipment at the site and identify restrictions that the emission zones have on the areas of the tank. Carriers registered with RFNSA have an obligation to ensure the EME guide is kept up to date. Site owners should note that that there may be significant differences between the theoretical field mapping of EME exclusion zones specified in the EME guide and the actual field mapping of EME exclusion zones on site. This can occur when the EME guides have not been kept up to date or are inaccurate (for example, a desktop study has been used by the carrier as opposed to actual site/field inspection). Some EME guides do not list the tank features, making it difficult to gain a perspective and determine if the EME exclusion zones encroach on the entry hatch to reservoirs or access stairs. These EME guides need to be reviewed before visiting sites, and to view if there are any "limited" conditions (such as the presence/exclusion of unknown antennas etc.) exist. This is making the determination of safe work areas difficult, thus impacting on worker safety. Site owners should check that the EME Guides are up to date/accurate and clearly detail all EME exclusion zone clearances. It is also good practice to leave a copy of the EME guide on site for workers and contractors who are required to access and maintain water reservoirs, to view.

Workers and contractors accessing or working near EME fields must be appropriately trained (RADHAZ) and wear appropriate instruments for monitoring EME exposure. This training must be kept up to date.

WH&S Concerns

There can be unacceptable worker safety risks associated with the installation of telecommunication equipment on water infrastructure. Some examples are set out below.

Controlling Operational Access to Undertake Inspections of Reservoirs

Positioning of Telco equipment has occurred in the past without due regard to the operational and functional requirements of the tanks. In some examples, this has led to site owners being unable to access the tank roof area due to emission zones over the ladders, or antennas installed on the roof area limiting the ability to carry out emergency, routine and maintenance requirements. This can lead to a loss of control of a site owner's audit ability of managing its assets. This can also be in conflict with a site owner's statutory obligations to ensure the water is safe to drink or continuance of supply of drinking water to the public.

Fire Risks and Smoke Hazards

Installation of carrier batteries and communication racks within a restrictive site of a reservoir structure can lead to fire risks and smoke hazards for workers – i.e. by installation of battery/electrical installations, which can overload the inside a high-level reservoir structure that has been designed with one access route, meaning the main entry can be compromised by smoke. Telecommunication equipment not being earthed properly (or not at all) can be susceptible to lightning strikes and become another source of fire hazard on rooftops. This could be a risk for sites located within bushfire classification overlays.

Trip/Slip and Unattached Overhead Hazards

This can occur with installation of cable trays running across access areas causing trip/slip hazards. Cable tray covers also require ongoing maintenance, and numerous covers have been found unattached on site or in neighbouring areas after being dislodged during a wind event.

Electrical Concerns

Many carriers have installed telecommunication sourcing power directly from site owners' switchboards, as opposed to using an independent supply of mains power. This can be problematic for site owners who operate pumps and water treatment plants, as they can experience power surges, in particular where a site has single phase power. It is also a problem during an emergency situation as it can lead to site owners being unable to isolate power in a timely manner. This is because it is an offence to interfere with telecommunication equipment under the *Criminal Code Act (Cth) 1995*. Consent to switch of, or to interfere with, carrier equipment requires carrier consent. In many instances, carriers are reluctant to allow site owners to "power-down" telecommunication antennas on water reservoirs so that workers can safely access, and carry out operations and maintenance of its water reservoirs on the basis that carriers operate under conflicting obligations to ensure that service coverage is maintained without any outages. This makes dissimilar obligations difficult to coexist on drinking water reservoirs and associated infrastructure, without compromising safety, asset management and water quality. The existence of unknown equipment can also become a problem for site owners as consent cannot be obtained, requiring site owners to make an application to the court to obtain consent otherwise risk committing an offence under the *Criminal Code Act (Cth) 1995*. This is not a good position for a site owner to be in. The water industry has been advocating for change in this regard.

Redundant Equipment

Removal of redundant and buried infrastructure such as cabling has been an issue for some asset owners. The redundant equipment becomes a problem as these can impact on a site owner's ability to perform asset maintenance; for example, in providing safe drinking water and increasing risks for worker safety with increased overhead hazards due to equipment falling into disrepair and/or becoming unsecured and susceptible to weather events. Future site expansions to meet the water utilities demands associated with increases in population growth (for example, equipment underground would need to be relocated at the expense of a site owner). Redundant equipment can also be a security issue for site owners in circumstances where owners of such equipment are unknown – creating issues of unlawful interference, in particular, for site owners operating critical infrastructure. Redundant equipment is a problem where there are multiple carriers on the same infrastructure and overcrowding exists, which can impact on a site owner's use and control of its water infrastructure. It has been known that carriers also intentionally leave redundant equipment in situ in order to reserve the spot (or real estate) per se from other carriers in competition with them.

Site Security

Often when attending sites with Telco equipment, there are additional padlocks on the gates for these companies to access the site independently. In the past, where the asset owner has restricted these by removing any unknown locks, they have attended the site later only to find that the chain has been cut and additional lock installed without the site owner's consent.

Site security can be further compromised by having additional Telco fixtures, such as site huts, cable frames and cabinets, on site that allow vandal access to bypass fences or security ladders. Sites have been compromised when subcontractors for the Telcos have installed scaffolding or left equipment within a locked site that allowed the local vandals to use as climbing frames to reach additional heights to conduct acts of vandalism.

Site restrictions can exist where Telco huts and compounds have limited the accessibility of the site for operational and maintenance requirements for site workers. Buildings and other infrastructure that prevent larger equipment, such as cranes or elevated working platforms, from setting up on site due to underground electrical cables, site huts or where antenna emission zones interfere with height works and require powering down of the Telco equipment to conduct the maintenance works. All these extra measures end up being a financial burden and a difficulty to the asset owner.

Structural Impacts

Steel tank coating damage has occurred when antenna supports have been welded to the wall area neglecting the heat impact for the internal coating, resulting in accelerated corrosion areas. Telecommunications equipment affixed to concrete reservoirs can also contribute to the degradation of reservoir structures. Factors contributing to reservoir structure due to the added telecommunication fixture/equipment may include:

- Local impacts on reservoir structures due to additional point loads and bending moments (including wind loads).
- Damage of the waterproofing due to poor workmanship of the installation of the fixtures supporting the telecommunications equipment.
- Concrete surface damage, including holes drilled remaining unsealed or unrepaired and thus allowing moisture ingress into the concrete surface that, in turn, can potentially lead to concrete degradation and steel reinforcement corrosion within the structure in the future. This is particularly a concern where reservoirs are located in a coastal environment, and the presence of chloride attack can initiate the corrosion process, resulting in loss of steel sectional area and cracking, delamination and spalling of the cover concrete well before the intended design life of the structure is reached.

In many instances:

- Certification of engineering assessment for carrier installations impacting on water infrastructure has not been obtained and/or maintained by carriers.
- Carriers have not maintained the upkeep and good working order of its equipment for its full life cycle. Where there are "common areas", such as cable tray and racks, identifying which Telco owns what equipment can be difficult and ensuring that adequate maintenance is conducted.
- Redundant antennas and structures remaining on site that can become hazards due to degradation and collapse, such as a fall object blowing off the tank during high wind events.
- In some instances, telecommunication equipment has been affixed to the barrier handrail of reservoir rooftops. This has led to degradation of handrails and in a known instance, dislodgment of the handrail. Unsafe or poor condition of handrails can mean that the telecommunication equipment attachments are not structurally sound and can pose a considerable safety risk, both to workers on the roof and those below as falls objects.

It is good practice to obtain a carrier's engineer certification/assessment with regards to its installation (pre and post) and to confirm that things have been installed properly, and a site owner's water infrastructure has not been impacted.

Water Quality Impacts

Birds (and other vermin) are attracted to the antenna structures for roosting and protection. This increases the risk for faecal material build-up in the roof area that can increase the risk to water quality.

Holes in roof areas from anchor points, or other Telco fixtures, can also allow roof drainage to enter tank and can lead to contamination of the drinking water supply.

The presence of carrier installation can restrict a site owner's ability to inspect and maintain its assets, thereby prolonging and extending a site owner's ability to respond. This can be a problem in the event of an emergency – for example, in cyclone-prone areas that may damage reservoir roofs needing replacement. Site owners have been unable to repair roofs in a timely manner, for example, the carrier may not cooperate or be rigid in when site owners can undertake works, time and date.

Figures 1 to 9 provide some examples of the issues raised above.

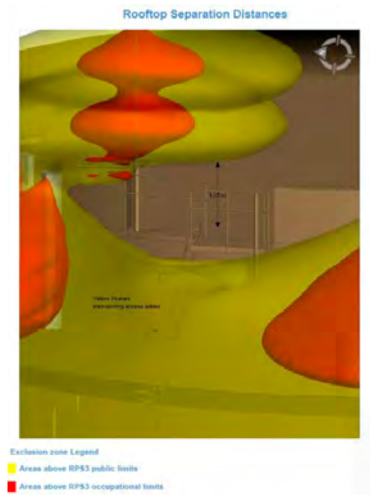

Figure 1. RF emission plume over an access ladder.

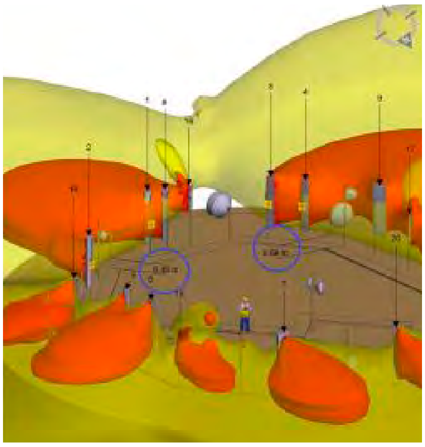

Figure 2. Antennas on a reservoir roof area.

Figure 4. Cable cover defect.

Figure 5. Aerial Intrusion around an operational working space.

Figure 6. Telco cable unattached and coating damage.

Figure 7. Reservoir entry hatch fully surrounded by aerials.

Figure 3. Telco fixtures allowing unauthorised access to tanks.

Figure 8. Cable tray cover missing after work on a reservoir roof.

Figure 9. Roof aerials poorly "fixed" directly to roofing materials.

Summing Up

Site owners should assess the risks of a carrier's installation of equipment and potential impacts on the water infrastructure and site, for both existing and future requirements. The water industry requires more diligent inspections and response times to any likely or possible risks to the stored water quality. There are water industry examples where communication with, and gaining adequate responses from, the Telco companies has been found to not be as simple or adequate as required. As the assets cyclic maintenance becomes evident, there is evidence that telecommunication installations on tanks have now added to the financial and time burden to water utilities, that they may not have initially been aware of. It is recommended that carrier installations occur on independent pole or tower as opposed to be mounted onto water infrastructure.

Site owners should note that the Australian Communications and Media Authority (ACMA) is responsible for ensuring that low-impact facilities are installed according to the Code of Practice. Where a carrier has breached the Code of Practice, ACMA may take enforcement action, which may include formal warnings or directions to comply with the Code. Complaints to ACMA regarding carrier activities or carrier obligations under Schedule 3 to the Act can be made to telephone.service.regulation@acma.gov.au. Asset owners are strongly encouraged to send their concerns and complaints through to ACMA.

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EMERGING LEADERS CULTURAL DIVERSITY PROGRAM: RECOGNISING THE SHARED VALUES OF WATER IN THE GOULBURN VALLEY REGION

Elise O'Keefe and Simon Walsh

Goulburn Valley Water (GVW) is committed to embracing inclusion as part of its culture. We recognise that to be a better workforce and corporate citizen, it is important to increase our understanding and learning of a range of differences among people in our community and society generally.

In early 2017, GVW Managing Director Peter Quinn and a prominent elder from the local Yorta Yorta community, Paul Briggs, put out an Expression of Interest (EOI) for young leaders to be involved in a 3-day program to learn more about local water management. For the GVW staff, it was an opportunity to learn about the local Indigenous community as a stakeholder in water management, and for the young Indigenous leaders, it was a chance to gain more knowledge in water management within the region. Four participants were selected from GVW, and 3 from the local Indigenous community.

The first day of the 3-day program was hosted by GVW at the Shepparton Water Treatment Plant. After some nervous introductions, we (the GVW staff) kicked off the day with a presentation on what services GVW provides, the footprint we cover, and our role in water and land management within the region. An emerging theme throughout the day was the significance of water for both parties. For GVW, we value water for the health and livability of our local community, and while the local Yorta Yorta community also values water for this reason, water holds great significance within its community for cultural and spiritual values.

The second day was hosted by the young Indigenous leaders at the Barmah National Park. Corey, representing the young Indigenous leaders, welcomed us to country with a smoking ceremony and then described the significance of the Barmah Forest for the Yorta Yorta. We then visited the Barmah Lakes and learnt that these lakes once provided an abundant source of fish for the Indigenous community, and that periodic flooding supported plant growth within the flood plain that provided natural medicines and materials for artwork.

Modern impacts on the Murray River, including water diversions and the introduction of alien land and water species, has significantly changed the river and lakes. Where these water bodies were once crystal clear, they are now muddy and turbid, which makes practicing traditional fishing difficult. Water diversions have altered the natural flooding regimes, changing the growth patterns and species that now dominate the flood plains. Given this, it is understandable that the local Indigenous community has a great interest in being involved in water management.

The young Indigenous leaders described other sites and places of significance that we were taken to (Figure 1). These included scar trees and old campsites from the Indigenous communities that lived in Barmah before European settlement, where the coals from fires and cultural artefacts had been found. The eroded banks of the river revealed layers of Aboriginal shell middens from generations past, evidence again of how the Murray River supported those that once lived there.

We then visited the Cummeragunja Aboriginal mission on the New South Wales side of the Murray River, which was established in 1881 and is still a community to this day. The Cummeragunja mission is the site of the first mass strike of Aboriginal people in Australia, which is a significant historical event for the Goulburn Valley region.

The third and final day of the program

Figure 1. Day 2 at the Barmah National Park and Cummeragunja mission.

Figure 2. Day 3 at the Rumbalara Community Centre in Shepparton (Elise is 3rd from left and Simon is 6th from left).

Figure 3. Artwork celebrating Indigenous leaders from the Yorta Yorta community of the GVW office building in Shepparton.

was held at the Rumbalara Community Centre. The photo of the participants on this day (Figure 2) encapsulates the 3-day program quite well – both the GVW staff and Indigenous leaders coming together around water, or "wala" in Yorta Yorta language.

The day was used to reflect on what we had shared and to workshop a way forward for GVW to continue to recognise cultural values in the Goulburn Valley region. As part of this, we identified several meaningful projects and local initiatives the group could work on and implement. Initiatives identified for development included ones around incorporating Indigenous language in GVW signage, the inclusion of cultural values of water in water operations training, and the inclusion of cultural sites in heritage tours.

Additionally, in 2017 GVW offered 2 traineeship positions designated for Indigenous applicants. Two local Indigenous young men were appointed to the positions, one of which has gone on to secure full-time employment at GVW. In response to the success of this traineeship, GVW will be offering another Indigenous traineeship in 2019.

Reflecting on the program, the participants from GVW agreed that the experience had been a positive one, with all of us coming out of it more informed about our local Indigenous community and its interest and values in water management.

Elise's Reflections:

"As someone who has grown up in the region but had very little knowledge on the Indigenous community or history, I put my hand up to participate. My biggest takeaway from the program was how little I actually knew about the local Indigenous history and culture of the region. I made some great friends, and the stories told were fascinating. The experience opened my eyes to the many values of water, some of them for reasons that I'd never considered before. I hope that this broadening of knowledge will enable my decision-making to consider all stakeholders when contributing to water management.

"I believe that GVW's participation in programs like this enables us to become a more inclusive and diverse workplace, resulting in more diverse ideas, allowing us to achieve better outcomes that ultimately benefit our customers and community."

Simon's Reflections:

"I was very honoured to meet our region's young Indigenous leaders, to participate in a program to share values we hold important within our community, and build on this to develop meaningful projects and initiatives. Similar to Elise, I grew up in this region and was aware of the strong identity the local Indigenous community has through our local co-operatives, sport, art, education and community health programs. However, I was unaware of the significant places, stories and iconic individuals that have shaped modern Australia, and advanced the recognition of Indigenous Australians. The experience highlighted our shared water values for quality of resource, the protection of places important us, and role for participation in the community in resource decision-making."

Since completing the program, we have used the experience to share our learnings with others at GVW and within our community. We believe that the relationships built with those that represent the Indigenous community, as well as a greater awareness of the cultural values of water and land, will allow us to become more informed and effective water managers. All in all, the program was very worthwhile, and at the end of the day, we all share the common desire to maintain healthy waterways that support our communities.

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