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FROM WASTEWATER TO COMMUNITY BENEFITS AND OPPORTUNITIES

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FROM WASTEWATER TO COMMUNITY BENEFITS AND OPPORTUNITIES

Paul Beard, *West Kimberley Operations Manager,* Water Corporation WA

ABSTRACT

The Water Corporation of Western Australia (WA) has established partnerships with community groups and not-for-profit organisations to successfully deliver a number of community-based projects that have resulted in economic and social benefits for people in the remote West Kimberley region of WA.

These projects include; delivering a community grants scheme solely funded through the wastewater disposal process, providing Aboriginal trainees with practical agricultural experience and partnering with an Aboriginal organisation to establish a seed bank of native plants using recycled water.

Viewed together, these projects redefine the value of recycled water and introduce a viable model for other water utilities to partner with local groups to benefit the community, particularly in regional areas.

1.0 INTRODUCTION

Water Corporation understands the value of community partnerships and is constantly looking for innovative ways to engage with the communities in which we operate.

Water Corporation has established three initiatives at a wastewater treatment plant (WWTP) near Broome, in the West Kimberley, that have created lasting benefits for a community with high levels of disadvantage. This was made possible by the Corporation's recognition of the benefits of recycled water and its strong community relationships.

These projects have demonstrated that wastewater is a valuable commodity with enormous potential, and not just a waste product requiring disposal. The Corporation now has ongoing opportunities to show its customers that it is socially conscious and aims to 'do the right thing.' This has already resulted in greatly improved attitudes towards the Corporation in the West Kimberley region and reaffirmed our social licence to operate.

This paper provides an overview of the projects underway in Broome, an explanation of how these were established and the key benefits generated for the community and our business.

2.0 DISCUSSION

The Broome North WWTP was built in 2011 to cater for increased flows generated by the growing popularity of Broome as a holiday destination in the dry season (April – September), and a growing core population. Prior to construction of the Broome North WWTP, Broome's wastewater was serviced by a single treatment facility located in town.

The Broome North WWTP has a licenced capacity to treat 3.5 mega litres per day (ML/day) and receives an average inflow of 1.35 ML/day. The remaining portion of the town's wastewater (1.7 ML/day) is treated at the other treatment plant.

2.1 Innovative Disposal of Recycled Water

The Broome North WWTP is located 12 kilometres northeast of town on a 220-hectare (ha) plot of Water Corporation land. The distance from traditional recycled water irrigation sites, such as public open space, prompted the Corporation to explore alternative disposal options. Irrigation of Rhodes grass (*chloris gayana*) with recycled water was identified as the best disposal option to meet environmental licencing conditions. This option also benefits the business by allowing it to control its disposal scheme; ensuring licencing conditions are met and minimising infrastructure requirements that might otherwise involve building a costly reticulation scheme back into town.

The Broome North facility consists of pre-screening, one facultative treatment pond (primary pond), a maturation treatment pond (secondary) and a treated wastewater storage pond. Wastewater undergoes secondary treatment via the primary and secondary ponds before being discharged to the storage pond. Treated wastewater undergoes disinfection by chlorination prior to being applied across a 32-ha plot of Rhodes grass using a centre pivot spray irrigation system. The Rhodes grass crop is harvested every 4 – 6 weeks, processed on site into fodder and sold locally as stockfeed.

In early 2018 the Water Corporation expanded the irrigation scheme by installing a second pivot irrigation system. The WWTP will eventually be developed in stages aligned with predicted population growth and is expected to reach its ultimate treatment capacity of 10.5 ML/day by 2040.

Incoming wastewater is treated to a secondary standard and classed as ‘low risk’ (‘class C’ in other Australian States). In accordance with the relevant guidelines, the WA Department of Health Guidelines for the Non-potable Uses of Recycled Water in Western Australia (2011), ‘low risk’ recycled water is suitable for application and irrigation of non-edible agricultural crops.

Water Corporation mitigates the risks of irrigating a fodder crop with recycled water by using specific methods, as per our license agreement with the WA Department of Environment Regulation, and in alignment with the WA Department of Health Guidelines for the Non-potable Uses of Recycled Water in Western Australia, 2011. Risk mitigation methods include:

- Use of chorine for disinfection of recycled water prior to irrigation;
- Fencing of the irrigation area to prevent public and animal access; and
- Subjecting the cut crop to a minimum 21-day holding period to limit biological (pathogen) risk.

The unconventional design of the Broome North WWTP has allowed Water Corporation to establish a number of successful community-based projects at minimal cost to the business. As Water Corporation’s primary purpose is to provide customers with essential water and wastewater services; community-based projects can often be prioritised as secondary. During the development stages of the West Kimberley projects, there was some resistance internally to pursue creative options for community involvement, leaving certain pockets of the business to pioneer the projects.

The success and exposure of the West Kimberley projects has helped to contribute to a greater cultural shift within the Water Corporation, making way for similar community initiatives to be established.

Having recognised trends within its own business, and the wider corporate environment, Water Corporation is now in the processes of developing a strategic plan to take a more active role to positively contributing to local communities, beyond the provision of essential services.

2.2 Kimberley Community Grants Scheme

Water Corporation's sustainable supply of Rhodes grass hay has met demands from local markets for fodder and subsequently generated thousands of dollars in revenue. Since March 2016, Water Corporation has contributed proceeds to a community grants scheme to benefit the West Kimberley and has so far raised $111,721 for grass-roots community projects.

The Kimberley Community Grants Scheme (KCGS) is delivered in partnership with the Lions Club of Broome, a reputable not-for-profit group with excellent community connections and experience in delivering grants in the Kimberley region.

Water Corporation chose to partner with the Lions Club of Broome because of their extensive experience in the administration of community grants and their capacity to facilitate the sale of Rhodes grass hay to local farmers, a responsibility that previously fell to our operators.

A memorandum of understanding for the administration of the grants scheme outlines the roles and responsibilities of the two parties, and safeguards the Corporation's control over its funds and the Rhodes grass operation.

Water Corporation developed the selection criteria and guidelines for grants scheme applicants to ensure that funding would support grass-roots projects that address a community need.

To ensure a transparent selection process, Water Corporation and the Lions Club of Broome appointed an allocations committee, responsible for making recommendations for successful applications against the selection criteria. The committee includes prominent members of the Broome community across a range of portfolios. This includes representatives from Goolarri Media (an Aboriginal media organisation), WA Netball Association, Department of Water, Shire of Broome and Broome Men's Shed. The committee is led by a senior Water Corporation employee.

2.3 Grants Scheme Outcomes

Since the grant scheme was established in 2016, Water Corporation has supported 20 community projects with $111,721 in funding. These projects have been undertaken successfully throughout the West Kimberley, meeting intended outcomes and generating positive media coverage and community feedback.

Given the population structure in the West Kimberley, many of the projects supported by the grants scheme directly benefit Aboriginal people, a group with known high levels of disadvantage. According to the Australia Bureau of Statistics (2016), Aboriginal or Torres Strait Islander Peoples make up 27.8 per cent of the population within the Shire of Broome, and 47 per cent within the Shire of Derby West Kimberley, which encompasses most of the West Kimberley area.

In 2019, Water Corporation opened the grants scheme to organisations in the East Kimberley, renaming the program; the Kimberley Community Grants Scheme.

2.4 Wunan

In August 2017, Water Corporation formed a partnership with Wunan to support an education program that gives Aboriginal girls from the East Kimberley the opportunity to attend high performing schools across Australia. The $28,260 funding contribution was generated by the sale of hay from the Broome North WWTP, which is also the funding source for the WKCGS.

The Kimberley Education Excellence Program has already proven successful for participating students and has also created positive flow-on effects for their families and the wider-community.

Water Corporation's contribution was used to provide 30 female students with tutoring services for science, technology and math subjects, as well as other essential items to support their schooling. The Aboriginal students are from the East Kimberley towns of Wyndham, Halls Creek and Kununurra.

2.5 Native Plant Seed Bank Project

In February 2016, Water Corporation partnered with Mamabulanjin Aboriginal Corporation (MAC) to trial growing native plants with recycled water from the Broome North WWTP.

MAC is a not-for-profit organisation based in Broome with demonstrated experience in delivering land care and horticultural projects that create employment and training opportunities for Aboriginal people. These credentials made MAC an ideal partner for the project.

An ex-gratia lease agreement with Water Corporation allows MAC to access 17.9 ha of land adjacent to the Broome North WWTP. MAC uses a specialised horticultural method whereby seedlings are planted amongst existing vegetation to preserve the natural environment. The project provides a diverse range of seeds for land care projects in the area, and products for commercial use, such as timber, fruit, cut flowers and oils. A number of rare plant species have been established at the site, so the project also contributes to the protection of threatened native flora.

MAC fenced the area and completed the site preparation work, which involved clearing invasive plants and the installation of a slow-release drip irrigation system. The seed bank is being established in stages, with planting occurring in the wet season months between November and April. As part of the first two stages of the project, MAC has planted over 5,500 native seedlings across 6.85 ha of land.

Depending on rainfall, each plant requires around 4 litres of recycled water per day until established, which can take up to 6 months depending on the species and seasonal conditions. As the plants are native to the area, they require very little irrigation once matured. The drip irrigation system is moved once the plants are established and used to develop further sections of the land.

All plants have responded well to the nutrient-rich recycled water, and further monitoring will continue as the project progresses.

2.6 Social Benefits

So far, over 90 young people from the area have gained valuable land care experience at the site, with some completing TAFE qualifications in horticulture and land management.

Many of the participants are part of the Federal Government Work for the Dole and Green Army programs, and some are minimum security prisoners. This project has provided people with employment, paid volunteer work and the opportunity to gain valuable new skills to improve job prospects.

Feedback on the impacts of the project from participants has been that they have experienced improved self-esteem, acquired new skills and formed social connections.

In addition to the employment and professional development opportunities, this project also helps to foster a connection between Aboriginal people and the land. In an area with high levels of socioeconomic disadvantage, the native plant seed bank project has helped to create much-needed social and employment opportunities for Aboriginal people.

2.7 Opportunities for Aboriginal Trainees

Water Corporation is committed to providing economic opportunities for Aboriginal people. As part of this commitment, we have proudly employed a highly capable Aboriginal trainee on a fulltime basis at the Broome North WWTP.

The trainee will earn a certificate III in water industry operations and gain experience in using advanced farming equipment, horticultural techniques and exposure to safe work practices.

3.0 CONCLUSION

In the Kimberley, recycled water has been transformed from a waste product requiring disposal, to a valuable commodity for the community. The Broome North WWTP Rhodes grass crop was expanded in 2018 with the construction of a second pivot irrigation system. The additional funding created by the expansion has allowed us to expand the grants scheme to benefit the entire Kimberley for the first time.

The KCGS provides a source of funding for a diverse range of community projects to empower people and groups to identify opportunities and address issues. The partnership with Wunan also provides valuable support for the education of Aboriginal girls.

The native plant seed bank will continue to provide seeds for MAC's land care projects and help preserve endangered flora, while also providing ongoing opportunities for local people to gain skills and employment.

The collective success of these projects has created a precedent for similar community-based initiatives and the Water Corporation is now exploring options for Aboriginal involvement in the water recycling scheme in the neighbouring East Kimberley and Pilbara region.

Water Corporation has improved its reputation and strengthened its social licence to operate, which is crucial for every good business, particularly one that is owned by government.

These projects set a rightfully high standard for government, business and utility providers to form collaborative partnerships with their communities.

4.0 ACKNOWLEDGEMENTS

The Broome projects were made possible by the Water Corporation's partnerships with MAC, Wunan and the Lions Club of Broome.

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SEPTICITY AND CORROSION ACTION PLAN

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SEPTICITY AND CORROSION ACTION PLAN

Amie Aldred, *Project Development Project Manager*, Logan Water Infrastructure Alliance
Mohammed Hayat, *Trade Waste Systems Officer*, Logan City Council

ABSTRACT

Over half of Loganholme's combined trunk and reticulation network is comprised of corrosion-prone materials (concrete maintenance holes, concrete pipe and ductile iron concrete lined pipe). In areas where septicity is high, accelerated corrosion will reduce the remaining life of these vulnerable assets and could lead to premature and costly asset renewals and odour complaints. Recently, Logan City Council (Council) recognised that an action plan is needed to better understand septicity and corrosion hotspots in the Loganholme WWTP catchment and develop a strategy to manage the issues.

This paper will review Council's Wastewater Septicity and Corrosion Action Plan. It will outline how to best use available data to estimate septicity and corrosion hot spots, and describe the multipronged strategy to mitigate septicity and corrosion. This will include actions to understand our wastewater better, as well as governance actions, preventative measures, operational adjustments, reactive and trade waste measures, continuous improvement, information management, collaboration and financing actions. The actions that have been carried out are in-expensive and straight forward, and the learnings may assist other small and medium sized water utilities in their journey toward septicity and corrosion control.

1.0 INTRODUCTION

Recently, there has been mounting pressure for Council to mitigate septicity and corrosion across the Loganholme Wastewater Treatment Plant (WWTP) catchment to minimise corrosion of assets, extend asset life and reduce odour complaints.

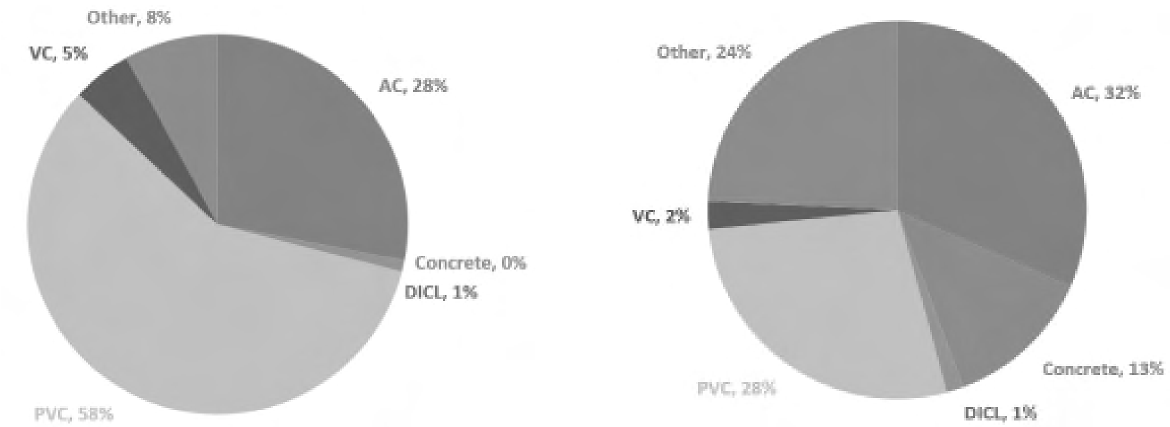
In the context of this study, septicity is defined as dissolved sulphide generation that occurs in the submerged portion of the wastewater network due to high sulphate concentrations, long hydraulic detention times, low dissolved oxygen concentration and sulphate-reducing bacteria which live in the slime layer and convert sulphates to dissolved sulphides. The dissolved sulphides exist in equilibrium with hydrogen sulphide (H_2S), and the bi-sulphide ion and the H_2S species exist in equilibrium as H_2S aqueous and H_2S gas. The lower the pH, the higher the temperature, and the higher the turbulence, the more H_2S gas that will be generated above the water line. Key problems associated with the build-up of H_2S gas in the sewerage network are:

- **Noxious odour:** H_2S gas smells like rotten eggs and can be a nuisance if it is able to vent from the sewer, close to residential areas or public spaces.
- **Toxicity:** H_2S gas is a safety risk for wastewater operators as it can affect the nervous system, causing headaches, nausea, irritation of the skin, eyes and respiratory tract. At high concentrations (greater than 100 ppm) it cannot be detected by human senses and can be life-threatening.
- **Asset deterioration:** H_2S gas can be converted to sulphuric acid in the presence of *Thiobacillus* bacteria that live on the pipe wall above the water line, especially in moist conditions. Sulphuric acid is highly corrosive to concrete maintenance holes, concrete pipes, asbestos cement (AC) pipes and ductile iron pipe (DICL), as well as inlet work facilities at WWTPs.

Previous investigations carried out by Council's Trade Waste team and by the Logan Water Infrastructure Alliance (LoganWIA) have proven that there are high levels of septicity in certain locations within the Loganholme WWTP catchment. H_2S gas concentrations higher than 500 ppm were recorded, and significant asset corrosion was evident at certain locations.

Figure 1 shows there is 1,781 km of pipework in the Loganholme WWTP catchment. This includes 142 km of trunk pipework (>DN225 to DN1650), of which over half is comprised of corrosion-prone materials (concrete, AC and DICL).

The concern is that if nothing is done, uncontrolled septicity and subsequent corrosion will prematurely reduce asset life. This will lead to early rehabilitation and significant costs to Council. For this reason, Council were prompted to develop a Wastewater Septicity and Corrosion Action Plan to better understand septicity and corrosion hotspots in the Loganholme WWTP catchment, using readily available data to develop a strategy to manage the issues.



COMBINED TRUNK AND RETICULATION (1,781Km) **TRUNK ONLY (142 Km)**

Figure 1: ***Loganholme wastewater network – pipe material (percentage by length)***

2.0 DISCUSSION

2.1 Initial Desktop Investigation

A desktop review of the following key septicity indicators was carried out using available data to develop a risk-based assessment framework to identify known septicity and corrosion 'hot spots' and support the Septicity and Corrosion Action Plan:

- Odour complaints
- Total pump station and rising main retention times
- Corroded maintenance holes
- Gravity main pipe material
- Pump station capacity
- Average rising main and gravity main velocities
- Significant trade waste dischargers
- Drop maintenance holes.

Septicity 'hot spots' were grouped into 'priority areas' and illustrated on a simplified schematic figure of the Loganholme WWTP catchment.

2.2 Septicity and Corrosion Action Plan

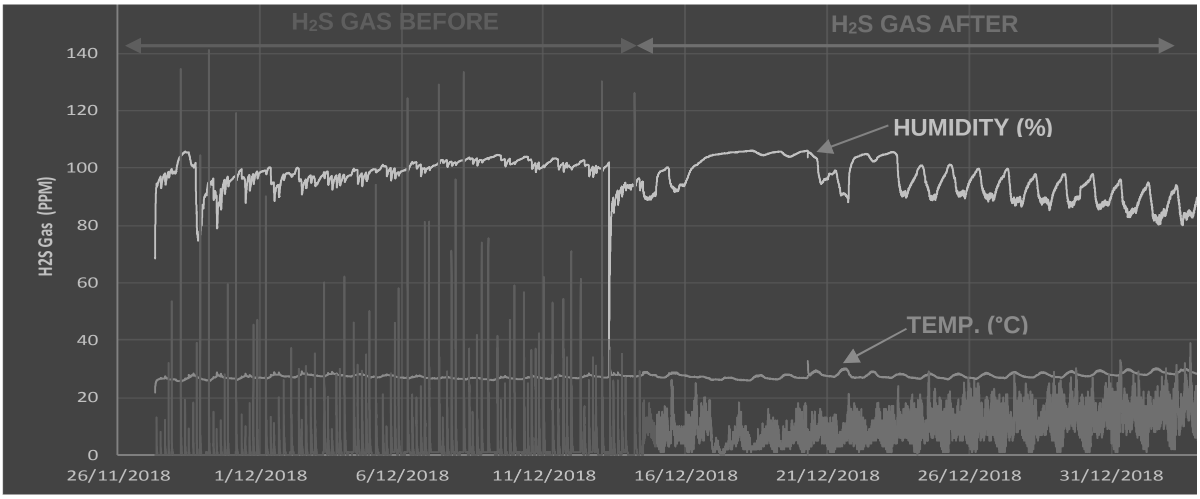
The Action Plan in Table 1 is a five-year rolling program from 2018/19 to 2022/23. It is the backbone of Council's septicity and corrosion management strategy and was compiled from findings gathered from background data, industry discussions and the risk-based assessment framework. This section describes some of the actions that have been carried out successfully to date. These may have potential use by other water utilities in the industry.

Table 1: ***Septicity and Corrosion Action Plan***

Action
Understand the Problem
Action 1. Background septicity monitoring
Action 2. Review of condition assessment data
Action 3. Long term monitoring of H_2S gas at the Loganholme WWTP Inlet Works
Governance
Action 4. Assign accountability for the 19 actions
Action 5. Action Plan – annual audit
Action 6. Assign Action Plan Project Managers
Preventative Measures
Action 7. Mitigate septicity through good design practice
Action 8. Chemical dosing
Action 9. Air valve condition assessment and renewal program
Operational Adjustments
Action 10. Optimise pump station control settings to minimise hydraulic detention times
Action 11. Pump station daily scour
Reactive Measures
Action 12. Odour control units
Action 13. Relining works
Trade Waste Measures
Action 14. Undertake septicity field tests and introduce septicity Trade Waste charges
Continuous Improvement
Action 15. Ongoing review of predictive tool developments and new capabilities
Action 16. Annual updates to Action Plan
Information Management
Action 17. Information systems to share monitoring data across the water business
Action 18. Improvements to general information sharing across water business
Financing
Action 19. Confirm funding availability

Effective management of septicity and corrosion requires a toolbox approach and should always start with good design practice to eliminate septicity in the first instance. Examples of good design practice include aiming for velocities in the range of 0.6 m/s to 1.8 m/s, smooth maintenance hole transitions, limiting bends to 45 degrees, avoiding inverted siphons or installing vent stacks on gravity mains. Other examples include minimising pump station and rising main hydraulic retention times, minimising free-fall and turbulence, avoiding partially full rising main conditions, having continuously rising profiles for pressure mains and providing completely submerged rising main discharges to completely absorb hydraulic energy. In a brownfield wastewater network with legacy septicity issues, easy, low-cost solutions should be addressed first. This includes pump station operational adjustments to reduce hydraulic retention time in the wet well and rising main.

Regular pump cycling through the low night flow period could be beneficial if there is a large base flow, or if it is possible to store some of the daily flow in the incoming gravity main. A daily scour of the rising main could also be beneficial in preventing the slime layer from forming if there is enough flow during the daily peak, or if flows can be stored in the incoming gravity main. The ability to perform operational adjustments depends on the characteristics and hydraulic performance of the network. A controlled trial is necessary to validate effectiveness of dissolved sulphide and H_2S gas reduction. Council has recently undertaken trials to assess the impact of changing pump station control settings to minimise hydraulic detention times. The results have been mixed, with only one out of six sites showing a distinct reduction in H_2S gas levels. The site that has shown favourable results (Demio Road SPS67) demonstrated that peak daily H_2S gas concentrations reduced from 140 ppm to 30 ppm (a 78% reduction), as shown in Figure 1. Reasons for such varied results are currently being investigated.



<u>Figure 2:</u> ***Demio Road SPS67 H_2S Gas (ppm) Before & After Control Changes***

Reactive measures and some preventative measures such as chemical dosing, should only be carried out as a last-ditch attempt to manage septicity, corrosion and odour. Chemical dosing should only be implemented if there is a compelling business case justifying a whole-of-life cost advantage compared with alternative measures, such as planned network rehabilitation (e.g., relining). Best outcomes are achieved when chemical dosing is strategically planned on a network-wide basis and known septicity sources (confirmed by background sampling). It should be operated with smart instrumentation that can guarantee pre-specified target outcomes through optimal chemical usage.

The governances, continuous improvement and information management actions are essential components of ensuring the Action Plan is driven forward efficiently and expediently, with collaboration across all areas of Council's Water Business.

Two of the most important and possibly underrated actions are to understand the problem through background septicity monitoring, and to introduce trade waste initiatives to minimise septicity. Of the 19 actions in Table 1, these are among the most progressed. A summary of both projects is provided in the Section 2.3 and Section 2.4, respectively.

2.3 Background Septicity Monitoring

A wastewater characterisation methodology and program was developed based on outputs from the risk-based assessment framework preceding the Action Plan.

The sampling period was 19 weeks in total and included an opportunistic condition assessment of the maintenance holes where sampling was undertaken. Table 2 outlines the parameters analysed and the instruments used for characterisation of the septicity. Over 72 sites were sampled, a mixture of rising main discharge maintenance holes and critical locations along the Slacks Creek and Scrubby Creek trunk gravity mains.

Table 2: ***Parameters Analysed***

Parameter	Instrument
Dissolved sulphides	HACH DR900 instrument and sulphide reagent set for onsite grab samples
pH	Eureka Manta II multiprobe for onsite grab samples
ORP	
Conductivity	
Temperature (liquid)	
Temperature (gas)	6 x 0 to 1000 ppm long deployment Acrulog H_2S loggers
H_2S (gas)	

In summary, the wastewater characterisation improved Council's understanding of the sources and mechanisms of septicity. High levels of septicity were confirmed at over half of the 33 rising main discharge maintenance holes sampled, the downstream sections of Slacks Creek and Scrubby Creek trunk gravity mains, and the Loganholme WWTP Inlet Works. The results have provided Council baseline data to determine the preferred locations for chemical dosing, if proven feasible compared with relining and improved ventilation, which is the next level of assessment to be carried out. They also confirmed that the desktop approach to identifying septicity 'hot spots' was an appropriate methodology.

2.4 Trade Waste Initiatives to Minimise Septicity

Apart from regular wastewater discharge monitoring, another source control measure employed by Council to minimise discharge of excessive water-borne contaminants produced by trade waste generators is to require an Effluent Improvement Program (EIP). The EIP is generated by trade waste dischargers and should include:

- A description and a clear objective of achievable targets of the discharge quantity and quality
- Assessment of how materials enter their business up to delivery to a customer (flow diagram)
- Examining waste prevention and recycling options, including water conservation
- A program or action plan to reduce contaminant levels, detailing expected outcomes, timelines and milestones
- Provisions for monitoring, recording and reporting waste quantity and quality for continual improvement and to reduce waste costs.

The findings of The Septicity and Corrosion Action Plan have prompted Council to revise the EIP requirements to include adoption of a H_2S gas sewer admission limit of 10 ppm, consistent with the Safe Work Australia permissible exposure limit for H_2S gas (8-hour time-weighted average). Should the 8-hour time-weighted average be exceeded in any one day, a daily charge of $1,320 per day will be applied to the trade waste generator. A history of high H_2S will also incur costs associated with setting up a permanent monitoring station, equipment calibration and repairs.

Calculation of the daily charge considered corrosion rates of infrastructure due to flow characteristics (pH, relative humidity, temperature of wastewater being discharged, volume being discharged, turbulence and microbial activity). Inclusion of the proposed charging of H_2S gas under an EIP is considered reasonable because:

- It is anticipated that Council will install a H_2S monitoring station at the discharge point for generators with a history of high H_2S to provide real-time data. This enables the discharger to respond within a reasonable time to meet target and critical limits of H_2S levels.
- A grace period of 6 months is proposed to allow trade waste generators to enhance their systems and processes to comply with the trade waste limit for H_2S.
- It communicates to trade waste generators the value that Council places on minimising safety risk to its employees and the community and sustaining its infrastructure network.

3.0 CONCLUSION

Logan City Council have developed a Septicity and Corrosion Action Plan which documents a multipronged and affordable approach to mitigate septicity, odour and corrosion across the Loganholme WWTP catchment. The 19 actions identified will be delivered over a five-year period between 2018/19 and 2022/23.

Some of the actions that are most advanced include:

- Commencement of a trial to understand the feasibility of changing pump station control settings, to minimise hydraulic detention times and reduce H_2S gas at the rising main discharge manhole. Results have so far been mixed, but favourable results have been observed at Demio Road SPS67 with a 367% reduction in peak H_2S gas concentrations.
- Completion of a background septicity monitoring project.
- Commencement of monitoring major trade waste generators of H_2S gas levels at discharge points, and calling on Council's revised and adopted EIP requirements.

The actions that have been carried out so far are inexpensive and straightforward, and the learnings may assist other small and medium sized water utilities in their journey toward septicity and corrosion control.

4.0 ACKNOWLEDGEMENTS

Special thanks to Troy Kasper, Aneurin Hughes and Council’s Trade Waste Team who helped with the development of the Septicity and Corrosion Action Plan.

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THE URBAN WATER CYLCE’S FUTURE CITIES

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THE URBAN WATER CYLCE’S FUTURE CITIES

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ABSTRACT

Only a fraction of the water on Earth is fresh and readably consumable. Securing its quantity and quality within the urban water cycle allows Australian cities to maintain a healthy existence. Climate change in the form of reduced precipitation and population growth (urbanisation) are increasing the pressure on water supplies and the environment. This is driving cities to evolve their management style. Water corporations should embrace adaptive, multifunctional infrastructure to future proof their place in this market. Reducing costs to service and enhancing the environment through water sensitive practices can help drive this outcome. Providing wastewater effluent water schemes to customers is one example of how this can be achieved.

1.0 INTRODUCTION

Total global water volumes have been estimated at 1.3 billion cubic kilometres (USGS, 2016). This is a quantity so large it becomes difficult to conceive. Yet, for human life on Earth the importance does not rest within this vast volume, but more so in the different types of water. 96.5% of the planet’s water is held within our oceans (Gleick, 1993) and a commonly understood fact is that humans cannot survive off drinking it. This is because our kidneys cannot remove the salt ion concentrations sufficiently when salt water is consumed (U.S.National Oceanic and Atmospheric Administration, 2018). Global fresh water supplies equal 1.47% within ice caps and glaciers, 1.69% within ground water, and 0.138% in lakes and rivers (Gleick, 1993). Our very existence is dependent on a limited amount of fresh water resources and for this reason it drive’s our industry’s valves: to protect the environmental and human health.

The following report will delve into how our industry is achieving these values by describing the emergence of the urban water cycle and how it has transitioned into its current form. It will detail emerging trends within the utilities sectors, and recycled water partnerships as a component of future proofing against these changes.

2.0 THE URBAN WATER CYCLE: FROM CONCEPTION INTO PRACTICE

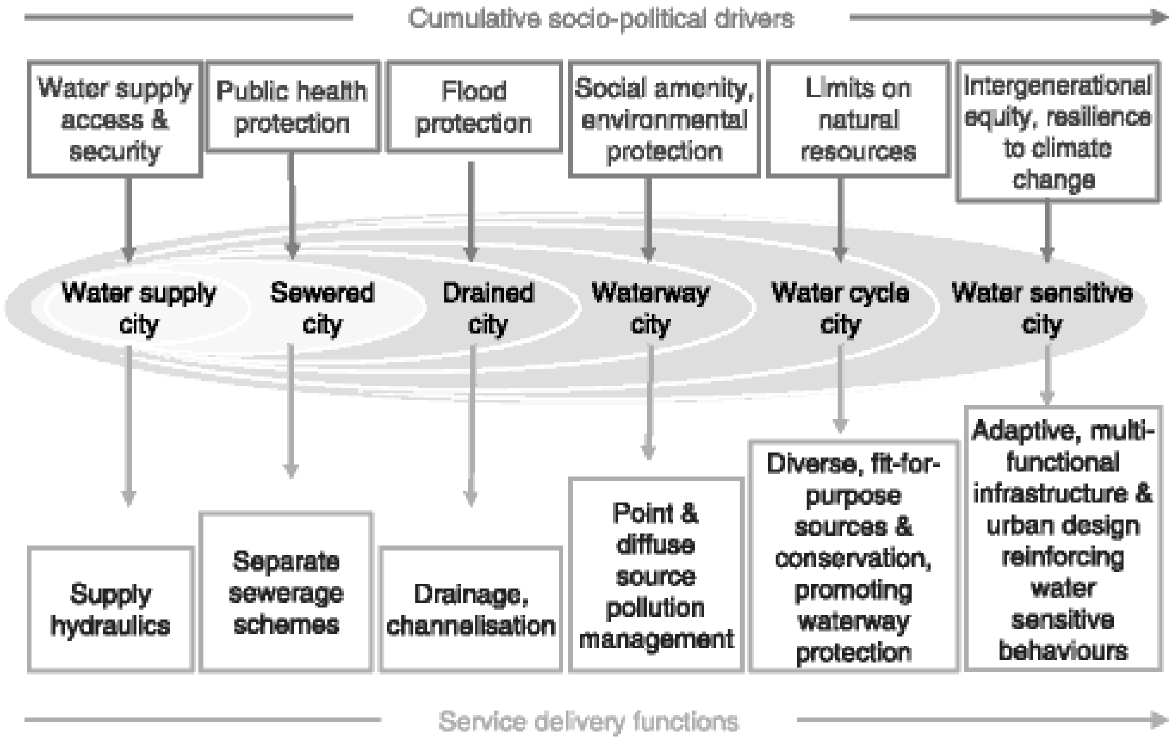
De-forestation, wetland destruction, and urbanisation are a few of the ways humans have altered the landscape of the globe. Alterations as such disrupt the natural water cycle; to sustain our modern existence these natural processes must be augmented with the managed systems of the urban water cycle. Nowhere can this be more dramatically observed than in metropolitan areas. In cities the urban water cycle is composed of: water catchment and impoundment; water treatment and delivery; wastewater collection and treatment; and stormwater drainage networks. These modern technologies are essential to sustaining urban water supplies. However, when they first came into practice their link to improved human health were not always understood.

An argument can be made this linkage was first realised through events that transpired in 1854 between Doctor John Snow and the London municipal council. At this time the belief was that miasma or ‘bad air’ was responsible for a terrible cholera outbreak occurring in the city. Using the process of elimination and reasoning Dr Snow was able to successfully connect the epicentre of the disease to a contaminated water pump the inhabitants were using. The Doctor was able to convince the council to have the pump handle removed ending the outbreaks in the area.

To this day in Australia, having access to clean and safe drinking water is known to contribute to a 10 year life expectancy gap between rural and urban inhabitants (Rajapske, 2015). Thus, efforts continue to be made to secure our water and way of life.

Executive Director of the Water Services Association of Australia, Adam Lovell, describes the two main threats to Australia's water security as being population growth and climate change. For example Brisbane has a population of 2.4 million people and a growth rate between 1.32 and 6.67% as such the city grows by 30,000 to 140,000 people per year (Population Australia, 2019). For Australia as a whole, prolonged periods of drought will be magnified by a forecast 15% decrease in rainfall precipitation by 2030 (Climate Council, 2018). As pressure on urban water supplies intensifies coping mechanisms need to be deployed but, successfully reaching this maturity in water management takes time and effort.

A city's water management developmental process has been postulated by Brown et al. (2009) as having a hydro-social contract between its citizens and the government in which taxes fund water supply, sewer and drainage services. Detrimental to the longevity of resource use, these three phases are thought to give little regard to the environment, allowing for over allocation and the release of pollutants in to waterways (Wong & Brown, 2009). Wong and Brown have since expanded the contract to include phases that progressively account for our environmental interdependencies and responsibilities as waterway, water cycle and water sensitive cities (Figure 1).



<u>Figure 1:</u> ***Water Sensitive Cities (Wong & Brown, 2009)***

As cities look to the future and strive for water sensitivity, four pillars of focus are seen as key segments in securing our needs: water recycling, sustainable practices, water impoundment and desalination.

3.0 FUTURE CITIES

An electrical energy supply paradox is occurring in Australia.
The threat of global warming has derailed coal and gas fired plants and the adoption of decentralised solar power grids has changed the energy market place. Large, carbon emitting power plants are being phased out by independent solar power farms and household rooftop systems. Could this be the future of the water market? One hypothesis is that high service prices could drive homeowners to treat and supply their own water or it could create a market place for independent water corporations that treat industrial waste or stormwater runoff. According to the Australian Competition and Consumer Commission (Figure 2), in Australia power prices have increased by 63% since 2007. The spike in cost is due to providing subsidies for renewable power and by the 'gold plating' of network infrastructure (Australian Broadcasting Corporation, 2017).

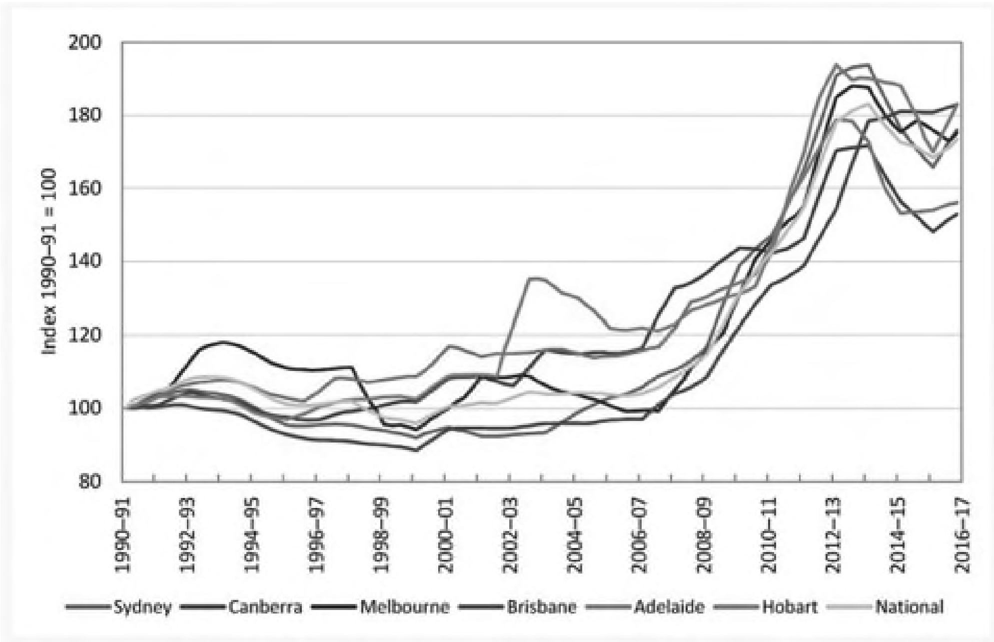


Figure 2: ***Australian Energy Prices (Australian Broadcasting Corporation, 2017)***

The 2017 AITHER Urban Water Pricing Reform report created for Infrastructure Australia has drawn correlations between the water and energy sectors reasoning that water bills could more than double by 2040 and it has encouraged the government to create private water sectors (The Australian, 2017).

Large water corporations should take heed from what has happened in the energy sector and adopt a continuous improvement model to lower to cost of service while advancing business practices. By adopting water sensitive principles such as having '*adaptive, multifunctional infrastructure*' programs can be built into the urban water cycle such as wastewater effluent recycling. Providing recycled effluent could reduce servicing charges if the product water is sold to industry or could lower the cost of homeowners' water bills by providing the 'purple pipe/3rd pipe' option at a reduced cost. At Queensland Urban Utilities the 2023 strategic direction is aimed at developing and maintaining schemes such as this. The strategic goals (Figure 3) specifically outline the objectives of adding to social-economical value by partnering with communities and turning waste into a resource.

Figure 3: *2023 Queensland Urban Utilities Strategic Goals*

A successful example of community partnership and providing alternative water supplies is currently running between the Wynnum Sewage Treatment Plant and Caltex Oil Refinery. The Wynnum Microfiltration and Reverse Osmosis (MFRO) plant produces Class A+ recycled water from wastewater effluent. Under the De-mineralised Recycled Water Supply Agreement, recycled water is supplied to the Caltex Refinery at Lytton for uses including: makeup process water for cooling towers; the de-mineralised water plant for resin regeneration and boiler feedwater production; makeup process water to a sulphur recovery unit and the de-salter wash water tank for crude desalting purposes (Reece Wong, 2019). Natural waterways can also benefit from this scheme. Additionally, by closing the urban water cycle loop water allocation can shift from demand on the potable water grid to budgeting for environmental release.

4.0 CONCLUSION

As a city's ability to thrive is underpinned by its ability to manage its urban water cycle, having a clean, secure supply of fresh water is intricately linked to maintaining human health. Water corporations in Australia will face challenges in the future as the climate changes and populations continue to grow. Adaptability and foresight will need to be employed to maintain their place in the market. Shifting towards water sensitivity will help to enable long-term stability by lowering or maintaining the price to serve and enhance environmental conditions.

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YARRAMAN WTP THM CONTROL THROUGH ENHANCED COAGULATION & TECHNOLOGY

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YARRAMAN WTP THM CONTROL THROUGH ENHANCED COAGULATION & TECHNOLOGY

Wayne Handford, *Coordinator Operations,* Toowoomba Regional Council

ABSTRACT

The Yarraman water scheme has always struggled with Trihalomethane (THM) failures in its reticulation network. In 2014. a THM event continued for over 12 months with the standard response of lowering treated water turbidity, optimising processes, reticulation controls, and PAC addition not being able to effectively reduce the THM results below ADWG limits.

This event was eventually closed off after a second raw water source came on line and an aeration system was installed in Reservoir #1.

With the expectation of "Health Based Targets" tightening treated water Turbidity limits and with THM exceedances continuing to come and go since 2014 a concerted effort has been made to understand what can be done to control THM production and determine a parameter that can be used to predict that THM production will not exceed the ADWG limits.

Total Organic Carbon(TOC) levels in the treated water are being used for that parameter. By monitoring TOC levels Operators can identify the effectiveness of coagulant adjustments, process changes, or raw water source selections and can be confident THM limits throughout the Yarraman reticulation network will be maintained.

1.0 INTRODUCTION

Yarraman has a population of around 1300 people and an average day's usage of 275kl. Two main areas were identified as opportunities to improve the Yarraman treated water quality and potential of the treated water to form THM's.

The main one was the performance of the WTP itself. The Yarraman WTP consists of an upflow sludge blanket clarifier and pressure filter. Sludge blanket clarifiers are notorious for being finicky to operate and rely on a functional well developed "sludge blanket" to perform best. Another problem is Yarraman is approx. 100km from the operations base. The "Yarraman" operator also maintains a biofilter WWTP during their day in Yarraman. Therefore, the time the Operator can spend at the WTP making adjustments and determining their effectiveness is extremely limited.

The second was the first time that Operators are made aware that THM's had exceeded the ADWG limit was when Lab results were received which could be 3 weeks after samples were collected. Also then, they only knew if operational changes were effective 3 weeks after they were made. This would result in any THM incident extending for considerable time periods. The Operators needed a reliable and early indication that THM limits may be getting close to limits.

As indicated in the graphs (*Figures 1 & 2*) Turbidity can be used as the guide but does not provide the operator with confidence that THM production is under control. IE: Even when Turbidity's in the treated water are consistently below 0.3 NTU, THM levels in the reticulation can still exceed ADWG limits.

In the past the operational changes made to combat THM production were to lower treated water turbidity as much as possible, lower Reservoir levels as much as possible to reduce contact time in the reticulation with chlorine, and also to lower chlorine levels as much as possible. These options come with their own risks and are not ideal or effective as long term controls.

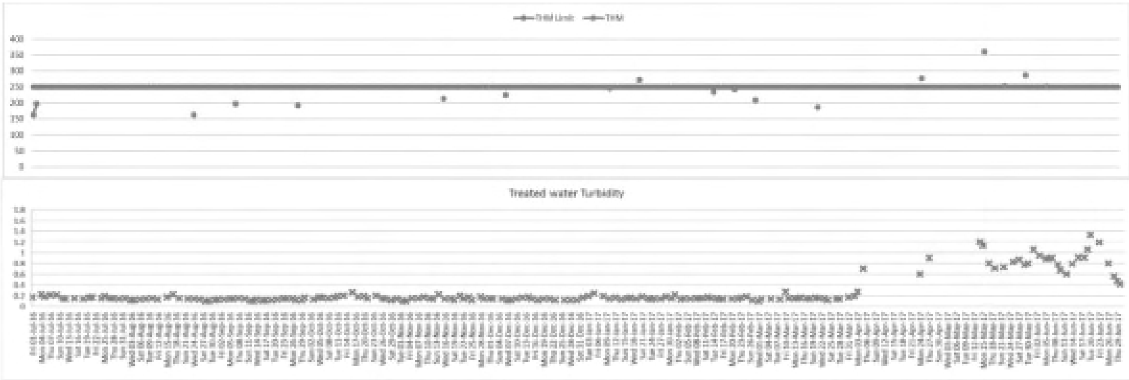


Figure 1: ***Turbidity and THM results July 2016-June 2017***

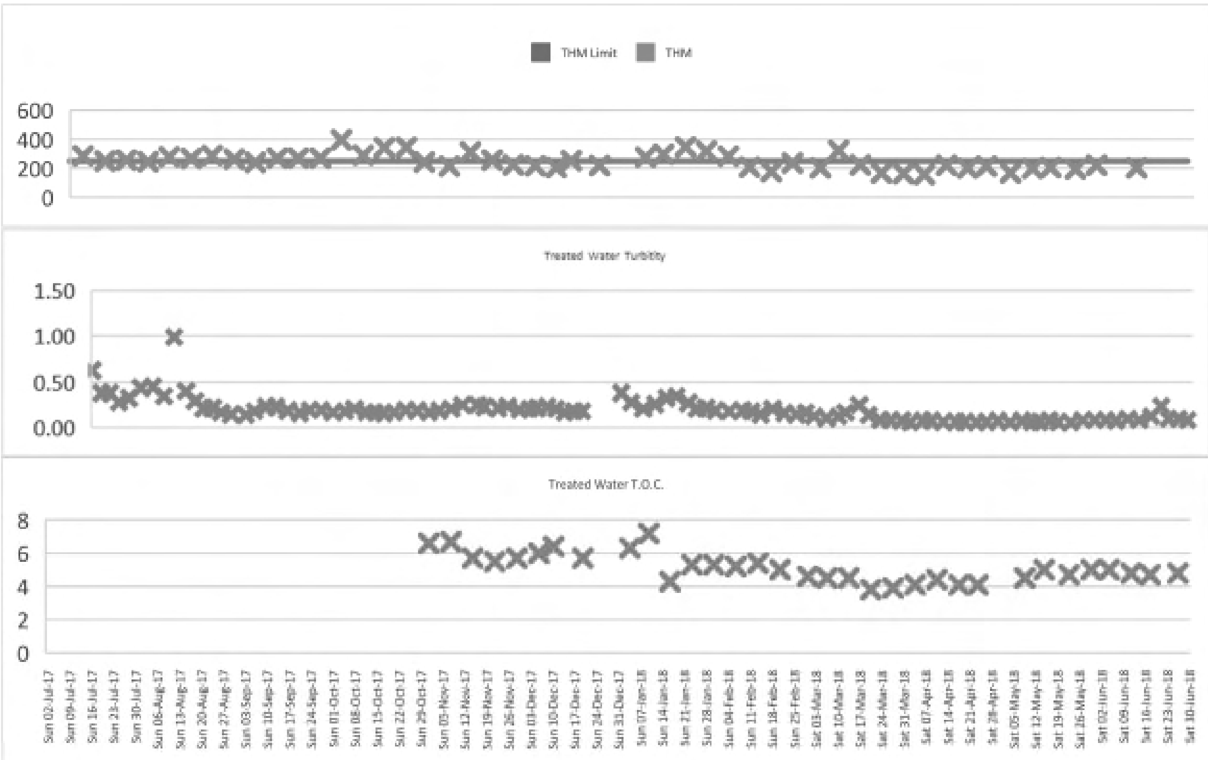


Figure 2: ***Turbidity and THM results July 2017-June 2018***

2.0 DISCUSSION

2.1 Yarraman WTP, Processes, and Reticulation Network

The Yarraman WTP built in 1980 consists of an upflow sludge blanket clarifier followed by a pressure filter. It is designed to treat a maximum of 14 l/s. Sludge concentrations and levels in the clarifier were controlled by timers opening & closing a sludge drain valve to draw sludge from the sludge cone.

The treatment plant has 2 raw water sources. The original source Ted Pukallus Weir and the second from Boondooma Dam that came on line in 2014.

The treatment includes coagulation, Powdered Activated Carbon (PAC), and uses Sodium Hypochlorite pre and post for disinfection. Pre chlorination added before the filter is utilised for Iron and Manganese removal in the filter via the DMI-65 media. There is no ability for pH correction.

The Yarraman Reticulation network has 2 pressure zones. Reservoir #1 680kl (which also fulfils the Clear water tank role) supplies the "low Zone' and a second Reservoir 820kl supplies the "High zone". Detention time of water in the network can be as high as 6 days.

2.2 WTP Performance Turbidity of Treated Water

Turbidity removal reliability was an issue, with limited opportunity for Operators to be on-site at the WTP to make process changes and monitor their effectiveness.

On line analysers are installed and report directly to SCADA to assist with remote monitoring of the process. Full computer control was finalised in 2014 which allowed remote control of all dosing pumps, backwashing, sludge drain, and Reservoir operating levels etc.

Filter Turbidity breakthrough was a problem. This was mostly due to flocc carry over in the clarifier with the sludge blanket performing poorly and being hard to create and maintain with low raw water turbidity.

Different coagulants were trialled with importance given to a coagulant that produced good solid flocc as quickly as possible. This is to create strong flocc as low as possible in the clarifier so a "sludge blanket" can be formed with as much density as possible.

However even with the treated water Turbidity averaging 0.16 NTU between January and March 2018 THM exceedances were still occurring (*Figure 2*).

2.3 Monitoring the "Sludge Blanket" Remotely

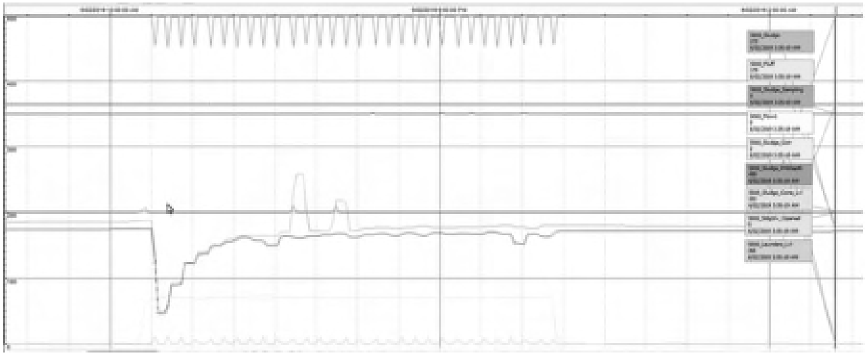
An effective "sludge blanket" is seen as the most important part of a sludge blanket upflow clarifier. The time an Operator has at the WTP meant visual inspection of the blanket performance and flocc carry over was limited. Also TRC rotate Operators at the WTP and one's perception of a blanket and flocc carry over can be very different from another's.

Monitoring of flocc carry over & sludge blanket levels determined how the Operator set the "sludge drain" timers. If the sludge drain is set to low flocc carry over can be excessive and/or the sludge blanket can rise to high in the clarifier break up and carry over into the filter which results in poor filter performance. If the "sludge drain" is set to high any sludge blanket developed can be drawn off which reduces its performance and can result in flocc carry over and result in poor filter performance.

Poor filter performance with turbidity breaking through the filter is a large contributor to the formation of THM's in the retic. Sludge blanket carry over can block the filter very quickly and getting the filter washed and back into operation can result in poor filter performance for an extended period.

A "Sludge Monitor" was installed in March 2018. The sludge monitor periodically drops a sensor into the clarifier. The sensor will return information on sludge density and sludge depths. The sludge monitor produces a graph (*Figure 3*). From this graph the "fluff" layer or lighter flocc (100 mg/L) can be seen. This indicates the extent of any flocc carry over. The graph also shows the "sludge blanket" or denser sludge (>1050 mg/L). The "Sludge Drain" control is now automated by the sludge monitor. If the "Fluff" of "Sludge blanket" level is higher than the "sludge cone" the sludge drain is opened for a set time.

By utilising the trended graph, the performance of the clarifier can be monitored remotely and over the complete operational cycle of the WTP. Any change in coagulant, or PAC dose can be monitored for its effectiveness and has resulted in no filter turbidity breakthroughs at the time of writing this paper since its installation.



<u>Figure 3:</u> ***Sludge Monitor Trend Graph***

2.4 Enhanced Coagulation

Enhanced coagulation is a term I have heard only recently in the industry. A quick google search states *"Enhanced Coagulation is the term used to define the process of obtaining improved removal of Disinfection by products precursors by conventional treatment"*. Often it involves lowering the pH considerably between 5 -6 to achieve desired results.

Other factors in the treatment process seem to impact on the Turbidity and TOC removal efficiency to further enhance the coagulation process effectiveness.

That TOC removal efficiency can be increased by increasing the coagulant is shown in Table 1. However, this high dose of coagulant does result in large amounts of flocc creation and carry over and requires frequent backwashing to maintain filter performance.

The addition of P.A.C. has a large effect on the TOC removed and the same removal efficiency can be achieved with a lower coagulant dose after the addition of PAC.

Acid dosing was trialled in October - November of 2017 (*Table 1*), results did not show it was effective in increasing TOC removal. pH levels in the treatment process was however only dropped to slightly below pH 7.0 because no ability for pH correction exists at the WTP. The TOC removal efficiency as a % has been seen as high as 40% dosing coagulant at 20mg/l and P.A.C. at 5mg/l. Dosing PAC at 5mg/l would indicate it increases TOC removal efficiencies by between 5 - 10% over whatever TOC removal occurs from coagulant alone.

The aeration system perhaps indicates it can reduce THM levels by 10 – 20%. However, the ideal situation would be not to create THM 's, not remove them after they have been created.

Table 1: *Results recorded since October 2017*

	Treated Water THM's					Blend Ratio Weir %	T.O.C.				COMMENTS	Suggested Explaination of results
	Treated Water	Res #1	Res#2	Memorial Pk	Budgen St							
24/10/2017		187	243	226	211	40%	Weir/Boondooma	Blended raw	Treated	% TOC removal	Started Acid dosing 27/10/17	
1/11/2017	153	154	199	214	212	40%	8.6/7.10	7.8	6.6	15		
8/11/2017		183	290	286	311	40%	8.6/6.7	7.7	6.7	12		
15/11/2017		162	248	222	255	40%	7.0/6.2	6.6	5.7	14		
22/11/2017		128	224	191	161	40%	6.6/5.8	6.2	5.5	11		
29/11/2017	115	124	216	171	156	40%	6.9/5.9	6.4	5.7	11		
6/12/2017		138	205	194	147	40%	7.9/6.2	7.0	6.0	14	Filled Reservoirs prepare for media replacement	
11/12/2017		175	243	252	202	40%	8.1/6.6	7.4	6.4	13	Filter media replaced 13/12/18	
20/12/2017		142	219	204	169	40%	7.4/6.1	6.8	5.7	16		
4/01/2018		174	276	256	201	40%	9.3/6.3	7.8	6.3	19	Fresh in Raw waters TOC's lifted	
10/01/2018		283	296	252	278	40%	9.0/6.4	7.9	7.2	9		High TOC's in Raw mainly Weir
17/01/2018		238	347	300	261	0%	_ /4.6	4.6	4.3	7	Weir off 15/1/18	
24/01/2018	175	183	318	227	214	0%	_ /6.0	6.0	5.3	12	Started PAC 29/1/18	Water detention time in Res#2
31/01/2018		160	282	213	245	0%	_ /6.0	6.0	5.3	12		Water detention time in Res#2
7/02/2018		114	208	181	132	0%	_ /6.6	6.6	5.2	21		
14/02/2018		130	167	176	151	0%	_ /7.0	7.0	5.4	23		
21/02/2018	136	130	237	222	155	0%	8.8 /6.4	6.4	5	22		
1/03/2018		138	197	204	151	0%	8.9/6.2	6.2	4.6	26	Trialled 10mg/l Nalco 71028 3 days	
7/03/2018		144	215	323	254	0%	7.7/6.2	6.2	4.5	27		Filter Tu break through during the week
14/03/2018		99	199	223	169	0%	8.0/6.0	6.0	4.5	25	Started dosing Nalco 12/3/18 15mg/l	Low Zone area flushed 14th or 15th
21/03/2018	91	94	163	146	168	0%	7.5/6.1	6.1	3.8	38	Nalco 71028 20mg/l	CBX commissioned 20/3/19
28/03/2018		97	144	164	161	0%	7.4/6.0	6.0	3.9	35	Nalco 71028 15mg/l	
4/04/2018		100	150	142	157	0%	7.2/6.0	6.0	4.1	32	Nalco 71028 15mg/l	
11/04/2018		154	186	220	168	0%	6.9/6.4	6.4	4.4	31	Nalco 71028 10mg/l	
18/04/2018	117	127	187	198	200	0%	7.2/6.2	6.2	4.1	34	Nalco 71028 18mg/l	
24/04/2018		139	197	209	214	0%	7.1/6.0	6.0	4.1	32	Nalco Ultrion 44697 15 mg/l	
2/05/2018		125	154	169	132	0%					Nalco Ultrion 44697 10 mg/l	
9/05/2018		132	170	199	149	0%	6.8/6.3	6.3	4.5	29	Nalco Ultrion 44697 10 mg/l	Res#1 aeration turned off
16/05/2018	172	172	206	215	179	0%	6.8/6.4	6.4	5	22	Nalco Ultrion 44697 12 mg/l	PAC dosing turned off
23/05/2018		156	179	194	160	0%	5.5/6.1	6.1	4.7	23	Nalco Ultrion 44697 8 mg/l	
30/05/2018		150	200	221	173	0%	6.1/6.2	6.2	5	19	Nalco Ultrion 44697 9 mg/l PAC 5mg/l	PAC dosing restarted 28th May (5mg/l)
6/06/2018						0%	6.4/6.9	6.9	5	28	Nalco Ultrion 44697 9 mg/l	
13/06/2018	187	178	184	203	188	20%	6.0/6.6	6.4	4.8	25	Nalco Ultrion 44697 10 mg/l	Started Blending Weir on the 11th
18/06/2018						20%	5.9/6.5	6.3	4.7	25	Nalco Ultrion 44697 10 mg/l	Lowered flow rates still blending 20%
27/06/2018						20%	5.7/6.4	6.3	4.8	23	Nalco Ultrion 44697 10 mg/l	
4/07/2018						20%	5.6/6.4	6.2	4.3	31	Nalco Ultrion 44697 10 mg/l	
11/07/2018	157	158	166	209	171	20%	5.6/6.2	6.1	4.2	31	Nalco Ultrion 44697 10 mg/l	Bromoform increasing (Bromides?)
18/07/2018						20%	5.9/6.5	6.4	4.6	28	Nalco Ultrion 44697 10 mg/l	
25/07/2018						20%	5.8/6.6	6.4	4.7	27	Nalco Ultrion 44697 10 mg/l	
1/08/2018						20%	6.0/7.2	7.0	5.3	24	Nalco Ultrion 44697 10 mg/l	
8/08/2018	162	159	206	229	171	20%	5.9/6.7	6.5	5	24	Nalco Ultrion 44697 10 mg/l	Bromoform increasing (Bromides?)
15/08/2018						20%	6.3/7.2	7.0	5	29	Nalco Ultrion 44697 10 mg/l	
22/08/2018						20%	6.0/7.1	6.9	5.4	22	Nalco Ultrion 44697 10 mg/l	
29/08/2018						20%	6.6/6.6	6.6	5	24	Nalco Ultrion 44697 10 mg/l	
5/09/2018	160	151	223	211	185	20%	6.0/6.6	6.5	5.1	21	Nalco Ultrion 44697 12 mg/l PAC 7mg/l	PAC indreased to 7 mg/l
13/09/2018						15%	5.9/6.8	6.7	5	25	Nalco Ultrion 44697 16 mg/l	Increased Coag and 7 mg/l PAC
19/09/2018						15%	6.2/6.7	6.6	4.7	29	Nalco Ultrion 16mg/l PAC 7mg/l	7mg/l PAC
27/09/2018						15%					Nalco Ultrion 16mg/l PAC 7mg/l	7mg/l PAC
3/10/2018	149	148	228	195	176	15%	5.8/6.4	6.3	4.4	30	Nalco Ultrion 16mg/l PAC 7mg/l	7mg/l PAC
10/10/2018						15%	6.3/6.5	6.5	5.9	9	Nalco Ultrion 16mg/l PAC 7mg/l	
24/10/2018						15%	6.1/	6	3.9	35	Nalco Ultrion 16mg/l PAC 7mg/l	LISA cleaned & zeroed (16/10/18)
31/10/2018	124	132	201	166	135	15%	6.1/6.0	6.0	3.9	35	Nalco Ultrion 16mg/l PAC 7mg/l	
7/11/2018						15%	5.1/6.2	6.0	3.8	37	Nalco Ultrion 16mg/l PAC 7mg/l	
14/11/2018						100%	5.4/6.2	6.1	3.7	39	Nalco Ultrion 16mg/l PAC 7mg/l	LISA cleaned chemical (14/11/18*)
21/11/2018						100%	5.9/-	5.9	4.4	25	Nalco Ultrion 16mg/l PAC 7mg/l	LISA cleaned (22/11/18*) with swispers
28/11/2018	179	187	312	321	342	15%	5.1/6.2	6.0	3.6	40	Nalco Ultrion 16mg/l PAC 7mg/l	Weir 100% (Bromide level 1.4)
5/12/2018		143	248	212	248	15%	5.2/6.2	6.1	3.6	40	Nalco Ultrion 16mg/l PAC 7mg/l	
12/12/2018		154	207	200	168	15%	5.3/6.3	6.2	3.9	37	Nalco Ultrion 16mg/l PAC 7mg/l	
20/12/2018		162	206	206	174	15%					Nalco Ultrion 16mg/l PAC 7mg/l	
3/01/2019						15%	5.1/5.8	5.7	3.6	37	Nalco Ultrion 16mg/l PAC 7mg/l	
9/01/2019						15%	6.1/5.5	5.4	3.6	33	Nalco Ultrion 12mg/l PAC 7mg/l	
16/01/2019						15%	4.9/5.7	5.6	3.7	34	Nalco Ultrion 12mg/l PAC 7mg/l	
24/01/2019	124	128	189	173	147	15%	5.3/6.0	5.9	3.8	36	Nalco Ultrion 12mg/l PAC 6mg/l	
30/01/2019						0%	- /5.0	5	3.4	32	Nalco Ultrion 12mg/l PAC 6mg/l	
13/02/2019						15%	6.4/6.1	6.4	3.9	39	Nalco Ultrion 12mg/l PAC 6mg/l	

2.5 On- Line TOC Sensor

Operators had a similar problem with TOC results as they had with THM results. TOC results were usually seen 1-2 weeks after samples were collected and if both raw sources and treated water were sampled weekly they proved to be costly.

The availability of an in-line sensor was investigated & in August 2018 an in-line TOC sensor was installed. The operators can see T.OC results in real time. Results are graphed using the SCADA system and a rising trend or changes to T.O.C.s either in the raw or treated water can be identified.

Monitoring TOC levels on-line quickly shows the removal efficiency. It also provides a quick and reliable indication of the effectiveness of any changes made to the process or chemical doses. Using TOC results allows the operators to be confident in the treated water quality and the performance of the treatment process. It also allows the Operators to determine the extent of the TOC removal efficiency needed through the "enhanced coagulation" process to eliminate THM exceedances into the future.

2.6 TOC V THM Control.

THM exceedances as shown in (Figure 2) were still a problem even with low turbidity in the treated water. Average treated water turbidity in early 2018 after the filter media was replaced was 0.16 NTU and was usually below the 0.15 NTU range which puts it within the proposed "health limits". However, THM exceedances still occurred. After the introduction of the "Sludge Monitor", a change of coagulant, introduction of enhanced coagulation, and Operators using TOC levels as their guide parameter from March the average turbidity in the treated water had dropped to average 0.08 NTU and no THM failures occurred.

From October 2017 weekly THM results, TOC results, and % TOC removal efficiencies were recorded along with any operational changes or plant upgrades such as the "Sludge Monitor" installation and filter media replaced noted (*Table 1*). The different coagulants trialled, different dosages trialled, performance of the aerations system, and PAC dosage are also noted in (*Table 1*).

These results may not satisfy scientific scrutiny with samples collected weekly and when changes were made the next sample determining its effect. They did however provide a guide to what worked and what effect it had.

From these results it has been determined that TOC levels in the treated water provides a guide to the potential of THM formation in the reticulation.

It could be argued that a lower average Turbidity in the treated water has also been seen and could be used to determine the treated water potential for THM formation. However, the Turbidity results are very similar and Turbidity results that averaged 0.16 NTU earlier in 2016-2017 did not result in exceedances of THM limits in what, are expected to have been lower T.O.C. periods.

The percentage of TOC removal efficiency has showed the effectiveness of "Enhanced Coagulation" and also the impact of PAC on TOC removal.

3.0 CONCLUSION

The THM limits within ADWG have not been exceeded in the Yarraman network since March 2018.

The "Sludge Monitor" provides a visual reference of what is happening with sludge blanket and fluff layers in the clarifier. Using the sludge monitor to automate the sludge drain process has allowed flocc carry over to be minimised and controlled throughout every run cycle of the plant.

By monitoring TOC levels easier determinations can be made on plant performance and the likelihood of THM's to be formed in the reticulation. A T.O.C. target can be set to provide that confidence. This same confidence cannot be provided when using turbidity levels alone.

The required TOC removal efficiency can be determined by using the treated water TOC target and if enhanced coagulation is required to meet this target its effectiveness can be monitored.

If turbidity levels of 0.08 NTU in the treated water is used as the target to control THM formation, overdosing of coagulant and PAC would occur to meet this NTU figure when it may not be required to ensure THM exceedances do not occur during low TOC periods.

Limited results and data has been recorded and analysed and further work will need to be done to be 100% sure on results seen. However, performance of the treatment process has been more reliable and THM exceedances have been eliminated to the date of this paper.

Enhanced coagulation at low pH levels may significantly increase TOC removal however the above results have occurred without acid dosing to lower pH. Average raw water pH levels between July 2017 – June 2018 were 7.5 pH raw and 7.7 pH treated.

KINGAROY NEREDA® WWTP RECYCLED WATER AND BENEFITS TO THE COMMUNITY

Paper Presented by:

Andrew Watson

Authors:

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South Burnett Regional Council

Shay White, *Process Engineer,*
Aquatec Maxcon

44th Annual WIOA
Queensland Water Industry Operations Conference and Exhibition
Bundaberg Multiplex Centre, Bundaberg
5 & 6 June, 2019

KINGAROY NEREDA® WWTP RECYCLED WATER AND BENEFITS TO THE COMMUNITY

Andrew Watson, *Senior Plant Operator*, South Burnett Regional Council
Shay White, *Process Engineer,* Aquatec Maxcon

ABSTRACT

In mid-2016, Aquatec Maxcon along with Royal HaskoningDHV commissioned Australia's first full-scale Aerobic Granular Sludge (Nereda®) WWTP. The WWTP has the ability to produce Class A+ Recycled Water providing community benefit to the local sporting field, golf course, show grounds and on-site reuse. The secondary effluent from the Nereda® is such quality that after disinfection and detention, it can be applied directly to the South Burnett Regional Council neighbouring 30Ha farm utilising two fixed pivot irrigators to commercialise a resource and further reduce the residual nutrient load that would otherwise end up in the catchment that supplies Kingaroy's water supply. As an operator, driving through town and seeing children playing on the fields that without recycled water would be dust bowls with prickles makes the extra effort in maintaining, monitoring, sampling and verification of the recycled water worth the effort 10 times over.

The only Nereda® WWTP in the world with the ability to supply Class A+ & Class C Recycled Water that Benefits the Community.

Figure 1: ***Kingaroy WWTP 2019***

Figure 2: ***Pressure Filters WWTP***

KEYWORDS
Recycled Water, Nereda® Aerobic Granular Sludge, Kingaroy

1.0 INTRODUCTION

The township of Kingaroy is located approximately 200km north west of Brisbane within the South Burnett region of Queensland and is administered by the South Burnett Regional Council. It is known as the peanut capital of Australia. The current population is approximately 12,500 people with 9,000EP connected to the sewer system. The average rainfall for Kingaroy is 670 mm of which most falls between November and late January. June to September is typically a dry environment for the year.

As an operator writing this paper, I believe that there should always be a priority with effluent "filter it, farm it and then discharge it - to the creek". Recycling wastewater is not a new idea, but with advancements in wastewater technology the recycled water process is more achievable and stable to produce. This puts less pressure on the natural water courses, aquifers and potable water supplies.

The local golf course and sporting fields take up to 690kL and 330kL of recycled effluent per day, respectively. Considering ADWF to the WWTP is around 1.8ML/d, it is easy to have at least half of the effluent diverted to good use. Since the irrigators have come online the plant has had days where the overall reuse of the effluent is up to 85% with the overall goal being capable of 0 discharge by reusing everything coming in during dry conditions and where demand is high. With the popularity growing in the recycled water use, it is nearly a full-time job to monitor usage, demand, delivery and supply from our Nereda® Wastewater Plant.

2.0 WHAT IS NEREDA® PROCESS & WASTEWATER PLANT EFFLUENT CHARACTERISTICS

Nereda® technology, or Aerobic Granular Sludge technology, was developed by DELFT University under Mark Van Loosdrecht's direction. The process is marketed by Royal HaskoningDHV, licenced by Aquatec Maxcon in Australia and New Zealand. This is the process that is now shaping the world's standard in biological treatment of municipal wastewater. The process within the bioreactor manipulates and encourages the formation of activated sludge or biomass to encourage granulation and grow granules. These granules are responsible for the biological removal of phosphate and nitrogen. Another benefit is the granules have an outstanding settling velocity compared to traditional activated sludge flocs. The Kingaroy system works through batched recipes via a balance tank that feeds one reactor at a time whilst the other reactor is in operation or reaction. Another major benefit is plant footprint is, at most, half the size of a conventional oxidation ditch treatment plant, resulting in significantly reduced capital expenditure.

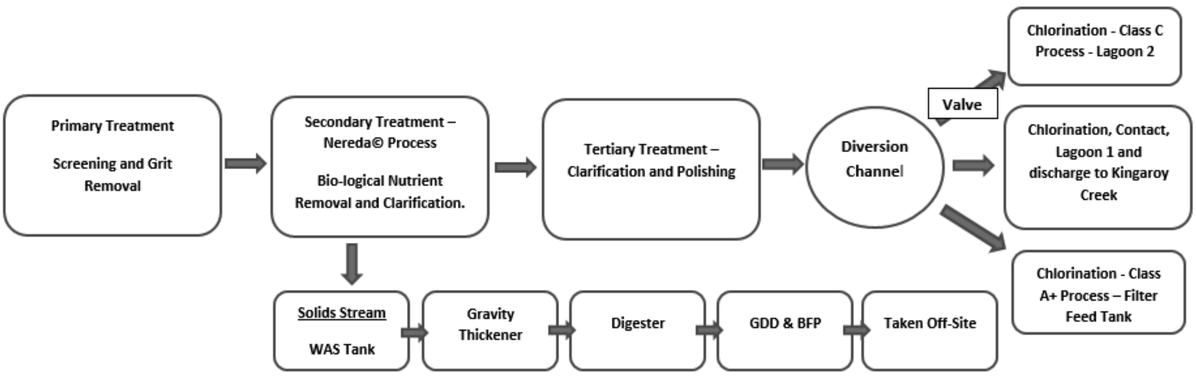
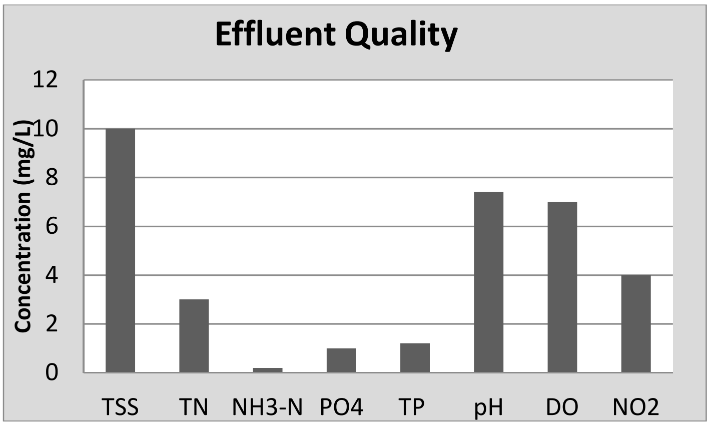
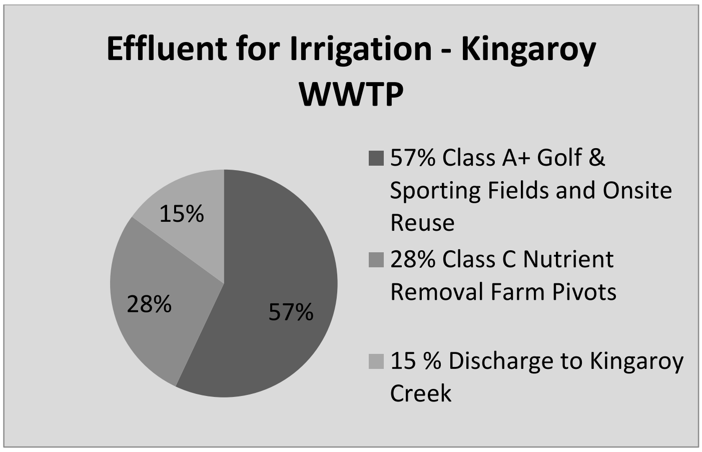


Figure 3: ***Liquid & Solid Stream Process Flow***

The influent enters the WWTP for primary treatment, passing through screens and grit removal infrastructure. The screened influent is held until fed into the reactor for secondary treatment. After secondary treatment is complete the effluent is passed through a secondary clarifier / filter feed tank where it is stored for the start of Class A+ Reuse. If the filter feed tank is full the effluent will be chlorinated and diverted to either detention lagoons for minimum 25 days by being passed through earthed and walled baffling before it is considered usable for Class C Irrigation on the farm or it is discharge to Kingaroy Creek via the final lagoon, then measured via flume for release. The process flow attached shows the ability to supply effluent to other locations of the site with only the use of one mechanical valve.



<u>Figure 4:</u> ***Typical Effluent Results 2017-2019***



<u>Figure 5:</u> ***Daily Effluent Release 2019***

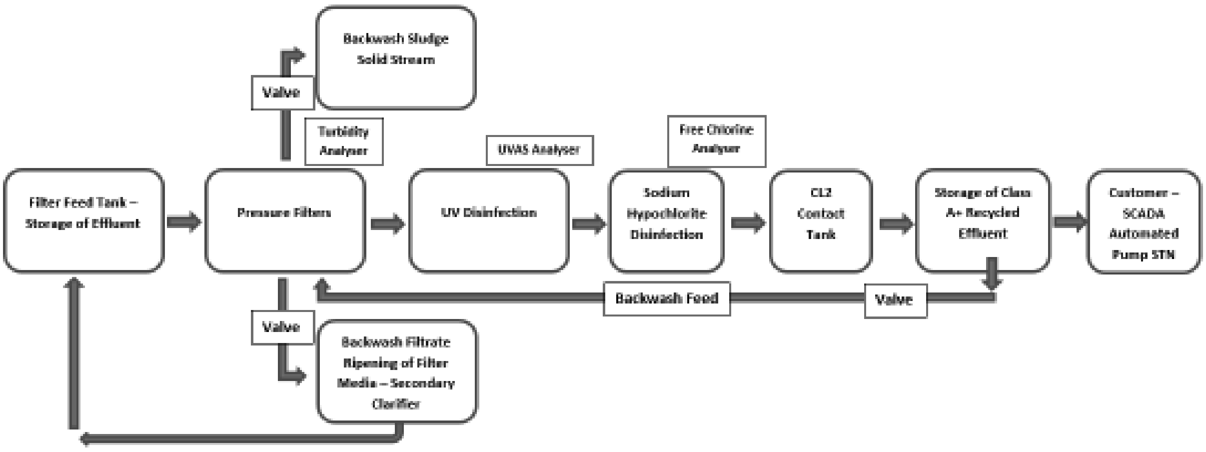
The influent received by the WWTP is relatively domestic apart from septage receival. The quality of effluent is stable year round with only minor rises in TN in the colder months. With stable effluent we can supply a reliable supply of Class A+ and C effluent irrigation to our customers.

3.0 THE OPERATIONAL ASPECTS OF THE CLASS A+ RECYCLED WATER

To meet the Queensland Government's Water Recycling Guidelines and produce Class A+ Effluent the secondary effluent passes through three barriers - Filtration and dual disinfection (Ultraviolet Light and Sodium Hypochlorite).

The recycled water system comprises a filter feed tank that is kept full by the means of a splitter box to enable flow to any of the three locations of separation of the final effluent. Duty standby submersible pumps deliver effluent to the pressure filters. Alum is dosed in line by dose pumps to coagulate the effluent prior to entering the filters. The two inline pressure filters are capable of 25 L/s. The effluent passes through the 3 stage filter media to then have a final turbidity of less than 1NTU. The next phase is UV disinfection through dual in-pipe UV reactors and finally dosed with sodium hypochlorite and contacted for at least 30 minutes before passing into a holding tank for delivery to customers or to be used on-site. Pump stations are onsite to supply customers via telemetry that have a requirement for the Class A+ effluent. Each consumer has a storage that can communicate with SCADA to ensure we are aware of when they require water and total volume pumped to each site.

Each pressure filter is serviced by air scour and backwash pumps. Instrumentation, or we call it the Wet Rack - consists of 3 ultra-turbidity analysers so the operator can monitor both filters, simultaneously and effluent in reactor at time of discharge. The rack also contains a transmissivity analyser that determine dosages for UV Reactors. The chlorination monitoring provides real time dosing and alarms for SCADA. All instruments are monitored by SCADA and this provides our failsafe if the instruments fail or recycled water goes out of scope. Maintenance is relatively simple, routine cleaning, calibration and inspections to ensure the plant delivers a good and safe product to our customers.



<u>Figure 6:</u> ***Class A+ Recycled Water Process Flow***

4.0 THE OPERATIONAL ASPECTS OF THE CLASS C RECYCLED WATER

"*If you can grow a cherry tomato in a sludge bed I reckon we can farm*"

In 2018, SBRC engaged a local contractor to install 2 fixed pivot irrigators to cover 30Ha to disperse the secondary Class C effluent over the farm by commercialising a resource and promoting management of a third process by further reducing the nutrient load that would otherwise end up in the catchment that supplies Kingaroy's water supply. This has been no easy task to prepare the farm. The wastewater farm was last used in the 1970s with a small team of workers to plough, plant and bale Rhodes grass. But as time went by and the failures within the lagoons, the detention time could not be achieved. This is a brief account of what can be achieved. The common goal was to get the lagoons desludged, baffles repaired, paddock burnt to reduce weeds and woody growth, plough to remove hard pan, commission the pivots without burning them down and plant that Rhodes grass.

- Pick a safe, but hot part of the year to achieve an intense fire to remove a large quantity of vegetation and regrowth.
- Ploughing the paddock had to be chisel ripped and deep, ripping to loosen up hard pan areas, to allow for unobstructed root growth, allows for higher water shedding and penetration, ability to successfully add lime or gypsum to further condition soil if require, all nutrients can be taken deep into the soil without run off and any nutrients in remaining effluent will be irrigated over the land and taken deep into the soil instead of entering the watercourse.
- 2 x Pivot installation and commissioning completed and lagoons start to fill
- Rhodes grass was selected because the ability to grow in wide variety of soil, drought and frost tolerant, ability to grow in nutrient poor soil, becomes the dominant species and out compete weeds, has tolerance to salinity soils, can be cut & baled, will regrow without seeding and it is a very good source of forage for cattle during drought times.

The secondary effluent from the Nereda® system is such quality that following a minimum 25 days storage in detention lagoons it can be applied directly to the South Burnett Regional Council neighbouring farm. The system was commissioned in late 2018 and planted with Rhodes grass in February 2019. Council expects this to be a good source of income and further nutrient removal within the local ecosystem.

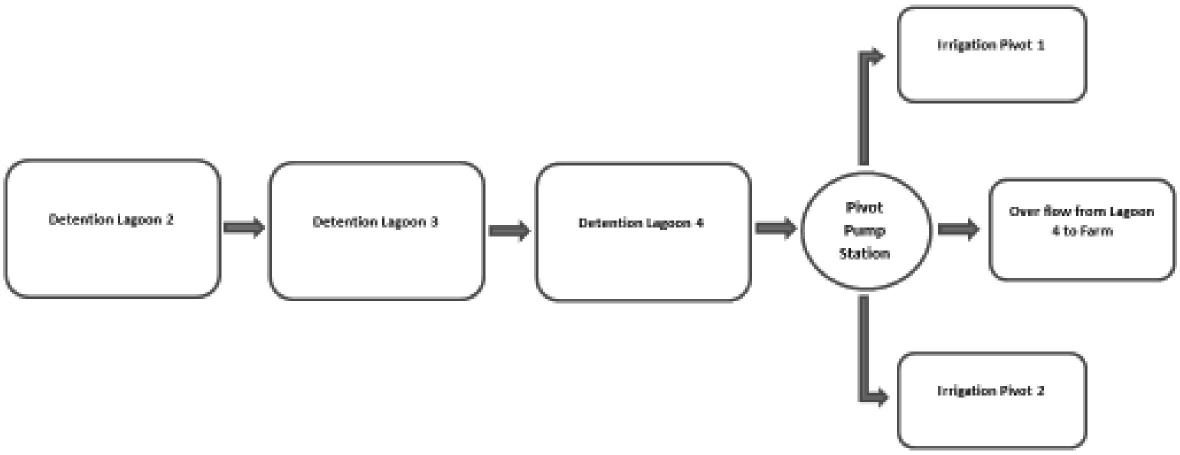


Figure 7: ***Class C Recycled Water***

Figure 8: ***Pivot Irrigation***

Figure 9: ***Final Lagoon***

5.0 CONCLUSION

Working for the South Burnett Regional Council, Water and Wastewater Section, operating and maintaining one of the newest wastewater installation in Queensland, being able to see the benefits to the towns sporting recreational areas, possibly being able to feed a few hungry cows on round bales grown on the farm and reducing the amount of nutrients into the creek is a definite fringe benefit of my job. I believe the most satisfying part of this position is ensuring wastewater releases to either surface water or irrigation are kept within licence as downstream of many wastewater treatment plants is a water treatment plant and unless it has reverse osmosis it will not take out the nutrients of a failing or poorly operated wastewater treatment plant. To continue to provide this recycled product is only achievable with support from Supervisors and ongoing maintenance from staff willing to make a difference and support these types of ideas through, too eventually see the “benefits to the community.”

6.0 ACKNOLEDGEMENTS AND FURTHER INFORMATION

South Burnett Regional Council – Water and Wastewater, Aquatec Maxcon, Royal HaskoningDHV – Nereda® Team – Amersfoort.

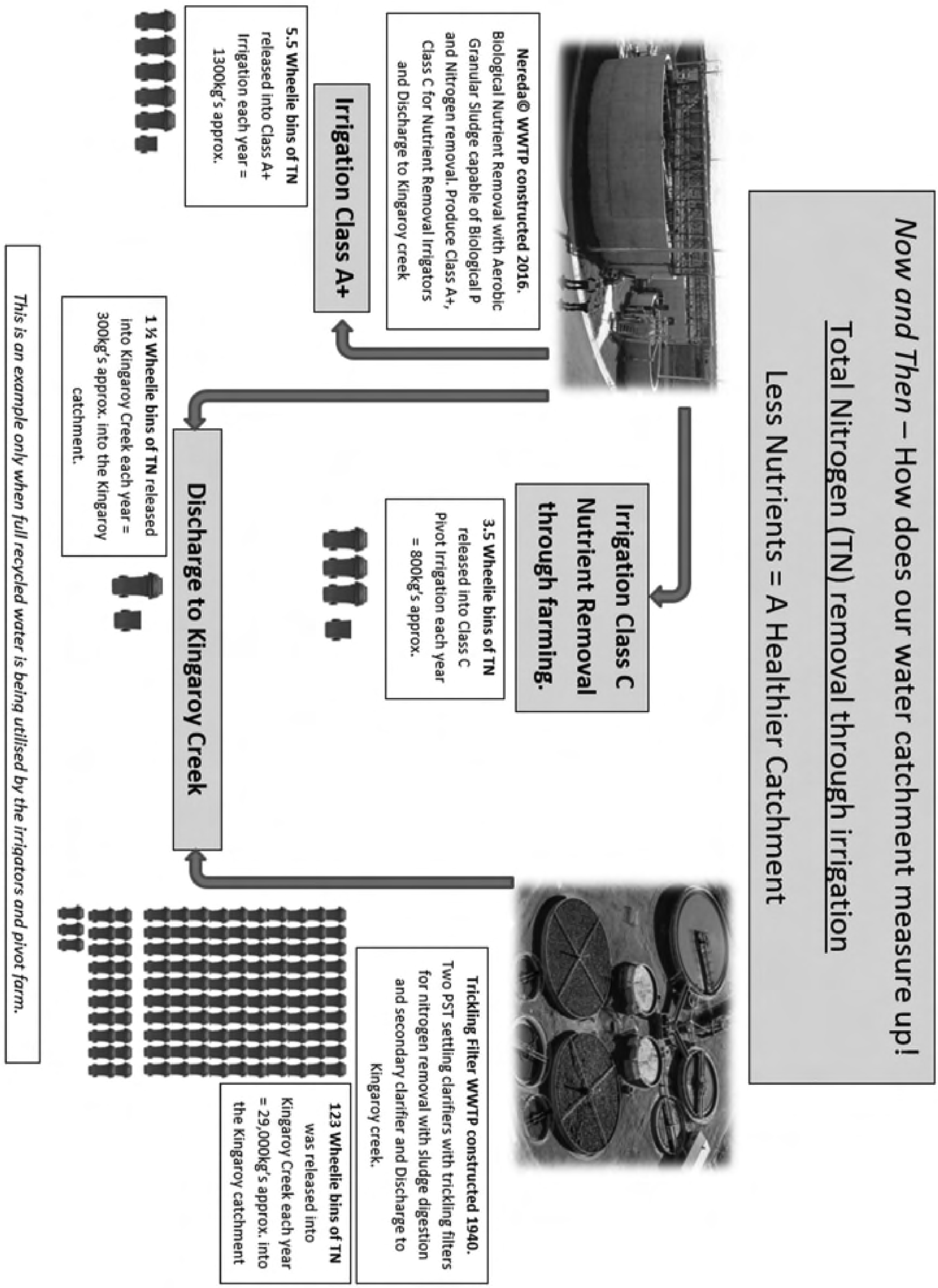


Figure 10: ***Poster to display TN reduction and discharges between both plants. This is only a guide to follow when full recycled water is in demand. One Wheelie bin = 240ls or 240kg. TN – Total Nitrogen***

For further information on Nereda® please read my 2017 WIOA Paper – *An Operators Perspective; The First Nereda® WWTP in Kingaroy, Australia.*
https://www.aquatecmaxcon.com.au/
https://www.royalhaskoningdhv.com/en-gb/nereda

ELIMINATING CONFINED SPACE ENTRY FOR PUMP MAINTENANCE AT MAJOR PUMP STATIONS

Paper Presented by:

Anthony Domanti & Scott Smith

Authors:

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Scott Smith, *Mechanical Maintenance Supervisor,*
Logan City Council

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ELIMINATING CONFINED SPACE ENTRY FOR PUMP MAINTENANCE AT MAJOR PUMP STATIONS

Anthony Domanti, *Project Development Project Manager,* Logan Water Infrastructure Alliance
Scott Smith, *Mechanical Maintenance Supervisor,* Logan City Council

ABSTRACT

The Alfred Street SPS69 wastewater pump station is the largest in Logan, servicing 200,000 people in the Loganholme Wastewater Treatment Plant catchment. Each pump at the station weighs five tonnes and is in a 22m deep wet well. Pump removal has been challenging for many years, requiring confined space entry, and the use of a ‘man-cage’, two overhead bridge cranes and a crane-truck.

This case study discusses how pump removal was simplified and made safer by manufacturing a specialised lifting device. This has eliminated the need for maintenance staff to be lowered into the wet well.

1.0 INTRODUCTION

Logan Water Infrastructure Alliance (LoganWIA) is a public and private sector enterprise involving Logan City Council and engineering services providers Downer, WSP and Cardno. Since 2009, the alliance (and its predecessor Logan Water Alliance) has been responsible for delivering new and improved water and wastewater infrastructure throughout Logan City; one of south-east Queensland’s fastest growing areas.

During its engagement, the alliance has been involved in upgrading the Alfred Street wastewater pump station site at Slacks Creek. This is the largest pump station in Logan City. The site contains two separate pump stations: the original SPS02 pump station and the newer SPS69 pump station. The SPS69 pump station (the focus of this paper) is a submersible pump-type station with an 8.5m diameter, 22m deep wet well (refer Figure 1).

Figure 1: ***Looking down into the SPS69 wet well***

The station is fitted with three 375 kW submersible pumps, each with a capacity of approximately 1,000L/s. The pumps weigh approximately five tonnes each and are over 3m in height (refer Figure 2).

Figure 2: ***Existing SPS69 pumps weigh approx 5 tonnes and are over 3m in height***

2.0 DISCUSSION

2.1 The Challenge

Removing the pumps from SPS69 has been an extremely high risk and labour-intensive activity. A team of at least six personnel and three cranes were required, with working at heights and confined space entry arrangements in place. A complete breakdown of resources required for the pump removal is listed below:

- 10-tonne overhead bridge crane to remove/refit the pumps
- 2-tonne overhead bridge crane to lower a person into the wet well to connect the pump to the 10-tonne crane
- Mobile crane truck required in case of rescue
- Six personnel including
    - Three crane operators
    - One person to supervise confined space entry
    - One person to be lowered into the wet well
    - One person to assist around the site
- A ‘man cage’ to carry personnel and equipment

This configuration was a major issue for Logan City Council’s operations and maintenance staff, as it required personnel to be lowered into the wet well via a ‘man-cage’ using the 2-tonne crane. The 10-tonne crane hook was lowered to the person in the well to manually engage the lifting point on the top of the pump (refer Figures 3 & 4).

This potentially hazardous activity required full confined space entry and parallel crane operations. It was not considered a prudent practice to continue this longer-term. The height restriction associated with using the existing crane hook and the pumps’ unsuitable lifting bail arrangement did not enable a proprietary ‘deep-lift’ pump removal system to be used for this application.

The pumps require servicing every six months and when any breakdowns occur. Pump servicing takes approximately eight hours to complete at a labour cost of approximately $4,080 (to Council).

<u>Figures 3 & 4:</u> ***The long-standing methodology for removing pumps relied on two bridge cranes and confined space entry into the wet well to shackle the pump (left). Looking down into the wet well when the pump was being shackled to enable its removal (right)***

2.2 Approach Taken

During the planning phase of LoganWIA's most recent Alfred Street pump station upgrade project, numerous discussions, workshops and site investigations were undertaken with Council and external suppliers to resolve the pump lifting issue. An option to raise the crane hook height by raising the existing superstructure and procurement of a propriety lifting device were discarded. This was due to the high cost and the inability to commercially retrofit the existing pump with a suitable lifting bail for a deep-lift system.

Following this, LoganWIA contacted specialist lifting organisations Stenhouse Lifting and RUD Australia to design and supply a lifting solution for the pump station that could overcome the physical site constraints. The agreed scope of work for the project involved the design of a new pump lifting point, and a lifting device that would operate when submerged in wastewater.

2.3 Summary of Activities

The key features of the pump lifter design included a self-latching hook, remote release mechanism, balancing counter-weight and axially adjustable guide for activation during the lift. The self-latching hook and remote release mechanism eliminates the need for personnel to enter a confined space for hook engagement and disengagement. The axial adjustment allows for a shift in the centre of mass during the lift and management of any minor misalignment of guide rails.

The counter weight at the opposite end of the guide mechanism helps to balance the lifting device when used without the pump. The lifting device was designed and manufactured in accordance with Australian Standards; with AS 4991-2004 Lifting Devices and AS 3990-1993 Mechanical Equipment - Steelwork being the key standards applied. The lifting device was rated with a Working Load Limit (WLL) of 6.5 tonnes. Three dimensional and finite element modelling were used to design key components of the lifting equipment and predict the behaviour of the product in real life conditions (refer Figures 5 & 6).

Figures 5 & 6: ***3D modelling (left) and finite element modelling (right) were used during the design of the pump lifter***

The lifting device tare mass is approximately 150kg. The tare mass was optimised using CAD software prior to manufacture. A new low-profile lift point and pump cable management system were also designed as part of the project.

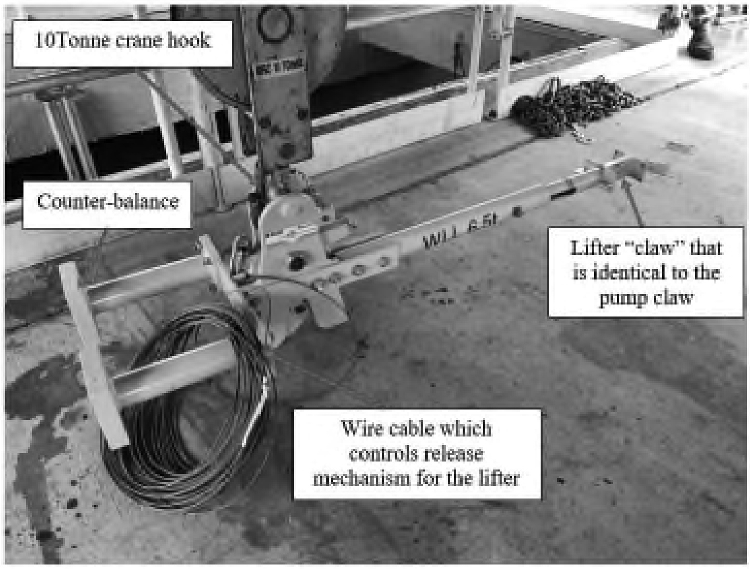
2.4 Summary of Outcomes and Measurable Impacts

Once manufactured, various in-house trials of the lifting device were completed. The device and the lifting point were then proof load tested to twice the Working Load Limit (WLL) as per AS 4991 2004 requirements. The lifting equipment and the new lift point were trialled on site. The trial was completed successfully by engaging with key stakeholders from LoganWIA, Council and project partners. The solution has now been proven as an ideal application for this, and potentially other, deep wet well lifting applications (refer Figures 7, and 8).

Figure 7: ***The pump being lowered into position by the lifter via the existing guide rails***

2.5 How It Works

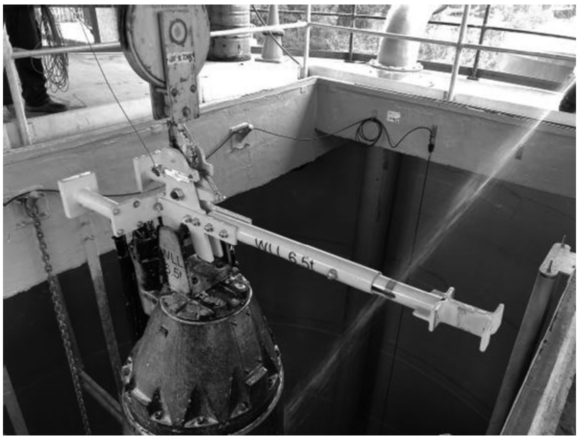
To operate the Alfred Street pump lifter, only two staff are required; one person to operate the 10-tonne crane and a second person to provide 'slack' to the wire cable which opens the release mechanism on the lifter. Key components associated with the lifter are shown in Figure 8.



<u>Figure 8:</u> ***Components of the lifter***

2.6 Pump Removal

The 10-tonne crane hook is engaged on the lifter and is lowered down onto the pump's guide rails (as demonstrated in Figure 7). The hook of the lifter has a spring-loaded mechanism that automatically engages when it finds the lifting bail located on the pump. Once the 10-tonne crane cable shows sign of slack, this indicates that the lifter has been engaged onto the pump and indicates to the operator that the crane is able to lift the pump. As an additional visual aid, the crane operator has a load display available on the crane which enables the operator to determine what load is being seen by the crane. Figure 9 shows the lifter removing the pump from the wet well.



<u>Figure 9:</u> ***Close-up view showing how the lifter engages onto the pump***

2.7 Pump Lowering

The 10-tonne crane hook is engaged to the lifter and is lowered down onto the pumps guide-rails (refer Figure 7). The hook of the lifter has a spring-loaded mechanism that automatically engages when it finds the lifting bail located on the pump. Once the 10-tonne crane cable shows sign of slack, this indicates that the lifter has been engaged on the pump and indicates to the operator that the crane is able to lift the pump. As an additional visual aid, the crane operator has a load display on the crane which enables the operator to determine what load is being 'seen' by the crane.

2.8 Achieving Sustainable Outcomes

The design, manufacture and commissioning of the lifting device cost approximately $40,000 and has reduced Council's pump removal operational costs considerably by reducing the number of required personnel from six to two. This results in a labour cost of $1,360 (i.e. a third of the cost incurred previously). In addition, key non-cost business outcomes of the Alfred Street pump removal project include:

- Operator safety has been significantly improved by eliminating confined space entry requirements and working at heights
- The lifting device has eliminated the need for high risk lifts using multiple cranes and reduced labour
- The lifting device can retrieve the pumps under wastewater if required
- The lifting design concept can be applied to other pump stations
- The lifting device is significantly more compact (a quarter of the height) than other proprietary deep-lift systems.

Figure 10: ***The completed Alfred Street pump lifter***

3.0 CONCLUSION

This project demonstrates that large and heavy submersible pumps can be extracted safely from very deep wet well configurations. Lessons learnt from this project are:

- Ensure that the lifting design has significant axial adjustment that will accommodate for misalignments that may occur during pump lifting and lowering processes
- Ensure enough tolerances are provided in the lifting design (i.e. clearance around the pump guide rails)
- Understand pump cable behaviour as this can impact on the performance of the lifter.

4.0 ACKNOWLEDGEMENTS

The authors wish to thank Council, LoganWIA and RUD Australia for their input, and the opportunity to present this paper.

TRIAL STUDY OF SENSOR-BASED TECHNOLOGY AT KENILWORTH STP

Paper Presented by:

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Unitywater

Jennie Metman, *Sales Manager,*
Control Components

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ABSTRACT

Effective measurement of *in-situ* sludge is key in operation and maintenance of the waste stabilisation ponds in Sewage Treatment Plants (STPs). Effective sludge measurements are also essential from a budget perspective. Current methods of sludge measurements are time-consuming and inconsistent mainly due to agreed settleability point of fluff and sludge blanket level.

Use of sensor-based technology has potential advantages over conventional methods. In October 2018, a sludge survey using Cerlic's Multitracker and Blanko - a flow through portable-hand-controlled optical sensor designed to measure suspended solids, temperature and sludge blanket level, was trialled at Kenilworth STP. The purpose was to:

- Measure the fluff and low/high suspended solids concentrations in the maturation pond;
- Establish the profile of pond depth by plotting against suspended solids concentration; and
- Estimate the sludge blanket level including its depth.

By measuring the sludge blanket level (where threshold concentrations exceeded 5,000 mg/L), the volume of the accumulated sludge was calculated using 'ArcGIS'. Numerical techniques were employed to validate the results. Sensor readings were compared against spot measurements using 'Sludge Judge'.

Sludge volume analysis demonstrated the estimation to be effective and accurate as well being more easily repeatable. Sludge accumulation rates were estimated at 31 to 37 mm/year. Recommendations include assessing the relationship between sludge distribution, pond hydrodynamics and design of remote-controlled equipment for ease in plant operation and monitoring.

1.0 INTRODUCTION

Operation of waste stabilisation ponds is simple, sustainable and requires little maintenance for sewage treatment. Although pond-based systems provide robust treatment, they also mean a greater footprint, a greater effluent volume and a greater sludge build-up requiring effective monitoring to maintain the operational efficiency. In saying that, the process of sludge formation and its rafting at the base of the pond is not well understood and is often difficult to predict. The plant operators often find themselves in a 'blind-spot' as its occurrence is invisible, well below the pond water surface. While the accumulation of sludge is a slow process, efforts to remove the accumulated sludge is time consuming. De-sludging is a very expensive, messy process that could lead to lengthy disruptions of the process treatment (Pohlner, 2017). The rate of sludge accumulation and volumetric measurements are therefore essential from a maintenance and budget perspective.

Despite several methods of sludge measurement such as using a 'Sludge Judge' currently-in-practice, effective monitoring is time-consuming and can yield in-consistent results.

Consistency of sample point/time, the rate at which the equipment is lowered (usually referred to as 'plunging'), the operator's understanding of the 'fluff' and 'sludge blanket' settleability and the identification of any interferences like invisible components or blockage of pipe bottom check-valve are key.

Kenilworth Sewage Treatment Plant (STP) is a small capacity (350 equivalent persons, 2018 based) site located in the Sunshine Coast hinterland in Unitywater's northern service area. The STP utilises three ponds – a combination of two facultative ponds and a maturation pond operated in series as part of its passive treatment process stream, with the resulting effluent being applied to land cultivation of Vetiver grass.

The ponds were desludged and re-lined in October 2010. Approximately 6,600 m^3 (combined) of sludge was removed. Removal and transport of the accumulated sludge had an associated cost of $540,000 (inflated to 2018) with significant discrepancies in values between the surveyed sludge volume and actual volume removed (38% increase).

Given the discrepancies in sludge volumetric measurements as well as inefficiencies associated with the physical measurements, it was of interest to Unitywater to trial a new 'sensor-based technology'. This trial was aimed at improving the efficiency and accuracy of sludge measurements which could have operational benefits and assist in the decision-making process on when sludge removal should be conducted.

2.0 DISCUSSION

During investigations into alternate methodology for *in-situ* sludge measurement, an opportunity to trial 'sensor-based technology' was chosen based on a market-sounding exercise. Initial investigations revealed the technology to have potential advantages over conventional methods such as a 'Sludge Judge' employed at other Unitywater STPs. Following many spin-off discussions with the equipment supplier and subsequent lab-scale demonstration, it was decided to conduct a trial study to evaluate this new technology at Kenilworth STP.

2.1 Cerlic Multitracker and Cerlic Blanko Sensor

The 'sensor-based technology' in question was the Cerlic's Multitracker and Blanko, which comprised of a control unit and a suspended solids sensor, respectively (Figure 1).

<u>Figure 1</u>: ***Cerlic's Multitracker and Blanko Sensor***

2.2 How It Works?

The Multitracker unit can be used to log a profile of Mixed Liquor Suspended Solids (MLSS) versus pond depth as the sensor is lowered down through the water column into the pond.

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 lower ‘fluff’ concentration was generally representative of the water column (usually 200 to 400 mg/L in most cases above the ‘sludge blanket’).

The Multitracker has built-in audio and vibration alerts when each of these thresholds are met. The unit would alert the operator as it reached two different concentration set-points. The unit also logs the 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.

2.3 Survey Methodology

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 the distance between survey points was not exact, this was acceptable because the curtain anchors (black dotted lines in Figure 2) provided the only way to geo-reference the survey results using ‘ArcGIS’ (without GPS coordinates). Each ‘zone’ between curtain anchors was split up evenly resulting in grid intervals that were ~6-7 metres, both-ways.

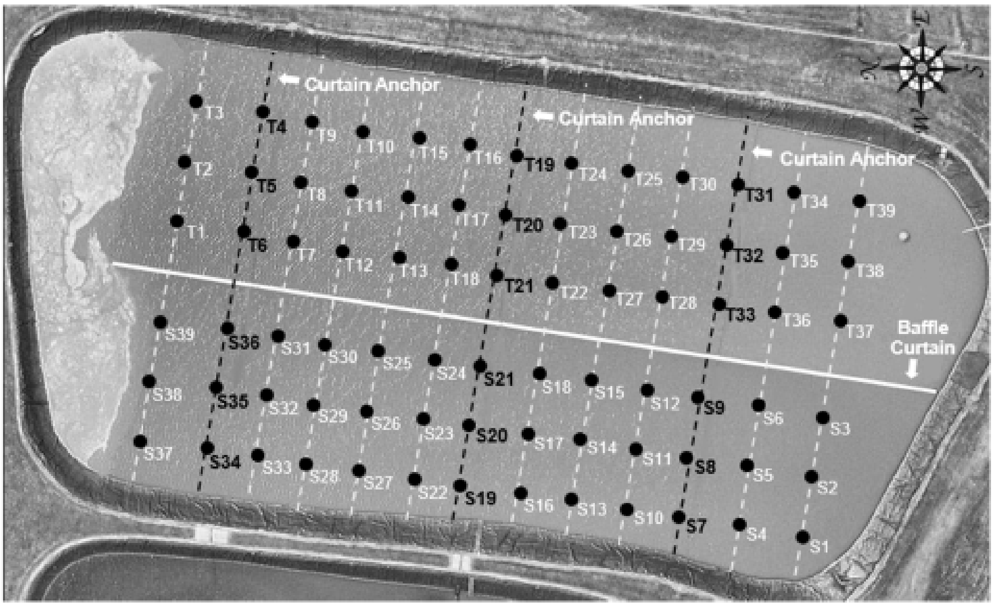

Figure 2: ***Sludge survey grid locations***

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.

At each survey location, the sensor was steadily lowered through the water column until it reached the pond bottom – this was evident through both ‘feel’ and a ‘profile graph’ that was generated on the Multitracker. If the data looked acceptable with no irregularities, the data was saved. The time of each reading was recorded to correlate saved data with the correct location.

These readings were periodically checked visually against physical readings from a ‘Sludge Judge’ to verify the depth of sludge accumulation and to ensure the digital readings were reliable and accurate.

2.4 Data

The results from the Multitracker and Blanko sensor were downloaded in the form of a CSV file. A real-time bar graph of the sludge profile was created (Figure 3). Two threshold depths for ‘fluff’ and ‘sludge blanket level’ as well as a temperature measurement and time of reading was also recorded.

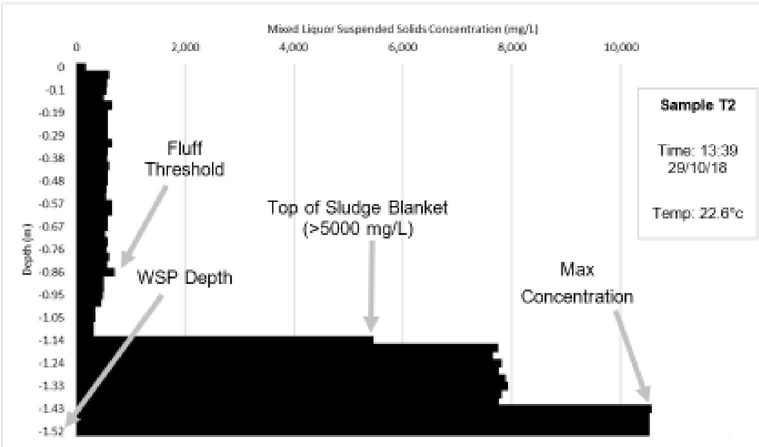

Figure 3: ***Multitracker data output***

2.5 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 discussed in Section 2.2.

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). The sludge deposition followed a centrifugal pattern as it flows out of the inlet, 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 which approximates integration (calculus). This technique was used as a spot check to validate the results produced using 'ArcGIS'.

<u>Figure 4</u>: ***Heat map of sludge accumulation***

These 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. It is expected that the 'representative' figure would be closer to 37 mm per year which was derived from the 'ArcGIS' and associated assumptions (including linear interpolation and extrapolation of additional survey grid points).

3.0 CONCLUSION

On completion of this trial study, the first 'take-home message' was that the pond was experiencing a 25% reduction in its operational capacity, due to sludge accumulation in the last eight years.

Secondly, the rate of accumulation was on par with expectations (typically between 25 to 50 mm per year), but it was not expected that there would be such variance in the sludge distribution pattern largely attributable to the improper pond geometry.

The second 'take-home message' was the identification of error in the as-built versus *in-situ* measurements.

One of the 'loud and clear messages' from the study, was on the potential in using new technology for studying the sludge characteristics and settling patterns within the maturation pond. Due to the ease in obtaining the MLSS results in a fraction of the time and the simple testing method involved, it was easier to identify the 'fluff layer' and 'sludge blanket layer' effectively.

The combination of Multitracker and Blanko sensor provided measurable benefits over physical sampling methods such as 'Sludge Judge' including getting highly accurate results with less opportunity for errors, ease of data storage, reduced reliance, time and labour. This is especially true if operators are interested in the stratification of the MLSS concentrations where time and cost associated with determination of the solids content in the pond becomes significant. Taking 78 samples with high resolution data in an eight-hour period would not be feasible with other methods. It appears the sensor-based technology brings in accuracy to the process supervision.

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 – this work is a step in the right direction with results that satisfy time, quality and cost.

Finally, it was recommended that:

- Additional surveys should be conducted at other ponds – not just 'a trial because it is useful and easy', but because it provides vital information to stay ahead of the de-sludging process which is currently a challenge.
- A broader use of this technology and potential applications in other innovation projects such as sludge blanket measurement in secondary clarifiers.
- More effort should be focussed on establishing flow patterns and stratification of deposited sludge – an aspect that we still have much to learn about.
- A remote-control unit specification should be designed for SCADA integration. This would enable a stationary unit to be integrated into the control system that allows for remote monitoring of the plant.

4.0 ACKNOWLEDGEMENTS

Many thanks to Unitywater staff:

- Sam Guy for help throughout the whole process;
- Glen James and Casey Staines during the survey;
- Chris Teitzel with the GIS analysis; and
- Jane Parker in paper preparation.

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MAGNISUM HYDROIXDIE DOSING TRIAL

Paper Presented by:

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44th Annual WIOA
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5 & 6 June, 2019

MAGNISUM HYDROIXDIE DOSING TRIAL

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ABSTRACT

In 2005, a sewer system was built for Mission Beach area allowing sewage to be pumped 23km to the township of Tully for treatment. It was discovered that the sewer between Mission Beach and Tully was not lasting as long as it should, with sections failing and needing to be replaced within a 10-year period. It was discovered that due to the long retention time within the sewer, Hydrogen Sulphide was forming and attacking the concrete lining of the pipe.

To extend the longevity of the sewer, it was decided to conduct a trial using Magnesium Hydroxide to reduce the effects of Hydrogen Sulphide forming in the sewer.

1.0 INTRODUCTION

In 2005, Cassowary Coast Council sewered the seaside towns of Mission, South Mission and Wongaling Beaches. Due to the current future population growth projections, the sewerage system and pump stations were designed to handle the increase in sewerage flow for many years to come.

Unfortunately, the Mission beach area experienced two cyclones within a few short years of each other. After the second cyclone, a lot of people moved away leading to a decline in sewage flows which ultimately led to the pumping stations being oversized for the flows they were receiving.

There are multiple pump stations that convey sewage to a main transfer station. The sewage is then pumped the 23km over two and a half days to the treatment plant located in Tully. Due to the low flow and time frame, the sewage turns septic in the pipe before it reaches the treatment plant.

These conditions have allowed the creation of hydrogen sulphides within the sewer, which in places has eaten out the concrete liner and caused major breakages in the sewer line.

There has also been odour problems caused by large rafts of fats, oils and grease building up in the pump stations, requiring removal on a regular basis.

The Tully sewerage treatment plant was also receiving high ammonia and high phosphate spikes, along with increased odours by the time the raw sewage reached the plant.

2.0 DISCUSSION

Due to the cost of continually repairing the sewer, and the possibility of a need for complete replacement within the near future, Council started to investigate ways to slow down the degradation process and improve the longevity of the sewer.

The objectives were to

- Reduce the amount of Hydrogen Sulphide being produced within the pump stations and sewer,
- Reduce the amount of Fats Oils and Grease in the pump stations to minimise pump out costs and to reduce odours.

In late 2017, Calix offered to carry out a trial, by dosing a couple of the pump stations with a refined product of Magnesium Hydroxide slurry, called “ACTI–Mag”.

2.1 What is Magnesium Hydroxide Slurry (MHL)?

MHL is

- a slurry based alkali – AKA “Milk of Magnesia”
- Neat MHL has a pH – 10.5
- Buffers at pH – 8.5 -9 when dosed
- Has slow alkali release by dissolution of slurry
- Is an excellent antacid and is totally safe to handle.

Two sites were chosen in the Mission beach area to dose MHL. One was at Wongaling Beach pump station No. 1 which covers the southern reaches of Mission Beach, and the other station was North Mission Beach No.1, covering the Northern areas of Mission Beach.

Monitoring within the network consisted of,

- pH logging
- H_2S Odour logging
- Build up of Fats Oils and Grease in pump stations

An odour logger was placed in the main transfer pump station which is the collection point for both NMB 1, and WB1 pump stations before the sewerage is pumped off to the Tully treatment works.

Within two days of dosing there was a dramatic reduction in H_2S and odours being emitted from the pump station. H_2S levels that were normally around the 80-120 ppm reduced to around 10 ppm.

Over a two to three week period from commencing dosing, it was noted that there was an increase of rag and screenings capture at the treatment plant. This was being caused by the fat rafts within the Mission Beach pump wells starting to break down releasing bound up rag and rubbish into the sewer. Over a period of time the fat rafts disappeared, the screenings catchment returned to normal and the pump wells have remained a lot cleaner, drastically reducing the maintenance cleaning.

Over the trial period most of the primary objectives were met, these being:

- Odour control within the catchment, with H_2S now less than 2 ppm
- Fatberg control within the pump stations, reducing build up and cleaning, and
- Presumed Corrosion control on the pumped Mission beach to Tully main sewer line, which will be confirmed by ongoing monitoring.

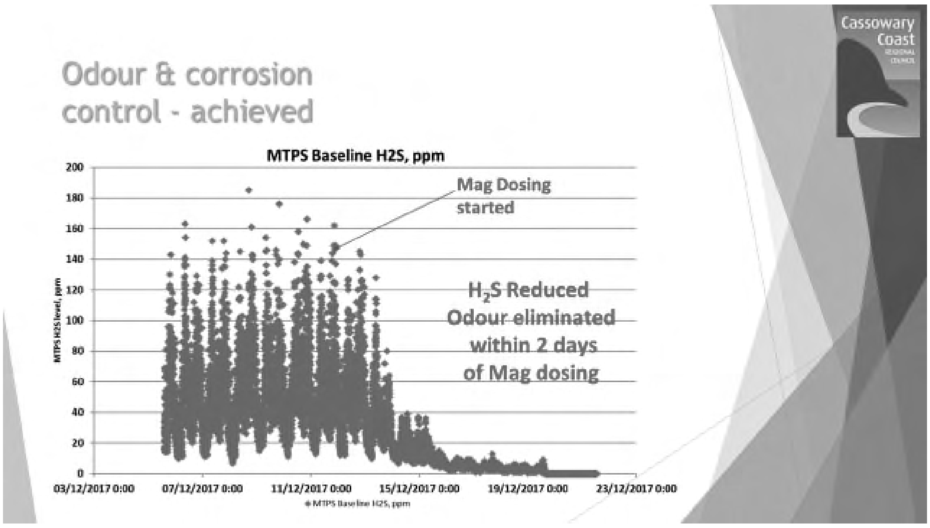

Figure 1: ***Graph showing odour and corrosion control***

2.2 Tully Sewerage Treatment Plant

The existing treatment plant was constructed in 2005 at the same time the Mission Beach area was sewered. The township of Tully had been sewered many years earlier and was serviced by a small package type plant located on the opposite side of the Banyan Creek to where the newer plant stands today.

Tully treatment plant consists of a circular Oxidation Ditch incorporating an anaerobic zone, alternating aerobic and anoxic zones, with a central clarifier before UV treatment. Solids disposal is by a Belt Filter Press.

The average dry weather flow is approximately 1800 – 2000 KL/day,

Prior to the ACTI – MAG dosing trial, lime was added to the process for Alkalinity and pH control and liquid Alum was added for Phosphorus control.

Due to the condition of the sewage entering the plant, there has on many occasions, been problems with high Ammonia and or Phosphorus entering or leaving the plant and on occasion has caused a breach in licence conditions. To help overcome this problem a 3 ML lagoon was constructed on site so that if a problem arose then we are able to divert either the raw sewerage or the effluent water to the lagoon until the plant recovers, then slowly feed the contents of the lagoon back through to the head of the plant.

It became apparent, that soon after dosing began at Mission Beach, there were some additional benefits or, knock on affects starting to happen at the treatment plant itself, these were:-

- There was no detrimental impact on the plant. Other than in increase in screenings entering the plant for a short time, there has been no negative affects to the plant throughout the trial, in fact the affects have all been positive.

- No more lime dosing. We were dosing 10 to 15.5 hours per day equating to approximately 80 to 120 Kg of lime being used, it is now down to Zero and has been soon after Mag dosing commenced at Mission Beach.

- Reduction of Alum dosing. Over a few months we were able to reduce the amount of Alum dosing from 8.75 hours per day, equating to approximately 200 L of alum being dosed, down to 0.3 hours per day or approximately 7 L per day. With the right conditions and a bit more playing around, we are confident that we may be able to eliminate Alum dosing altogether.

- The Alkalinity. The alkalinity entering the plant has become more stable and tends not to drop away as much as it did when we experience wet weather conditions. This has helped to keep the pH steady and we have noticed under the microscope that the microorganism population seem to be in abundance and look very healthy. This could be part of the reason why we have been able to reduce the Alum dosing as much as we have.

- And lastly, odour control. It has been noticed that there has been a dramatic decrease in the amount of odour hanging around the inlet works of the plant. The incoming sewage does not look as dark or as septic as it did prior to the commencement of dosing some 23km away.

3.0 CONCLUSION

In summary, this trial carried out by Calix has shown that by dosing the sewer system with Magnesium Hydroxide we were able to achieve the following:-

- Odour and Corrosion control (Buried assets are expensive)
- Fatberg control in sewerage pump stations
- Provides alkalinity which means no more lime dosing at the treatment plant
- Reduction of Alum dosing
- Saving in plant chemical costs
- Reduction in sewer maintenance and cleaning costs, and
- A reduction in repairs in sewer rising main costs.

BIOLOGICAL ACTIVATION OF GRAVITY FILTERS BY DECHLORINATION OF BACKWASH WATER

Paper Presented by:

Shahzad Sandhu & Kendall Niblett

Authors:

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Lower Murray Water

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5 & 6 June, 2019

BIOLOGICAL ACTIVATION OF GRAVITY FILTERS BY DECHLORINATION OF BACKWASH WATER

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Kendall Niblett, *Coordinator of Treatment Plants - Northern,* Lower Murray Water

ABSTRACT

Since the commissioning in 2005, the dual media gravity filters of Mildura West WTP (20 ML/D) were backwashed with retic water containing residual amounts of chlorine (1-1.2 mg/L). This eliminated the biomass development in the filter bed and PAC was dosed continuously to remove the Geosmin associated earthy/musty odour in the filtered water. The understandable solution was to use filtered water for backwashing, but it would have involved major capital costs and augmentation of existing infrastructure, so instead, operations chose to trial dechlorination of backwash water with Sodium Metabisulfite (SMBS). Since October end 2018, Geosmin levels in the filtered water that had previously hovered in the range of 3-8 ng/l, dropped to 1 or <1 ng/L without any PAC dosing at a chemical cost of $3.0 per backwash. SMBS dechlorination of backwash water biologically activated gravity filters, reduced Geosmin levels and has improved taste and odour of the filtered water.

1.0 INTRODUCTION

Continuous PAC dosing to eliminate taste and odour compounds at MDA West led various internal stakeholders of LMW to hypothesise that backwashing of gravity filters with chlorinated water decreased the biomass activity and eliminated the biofilm, essential for degradation of Geosmin and MIB. In the first half of 2017, lab tests were conducted, PAC usage was compared with MDA WTP and Taste/Odour (T/O) complaints data was analysed to validate further investigation.

<u>Table 1:</u> ***Geosmin & MIB Levels (ng/l) (Without PAC Dosing)***

	Geosmin		MIB	
	MDA WTP	**MDA West WTP**	**MDA WTP**	**MDA West WTP**
Raw Water	4	4	56	9
Filtered Water	<1	4	2	8

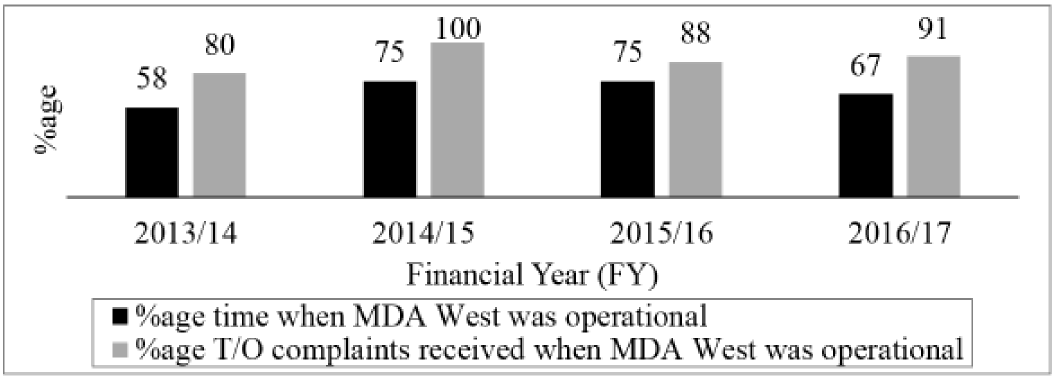
Table 1 shows limited process capability of MDA West compared to MDA WTP to remove Geosmin and MIB from the filtered water. PAC dosing was deliberately stopped at MDA West to get PAC-free samples in April 2017.

<u>Table 2:</u> ***PAC Usage Comparison between MDA West WTP and MDA WTP***

	MDA West WTP	**MDA WTP**
Days considered (1st Jan 2013 – 1st Feb 2017)	1,492	1,492
Days of operation	1,042	1,492
%age of water treated with PAC	**83%**	**11%**

Table 2 shows complete operational dependence of MDA West WTP on PAC. Besides, the plant was strategically put offline for four months annually, leaving MDA WTP as the plant of choice needing PAC dosing in times of algal blooms only. Savings of $43,697/- could have been generated annually, if PAC had been dosed less frequently in the period considered.

Figure 1 reveals that despite continuous PAC dosage, there had always been a higher probability of receiving a taste and odour complaint when MDA West was operational.

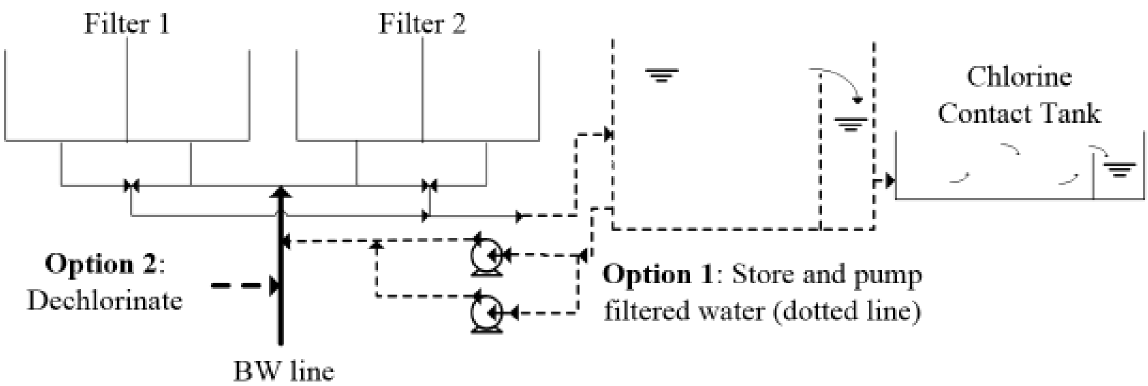


<u>Figure 1:</u> ***Taste/Odour (T/O) Complaints***

2.0 DISCUSSION

The reason for continuous PAC dosage at MDA West WTP was neither an operational nor a design issue. Filters were stipulated to be pre-chlorinated for occasional Manganese removal, but occurrences of high Mn in raw water were so rare that pre-chlorination was hardly ever used at the plant. However, turning off pre-chlorination proved to be inadequate while filters were still backwashed with chlorinated water.

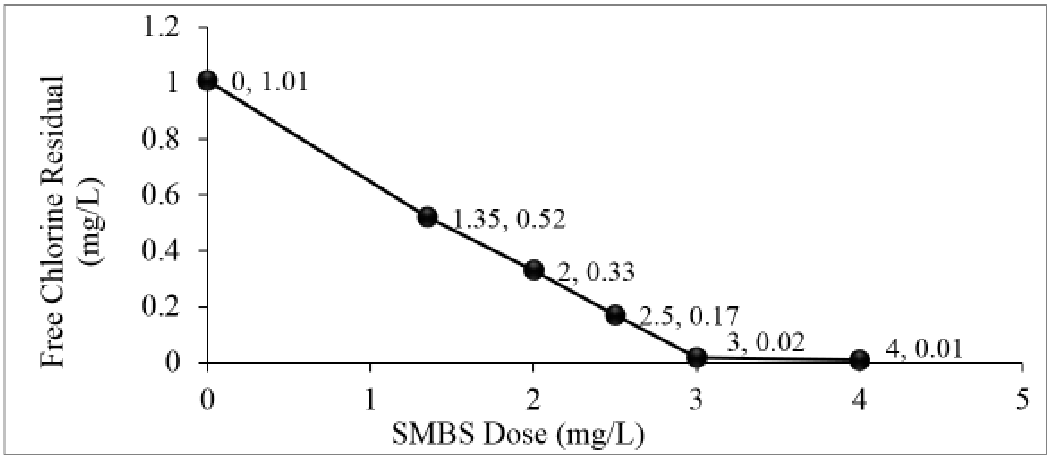
Figure 2 shows the two main options considered, either storing and pumping the non-chlorinated filtered water for backwash or dechlorinating the existing backwash line.



<u>Figure 2:</u> ***Options Considered for Backwashing Without Chlorine Residual***

In August 2017, Jar tests were performed to test the effectiveness of Sodium Metabisulfite (SMBS) for dechlorination. Increasing concentrations of SMBS were added to 1 litre treated water samples containing 1.01 mg/L residual chlorine.

After SMBS addition, samples were stirred at 40 rpm for 22 seconds and at 100 rpm for another 6 seconds. In theory, 1.34 mg of sodium metabisulfite will remove 1.0 mg of free chlorine. In practice, however, 3.0 mg of sodium metabisulfite is normally used to remove 1.0 mg of chlorine, which is exactly what was found in jar tests. Figure 3 shows an inverse linear relationship between Free Chlorine Residual (FCR) and SMBS.



<u>Figure 3:</u> ***Jar Test Results – Dechlorination by SMBS***

After getting jar tests results both options were compared in detail, and it was decided to give dechlorination a chance before a major capital expenditure decision of having a storage of ~150 kL, a centrifugal pump set at 250 L/s with VSDs, interconnecting stainless steel piping, PLC / SCADA programming could be made.

2.1 Sodium Metabisulfite (SMBS) - WQ Risk Assessment and Safety

SMBS is included in the NSF/ANSI 60-2016, "Drinking Water Treatment Chemicals – Health Effects". This standard establishes minimum health effects requirements for the chemicals, the chemical contaminants, and the impurities that are directly added to drinking water from drinking water treatment chemicals. The standard states that the chemicals used for dechlorination are used by the reaction and residuals of these products are not likely to be found in the finished drinking water.

NSF chemical finder list sets maximum dose of SMBS at 15 mg/L and sulfite residual levels in the finished water are to remain below 0.1 mg/L. For dechlorination at Mildura West, the expected dose is ~3.0 mg/L, many times less than the allowed max dose and sulphite levels were tested to be below 0.1 mg/L after trial commencement.

The sulfite levels were never expected to go near 0.1 mg/l as SMBS is added in backwash water and not filtered water and the WTP has "Filter to Waste" step at the end of the backwash sequence, which ensures cessation of SMBS dosing and resumption of filtration operation well before filters are brought back online (15-25 minutes).

Recirculation from sludge lagoons might contain minute quantities of sulfite but it was deemed unnecessary to monitor regularly when recirculation was only 10% of raw water flow. Furthermore, the chemical used is of food grade quality and Cobalt free and is widely used in the food industry.

If breathed in SMBS can irritate nose, throat and lungs, causing coughing, wheezing and/or shortness of breath. Contact can irritate the skin and eyes.

2.2 Trial - Design and Set-up

The trial needed a batching system, a dosing board, a dosing line, four sample lines and a chlorine analyser. Since the chlorine residual in the retic remains constant around 1 mg/L, a feed forward and flow paced operation was preferred over a feedback control.

Mildura West WTP was originally designed with the capability of dosing sulphuric acid for the treatment of saxitoxins but this system has never been required. It was decided to use the existing sulphuric acid area and dosing pump pipework which ran past the filter gallery. An unused urea dosing system at one of the wastewater treatment plants, which had a hopper and a batching tank, was disassembled and reassembled in position in the sulphuric dosing area. A spare chlorine analyser from another WTP was installed in the existing cabinet, dosing pumps were purchased new and the pipework was built from the suction point to the existing delivery point. All works were carried out by in-house staff.

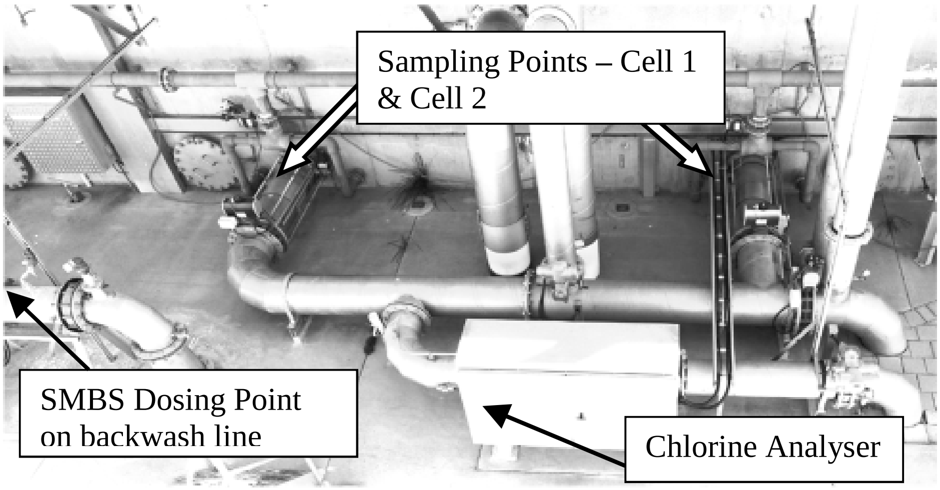


Figure 4: ***Trial Set-up (Filter 1 shown only)***

2.3 Operational Challenges and Optimisation of SMBS Dose

- Dosing pump: A more suitable dosing pump was sourced and installed due to an oversight on the pressure requirements in the backwash line.
- Loading valve: Loading valve allowed the dosing line to partially empty, allowing chlorine into the filters for a short period during each backwash. A pressure sustaining valve was installed in place, which fixed the issue.
- Long dosing lines to dosing point: If batch strength is altered, there is a lag between making the change and the time it takes to reach the dosing point. Currently it requires 3 backwashes to completely turn over the line contents.
- Batch strength: The lower the strength, the lower the shelf life. Shelf life is important as filter run times determine how long a batch would last. We currently run a batch strength of 25% giving us a few months for each batch. Before we realised the issue of loading valve, we were running lower batch strengths but dosing harder to get de-chlorination occurring earlier in the backwash (low speed backwash).
- Dosing point location: The distance between the dosing and sampling points is short providing contact time of only a few seconds. This has not proven to be an issue due to vigorous mixing achieved in the high-pressured backwash pipe.
- Dose rate: We started with a dose rate of 3.0mg/L as per our jar test results but have crept this down to 2.7mg/L successfully with no ill effects. A typical backwash profile, where zero chlorine residuals are achieved is shown in Figure 5

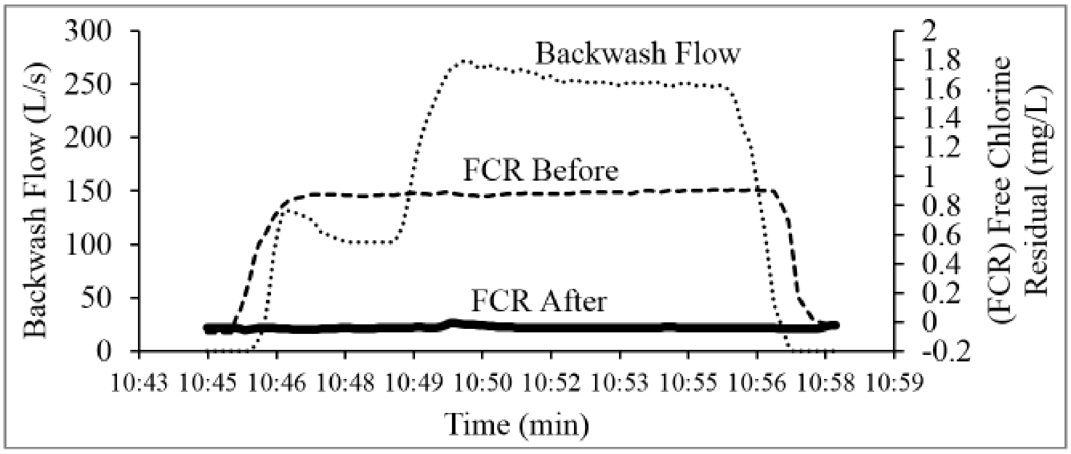


Figure 5: ***A Typical Backwash Profile – Before and After Dechlorination***

2.4 SMBS Cost

SMBS is sourced locally in 25kg bags. Each bag is $80 (incl. GST). The amount dosed per backwash at a batch strength of 25% and a dose rate of 2.7mg/L, is 3.76 litres. This amounts to 0.94kg of dry SMBS. Therefore, each backwash costs $3.

2.5 Monitoring Program and Trial Results

A fortnightly program for testing Geosmin, 2-MIB, UV254 and TOC (DOC was also tested on a few occasions) in raw and filtered water was organised with the WQ Department. Testing was and is still being carried out for both MDA WTP and MDA West WTP.

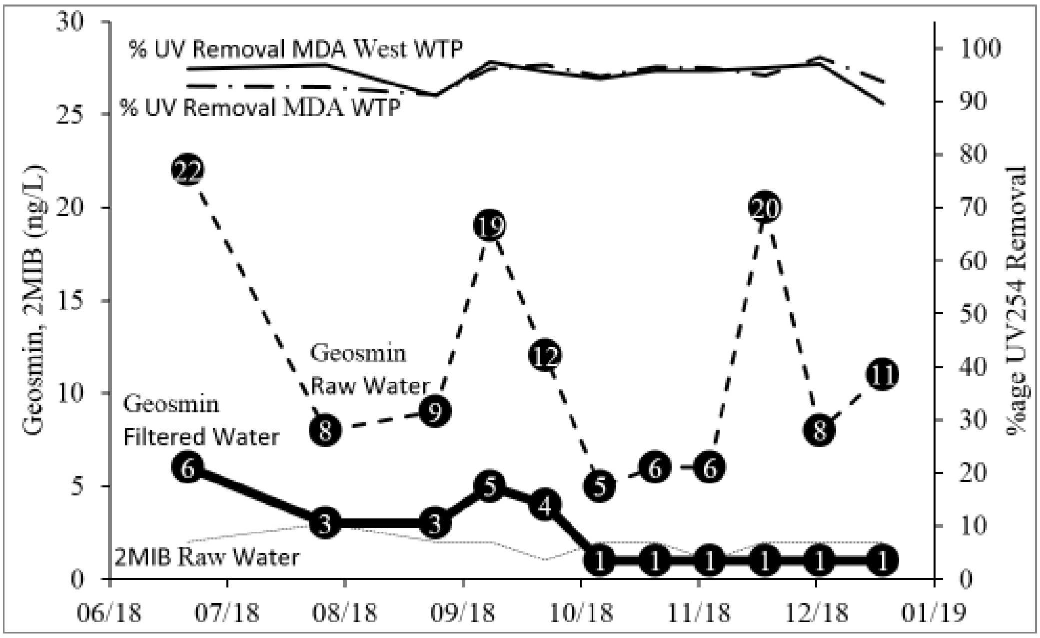


Figure 6: ***Geosmin Removal Process Capability – Without PAC Dosing***

Figure 6 shows Geosmin removal capability gained at the end of October 2018 without any PAC dosing. Even though SMBS dechlorination operation started at the end of July 2018, there were periods when SMBS dose was missed. Regular dechlorination started on 1st September 2018. UV254, TOC and DOC removal %ages were the same for both plants (only UV254 %age removal shown in Figure 6).

Figure 7 compares MDA WTP with MDA West WTP. Points on the slant line indicate a similar geosmin removal capability. Before October 2018, MDA West could only remove less than 75% of Geosmin in the raw water.

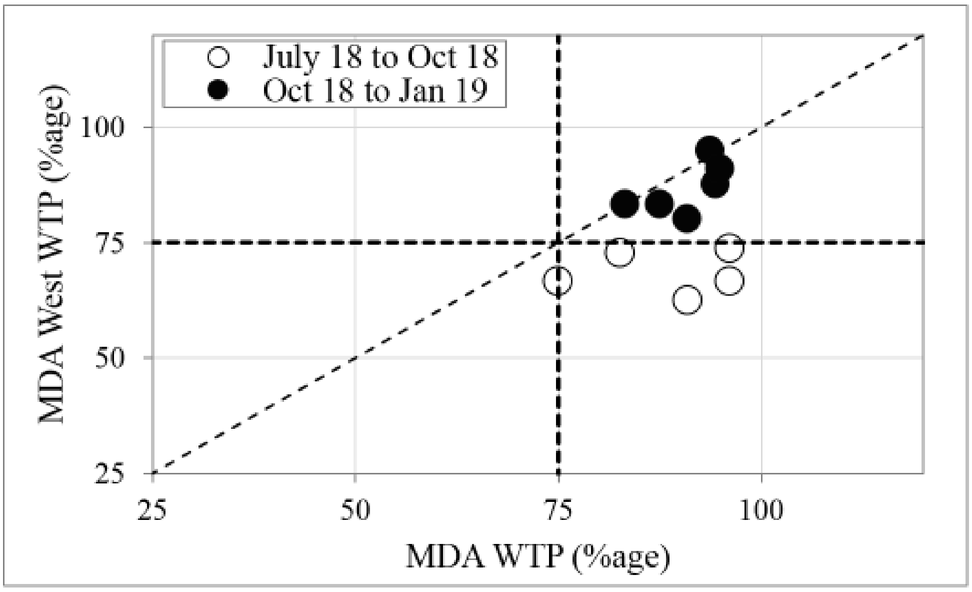


Figure 7: ***Percentage Geosmin Removal – MDA West WTP vs. MDA WTP***

3.0 CONCLUSION

- MDA West WTP appears to have gained the process capability of biologically removing taste and odour compounds comparable to other LMW WTPs.
- After months in waiting, Geosmin removal capability was attained quickly. This strongly indicates that biomass growth levels must exceed a certain threshold to be considered activated.
- It takes 2 - 3 months to biologically activate MDA West filters.
- Geosmin in the raw water is a year-round problem, whereas MIB appears in algal blooms only.
- Neither of the three, UV254, TOC or DOC is a surrogate measure for Geosmin.
- SMBS can reliably dechlorinate backwash water from the retic. A missed SMBS dose does not eliminate the biomass altogether, it would need a few successive backwashes to biologically deactivate filters.
- Monitoring will continue until July 2019. If trial is deemed a success, feasibility of relocating the dosing system closer to the dosing point will be assessed.
- Dechlorination could potentially save ~$50,000 at a cost of ~$1,500 annually. It will further eliminate the need for undertaking the capital-intensive project of more than $0.5 million for storing and pumping filtered water for backwash.

4.0 ACKNOWLEDGEMENTS

A sincere thanks to LMW colleagues who contributed towards the dechlorination trial.

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ABCD COMPACT MODULAR OUTDOOR ARC-FLASH CONTAINMENT SWITCHBOARD

Paper Presented by:

Peter Taylor

Authors:

Peter Taylor, *Managing Director & Founder,*
Allan Morton, *CEO & Chairman,*

P.T. Automation Solutions

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ABCD COMPACT MODULAR OUTDOOR ARC-FLASH CONTAINMENT SWITCHBOARD

Peter Taylor, *Managing Director & Founder,* P.T. Automation Solutions
Allan Morton, *CEO & Chairman,* P.T. Automation Solutions

PTAS's ABCD (Arc-Blast Containment and Diffusion technology) is a unique invention that enables a compact outdoor switchboard to be capable of containing the catastrophic outcomes of an electrical arc-flash explosion. Such explosions are not common but hospitalise 39* electrical operators and electricians each year with significant 3rd degree burns. Fatalities do occur.

It's the first NATA tested and certified, fully designed, developed product manufactured in Australia. The project was motivated by the adoption of AS61439.1 in May-16 and Sep-17 QLD 'industrial manslaughter' laws.

Technical developments for indoor boards have provided a range of engineering solutions. However severe accidents still occur regularly. Outdoor switchboards had been considered too-hard to reengineer because of their weather-proofing requirement.

The ABCD board adopts fundamentally different approach to arc-flash risk mitigation in outdoor switchboards. PTAS applied mechanical / structural design to reengineer the risk, a highly desirable and very cost-effective strategy. Service life reliability, durability of structure and ease of use were high priority design considerations to reduce lifetime cost.

Capital cost premium is typically 3%. On top of the significant safety benefits, there's rapid operational payback as operators no longer need to wear cumbersome unproductive PPE, nor be licensed electrical staff, nor establish large exclusion zones.

1.0 INTRODUCTION

Significant Impact of Unpredictable Arc Fault Explosions

The result of an arc fault is a massive electrical explosion with unpredictable characteristics. The total incident energy is likened to several of sticks of dynamite.

An arc fault results from either a phase-to-ground or a phase-to-phase fault caused by occurrences such as;

- Unsafe Operation Procedures: accidental contact with electrical systems, dropped tools, and improper work procedures.
- Protection Equipment Failure: Incorrect components and malfunctions.
- Environmental Deterioration: build-up of conductive dust, ingress of snakes, corrosion, aging or poorly maintained equipment
- External Supply Changes: Upstream protection devices and upsized transformers.

Arc-fault incidents generate two dangerous components. Initially the blinding UV and IR light and heat generated by the explosion is the 'arc-flash', where the temperature can reach 22,000°C. This releases hot plasma toxic gases and concentrated radiant energy which melts metal and cause severe radiation burns, damage eyesight, and can result in fatalities.

The ‘arc-blast’ follows as accompanying 165dB pressure waves that can damage hearing and/or brain function. High pressure gas readily blows the doors off switchboards, and sends loosened equipment, machinery and shrapnel debris flying at supersonic speed to cause further injuries to people nearby and more damage to equipment.

Arc Flash Injuries Are Not Insignificant

While arc flash incidents occur less often than other electrical accidents, they represent about 50% of all electrical injury costs.

In November 2018, Workplace Health and Safety Queensland [1] published that since 2013 there have been 32 reported incidents involving an arc flash. Of these, 20 resulted in injuries requiring hospitalisation. It’s generally known many incidents remain unreported, being treated as outpatients.

NSW reported that between 2005 and 2015 [2], that there were on average 11.6 people burned working on or near electrical apparatus each year from arc faults. 81 of the 129 reported incidents for the period involved switchboards. Burns to the head/face area was the second most common burn site, involved in 57% of injuries.

A report published in Industrial Safety and Hygiene News[3] estimated that, on average, there are 30,000 arc flash incidents in the USA every year. The report went on to estimate that those incidents resulted in average annual totals of 7,000 burn injuries, 2,000 hospitalizations, and 400 fatalities per year.

Beyond the initial and direct cost of the incident, which for example may be $100,000, organisations also become exposed to operating losses, reputational loss, future litigation, and ongoing disability claims that can elevate the incident cost towards $1M per incident.

Second Degree Burns Should Not Be the “OK” Standard[4]

The accepted ‘Standards’ used for arc-fault design calculations are probably too low.

The level for acceptable risk is currently defined by ‘survivable 2nd degree burns’; or arc-fault incident energy exposure level, of 1.2 cal/cm^2, which defines the safe boundary where one only gets 2nd degree burns.

A second degree burn causes damage deeper than the top layer of skin. It still represents intense pain and significant suffering from blisters and swelling. Despite the mental health impact of a near miss incident, 2nd degree burns are physically survivable injuries.

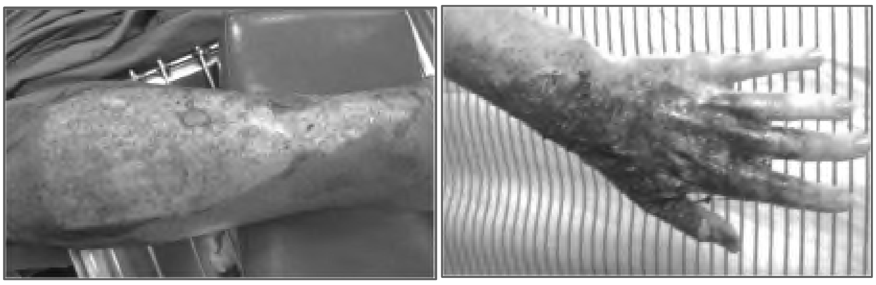

Figure 1: ***Second degree arc-flash burns***

Research indicates that indicated a 330% higher incident energy level is likely in typical switchboard configurations with vertical pathways. This suggests that designers should adopt conservative assumptions.

New Switchboard Standards Introduced; AS61439.1
In May 2016 a new (higher) standard of design safety and testing requirement was adopted in Australia. A change period until 2021 allows the cheaper / older / less safe switchboards to continue to be supplied into the market. Given switchboards have a 25-30 year life, making the change early provides long-term benefits to operating personnel and public.

Changing Safe Work and Health Legislation
Directors and officers of organisations have a legal duty to eliminate and minimise risks as far as "reasonably practical"; meaning within the available knowledge of the hazard, means of reduction and their relative cost to implement. The increasing accountability of PCBUs is characterised by Queensland's 2017 'industrial manslaughter' legislation.

Managing Risk by Reengineering
Administrative controls and requirement to wearing of HRC rated PPE, including bulky 'bomb suits' is the common way organisations manage risk, which works best in large facilities with dedicated switch rooms. Outdoor switchboards are often overlooked as a safety risk to employees and the public, yet they are the most exposed to environmental deterioration, entry by rodents and snakes and the least safety management attention. The outdoor switchboard is designed to contain the arc-flash and blast energy of the explosion inside the switchboard. Modern risk mitigation thinking.

2.0 DISCUSSION

The PTAS R&D project set out to design, build, test & certify an outdoor – public space switchboard that would meet the new standards. To meet the wide range of design configurations and remain economic, an expandable modular design was required. Low total cost of ownership through improved operator productivity, durable materials and construction methods were design drivers.

2.1 Engineering design to deliver in-field safety

Engineering Control of Hazard Risk
Prior to the invention of the ABCD switchboard, safety of personnel relied on lower order PPE and Administrative hazard control measures. The goal was to redesign the switchboard to include Engineering controls. These higher-level controls are preferred as they reduce the need for unreliable controls and enable more productive work practices to be employed.

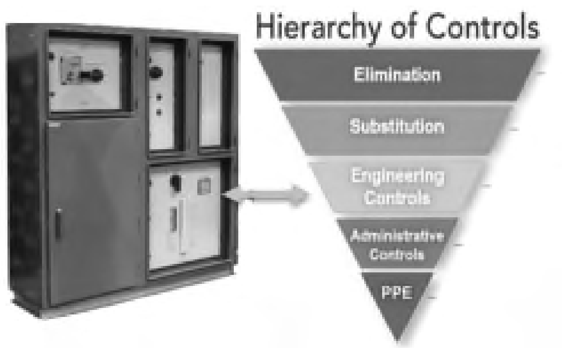

Figure 2: ***Engineering Controls eliminates arc-flash hazard with outer doors opened***

Arc Blast Containment and Energy Diffusion
Core of the ABCD technology is an internal device fitted between each section, which shields and attenuates the pressure waves and energy within the structure of the enclosure.

The design delivered a system that achieves Cat 0 with the outer doors open; at escutcheon level. This allows operators access to controls (for stop – start, meters) and the RTU section.

Modular Design Strategy
A modular design for the ABCD board was required because it's impossible to test every variant of outdoor switchboard employed by industry and public utilities. To date, four different sized modules, a wide range of functional escutcheons and two variants of exterior doors, have been certified. These represent 95% of all water industry outdoor applications.

Figure 3: ***Modular sections required to configure to suit a wide range of applications***

The test unit designs were built and fitted out with VSD and Soft Starter, Distribution section, MCCBs, external button controls, meter enclosures, RTU/PLC sections. This enables PTAS to build a huge variety of switchboards that easily scale up to incorporate combinations of these tested and certified modules.

Durable Construction Materials
PTAS built, tested and certified the design in two materials; marine grade aluminium and stainless steel. Tests proved our belief that these materials would perform differently; it is impossible to verify the effects of destructive energy release by calculation or even extrapolation from a single test. We proved what works.

2.2 Testing Validated Performance

Validation by Testing
While many switchboard characteristics can be verified by calculation or by extrapolation of an existing design, AS61439.1 requires that some important ones can only certified only by testing; like arc-flash containment.

Figure 4: ***Contrasting outcomes demonstrated in testing laboratories***

Tests proved the ABCD switchboard design can endure an arc-fault incident and be returned to service.

This involves;

- Protection against electric shock and integrity of protective circuits
- Strength of materials and parts
- Clearances & creepage distances
- Dielectric properties
- Mechanical operation.

Results Complied

- Verification and Certification by testing conducted at Lane Cove testing facility during March 2018, was for 20,000A for 0.3 sec duration, on both line and load side.
- Tested to the new AS/NZS 61439.1 standard and certified as an outdoor solution
- (Stainless Steel and Aluminium) with certification on arc fault containment (IEC/TR 61641:2014) and ingress protection. (IP56). A first for Australia.

Table 1: ***Results of NATA testing on ABCD modular test board***

	IEC/TR 61641:2014 – Protection of Personnel Criteria Requirements After Arc-flash Incident	**Test Result**
✓ **1**	Doors and covers remain closed	Complied
✓ **2**	Parts remain intact	Complied
✓ **3**	No holes formed in the accessible parts of the enclosure	Complied
✓ **4**	Vertical indication did not ignite (no external flash)	Complied
✓ **5**	Equipotential bonding arrangement of accessible parts remained effective	Complied
✓ **6**	No propagation of arc to other areas of the assembly	Complied
✓ **7**	Satisfied the dielectric test	Complied

2.3 Lowering Cost of Ownership and Improving Safety

Personnel less reliant on PPE for safety

By engineering out the risk, employers are less reliant on their outdoor staff to do the right thing and wear correct standard of PPE, especially at remote regional sites. The ABCD design approach of making the escutcheon the primary blast barrier increases the isolation of the arc-blast hazard from people working on or near a board.

Employee productivity

The opportunity to rethink outdoor IP56 & IP66 switchboard design enabled PTAS to add design features that makes it easier to work while increasing safety. Designing for easy access now makes it safe for maintenance and operating staff to work from the switchboard internal escutcheons, without shutdown nor requiring attendance of registered electricians. Systems can be safely kept on-line during maintenance. Less downtime.

Options Tested

A range of alternate doors and internal fittings have been tested to provide variations for different equipment or applications that require sunshields and ventilation cowlings. The ABCD modular design certification offers customers flexible configurations; units are being be built as double sided, three sided, and longer units for a wide range of equipment.

Figure 5: ***Three forms of ABCD modular outdoor board in production and installation***

Public safety assurance
Switchboards in high traffic public spaces, like parks, footpaths and shopping areas, offer a significantly lower hazard. Large (and expensive) exclusion zones required with old designs can be reduced, with less public disruption.

3.0 CONCLUSION

This *IP56 | ABCD arc fault containment modular compact outdoor switchboard development represents a major step forward in hazard reduction for water industry personnel and public. It also reduces the total cost of ownership for utilities by increasing productivity of operations, reduced cost of maintenance and safety.

These switchboards meet and exceed current switchboard standards, with higher safety levels and negligible capital cost premium. This technology allows directors and operators of utilities to better fulfil their obligations under increasingly arduous WH&S legislation.

Having proven that arc-fault containment in outdoor switchboards is achievable with commitment and thoughtful design, we believe that other water utility clients will recognise and specify to this new benchmark. Then other manufacturers will follow PTAS's lead.

4.0 ACKNOWLEDGEMENTS

The authors would like to thank Queensland Urban Utilities electrical and safety management staff for their critical encouragement of our development project. Also, Roland Barrett, PTAS Senior Engineering Project Manager and the team at PTAS who have embraced and supported the development with their ideas and commitment to safety innovations.

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THE BENEFITS OF BIO-AUGMENTATION TECHNOLOGY AT THE ATHERTON WWTP

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44th Annual WIOA
Queensland Water Industry Operations Conference and Exhibition
Bundaberg Multiplex Centre, Bundaberg
5 & 6 June, 2019

THE BENEFITS OF BIO-AUGMENTATION TECHNOLOGY AT THE ATHERTON WWTP

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Scott Buckley, Water Treatment Specialist, *Water Treatment Services*

ABSTRACT

The Atherton WWTP received an influent with high FOGs and irregular septic loads that cause plant upsets and bacterial foaming. A new to Australia bio-augmentation treatment "WTS 13-Biotifx Ultra" was implemented to help reduce the bacteria foaming and to help improve the overall plant operations. The bio-augmentation treatment led to a substantial decrease in bacteria related foaming, reductions in sludge volumes, improvements in a number of regularly analysed plant parameters and a reduction bio-solids and the associated transportation costs.

1.0 INTRODUCTION

The Atherton WWTP is a municipal treatment system operated by the Tablelands Regional Council in Far North Queensland. It processes approximately 1.8 – 2.0 ML of municipal-type influent per day, with flows increasing up to 3-fold in the wet season. While the influent is mainly domestic-waste, there are high trade waste loads from local restaurants and food-based industries, as well as irregular deliveries of septic waste.

The plant is a dual train SBR system, which run on 4 hr cycles, which consist of 2 hr influent fill times followed by 2 hrs decant. The mixed liquor is aerated to a DO set-point during the fill period, with decanting occurring during the settling period.

WAS is thickened by a gravity drainage deck (GDD) before entering an aerobic sludge digester. The digested sludge is fed to a belt filter press with the resulting "dry" bio-solids transported offsite for re-use on farm lands.

The daily influent flows are currently 20-30% above the plant design specification and combined with septic shock events and high FOG loads, this leads to ongoing operational issues, including plant upsets, high oxygen demand, bacterial foaming, poor settling and high decant suspended solids. This results in constant operational and regulatory issues for the operators of the plant.

It was proposed that implementing the bio-augmentation treatment product WTS 13-Biotifx Ultra, would reduce bacterial related foaming in the SBR basins and reduce plant upsets and flow-overloading related operational issues. It was decided that a front of plant treatment would allow the treatment to target the bacterial foaming and help the plant recover from toxic upsets.

Another concern for the plant operations was the efficiency of the aerobic digester and bio-solids removal plant. The digester has not been operating efficiently, with independent reports indicating lower than optimal aeration, low nutrient uptake and high bio-solid haulage costs. As such, a second trial was conducted to investigate whether WTS 13-Biotifx Ultra could improve the overall efficiency and operation of the aerobic digester and bio-solids plant.

Hence the objectives of the trial were to demonstrate improved plant performance, decreased bacterial foaming and effluent suspended solids, improved aerobic digester performance and a reduction in bio-solids transportation costs by utilising the WTS 13-Biotifx Ultra treatment program.

2.0 DISCUSSION

Atherton WWTP treatment operators implemented the dosing of WTS 13-Biotifx Ultra as a bio-augmentation treatment program based on information from previous successful trials in the USA. This treatment involves the introduction of specially selected, high enzyme expressing bacillus spores into the inlet structure of the plant with the aim to propagate these beneficial microbes in the activated sludge reactors. The highly efficient bacillus species target FOGs and organic sludge as food sources and help to reduce the negative effects of FOGs, septic waste streams and toxic events, and augmenting the native microbial populations.

Our initial aim was to see a visual reduction on foam in the SBR basin, while also monitoring other chemical and nutrient parameters at the plant. Effects on the overall operation of the plant (aeration requirements, sludge haulage) was also assessed during the trial.

2.1 Treatment Information

The WTS 13-Biotifx Ultra product is part of the WTS Nutritune Treatment Program and uses a blend of six (6) or seven (7) specially selected Bacillus strains in various ratios (depending on the application) combined with a proprietary blend of micronutrients that enhance the ability of natural bacteria to degrade organic pollutants.

The treatment proves to be highly effective and useful for numerous treatment applications and industrial sectors and addresses the universal facility challenges surrounding FOGs, H_2S, odours and sludge. This treatment program has been utilised extensively across municipal waste plants and lift stations in the USA and is only recently been available to Australia.

2.2 Trial Methodology and Evaluation

Historical data was available from the plant, including effluent suspended solids, SSV and other plant performance parameters.

WTS 13-Biotifx Ultra was slug dosed to the system at 5 mg/L (10 kg), with ongoing treatments of 1 mg/L (2 kg) of WTS 13-Biotifx Ultra dosed to the inlet structure of the plant Monday to Friday. The dosing consisted of mixing 500g dissolvable bags of the WTS 13-Biotifx Ultra powder into a 10L bucket and pouring this suspension into the inlet structure of the plant. No specialty equipment was required.

Visual inspections and photographs were taken to monitor the treatment effects on the foaming in the SBR basins (see section 2.3 Reduction in Bacterial Foaming).

Plant parameters were assessed before and during the trial (see section 2.4 Evaluation of the Plant Performance).

A secondary trial was implemented, whereby the aerobic digester was directly treated with 500g of WTS 13-Biotifx Ultra once per week (see section 2.5 Aerobic Digester Treatment).

2.3 Reduction in Bacterial Foaming

The most visible sign of issues with the plant came from the ongoing presence of bacterial foam in the SBR basins. While other plants in the area have seasonal occurrences of bacterial related foaming (dry season), the Atherton WWTP has an all year-round presence of the foam, which effects sludge settling and supernatant decanting.

Figure 1 below (LEFT) shows the centimetre thick foam in basin 1 that was present in the lead up to the start of the WTS 13-Biotifx Ultra trial.

Once the dosing of WTS 13-Biotifx Ultra treatment was started, the foam began to reduce and by the second week of the trial a very clear improvement was noted and can be seen in Figure 1 (RIGHT). As such, the trial has been shown to be very effective at reducing bacteria related foaming by reducing FOGs, outcompeting the filament our bacteria for nutrients and improving the environment for the native nutrient reducing bacteria.

Due to the successful reduction in bacterial foaming by the WTS 13-Biotiflx Ultra treatment, the plant has continued to utilise the product with continued good effect. Dosing has been reduced from the trial dose of 2 kg x 5 days per week (0.7 mg/L), to an ongoing treatment of 1 kg x 3 days per week (0.2 mg/L). The ongoing treatment cost has been reduced to $270 per week.

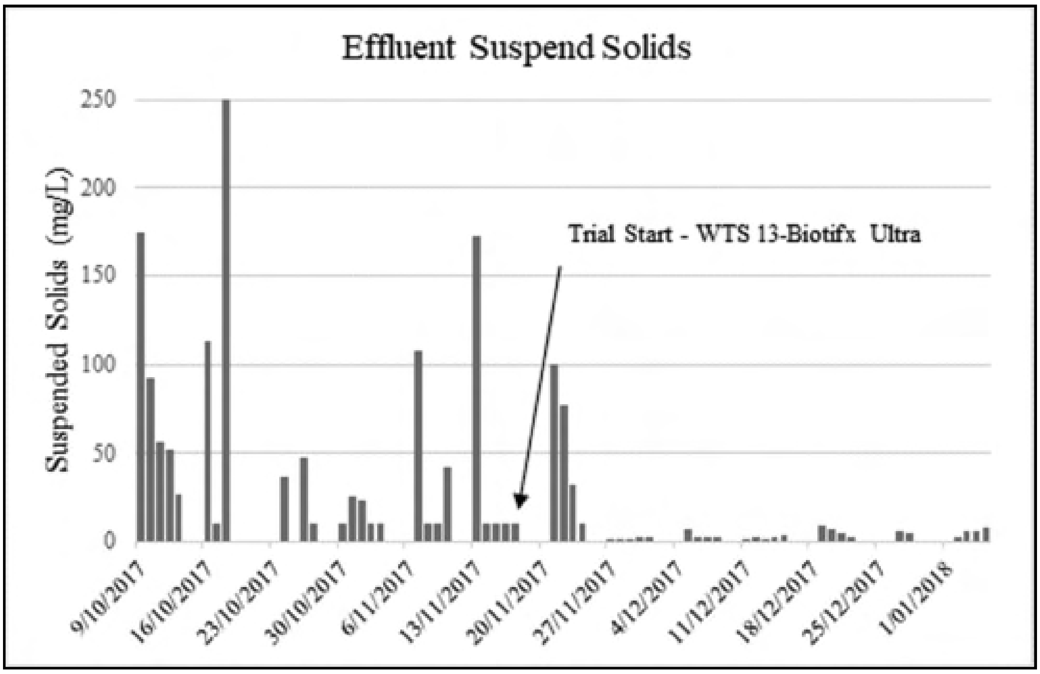
<u>Figure 1:</u> ***LEFT: Before Trial Bacterial Foam; RIGHT: During Trial: Reduction in Bacterial Foam***

2.4 Evaluation of the plant performance

The Atherton WWTP experiences ongoing plant performance issues due to plant overloading, high FOGs and toxic upset events from large influx of septic waste loads. A number of parameters were monitored before and during the trial to gauge the overall effect of the WTS 13-Biotifx Ultra treatment on the plant performance.

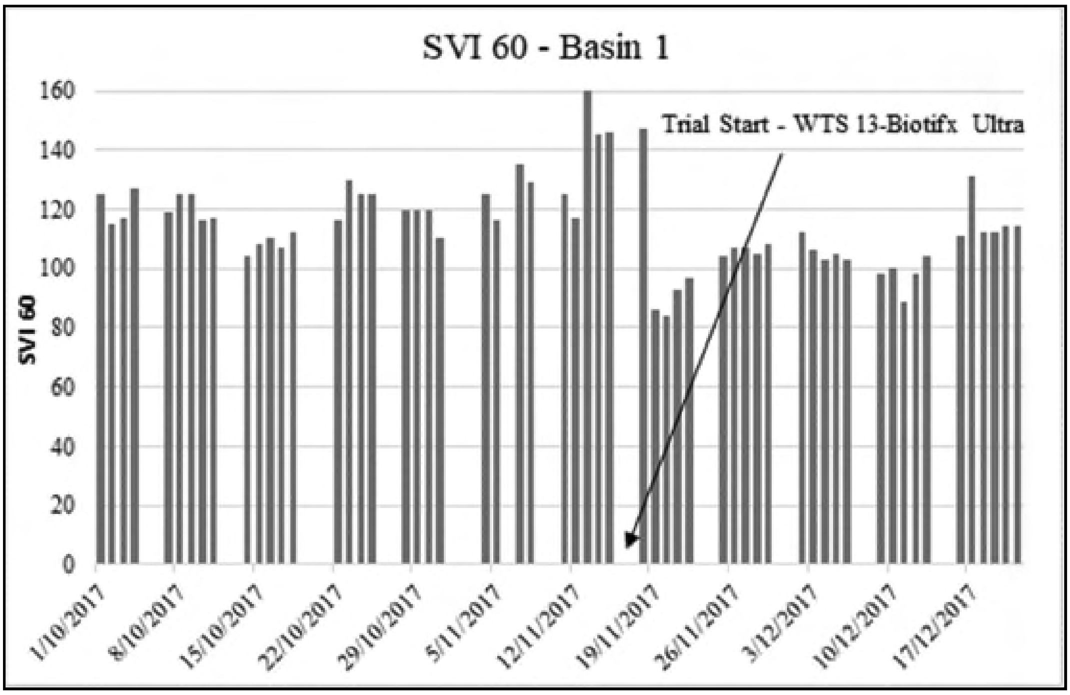
Effluent suspended solid levels were shown to often be extremely high, with values above 100 mg/L seen 6 times in the past 2 months, and the 30 days pre-trial averaging at 49 mg/L.

A large improvement in effluent suspended solids was noted from the start of the WTS 13-Biotifx Ultra trial, with suspended solids reduced by the second week of the trial, and suspended solid levels remaining below 10 mg/L going forward (see figure 2).



<u>Figure 2:</u> **Effluent clarity before and during WTS 13-Biotifx Ultra trial**

Mixed liquor grab samples also showed improved settling in lab testing. This is seen in figure 3, with SVI 60 values reduced during the trial with a better settling rate and more compact sludge. This allowed for an improved wasting cycle to the GDD/aerobic digester, with a thicker sludge sent to the digester and better solids/liquid separation in the SBR. Wasting times were reduced from 80 minutes to 65 minutes due to the lower sludge levels in the SBR basins.



<u>Figure 3:</u> **Effluent clarity before and during WTS 13-Biotifx Ultra trial**

2.5 Aerobic Digester Treatment

Following the success of treating the front of the Atherton WWTP with WTS 13-Biotifx Ultra product, a follow up trial was conducted where the aerobic digester was directly treated with WTS 13-Biotifx Ultra by throwing 1 x 500g dissolvable bag into the digester once per week.

This treatment was observed to have very positive effects on the overall operation of the aerobic digester. Dewatering operation times were reduced from 80 – 90 minutes per day to 45 – 55 minutes per day during treatment period.

Figure 4: **Atherton WWTP Aerobic Digester**

It was also observed that the aerobic digester sludge volume was being reduced, improving the wasting capacity of the plant and reducing the overall bio-solids. This overall reduction in bio-solids is seen in the average monthly haulage tonnes from 2018 (untreated) vs the first three months of 2019 (treated). During 2018 an average of 99.7 tonnes per month was being hauled, which was reduced to an average of 86.0 tonnes per month during the trial (Jan – March 2019). This equates to a haulage reduction of 13.8% and gives a cost saving of approx. $1000 per month, a significant saving for the Atherton WWTP. This compares favourably with the treatment cost of $195 per month, to give an overall saving of approx. $800 per month.

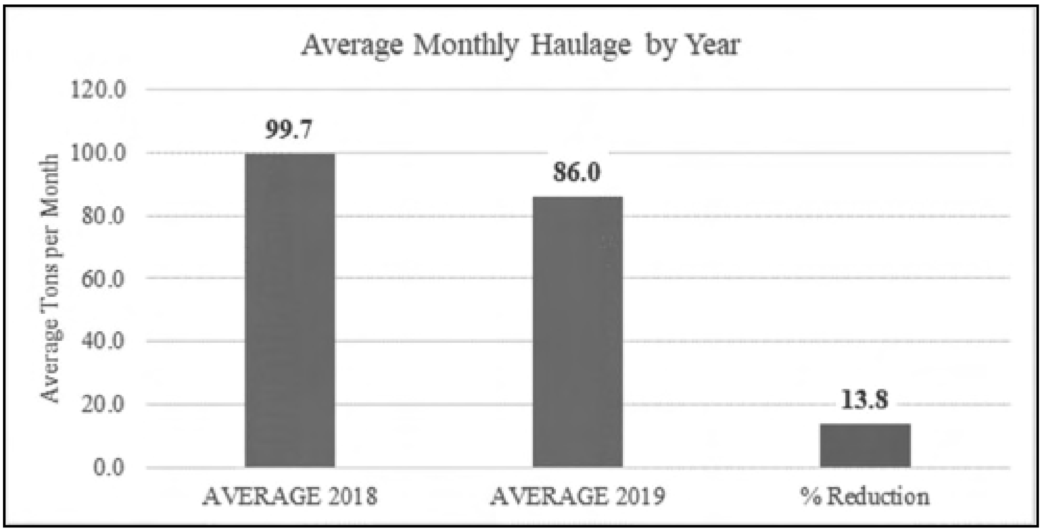


Figure 5: **Average monthly haulage of bio-solids for 2018 (untreated) vs 2019 (WTS 13-Biotifx Ultra treated)**

2.6 Implications for other Waste Water Municipal Plants

The improvements in the operational performance at the Atherton WWTP demonstrates the positive effects that are possible using bio-augmentation technology. The Atherton WWTP has continued to dose WTS 13-Biotifx Ultra at the front of the plant to offset bacterial foaming issues and plant upsets, and the aerobic digester trial is ongoing.

The operators have also extended the use of WTS 13-Biotifx Ultra to other Tablelands Regional Council plants – Tinaroo WWTP, Yungaburra WWTP to improve sludge settling and to reduce overall bio-solid loads.

The bio-augmentation treatment would be suitable for any plant suffering similar issues with seasonal bacterial foaming, plant overloading, toxic upsets, odours and/or high bio-solids loads.

3.0 CONCLUSION

The bio-augmentation trials at the Atherton WWTP achieved the objectives outlined. Dosing WTS 13-Biotifx Ultra resulted in several operational improvements at the WWTP including:

- an almost total reduction in bacteria related foaming
- enhanced SV60 settling times and SVI values resulting in significant improvements in reactor supernatant and final effluent clarity.
- reduced WAS-wasting volumes to the sludge digester, gravity drainage deck and belt filter press leading to significant savings in chemical and bio-solid haulage costs for the plant.

Other improvements to the plant, such as reduced aeration cycles and energy costs, are still being investigated.

The ease of implementation of this treatment program combined with no requirement for special dosing or monitoring equipment, meant that the trial was implemented and monitored effectively by the plant operators. As such the bio-augmentation treatment with WTS 13-Biotifx Ultra is utilised in an ongoing manner at the Atherton WWTP and at other Tablelands Regional Council waste water plants.

4.0 ACKNOWLEDGEMENTS

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ABSTRACT

Built in the 1960s the Port Pirie wastewater treatment plant consisted of a series of lagoons; an upgrade in 2004 installed an activated sludge, sequencing batch reactor (SBR) plant with a design capacity of 4.1 ML/D, which decants into the remaining lagoon system from where final effluent flows into the Spencer Gulf.

Deterioration of clay pipes within the sewer network led to significant infiltration in recent years; the plant's daily average flow is 3.5 ML/D however, during heavy rainfall events the plant receives up to 6 ML/D, well in excess of the design capacity. Increased influent flow causes the plant to change into high flow mode where the treatment cycles within the SBR are shorter. During these cycles the influent is not treated as effectively and in an exceptionally high rainfall events the SBRs are bypassed with the untreated sewer discharged into the lagoon system. As a result, the plant was not effectively treating wastewater, with elevated ammonia concentrations and higher suspended solids decanting into the lagoons.

Multiple solutions for dealing with the increased incoming flow were investigated including: repair of the sewer mains and the trialling of granular activated sludge, all likely to cost thousands or millions of dollars. The plant operator had been doing several settling comparison tests, checking the travel of the decanters and adjusting settling times within the plant's PLC whereby he suggested lowering the bottom water level (BWL) of the SBRs by 400mm. To enable this change the settling time was decreased from 60 minutes to 30 minutes and the decant period was increased from 60 minutes to 90 minutes.

The results were immediate, since changing the BWL the plant experienced only 2 instances of high flow mode, down from 54 in 2016. The effluent results have remained stable and there is a considerable reduction of sewer short circuiting through the SBR with reduced high flow cycles. The hydraulic capacity of the plant has increased by 36% and additionally the expected capital costs have been saved.

1.0 INTRODUCTION

Located on salt flats, Port Pirie, a coastal town located 220 km north of Adelaide has a population of around 15,000. Built in the 1960s the original design was a lagoon wastewater treatment plant; two aeration lagoons followed by three polishing lagoons and an outlet into a Second Creek that flows into the Spencer Gulf. In 2004 an environmental improvement project installed a sequencing batch reactor (SBR) activated sludge treatment plant was built. The new plant comprises: inlet works (screenings and grit removal) and two reactors, additionally one of the existing polishing lagoons was halved to create two smaller lagoons. Each reactor contains an anaerobic selector, aeration diffusers, a decanter, and pumps for return and waste solids. The decanted effluent gravity flows from the SBR into the remaining polishing lagoon system and through into the outfall. The wasted sludge gravity feeds into one of the two original aeration lagoons that are now used as sludge lagoons.

The SBRs have three phases: aeration, settle and decant. During aeration blowers provide air into fine bubble diffusers mounted on the bottom of the reactor, during settle the blowers are turned off and the microorganisms are able to settle to the bottom of the reactor.

The decanting phase occurs after the settling period where a moving weir is slowly lowered into the reactor. The top, clear effluent is decanted into the polishing lagoons and the settled material remains at the bottom of the reactor. The reactors operate out of phase; when one reactor is in aeration the other reactor is either in settle or decant. During the aeration phase the reactor inlet valve is open enabling flow of incoming sewage, when the basin switches into settle mode its inlet valve closes and the second reactor's inlet valve opens and it changes into aeration mode and receives sewage. During normal operation the reactors will only receive sewage during aeration phase.

The Port Pirie sewerage network, comprised predominately of clay pipes, has considerably deteriorated overtime and due to the shallow ground water depths a large proportion of the pipes are immersed in highly saline ground water. Due to the poor condition of the pipework, ground water infiltrates into the network significantly increasing salinity and inlet flows into the treatment plant. The increased flows caused significant hydraulic issues within the plant; the plant has a design capacity of 4.1 ML/D however during high rainfall events will receive up to 6 ML/D.

Higher inlet flows result in the plant entering a high flow mode (termed "high flow mode") which is where the treatment phases are shorten to prevent overflow. As seen in Table 1 the aeration period during a storm mode is reduced by 25% compared to a normal cycle.

Table 1: ***Treatment cycle times, normal and high flow mode***

	Normal Cycle	**High flow Mode**
Aeration (minutes)	120	90
Settle (minutes)	60	35
Decant (minutes)	30	55
Total	240	180

Due to the batch nature of the process, high flow mode most days. Consequently the decant effluent quality and the quality of water released to the Gulf were impacted. Specifically ammonia, nitrate and total solids were increased in the decant effluent. The plant was not achieving its design purpose and investigations were made into increasing the plant's hydraulic capacity.

2.0 DISCUSSION

Ideas to address the decant effluent quality and address capacity restrictions at the treatment plant were proposed and investigated. As the issue originated within the network, it was suggested that it should be addressed within the network. Multiple investigations were conducted on where the network was in poorest condition and how this could be fixed, both relaying sections of the network and relining the existing pipework was considered. Unfortunately due to the high number of connections it is not practical to reline the majority of the network. The investigations determined that most of the network was in poor condition and the only way to significantly reduce infiltration within the network would be to relay the majority of sewerage network within Port Pirie. There is approximately 115 km of sewerage mains within the Port Pirie network which would cost in the order of $100 million to replace. Due to high capital costs this option has not progressed further than the exploratory stage.

As the infiltration issue could not be addressed within the network further investigations centralised around managing the high hydraulic inlet flows at the treatment plant.

As the plant design capacity was exceeded there were several options suggested around building additional infrastructure to increase the plant's treatment capacity. The option to install a third activated sludge reactor was considered, and different configurations of operation were briefly investigated. However, whilst the hydraulic load into the plant is high the organic loading into the plant is low, due to the dilution by infiltration. Therefore, it is likely that the incoming sewage would not have sufficient organic load to maintain the micro-organism growth within three reactors. Additionally, the capital cost of designing and installing a third basin is high and ongoing operational costs would also increase.

Another proposal was to convert the SBRs into a continuous flow plant by installing clarifiers downstream of the decanters. Flow would then continuously pass through both reactors and into the downstream clarifier where it could settle prior to being released into the polishing lagoons. Again the work required to install new equipment (earth works, design, installation) makes the cost of the solution very high.

A further suggestion was to remove the existing anaerobic selectors and install diffusers within the current anaerobic zone, increasing the aeration volume within each reactor. Increased aeration volume within the reactor could achieve wastewater treatment within a shorter aeration period, therefore reducing the cycle time and enabling additional cycles per day and increased capacity. This solution would have only slightly increased the plant's capacity and therefore would not fully address the issue of decreased aeration periods due to high hydraulic loading. Additionally, the capital cost for implementation was high.

The installation of larger decanting weirs was considered; larger decanting weirs would decant more quickly, therefore the decant period could be decreased. The decreasing of the decant period would allow for shorter cycle times and therefore more cycles within a day, however, decreasing decant times is only beneficial if the aeration periods are also decreased as the total period of settle and decant must be equal to the aeration period. The other issue with increasing the decanting effluent flow is the likelihood of solids carry over; sludge blanket shearing occurs when decant flows increase.

The final investigation was into a relatively new technology called "granular activated sludge". Similar to conventional activated sludge, granular sludge treats wastewater through the use of microorganisms that thrive in aerated conditions. However, Granular sludge is a denser, granular shaped sludge that has much faster settling times that conventional activated sludge. It is selectively chosen by decreasing settling times over a period of months so that only the fastest settling sludge remains within the reactor, slower settling biomass is decanted in the effluent. It was hoped that granular activated sludge would enable a decreased settling time to occur and therefore the cycle times could be adjusted. Trials proved that while the sludge settling did increase we were unable to grow the granules with the current treatment plant configuration and the modifications to the reactor were priced at nearly $200,000.

2.1 Lowering The Bottom Water Level

Whilst the granular sludge trial was occurring additional settling tests were being conducted on the reactors. It was discovered that the activated sludge in the control basin reached full settleability after 30 minutes with a very clear supernatant. The sludge blanket depth was also monitored over time, both via extrapolation from the settling tests and from operator observation of the basins. It was found that the sludge blanket very rarely increased above 2 meters in height. An approximate sludge blanket height can be calculated from the settling test: if the 1:1 settler is settled to 300 mL / 1000mL then it will be approximately 30% of the total volume.

For a BWL of 3.4 m the sludge blanket is approximately 1.02 m. Operator observation suggests that settling within the reactors is slightly better than the settler test within the measuring cylinders.

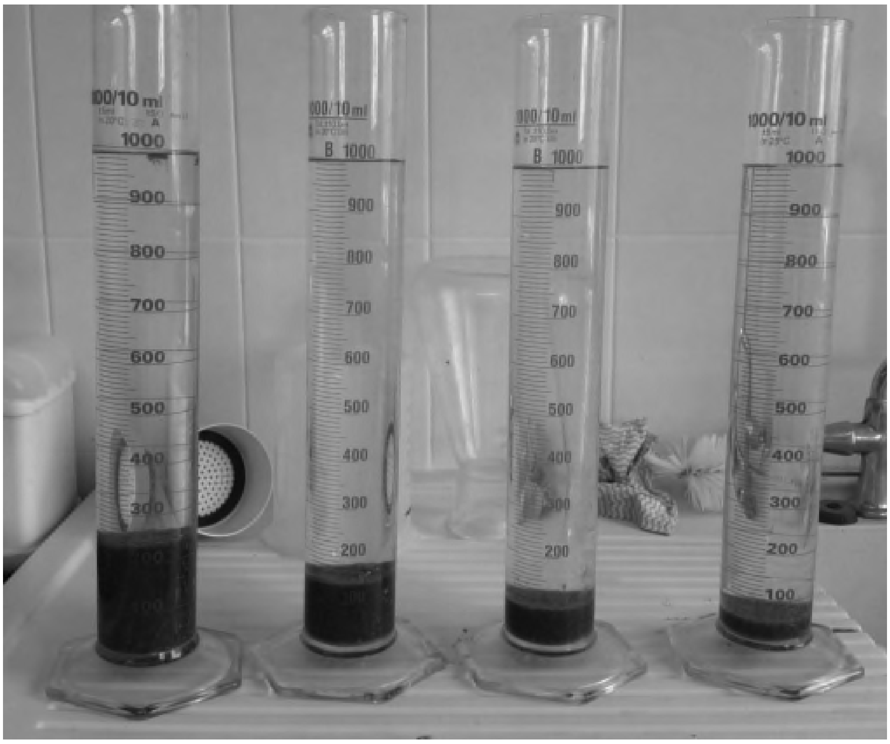


Figure 1: ***Settling test conducted for 30 minutes, dilution factors L-R: 1:1, 2:1, 4:1, 8:1***

The operator suggested lowering the bottom water level (BWL) from 3.4 m to 3.0 m. The bottom water level is controlled by the depth that the decanter goes into the water and therefore could theoretically be adjusted by making some changes to the decanter. Decreasing the bottom water level means that more treated effluent could be removed after each cycle, increasing the capacity of the treatment process. As decanting to a deeper level would take a longer period of time than decanting to the existing BWL additional time within one of either the aeration or settle cycles would need to be found. Luckily, with the quick settling times that the activated sludge was achieving it would be possible to reduce the settling period by 30 minutes and increase the decant period by 30 minutes.

The decanter and actuator supplier manuals were reviewed to ensure that the infrastructure was capable of operating in the lower position. It was determined that there was sufficient ability for the decanter to reach 3.0 m. Minor changes to the coding within the PLC were almost made to ensure the program could request the decanter to lower further. All investigations and PLC changes were conducted by the plant operator and internal electricians over a week long period. Once we confirmed that the decanter could be conducted we made changes to the BWL within one of the reactors, the BWL of the other reactor remained the same over a 4 week trial period.

Daily testing was done on each reactor’s decant effluent comparing: ammonia, phosphorus and suspended solids. Minimal differences were found between the effluent quality of the two basins however, the triggering of storm mode was no longer occurring in the trial basin so after a period of 8 weeks the changes were made to the second basin and its BWL was also decreased.

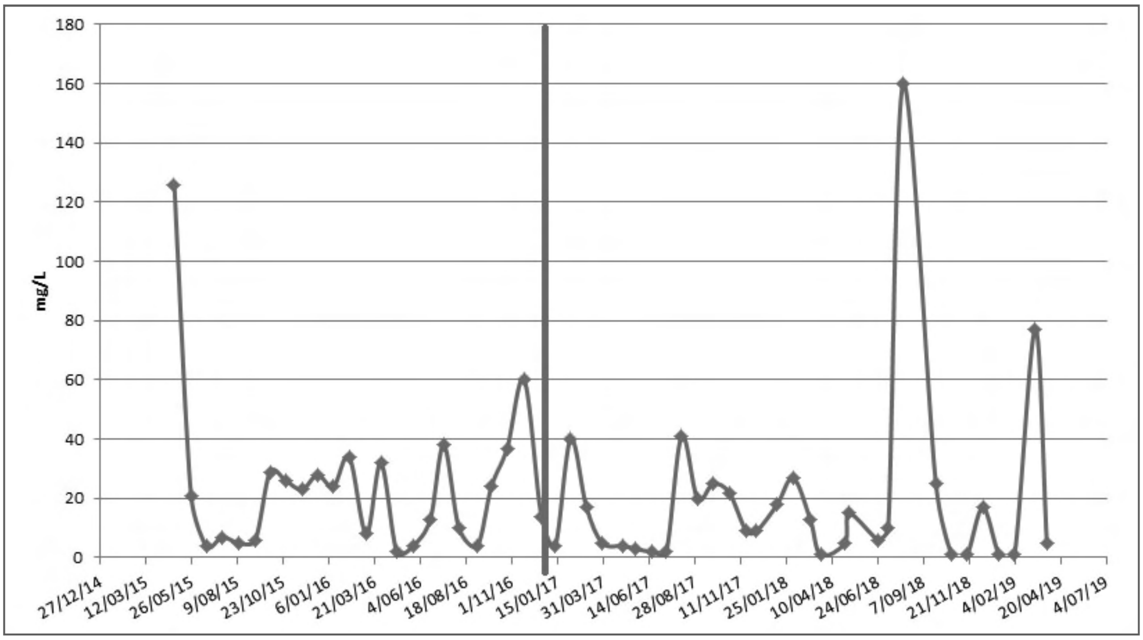
2.2 Comparison of Results

Since the BWLs were lowered there have been very few instances where the reactors have entered high flow mode. Table 2 shows that in 2016 high flow mode was trigged 54 times, with a high number of them occurring during September and October. In 2018 there were only 2 occasions that the reactors triggered high flow mode and these both occurred during high rainfall events. By June 2017 the trial was considered successful and has since been considered normal operating mode.

<u>Table 2:</u> ***Number of High Flow modes triggered prior and post BWL changes***

	High Flow Mode	Storm Mode
1/1/16 – 1/1/17	54	2
1/1/18 – 1/1/19	2	0

The suspended solids concentration in the decant effluent over the last 4 years is shown in Figure 2. Discounting the two outliers it shows that the suspended solids concentration is stable and has slightly decreased since the BWL change (showed by the vertical line). The one disadvantage with the decreased BWL is that the top of the sludge blanket is now closer to the BWL and therefore if the sludge blanket height increases, during process upset events, there is more chance that suspended solids can carry-over into the decant effluent. The two sample results with elevated concentrations of suspended solids (160 mg/L 5/8/18 and 77 mg/L 9/3/19) are instances where the settling characteristics of the sludge have not enabled complete settling of the sludge blanket to below 2.0 m and some sludge blanket shearing occurred.



<u>Figure 2:</u> ***Decant effluent suspended solids concentration***

Figure 3 shows the decant effluent total nitrogen concentration both prior and post the BWL changes. Unfortunately, there was a prolonged operational issue with aeration from March to August 2018 which resulted in poor aeration and reduced treatment capacity where ammonia and nitrogen concentrations significantly increased. However, excluding this period, we can see the total nitrogen trend has decreased from above 10 mg/L to less than 10 mg/L compared to before and after the BWL (shown by the vertical line).

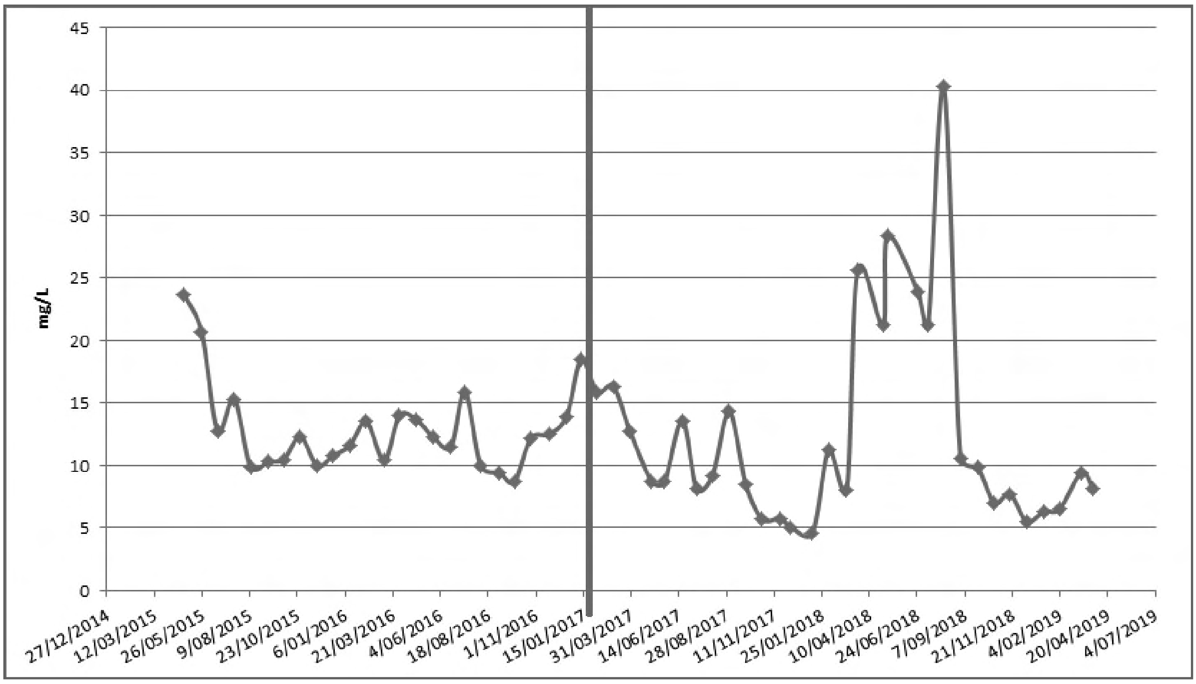


Figure 3: ***Decant effluent total nitrogen concentration***

2.3 Further Benefits

A decrease of 400 mm to the BWL has increased the hydraulic capacity of the treatment plant by 36% and the plant's treatment capacity is 5.5ML/day. The cost of the works was purely operational; time was required by the plant operator and electricians, no capital investment was used.

The success of lowering the BWL has removed $7 million dollars from the future capital plan by increasing the plant's hydraulic capacity by approximately 25 years. Driven by the operator the solution was trialled within weeks of the idea germination, this is a huge advantage over large projects that often take years to go from problem statement, design, construction and commissioning.

3.0 CONCLUSION

The ongoing Port Pirie wastewater treatment plant hydraulic capacity issues were addressed by lowering the bottom water level of the activated sludge reactors by 400 mm. Decreasing the BWL to 3.0 m has increased the hydraulic capacity to 5.5ML/d a 36% increase. This increase extends the hydraulic capacity by 25 years based on current population modelling. Since decreasing the BWL the plant only experienced high flow mode twice in 2018, compared to 54 times in 2016.

The idea, initiated, researched, trialled and commissioned by the plant operator has saved millions of dollars in infrastructure and time and has delivered an outcome years earlier than possible with other ideas. It is clear proof that the best option isn't always the most expensive but sometimes the simplest and most obvious.

MACGYVER'S GUIDE TO CONDITION ASSESSMENTS

Paper Presented by:

Janice Wilson & Gary Edwards

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MACGYVER’S GUIDE TO CONDITION ASSESSMENTS

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Gary Edwards, *Project Coordinator*, DGH Engineering
Emma Schmitz, *Treatment Engineer*, Mackay Regional Council

ABSTRACT

Mackay Regional Council (MRC) and Whitsunday Regional Council (WRC) are two regional water and wastewater utilities located in central and north Queensland. DGH Engineering is a Mackay-based, locally owned engineering and maintenance service company engaged by both councils to provide mechanical and planning support for a series of condition assessments across the region. The condition assessments were undertaken as part of a movement to improve each organisations asset data, condition and residual useful life as part of an overall strategy to maximise the utilisation of assets.

The condition assessments required significant planning and coordination given the high-risk nature of the tasks (confined space entry, hot work, working at heights, crane interactions), potential implication of water restrictions or environmental non-compliances should any process fail and coordination across a number of diverse crews (operations, maintenance, crane hire, structural consultants, divers) on tight schedules. Prior to kick-off of the condition assessments, a significant number of maintenance projects had to be completed to ensure safe access and positive isolations, requiring creative solutions to complex problems indicative of the varying age and condition of the assets, a common issue across utilities in Australia.

1.0 INTRODUCTION

The water and wastewater industry faces many sustainability challenges year after year. Global best practices in asset management are a high priority for the industry, and asset management has rapidly evolved to address risks such as aging water and sewer infrastructure. As part of this industry shift, both MRC and WRC have developed strategic asset management plans and implemented condition assessment programs to collect and ground truth asset data with the objective of providing the required level of service in the most cost-effective manner. Two of these programs include the Transition Project and the Mackay Water Strategy.

MRC and WRC joined together on a regional collaboration project under the Whitsunday-Isaac-Mackay Water Alliance (WIM Alliance) in 2018-19 to transition from external contractor delivered operations and maintenance to inhouse resourcing of wastewater treatment plant operations and maintenance.

To successfully transition the infrastructure, operations and staff under each council’s jurisdiction a program of works was undertaken, including a comprehensive and extensive range of preliminary condition assessments in order to better understand the condition of the assets to be handed back and to satisfy requirements under the contract for both organisations. These plants include Cannonvale Sewage Treatment Plant (STP), Proserpine STP, Mackay North Water Recycling Facility (MNWRF) and Mackay South Water Recycling Facility (MSWRF). These four major plants service most of the populations of Mackay, Proserpine, Cannonvale and Airlie Beach, respectively.

The Nebo Road Water Treatment Plant (WTP) is located in West Mackay and is the sole source of treated water for the Mackay water supply scheme, serving a population of approximately 100,000 people. MRC has updated the water strategy for the Mackay urban area supplied by the Nebo Road WTP. This strategy identified, that instead of building a new WTP and expending a significant amount of capital, the preferred option moving forward for Nebo Road WTP is to upgrade the plant from its current rating of 55 ML/d to 90 ML/d.

This decision was the preferred option providing technical advantages, lowest whole of life cost for MRC and the community, and maximising the utilisation of existing assets. This represents a different financial and risk profile to the organisation with increased spend on maintenance required in order to defer capital. Pivotal to the execution of this strategy is a strong understanding of asset condition, and an increased focus on undertaking condition assessments in order to inform maintenance strategies and replacement and renewals profiles.

The Nebo Road WTP was reviewed against best practice standards and relevant guidelines to assess the current performance to identify “pinch points” that limit current and future capacity given the decision to aim for a 90 ML/d design horizon. The treated water storage tanks were identified as requiring investigation specifically with regards to their current condition and maintenance practices. Additionally, a recent review of the Drinking Water Quality Management Plan (DWQMP) identified this investigation program under the Risk Management Improvement Plan (RMIP).

2.0 DISCUSSION

Condition assessments covered by both programs (the Transition Project and the Mackay Water Strategy) were undertaken in accordance with the Institute of Public Works Engineering Australasia (IPWEA), specifically Practice Note 7 v2 (Water Supply & Sewerage).

2.1 Project One: Transition Project

As part of the Transition Project, structural condition assessments of inlet works occurred at Cannonvale STP, Proserpine STP, MNWRF and MSWRF. Each project required that the inlet works were bypassed in a safe and timely manner without disrupting treatment processes resulting in a potential environmental non-compliance.

No plant included any type of built in bypass of the inlet works, therefore alternative arrangements were developed. Flow control was managed by each council with the assistance of DGH Engineering. For Cannonvale STP and MNWRF, the structural condition assessments took place at night from 11 pm to 4 am during lower flows to the plants, allowing for better management of the sewer networks. The Proserpine STP was able to be inspected during regular working hours due to the process configuration. Sewage pump station attendants were consulted and network modelling was undertaken to identify pinch points within the network with remote monitoring undertaken during the night works to eliminate risk of a sewage network spill. Local sucker trucks were engaged to transport raw sewage from the sewage pump stations to a bypass balance tank and drying fields, allowing the raw sewage to be pumped into the plant and then treated. A more comprehensive program to isolate and bypass the inlet works was required at MSWRF due to the size of network inputs to the plant.

A lead up maintenance program occurred in the months prior to the structural condition assessment to trial shutdowns, test valves and confirm isolations prior to implementing the actual inlet works bypass.

Confined space entry and rescue along with the high level clean of the inlet works was managed by DGH Engineering. The clean of the internal surfaces was required to sufficiently identify any significant cracking or any previous repair or remedial works to the structures. Pumps were set up across each site in critical areas to act as emergency flow management in case of overflows. Valves critical for isolation needed to be checked and confirmed closed prior to start of works. Repairs were undertaken on a short timeline to avoid delay of the structural condition assessments due to the timing of the works (October for Cannonvale STP, Proserpine STP, November for MNWRF and April/May for MSWRF) to work around the tropical wet season impact on inflows to the plant.

<u>Figure 1:</u> ***Overall View of the Cannonvale STP Inlet Works (Looking North-East)***

<u>Figure 2:</u> ***Delaminated Protective Coating Within Drum Screen Channel at Cannonvale STP***

The results from the structural condition assessments were consistent across all four plants despite different process configurations and plant sizes. The assessment found the following issues: inlet works protective coating delamination, surface softness/friability throughout each inlet work due to hydrogen sulphide attack and fibreglass covers delamination requiring a future program of works across both councils.

2.2 Project Two: Nebo Road Water Treatment Plant

General condition assessments of three treated water storage tanks took place at Nebo Road WTP in Mackay. In order to isolate the treated water tanks, three DN350 scour pit valves installed in the mid-1950s had to be replaced with new along with reconditioning of a DN600 discharge valve gearbox so the valve could be operated. All valves are in pits that are approximately 4-5 m deep and only have room for 1 person at a time. These pits are situated just outside the treated water storage tanks and are classed as a confined space.

Ladders providing access to the valve pits were also in poor condition, so prior to inspecting these valves, replacements were fabricated and installed to allow for safe access. Extension spindles were locally fabricated and installed by DGH Engineering, so valves could be operated and exercised from ground level, a positive outcome for the operations and maintenance of these assets.

MRC required each treated water balance tank to remain full for all work on each valve to avoid any interruption to the drinking water supply. To be able to replace the valves with the tanks full, detailed isolation plans were developed and tested by MRC operations to ensure the safe entry for the divers and for double isolation for the valve replacements. Risk assessments were coordinated with MRC workplace health and safety, MRC operations, DGH Engineering and the diving team.

Part of the isolation for the work on the valves was the fabrication of engineer-certified blanking plates. These blanking plates were installed by the divers into position and the isolation verified before removing each valve.

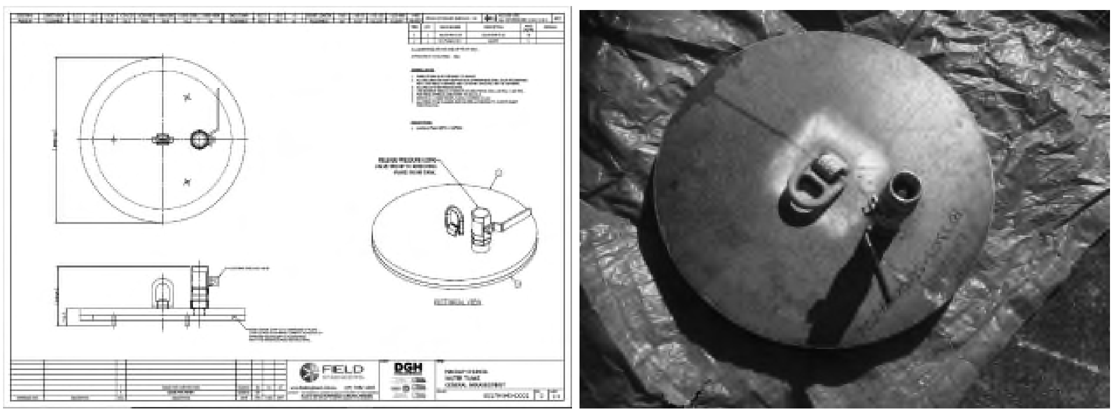

Figure 3: ***Blanking Plate***

<u>Figure 4:</u> ***Scour Pit 3 Valve & ladder***

When operating the discharge valve for treated water balance tank 3, it was found that the valve could not be turned and could not be isolated. To operate the valve, a confined space entry was required, as personnel needed to get into the pit to operate the valve.

The gearbox was removed and was fully reconditioned at the DGH Engineering workshop. Once it was repaired, it was reinstalled. A new pit cover was fabricated and installed along with an extension spindle that could be operated from outside the pit. Upon installation of the reconditioned gearbox and the new extension spindle, the valve is now fully operational and can be operated without entering the pit.

<u>Figure 5:</u> ***Balance Tank 3 Discharge Valve Gearbox***

In conjunction with the valve replacements, the divers cleaned all sediment build up inside each treated water balance tank and conducted detailed condition assessments inside the tanks.

2.3 Lesson Learned

These condition assessments under the Transition Project and the Mackay Water Strategy were implemented with success thanks to the strong working relationship and collaborative efforts between MRC, WRC and DGH Engineering. Engaging the operations and maintenance team, be they external contractors or internal stakeholders, is critical during the early planning process through to execution and delivery of important service reports that feed back into the asset management program.

Liaising with the operations and maintenance team will help to identify the critical assets required to undertake safe isolations and access. There may be a pre-program of works required to undertake before embarking on the actual condition assessments which should be allowed for in project schedules. This information should be communicated to all stakeholders to manage expectations about the condition assessment program. Creative solutions to complex issues, such as how to positive isolate a tank with a leaking discharge valve, or how to bypass an inlet works that has never had a complete bypass before should be encouraged as this helps to develop skillsets and allow for more cost-effective and timely project options.

3.0 CONCLUSION

By undertaking these condition assessment programs, both organisations were able to identify condition rating and remedial works required to inform future work plans. These programs helped each council gain confidence about the life of the assets as crucial inputs to strategic asset management plans. In addition, undertaking this work further developed the skillset of the teams involves in each creative solution to each complex issue. By collaborating on a regional basis, lessons learned can be shared to improve outcomes.

4.0 ACKNOWLEDGEMENTS

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https://www.qldwater.com.au/QWRAP_WhitsundayROC

WATER TREATMENT – DOES IT STOP AT THE PLANT?

Paper Presented by:

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WATER TREATMENT – DOES IT STOP AT THE PLANT?

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Terry Heness, *Senior Water Supply Operator*, Toowoomba Regional Council

ABSTRACT

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 prior to supplying the distribution system. The reservoir system has a total capacity of 30.5 ML.
Treated water enters the reservoirs with a chlorine residual of 3.4 – 4.0 mg/L. An ideal chlorine residual range of 1.9 and 2.1 mg/l is required leaving the reservoirs. 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.

The reservoir flow configuration resulted in unacceptable chlorine residuals entering the distribution system.

A trial took place installing a mixer in one of the Mt Kynoch reservoirs R3, to mix all water stored in the reservoir in an effort to improve overall chlorine residual and improve water quality. This paper explains the lead up to the trial and results identified after using a mixer in the reservoir.

1.0 INTRODUCTION

The Mt Kynoch Water Treatment Plant provides drinking water to consumers in Toowoomba and surrounding areas. Treated water is pumped into three bulk water reservoirs located adjacent to the WTP, prior to supplying reservoir and reticulation networks. The reservoir system has a total capacity of 30.5 ML.

The WTP clear water tank is dosed with chlorine gas to achieve a residual of 3.4 – 4.0 mg/L, chlorinated water is then pumped into the Kynoch reservoir system. An ideal chlorine residual range of 1.9 and 2.1 mg/l is required in potable 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 a single Chlorine Analyser on R3 measuring chlorine residual as water leaves the Mt Kynoch reservoirs. R1 and R2 have no online instrumentation, leading to a large uncertainty of chlorine levels exiting the system.

The flow configuration 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, there are interconnecting pipes between each reservoir. This configuration maintains one large body of water, capable of supplying the distribution system a free flowing supply. Unfortunately the configuration proves difficult to maintain a homogeneous body of water maintaining a constant chlorine residual.

2.0 ISSUES

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.

Known issues in all reservoirs include dead zones, short circuiting and high chlorine decay rates. In short Council cannot guarantee the quality of the water leaving the Mt Kynoch bulk water reservoirs. Figure 1 identifies the inlet, outlet and interconnector configuration of the KWTP reservoir system.

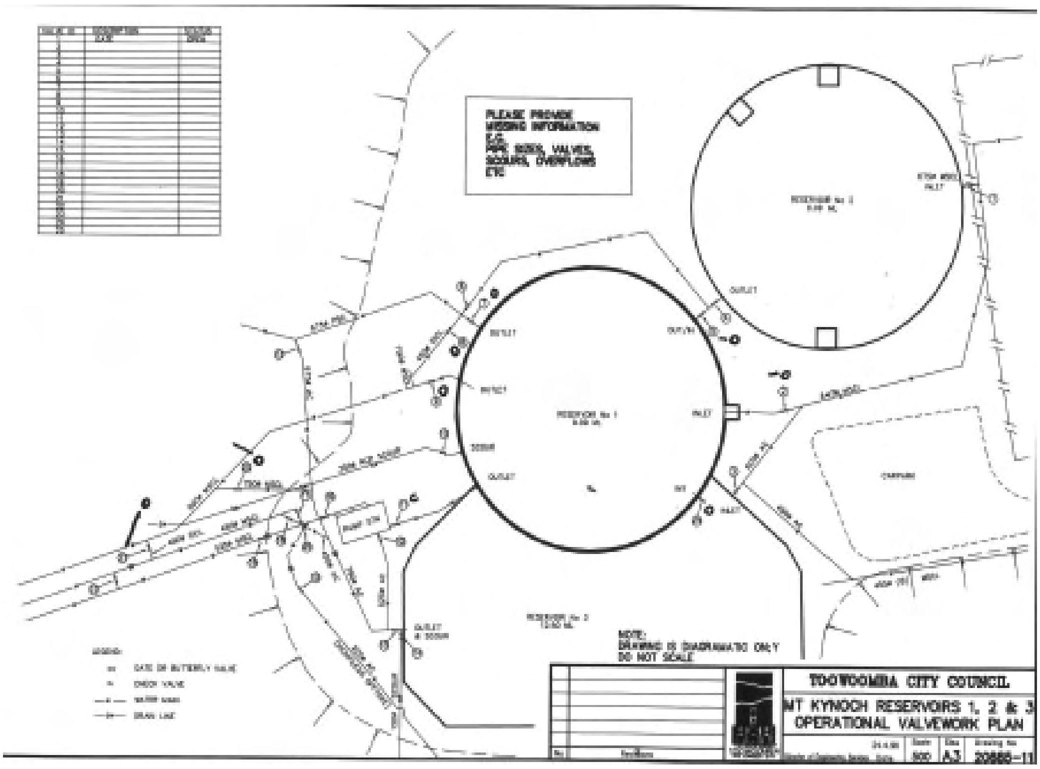


Figure 1: ***Mt Kynoch reservoir configuration***

Online chlorine analysis results show the required ideal chlorine residual of 1.9 - 2.1 mg/L are not achieved leaving the reservoir system. Additionally, WTP Operators only have a chlorine analyser on the discharge of R3. R1 and R2 do not have online analysers. Daily grab samples are required to monitor chlorine residual providing a snap shot of water quality leaving the reservoirs.

3.0 SOLUTION

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 R3. The mixer is mounted on a floating pontoon anchored to the reservoirs internal columns, a cable / 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. 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 improving 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 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 trihalomethanes (THM's) 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.

Table 1 shows a two month period of chlorine residual leaving R3, chlorine residual is monitored using an online chlorine analyser. The graph indicates the required range of chlorine residual was achieved 30% of the time during the sample period. From a public health prospective achieving guideline limits 30% of the time is not acceptable.

<u>Table 1:</u> ***Chlorine residual pre mixer***

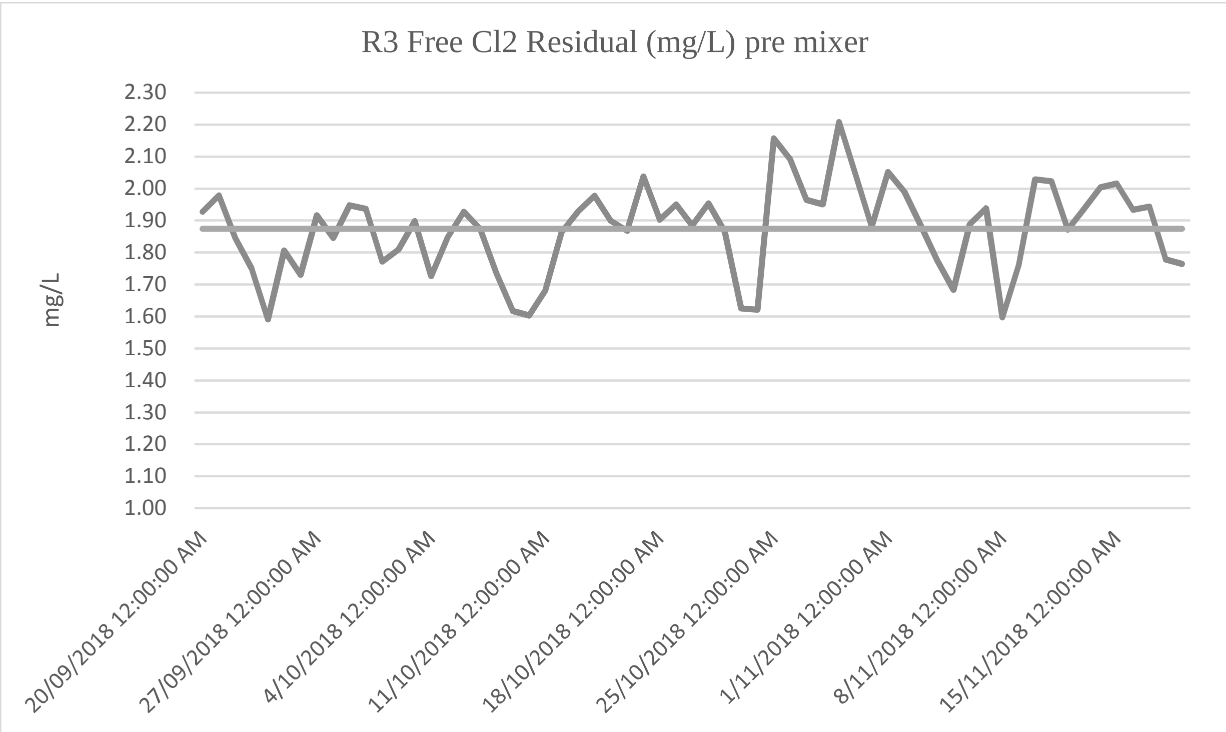
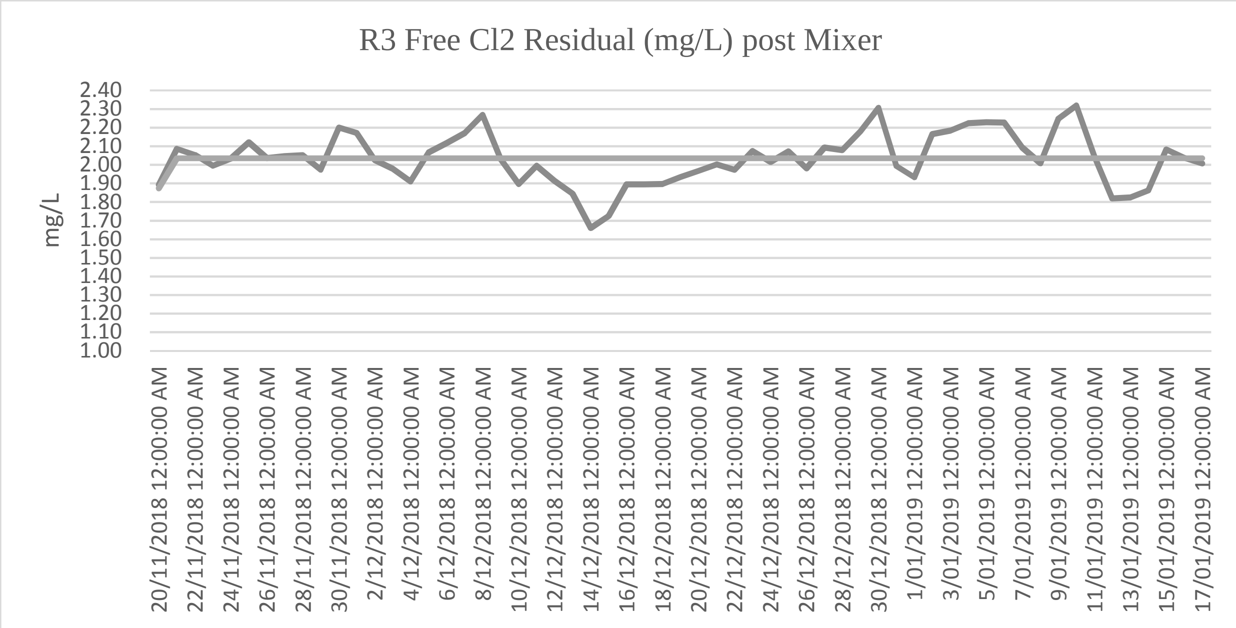


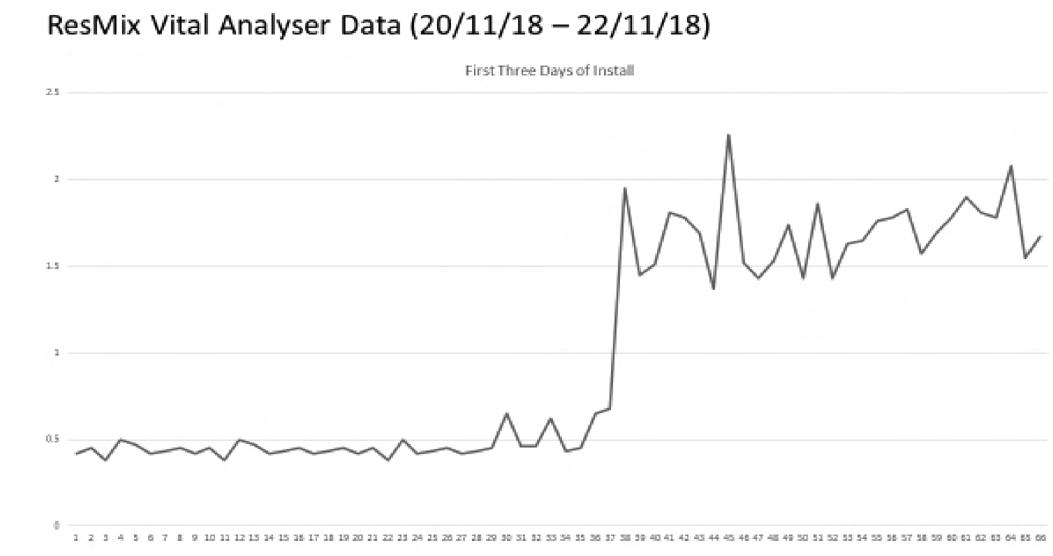
Table 2 identifies chlorine residual in R3 during the mixer trail. Chlorine residuals were smoothed out with 62% of readings meeting guideline requirements. Further chlorine residual improvements are expected if all three reservoirs at Mt Kynoch have mixers installed.

<u>Table 2:</u> ***Chlorine residual post mixer***



At the time of installation 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 instantaneous improvements were observed, see Table 3.

<u>Table 3:</u> ***Chlorine residual in R3 pre and post mixer***



Data collected during the trial indicated an overall improvement on chlorine residual in R3 while the mixer was operational. Table 4 demonstrates the comparison of water quality before and after the mixer trial.

<u>R3 Outlet Data – Data Comparison.</u>

With a target of 2mg/L at the outlet, the acceptable range of for chlorine residual is1.9mg/L – 2.1mg/L, this is a 5% variance. Table 4 below highlights the improvements in water quality as a result of the installation of one mixer in R3.

Table 4: ***Chlorine residuals analysed pre and post mixing***

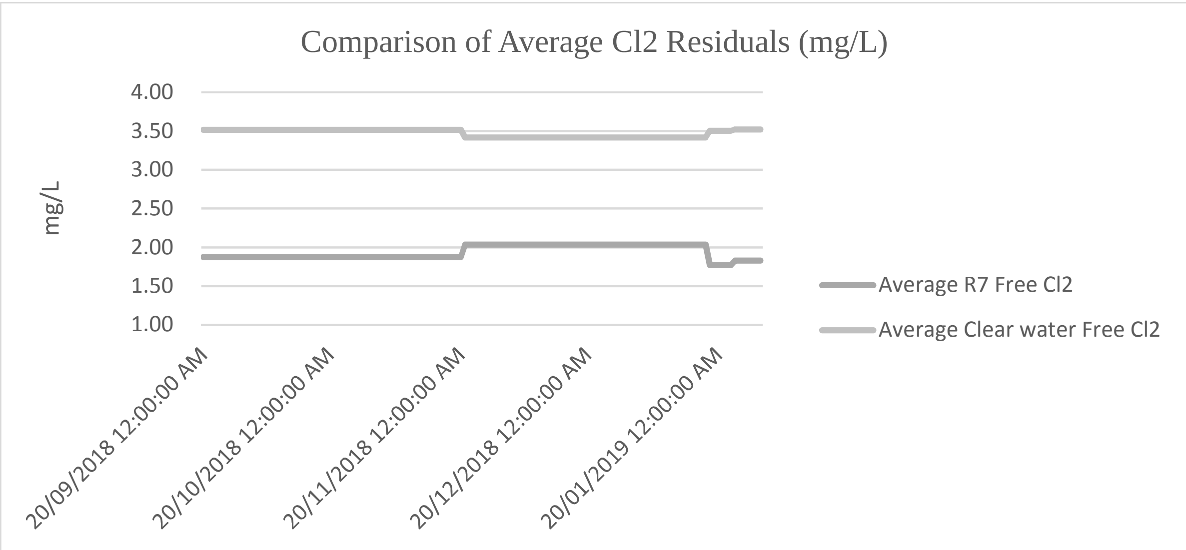
Prior to ResMix Vital install	Post ResMix Vital Install
30 % of readings within range	62% of readings within range
62% of readings <1.9mg/l	12%of readings <1.9mg/l
36% of readings <1.8mg/l	3% of readings <1.8mg/l
22% of readings <1.7mg/l	0.5% of readings <1.7mg/l
8% of readings >2.1mg/l	27% of readings >20.1mg/l
3%of readings >2.15mg/l	8% of readings >2.15mg/l

In order to gain a balanced view of the performance of the reservoir mixer, Council requested the unit be 'turned off' during the demonstration. The planned period of shut down was 1 week. Within 2 days there was a significant reduction in the chlorine residual measured at the R3 analyser requiring the chlorine dose rate to be increased at the WTP. Once the mixer was switched back on (4 days later), Chlorine residuals re-stabilised.

4.0 BENEFITS

Once the mixer trial was completed and the data reviewed, it was evident permanently installing a mixer would be beneficial to the continued treatment process. Table 5 shows during the trial period less chlorine gas was required to be dosed in the clear water tank while achieving an improved chlorine residual in R3. Additionally, re-dosing chlorine in the distribution reservoirs was largely reduced, and THM results declined.

Table 5: ***Chlorine residuals for R3 & clear water tank before, during and after trial.***



5.0 CONCLUSION

The mixer demonstration in R3 has proven water treatment needs to be continued beyond the WTP and into the reservoir system. Mixing improves water quality and maintains a fully mixed reservoir that in this instance reduced chlorine dose rates, while maintaining adequate chlorine residual. The trial period indicates an approximate savings of $8,000 / year on chlorine while improving water quality and public safety.

CAIRNS REGIONAL COUNCIL DIFFUSER MEMBRANE REPLACEMENT PROGRAM

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CAIRNS REGIONAL COUNCIL DIFFUSER MEMBRANE REPLACEMENT PROGRAM

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ABSTRACT

Cairns Regional Council owns and operates the three following Wastewater Treatment Plants; Marlin Coast (8.3ML/day), Northern (19.45ML/day) and Southern (19.45ML/day). Between 2017 and 2018 Council replaced the existing diffuser membranes due to poor asset condition, which had been in service since 2009.

The existing diffuser grids were removed from service while the treatment plants remained operational. Removal of the diffuser grids was made more challenging due to the large amount of debris which had accumulated on the diffuser grids.

As a result of the replacement works, Council has achieved a total annual power saving across all three plants of $135,000.00 and reduced power consumption by 730,000 kWh.

KEY WORDS
Wastewater, Treatment, Diffuser, Aeration, Cairns.

1.0 INTRODUCTION

In 2009, Cairns Regional Council (Council) as part of the $188 million Cleaner Seas Alliance completed the upgrade and construction of four Wastewater Treatment Plants (WWTPs); Marlin Coast (8.3ML/day), Northern (19.45ML/day), Southern (19.45ML/day) and Edmonton. Diffuser membranes where installed at all plants expect for Edmonton WWTP.

In 2016, Council staff had observed irregular aeration patterns, in particular at Southern WWTP and commenced work on a diffuser membrane replacement strategy. The existing diffuser grids had to be removed and replaced while the treatment plants remained operational as there was no redundancy for offline removal and replacement. Furthermore, the existing diffuser grids were installed with three stainless steel lifting cables and a number of these cables were observed to be frayed and therefore, unsafe for use. Council decided to replace the lifting cables with 316 Stainless Steel lifting posts.

Figure 1: ***Original diffuser grids with lifting cables***

Figure 2: ***New stainless steel lifting post***

The diffuser membranes at Southern WWTP were replaced in 2017, followed by Marlin Coast and Northern WWTP in 2018. Council awarded a contract to Xylem Water Solutions for the supply and installation of Sanitaire Fine Bubble Silver Series two diffusers.

Southern WWTP has 25 diffuser grids totalling 5,700 membranes within the oxidation ditch. Marlin Coast WWTP has 15 diffuser grids totalling 1,818 membranes and Northern WWTP has 20 grids which contain 3,282 membranes, within the bioreactor.

2.0 DISCUSSION

2.1 Project Planning

The replacement works required the treatment plants to remain operational as there is no means to isolate flows to the diffuser grids. To facilitate this, the project delivery team liaised with plant staff and the Contractor to develop a methodology to mitigate the impact on the treatment process and the surrounding environment.

Key items which required attention was the sequence of grid removal to ensure sufficient aeration, set down area for replacement of the diffuser membranes to ensure all waste was captured and correctly disposed and any external factors that could impact the replacement works. The following factors were identified as potentially impacting the replacement works; waste removal, delivery of chemicals and restriction imposed by Cairns Airport.

2.2 Sequence of Gird Replacement

To ensure adequate aeration during the replacement works, a sequence of removal was developed for each respective plant. For Southern WWTP consisting of 25 diffuser grids aligned within the oxidation ditch, the methodology developed was to work within sections and to replace alternating grid before returning to the start. E.g. 1, 3, 5, 2, 7, 4, 9, 6, 10…23, 21, 25 etc.

Figure 3: ***Diffuser replacement at Southern WWTP***

Due to the bioreactor arrangement of Marlin Coast WWTP and Northern WWTP, the grids were removed from alternating anoxic zones (Anoxic Zone 1 and Anoxic Zone 3) to ensure adequate aeration between the removed grids. Once all the grids were replaced in Zone 1 and Zone 3, the Contractor commenced the replacement of grids within Zone 2 and Zone 4. NATA testing is completed on Tuesday's at Marlin Coast and the swing zone grid is critical in the treatment process. As such, the swing zone grid was scheduled for replacement on Wednesday to allow operators to correct any issues before the next testing day.

No more than two diffuser grids were removed at any one time to ensure adequate aeration and due to the limited set-down area.

2.3 Site Constraints

To facilitate the removal, cleaning and replacement of the existing diffuser membranes, the Contractor required a set-down area adjacent to the work site for each grid. Treatment plant staff at Southern WWTP suggested the idea of utilising the chemical delivery bund as this drained back into the plant and would contain the waste.

Both Marlin and Northern WWTP have a kerbed bitumen section adjacent to the bioreactor with stormwater pits that gravitate to an outlet pipe. Council installed a 200mm plug into the outlet of the pipe and installed a submersible pump in the stormwater pit. This was used to collect and dispose of liquid waste during the removal, cleaning and replacement of diffuser membranes.

There were no environmental incidents and no breach of license of the treatment plant during the replacement works.

2.4 Project Challenges

The existing lifting arrangement at all three treatment plants are rated to 3 tonne. The existing stainless steel cables used to lift and remove the grids were observed to be in a poor condition and Council had advised they should not be used by the Contractor. A unique lifting arrangement design was proposed by the Contractor to safely remove the grids without the need for divers.

Northern and Southern WWTP have 5 mm step screens located upstream of the rotary drum screens. Whereas Marlin Coast WWTP simply has 5 mm step screens. The amount of rag and debris entangled on the diffuser grids, particularly at Marlin Coast WWTP added to the challenges. Over the course of the replacement works, the following amount of waste was removed:

- Marlin Coast WWTP – 15.5 tonne;
- Northern WWTP – 2.8 tonne; and
- Southern WWTP – 3.7 tonne.

<u>Figure 4:</u> ***Cleaning of diffuser grids at Marlin Coast WWTP***

The additional screens at Northern and Southern WWTP assist to remove a large amount of debris from the system as reflect by the amount of debris entangled on the diffuser grids compared to that of Marlin Coast WWTP.

The Contractor required the assistance of machinery to collect and transport the waste from the grids to the skip bin after the replacement works.

The large amount of debris entangled on the diffuser, made removal of the grids difficult as the lifting equipment was rated to 3 tonne. Debris had to be cut away from the grids before being lifted out. Some grids therefore could not be lowered back into the original position due to the large amount of debris positioned under the grids or entangled around the guide rails. Council attempted to use a high pressure lance to cut away debris from the guide rail and when unsuccessful, the Contractor had to weld a section of pipe to accommodate the added height.

Northern WWTP is located adjacent to Cairns Airport and the Contractor was required to liaise with the Airport due to the height restriction imposed. All replacement work was completed utilising a 100 tonne crane as the additional reach reduced the number of times the crane would have to re-position.

The day which replacement works were scheduled to start at Northern WWTP, the working height was reduced by 10 metres, giving just enough clearance for the diffuser grids to go over the handrails around the bioreactor. Possibly due to the APEC submit that was being held in PNG, Cairns was hosting the President of China, VP to the United States and other world leader.

The Contractor was able to work in with the Airport and the imposed height restriction.

2.5 Outcomes

The primary purpose of the diffuser replacement works was to address the deteriorate condition of the diffuser membranes. Consequently, Council was able to reduce blower power consumption as a result of replacing the diffuser membranes.
At Southern WWTP, the average daily blower power consumption prior to the diffuser

replacement works was 104kWh. Following the replacement works on all 25 grids, the average daily blower power consumption dropped to 61kWh. The replacement of diffuser membranes resulted in a 40% reduction in power consumption. 12 months following the replacement works, the average daily blower power consumption at Southern WWTP is 63kWh, which is only a minor increase.

The reduction in power is estimated to have saved Council approximately $71,000 per annum by saving 388,414 kWh at Southern WWTP.

The average daily blower power consumption at Northern WWTP was 141kWh prior to replacement works and this reduced to 109kWh after, resulting in a 23% reduction in blower power. Marlin Coast WWTP average daily blower power consumption prior to the diffuser replacement was 76kWh. Once all the diffuser membranes were replaced, the average daily blower power consumption was 70kWh; this is equivalent to a 9% reduction.

Council has estimated that the work at Northern WWTP has achieved an annual power saving of $52,000 by reducing power usage by 284,536 kWh. Similarly, at Marlin Coast WWTP, Council estimates a power saving of $12,000 per annum by decreasing power consumption by 57,807 kWh.

In total, the diffuser replacement works are estimated to be saving Council $135,000 per year. Based on these current savings seen from the reduction in blower power consumption, a payback period of 9 to 10 year is likely.

3.0 CONCLUSION

The diffuser replacement works were able to be successfully completed without an environmental incidents or breach of licence for the treatment plants. The involvement with plant staff before and during the replacement works, greatly contributed to the successful delivery of the project.

The Contractor had a wealth of experience and whilst they encountered challenges, their experience also contributed to the timely resolution of issues and successful delivery of the project.

Marlin Coast WWTP is continuing to be reviewed to tweak the aeration and it is hoped that additional power savings can be achieved.

Council has been able to establish a base line for blower power consumption at the three treatment plants and will be reviewing the power consumption annually to observe any changes. This will hopefully identify when maintenance activities would be required and be used to determine the affect these activities will have on the performance and lifespan of the diffuser membranes.

4.0 ACKNOWLEDGEMENT

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SAFER WORK PROCESSES: AN EVALUATION OF THE CODESAFE SYSTEM

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ABSTRACT

Construction workers possess valuable information about work health and safety (H&S). However, most workers are not involved in decision making about how work is designed and performed. There is a gap between ‘work as imagined’ and ‘work as performed’. Work as imagined refers to documented H&S procedures and method statements, which are often overly long and complex, yet still, do not cover all eventualities. Work as performed refers to adaptive behaviour and “workarounds” sometimes used by workers to perform their work safely. CodeSafe Solutions has developed an innovative process to make explicit construction workers’ H&S knowledge, enabling it to be used in the redesign of work processes. Two case studies are used to illustrate H&S improvements realised through the strategic use of workers’ knowledge obtained during the implementation of the CodeSafe system.

1.0 INTRODUCTION

Improving H&S capability is an important objective in the Australian Work Health and Safety Strategy 2012-2022. However, research demonstrates that conventional H&S training methods are not particularly effective in the construction industry. This is partly because workers have relatively low levels of education and literacy compared to workers in other sectors (ABS, 2013). An increasing number of migrant workers creates additional challenges for the communication and comprehension of H&S information (Loosemore and Trajkovksi 2006).

But a more fundamental reason for the low level of training effectiveness may lie in the general pedagogical approach adopted. H&S training typically involves an “expert” instructor transmitting knowledge to recipients. This approach is arguably inappropriate and ineffective when applied to adult learning (Wilkins 2011). Concerns have also been raised about the growing proceduralisation of H&S because critical information workers need is ‘buried’ inside long and overly complicated documents (Bieder & Bourrier 2013).

Despite their length and complexity, formal H&S documents record ‘work as imagined’ by managers rather than ‘work as performed’ by workers (Borys 2012). Because they sometimes do not reflect the reality of task demands, these documents may be ignored. For example, safe work method statements (SWMSs), a mandatory requirement for high-risk construction work, are sometimes written by managers and supervisors with little input from workers. Documented work procedures can never cover all eventualities and are, by necessity, adapted by workers in the field. Thus, workers’ H&S competence in performing their work is likely to be more important than the volume and content of H&S documentation.

2.0 DISCUSSION

Construction workers offer a largely untapped source of H&S information because traditional H&S approaches focus on top-down management control of workers (Saksvik & Quinlan 2003).

Such approaches emphasise enforcing workers' compliance with rules managers and technical specialists establish. Ayers et al. (2013) describe how, despite a statutory requirement to consult workers, most construction organisations do not involve workers in making strategic decisions about H&S. For example, it is rare for workers to participate in the design of workplaces or systems of work.

This is a missed opportunity because workers possess a wealth of knowledge about H&S hazards associated with their tasks and ways to work safely. Much of this knowledge is tacit, i.e., it is difficult to transfer to another person through writing or verbalizing (Polanyi 1958). It can be described as "know how," rather than "know what." For example, knowing how to perform a complicated work task safely is a form of tacit knowledge. Construction workers may not appreciate the extent and value of their knowledge and are unlikely to possess the skills to communicate it to others easily. Tools that can help to unlock this tacit knowledge have significant potential to produce H&S improvements.

Recent developments in H&S have recognised the benefits associated with engaging workers in H&S improvement processes. Critical is the understanding that providing workers with input into decisions that affect them produces better H&S outcomes. For example, participatory (worker-led) training approaches have produced demonstrably better results in terms of knowledge acquisition and injury prevention than traditional H&S training approaches (Burke et al. 2006). However, research shows that the way in which H&S is spoken and written about on construction sites reflects an emphasis on enforcement rather than engagement (Sherratt et al. 2013).

2.1 The CodeSafe System

The CodeSafe system addresses some of the challenge with a standardised process for:

(1) eliciting the tacit knowledge of construction workers relating to the H&S aspects of their work tasks,
(2) engaging construction workers in scripting, acting and recording videos to visually represent this tacit H&S knowledge, and
(3) using QR codes to make this knowledge quickly and easily available to other workers who need to access it.

The CodeSafe system uses an andragogical approach which does not dictate H&S knowledge to workers but, instead, facilitates learning based on practical experience (Wilkins 2011). Workers are regarded as subject matter experts in performing their work tasks. Their H&S knowledge is captured using an experiential learning model appropriate for adult education. In developing and scripting the videos, workers "unpack" work sequences and identify habitual behaviours that are unspoken but critical to performing a task safely.

The involvement of workers in producing videos reflects an engagement, rather than an enforcement orientation to H&S. Providing critical H&S information visually is also likely to be an effective way of ensuring that important knowledge is understood by workers with low levels of language and literacy. Research shows that training is also more likely to be transferred into practice if the trainer is credible and the training situation closely resembles the work environment (Holton et al. 2000). Therefore, videos featuring workers depicting how to perform a task in a field setting may support the transfer of knowledge into practice more effectively than alternative modes of training delivery. Delivering videos via QR codes enables workers to access H&S information quickly and easily when they need it – even at point of task.

2.2 CodeSafe System Evaluation

The research explores how effective the CodeSafe system is in exposing gaps between work as imagined and work as performed. It identifies problems with documented safe work procedures, and utilises workers' H&S knowledge to develop safer and more healthy ways to work.

In-depth interviews were conducted with five organisations that have implemented the CodeSafe system. Interviews explored the choice of work tasks to be analysed and filmed, the way that workers and managers responded to the CodeSafe system and the perceived benefits/impact. The interviews were audio-recorded, transcribed and subject to thematic content analysis.

The interviews revealed how the gap between work as imagined and work as performed could be exposed during the filming of the videos. One participant comment: *"During the process, it's amazing how many things the crews themselves picked up… they said 'oh actually what we do in practices is not what the document says.' So, it actually resulted in improvements to written safe work method statements to better reflect what crews were doing."*

The identification of safety issues inherent in standard operating procedures and H&S documentation was a recurrent theme. The interviews revealed how filming and reviewing the footage of workers undertaking work tasks enabled some H&S issues that were previously unrecognised to be identified and resolved.

2.3 Case Example 1: An Innovative Approach to Accessing Ceiling Spaces

The CodeSafe system revealed problems inherent in the documented standard operating procedure for accessing ceiling spaces in the installation of insulation in the domestic construction sector. Much of the installation work undertaken by the company involves accessing ceiling manholes at the height of between 2.4 and 2.7 metres from the floor. The company has a safe operating procedure for the safe use of ladders and working at height. We decided that this would be the subject of a CodeSafe video.

The script was based on the documented safe operating procedure and distributed for comment. The H&S manager commented that "*no-one had an issue with it theoretically*." However, when it came to the filming: "*shooting it and viewing it through the camera's eye, we had to stop… the camera doesn't lie*." She explained: "*To place a straight ladder at the 1:4 ratio just doesn't work, you can't get a body in there as well because it blocks off the access and you have to contort yourself to get in [to the ceiling space].*"

The safe operating procedure also requires the ladder to extend 900mm beyond the "step off" point, which was almost impossible to achieve due to conduits, cables, beams and other obstructions. The manholes' small size did not allow adequate entry for the ladder, the worker and the pack of insulation. The H&S Manager described the process for passing ceiling packs through the manhole. Workers used a straight ladder meaning they have to contort their bodies to manoeuvre themselves into the ceiling space, then move the ladder to get the packs in. The H&S Manager explained that, if the workers used an "A-frame" ladder, "*which they do because they can't use a straight ladder,*" they are forced to work unsafely because they have to step off the top rung of the A-frame to get their bodies up into the ceiling space.

The practical difficulties associated with following the safe operating procedure became apparent during the filming of the CodeSafe video. The filming was halted, and the company searched for an industrial rated solution for accessing ceiling manholes at the height of 2.4–2.7 metres, and which could extend 900mm beyond the manhole. The H&S manager identified a solution used by arborists in New Zealand. The ladder has curved rungs which envelope the body "*so it is easy to get three points of contact, and you don't need the 1:4 ratio lean so you can place it, so it does not encroach on the manhole opening space and there is a clear shaft opening for the ceiling packs*". It could be used around the frame of a house because the ladder's adjustable legs provide secure support. The system is currently undergoing a few engineering modifications before being trialled. The H&S Manager attributes the innovation to identifying the insulation installers' access problem "while filming the CodeSafe video."

2.4 Case Example 2: Process for Coating Concrete Sewage Channel Beams

Workers were coating concrete sewerage channels with epoxy to prevent corrosion, which was a hazardous task because the channels contain aerated liquid. A fatality had occurred during a similar operation at another facility, six months before making the CodeSafe video. This fatality occurred when a worker fell into an aerated sewerage channel and drowned. The prosecutor in the case commented that if someone were to fall into a channel like this, it is almost certain they would drown.

In order to apply the epoxy to the channel beams, work was performed from a barge. The operation for getting safely into a barge was scripted and filmed as part of the CodeSafe implementation at the site. The Project Manager describes how in *"even just a little thing, how they hooked themselves onto the safety line we identified there was a little gap. There was virtually a 10-second gap [during which time] they weren't hooked on."* The manager describes how "only when they acted it out that they were conscious of…" the period of time workers had no protection against falling into the sewage channel.

As a result, a new work process was developed in which multiple connection points were utilised. This meant that workers were protected from falling at all times.

2.5 Utilising Workers' H&S Knowledge to Produce Improvements

One project manager described how the CodeSafe system was initially used to provide instructional material to workers. However, it has evolved to develop H&S materials based on workers' involvement and experience. Workers' participation in creating the CodeSafe video "unlocked" a great deal of valuable H&S knowledge that would otherwise not have been available. The participatory process of seeking workers' input into and involvement in making videos encouraged workers to make suggestions to improve H&S in their workplaces. One H&S manager commented, *"They're not afraid to bring forward their ideas because they think everything's going to be considered."*

Another H&S Manager described workers' antipathy to written H&S procedure documents that are often developed without workers' input. She contrasted this with participatory development of the CodeSafe visual H&S procedures, saying, *"They [the workers] can see that it's not fixed in concrete. They have an ability to improve it and contribute to it and it's made up of what comes from them."*

3.0 CONCLUSION

The two case examples suggest that the visual aspect of the CodeSafe system is particularly useful in creating opportunities for reflection about how work is performed and developing safer and better ways of working. The benefits of using visual methods were expressed by a Project Manager who as follows: *"the guys are often in a trade because the written word is not their specialty and its more seeing and doing, its more visual. I think in the industry we have to become more visual in communication."* The Project Manager described how his organisation used CodeSafe *"to bring to life some of our procedures and processes; we quickly saw the benefit in having the visual aspect brought to life."*

In example 2, the H&S problems became apparent when workers and managers reviewed the footage and noticed problems associated with standard operating procedures that had not been previously recognised or acknowledged. This suggests that the visual representation of work processes and the use of video can be a powerful tool for re-thinking the H&S aspects of commonly performed work tasks in construction.

Visual representation is also ideally suited to the depiction of knowledge relating to 'know how' rather than 'know what,' making it particularly useful as a method to represent ways of working safely. Case example 1 illustrates this point as the content of the safe operating procedure and film script was accepted before filming. The script was correct "in theory" however, the practical challenges associated with the task of entry into a ceiling space became apparent during filming. A substantial gap was revealed between knowledge about what should be done (as documented in the safe operating procedure) and how the work was actually undertaken. It was understood, that this gap could be addressed, and a safer, practical and effective way of accessing ceiling spaces could be found.

Organisations with high H&S standards actively seek employee participation and feedback in H&S planning, decision-making and improvement (Torner & Poussette 2009). Yet Australian research reveals that construction workers' input into H&S is limited to the resolution of trivial issues, such as those relating to housekeeping or personal protective equipment (Ayers et al. 2013). Further research is currently being undertaken using quantitative data collection and analysis approaches to examine the extent to which the CodeSafe system produces measurable improvements in H&S culture and performance.

The examples highlight the significant benefits associated with engaging workers in the search for and development of safer and healthier ways to work. These are immediately apparent in the H&S improvements that were achieved in each case. However, the broader environmental and organisational impact of involving workers in the CodeSafe process also emerged as a key theme in the interviews.

These benefits included improved two-way communication about H&S, increased worker involvement in H&S activities and elevated levels of trust in the organisations' H&S processes. For example, one manager explained how the system dramatically improved H&S communication in his organisation, commenting: *"it [the CodeSafe system] just created that openness that 'Look, we're here to listen to what you want to say and we're willing to put in place your ideas into our systems', and that's what makes safety more credible really."* Another manager described *how "the camaraderie is great, which opens up free thinking and free speech and things come forward. When you ask their [the workers'] opinion, they feel valued."* Another H&S Manager described how workers developed a strong sense of involvement in H&S through the system. They interacted more openly with H&S staff in the corporate office than they did previously.

The case studies also suggest the benefits of the CodeSafe system extend well beyond the development of instructional H&S videos and the delivery of these videos using QR codes. The real innovation and impact of the system lie in the social and cultural changes that can be realised through engaging workers in organisational H&S improvement efforts. As one project manager commented: *"CodeSafe is more than just a funny sort of digital pixelated marker and being able to view a video off it. That's not the value of it, you've got to have it embedded in a broader program…in a genuine attempt to bring workers' input and involvement."*

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ALGAE CONTROL IN POTABLE WATER DAMS AND OTHER AQUATIC SYSTEMS

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ALGAE CONTROL IN POTABLE WATER DAMS AND OTHER AQUATIC SYSTEMS

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ABSTRACT

Earth Science Laboratories (ESL) is an innovative technology development company in the USA that has developed products for the drinking water, agricultural and swimming pool industries. Aquapac is a water treatment specialist company based in Australia and has become the sole distributor for the ESL product range in Australia.

1.0 INTRODUCTION

EarthTec® is a copper-based algaecide/bactericide that has a record of 20+ years of safe and effective use throughout the U.S. for treatment of potable water reservoirs, lakes, pipelines, canals, aqueducts, and even within water treatment plants, where it prevents algae and improves the drinking water treatment process. Some water utilities use EarthTec to eliminate geosmin and other compounds that cause taste and odour problems in drinking water.

EarthTec is NSF-approved for drinking water and is most often applied in lakes, reservoirs and at the intake of water treatment plants.

EarthTec employs a unique formulation of copper to keep it entirely in the cupric ion form, Cu^{++} – the most biologically active form of copper – and therefore works at a significantly lower copper dose than conventional copper sulfate or chelated copper products. There is virtually no waste or loss to precipitation or settling, and for that reason EarthTec is arguably the most environmentally safe and responsible way to apply copper for pest control.

Given that EarthTec is certified for use in drinking water, for many locations and utilities it is the only practical and economical choice available.

Advantages of EarthTec:

- It is a liquid formulation and is self-dispersing, thus greatly improving efficacy and reducing time and labour for application.
- The copper is formulated in the biologically-active form (as cupric ion, Cu2+), and stays in solution until it encounters a cell wall to bind to and penetrate, so virtually 100% of the copper applied is effective, with no waste or copper precipitating into bottom sediments.
- EarthTec is NSF-approved for drinking water, reservoirs, lakes, irrigation canals, and even for swimming pools & spas (under another name and label). It's also approved for raw water intakes or sedimentation basins within water treatment plants.
- Reduces odour, taste and precursors of disinfection by-products including THMs and HAAs.
- Long history of effective use with no negative impacts on fish and other non-targets.
- EarthTec provides effective control of algae and biofilm.

Because EarthTec is formulated as Cu^{2+} ions, after applying to an aquatic system it rapidly disperses throughout the water column and begins inhibiting the target pests. These cupric ions remain in solution even after being applied to the treated water rather than precipitating to the sediment, and that enables the product to be effective at unprecedentedly low doses, in the range of 30-240 ug/L as copper (equivalent to 0.5 to 4 ppm as product). Consequently, EarthTec is the most environmentally sound way to use copper for pest control.

In the USA Waters treated with EarthTec have no restrictions regarding immediate use for recreation, agriculture, drinking water plants, and aquaculture farms.

2.0 DISCUSSION

EarthTec has been used by more than 200 water utilities to stop or prevent algal and/or cyanobacterial blooms. Although other algaecide products may contain copper sulfate pentahydrate as the active ingredient, EarthTec's novel formulation is NSF-certified to Standard 60 (approved as a drinking water additive) and readily mixes and rapidly disperses throughout the water body. Laboratory and field studies have demonstrated that EarthTec does not cause rapid lysis of algal cells and, as such, there is no immediate widespread release of algal/cyanobacterial toxins into the surrounding water.

EarthTec has been used to treat impoundments, reservoirs, pipelines, canals, raw water intakes and pumping stations for the control and prevention of algae/cyanobacteria. EarthTec forms no disinfection by-products (DBPs), making it an attractive alternative to chlorine for pre-treatment of drinking water. Treated water also yields reduced concentrations of total organic carbon (TOC). EarthTec has also been shown to reduce/eliminate taste and odour complaints by reducing concentrations of geosmin and related compounds. Other documented advantages include cost savings through reductions in the amount of activated carbon needed in water treatment plants, reduced ozone consumption, enhanced coagulation of inorganic and organic materials, and extended filter runs.

An important advantage of EarthTec is that significantly less copper is needed to control/eliminate problems resulting from algal and/or cyanobacterial blooms. For example, the City of Norwalk, Ohio has a reservoir that serves as source water for the city and was historically treated with copper sulfate to control algal/cyanobacterial bloom-related problems. After changing the treatment program to EarthTec, the total amount of copper applied annually was reduced by 80%.

Furthermore, the water plant operators found they could achieve appropriate control of problematic organisms with fewer treatments per year.

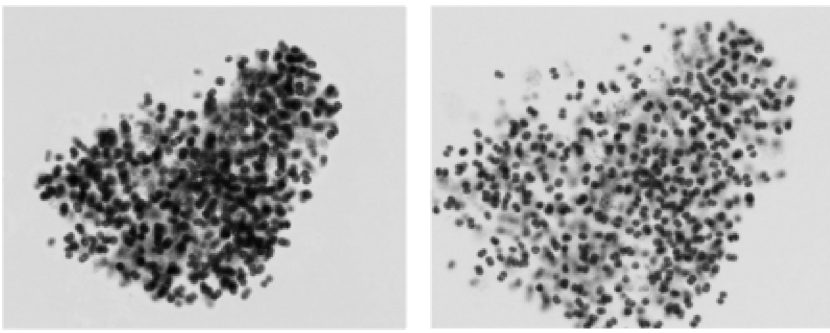
Herriman, Utah has a recreational lake called Blackridge Reservoir that had to be closed due to a toxic cyanobacterial bloom. The lake was treated with 4 ppm of EarthTec (240 ug/L as copper) and within 2 days it was reopened to the public. A maintenance program consisting of periodic follow-up doses of 2 ppm kept the reservoir open for recreation the rest of the season.

2.1 How do Bloom-causing Organisms Die and Not Cause a Significant Increase in Concentrations of Algal and Cyanobacterial Toxins?

Laboratory studies were conducted on cyanobacteria collected from a waterway in South Florida during a severe cyanobacterial bloom event in 2016. The primary goal was to determine if treating the water with EarthTec would result in lysis of cells as has been reported in the literature. Near the point of sample collection, the biomass at the surface was measured to be ~8" thick. Samples were collected in areas without a surface layer of biomass and microscopic observations of subsamples showed large numbers of cells of a *Micrococcus* sp. growing in floating colonies. These assays were typically carried out for up to 96 hr. The structural integrity of cells within the colonies was evaluated on the basis of "optical density" relative to the illuminating light beam.

Untreated controls showed some flattening and compression of the colonies, but the colonies maintained structural integrity (see fig. 1 and note differences in colony dimensions after 18 hr). Individual cells within the colonies remained intact and retained their original intracellular materials as indicated by shape and optical density of the cell biomass. In some studies, algae contained on a wet-mount slide remain viable and active for up to 7 days (data not included herein).

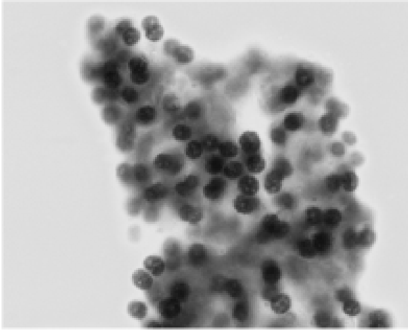
Time 0 Time 18 hr



<u>Figure 1:</u> ***Untreated control Microcystis colony on a wet-mount slide (250X magnification)***

Cells treated with 120 ppb copper (applied as EarthTec) appear in Figure 2, where at T = 0 (left image), the 3-D shape of the *Microcystis* colony is apparent and all cells within the colony were optically dense, i.e., dark with chlorophyll. After 18 hr incubation at 24^{o} C, the colony had flattened and the cells were still within the colony matrix (right image), but it is noteworthy that while all cells within the colony were significantly less dense (loss of chlorophyll), they still retained their overall cell morphology, including integrity of the cell wall structure, etc.

Time 0 Time = 18 hr



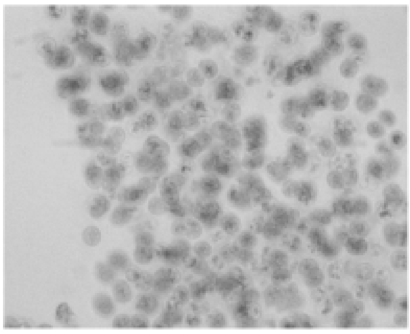


Figure 2: ***Comparison of colony and cell morphologies of Microcystis treated with 120 ppb Cu (supplied in EarthTec). Source water was treated for 1 hr before a subsample was transferred to a wet mount slide (400X magnification)***

Treated water samples were also assayed spectrophotometrically to compare absorbance spectra in the 200-350 nm range. The scans were performed to determine if leakage of organic materials could be detected in the water after centrifugation and removal of cells and particulate materials from the water. As illustrated in figure 3, there were dose-dependent increases in concentrations of general classes of organics that are known to have specific absorbance maxima, e.g., proteins, nucleic acids, etc.

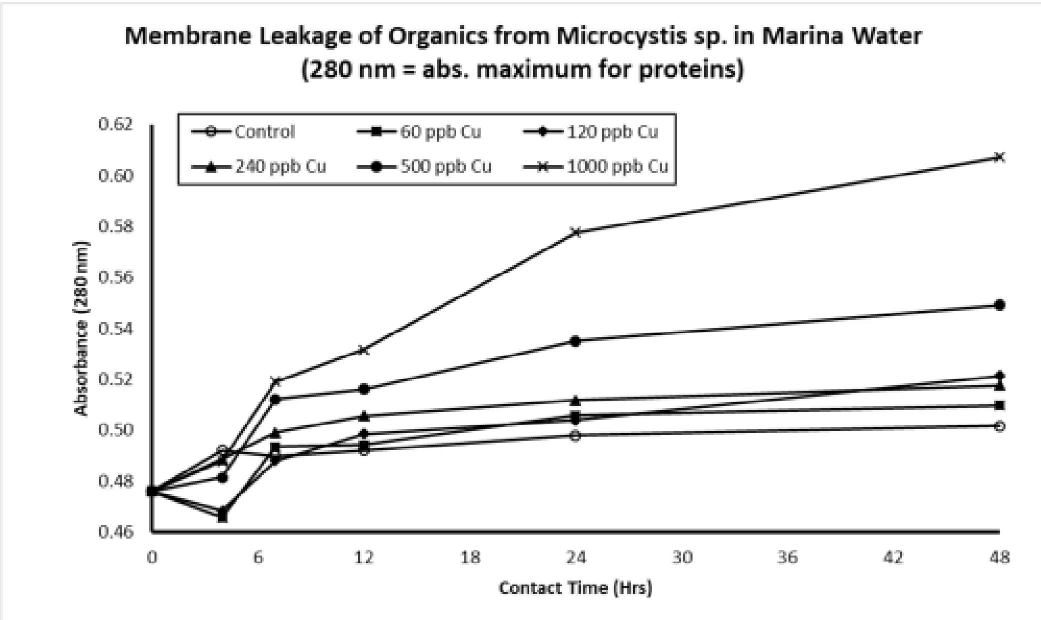


Figure 3: ***Dose-response of cells treated with selected concentrations of EarthTec***

2.2 Key Conclusions from this Observational Study:

- EarthTec does NOT cause immediate or extensive lysis of Microcystis cells when used at the recommended doses of 60 to 400 ug/L as copper.
- EarthTec treatment results in cells slowly leaking their cytoplasmic materials into the surrounding water, not a catastrophic rupture of the cell walls.
- Non-target microorganisms that consume leaked cytoplasmic materials are not inhibited -- this allows for a “mini-food web” to be established so that toxins, TOC, and DOC will be reduced via heterotrophic metabolic activity of the indigenous bacterial flora.

Treatment of Water for Taste and Odour Control

The main cause of earthy (musty) tasting water in a number of water treatment facilities in Australia Is production of geosmin by problematic species in the water and/or sediment. Activated carbon is traditionally used to remove geosmin and related compounds via absorption onto the carbon granules. ESL has had success in several locations with preventing formation of geosmin by applying EarthTec to the water source.

Municipal Water Treatment for Control of Algae

Citrus in California had a major issue with their drinking water storages. The treatment plant reservoir is connected to a "feeder" reservoir via a 16 km pipe (fig. 4). The systems were experiencing an algae bloom that was affecting taste and odour of the treated water.

__Figure 4:__ ***Photographs of the two pipeline-connected reservoirs used as the source of municipal water in Citrus, CA***

EarthTec was added to the lined water reservoir and, as illustrated below, numbers of problematic algae were reduced to an acceptable level within 48 hr. A qualitative index of the success of this treatment program was that the treatment plant was backwashing their filters at 2-hr intervals – after EarthTec was applied, the backwash interval increased to once every two weeks.

Little to No Adverse Effect of Fish or the Ecosystem

Results of field studies have demonstrated that, when used according to label directions, EarthTec provides safe, effective control of problematic species. Any impact on non-target species is quickly overcome as the treated system achieves homeostasis. After treatment, the concentration of Cu will usually decrease to background levels within a few days. One key factor in the overall mode-of-action of EarthTec is that harmful algae/cyanobacteria are inhibited without causing cell lysis. As a result, intracellular materials slowly leak out of treated cells and are subsequently metabolized by the indigenous heterotrophic bacterial community. This results in an increase in the size of the bacterial community with a concomitant decrease in total and dissolved carbon in the water column.

3.0 CONCLUSIONS

- Results of field and laboratory testing have demonstrated that, when used as per label directions, EarthTec provides cost effective control of problematic bloom-causing algae/cyanobacteria.
- Because of the unique method of production and formulation, the active ingredient in EarthTec products, Cu++ ions rapidly and evenly disperse in aquatic systems without the need for mixing or agitation.

- Control of problematic microorganisms and macroorganisms is achieved with low doses of Cu++ ions when applied as EarthTec products. In addition to durational control of harmful algal/cyanobacterial species, these products result in
- Reduced TOC (Total Organic Carbon)
- Reduced concentrations of undesirable taste and odour compounds, especially geosmin
- No production of DBPs, THMs or HAA5's (regulatory issues)
- Reduction many types of bacteria, especially enteric bacteria such as E. coli.

4.0 ACKNOWLEDGEMENTS

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Dr David Hammond

EVOLUTIONARY APPROACH OF CHEMICAL DOSING AT LOGANHOLME WWTP FOR PHOSPHORUS TRIMMING

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5 & 6 June, 2019

EVOLUTIONARY APPROACH OF CHEMICAL DOSING AT LOGANHOLME WWTP FOR PHOSPHORUS TRIMMING

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ABSTRACT

The paper describes an evolutionary approach on improving a chemical dosing system that was installed in 2007/08 and was never used for seven years until 2014. A chemical dosing trial was conducted in 2014 using Ferric Chloride; several improvement opportunities were identified including flow paced dosing and flow capping to avoid overdosing of chemical. A major upgrade of the chemical dosing system was carried out as a result of the first trial. Permanent chemical dosing was commenced in November 2016 using Ferrous Chloride. Ferrous Chloride dosing at Loganholme Wastewater Treatment Plant has been proven effective. With 0.005% v/v chemical dosing, target long term TP of 1.5 mg/L in treated effluent can be maintained efficiently. Ferrous chloride dosing showed positive impact on sludge dryness because it improves sludge settleability. As ferrous ions deposit on magflow meter tube, it is recommended to use Ferrous/Ferric Chloride dosing downstream of any magflow meter and should not be adjacent to a magflow meter.

1.0 INTRODUCTION

Loganholme wastewater treatment plant is a medium-large size plant which has an ADWF capacity of 51 ML/day. Current average dry weather flow is 41 ML/day. This plant comprises four conventional oxidation ditches and eight secondary clarifiers. Before commissioning of the chemical dosing system, nutrient removal was fully biological with full long-term compliance of total nitrogen and total phosphorus. Before upgrades, the chemical dosing system was a standalone and fixed rate system that consisted of three chemical storage tanks, two dosing pumps and a single dosing point at the old inlet works. The improved chemical dosing system (completed in 2016) is a SCADA controlled dosing system with capped chemical dosing rate, which consists of three storage tanks and two new dosing pumps. Two parallel dosing points (parallel to oxidation ditch/clarifier systems) are located in the mixed liquor lines to secondary clarifiers.

Ferrous Chloride, also called spent pickle liquor (SPL), is currently being used at Loganholme Wastewater Treatment Plant for total phosphorus trimming. The purpose of the chemical dosing is to give an extra boost of phosphorus removal with minimum hindrance to biological phosphorus removal. Before the operation of chemical dosing, the long-term biological phosphorus in treated effluent was 3.4mg/L (compliance limit is 5 mg/L).

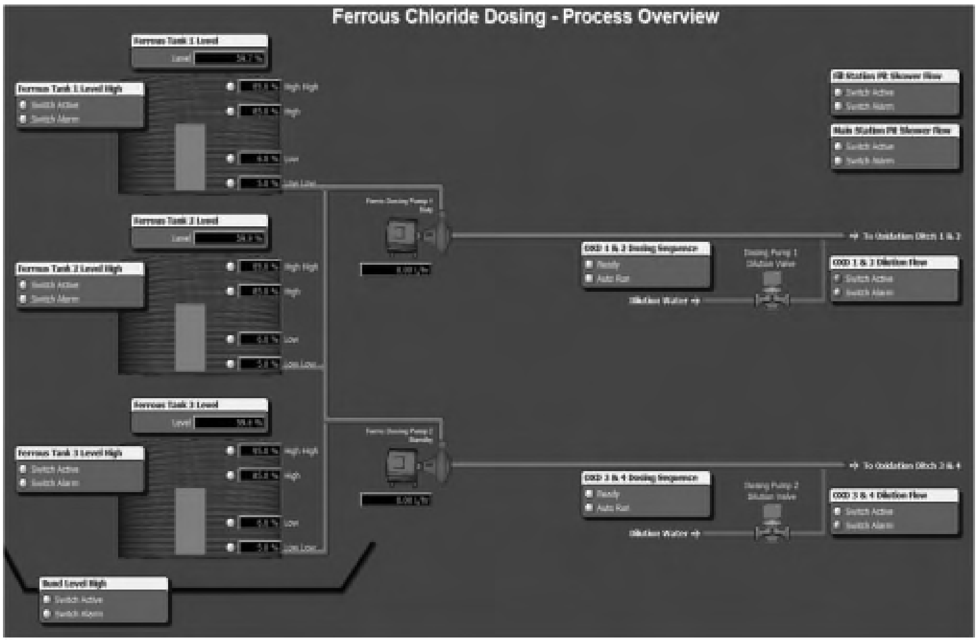


Figure 1: *Ferrous Chloride Chemical Dosing System (operational since Nov 2016)*

2.0 NUTRIENT IN PLANT EFFLUENT BEFORE COAGULANT DOSING

Loganholme wastewater treatment plant consists of a conventional oxidation ditch system which efficiently removes pollutants from raw sewage. However, phosphorus removal is only limited to 40-50%. The Ferric Chloride dosing system was installed in 2007/08 but was never used until 2014, when a full-scale trial was conducted for four months. The main focus of the Ferric Chloride dosing trial was to identify the merits of the system and possible improvements. Compliance limits of long-term TP and TN for Loganholme is 5 mg/L which was being complied consistently even before the chemical dosing. However, as part of a commitment for continual improvements of annual nutrient discharge into the river and to maintain long term TP below 3 mg/L, the Ferric Chloride dosing trial was commenced. Table 1 shows the last six years long term TP and TN of treated effluent at Loganholme wastewater treatment plant.

Table1: *Historical long-term total nitrogen and total phosphorus*

Financial Year	End of FY Long Term TP (mg/L)	End of FY Long Term TN (mg/L)
2012/13	3.7	3.0
2013/14	4.2	3.0
2014/15	4.0	3.2
2015/16	2.8	3.2
2016/17	1.8	3.2
2017/18	1.2	2.3

3.0 COAGULANT DOSING AT THE PLANT

The coagulant dosing in the last ten years at Loganholme plant is divided into four stages:

- No coagulant dosing (2008 to 2014)
- Trial Ferric Chloride dosing (06 May 2014 to 22 September 2014)
- Improvements of dosing facility (2015/16)
- Permanent Ferrous Chloride dosing (26 October 2016 till to date)

4.0 NO COAGULANT DOSING

The chemical dosing facility was installed in 2007/08. Since the installation of the chemical dosing facility, it was not operational for another six years. The dosing system consisted of three chemical storage tanks, two fixed speed chemical dosing pumps. The dosing point was at the wet well of old inlet works.

5.0 Trial Ferric Chloride Dosing

The Ferric Chloride dosing trial was conducted at Loganholme Wastewater Treatment Plant from 06 May 2014 to 15 September 2014. This trial was done to identify the potential of process improvements and the impact on plant operation. The dosing was not continuous due to insufficient chemical supply, malfunctioning of various components including the leaking of the chemical from every possible "O" ring. Following are the fixed rate dosing applied in the different stage of this trial:

1. 06 May to 29 June 2014: Seven hours dosing per day @ 100 litres/hour
2. 30 June to 29 July 2014: twelve to eighteen hours dosing per day @ 100 litres/hour
3. 05 August to 15 September 2014: twenty-four hours dosing per day @ 80 litres/hour.

5.1 Stage 1 Trial: Fix the System

This stage of trial identified some improvements opportunity (for long term operation) including fixing of all "O" ring joints, replacement of faulty level sensors, improvements of drainage in the chemical bunds, change the location of dosing points, implementation of flow paced control, flow capping for optimum chemical usage and changing of old dosing pumps.

As the Ferric Chloride dosing was at a fixed rate, therefore overdosing of the chemical might have happened from 1:00 am to 6:00 am every day as plant flow was nearly stagnant (nearly zero). All four oxidation ditches suffered from the accumulation of scum and foam. Therefore, mixed liquor and foam samples were collected on 28 October 2014 for analyses of filamentous bacteria. The microbiological assessment identified the following:

- Compact flocs were observed; however round compact foams were rarely observed
- Typical finger like flocs were present in Oxidation Ditches (particularly in Oxidation Ditch 4)
- Zooglea Sp. was causing poor morphology of floc structure of mixed liquor, and suggested poor settling and possibly bulking
- High F/M ratio environment in mixed liquor with low pH caused the formation of Zooglea Sp.

Historically, the pH of Loganholme mixed liquor was 6.9 to 7.0 before the application of Ferric Chloride. During the Ferric Chloride trial, mixed liquor pH was dropped to about 6.5 in the worst cases. This probably became much worse in low flow time, particularly in early morning. Early morning pH in the oxidation ditches was not monitored due to the unavailability of online pH monitor.

During this trial period, Ferric Chloride dosing was a stand-alone system by which dosing was maintained at a constant rate.

With a constant rate of dosing, there were two probable drawbacks:

- Under-dosing during high diurnal flow and overdosing during low flow periods. Under-dosing caused inefficient TP removal. Overdosing in low flow time caused the reduction of mixed liquor pH to probably unacceptable levels and therefore reduced nitrification rate.
- Reduced pH (along with high F/M) caused the formation of filamentous bacteria, less compact floc and excessive formation of foam. This was proven by the microbiological analysis described above.

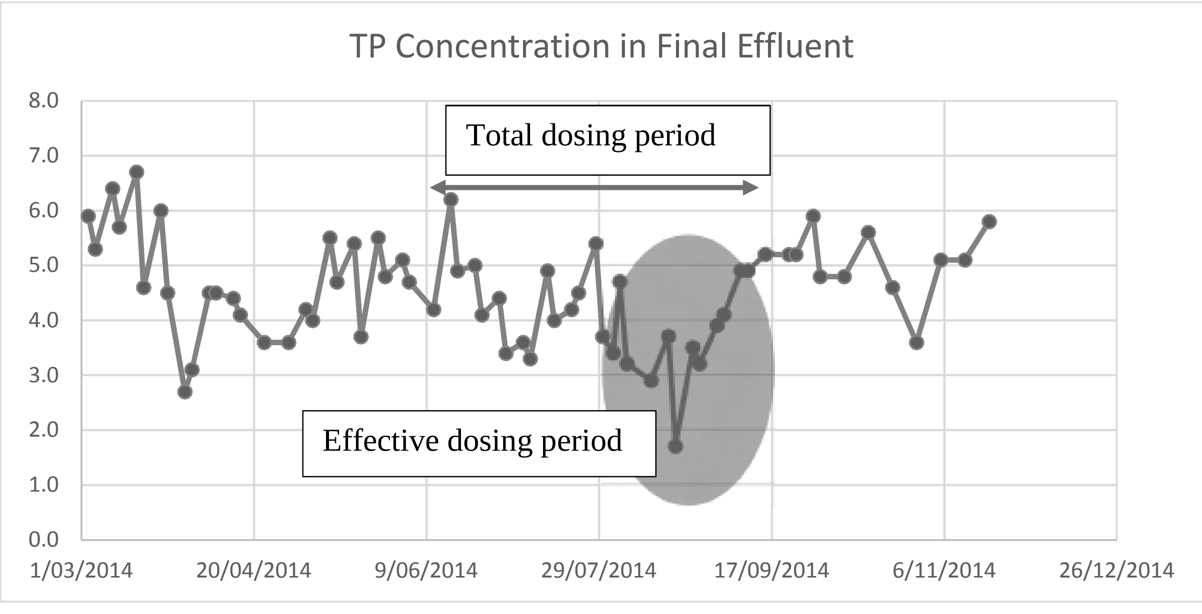
To make the Ferric Chloride dosing system operate efficiently, the following improvements were required before full commissioning.

- Fix all identified leaks in pipes and joints;
- Automate Ferric Chloride dosing system (SCADA controlled) and implement flow capping to reduce chemical usage
- Change the faulty dosing pumps
- Change the faulty level sensors in storage tank 1 and storage tank 2;
- Lower the drainage outlet in the bunded storage area;
- Include Perspex cover in the pump cabinet;
- Purchase chemical from reliable suppliers to meet the demand of chemical;
- Flexible dosing points (a) dosing in MLSS lines before secondary clarifiers (b) raw sewage distribution box.

5.2 Stage 1 Trial: Nutrient Reduction

The trial described in section 5 showed 21% reduction of TP in treated effluent with maximum removal efficiency of 81%. The percentage increase in TP removal using chemical dosing was not consistent due to several difficulties during the trial. Further improvement works were recommended (as described in the previous section) to operate the dosing system efficiently.

This stage of the trial identified a probable increase of biosolids within13% to 43.3% if measured concerning COD and BOD, respectively.



<u>Figure 2</u>: ***Total Phosphorus concentration in Final Effluent during the trial period***

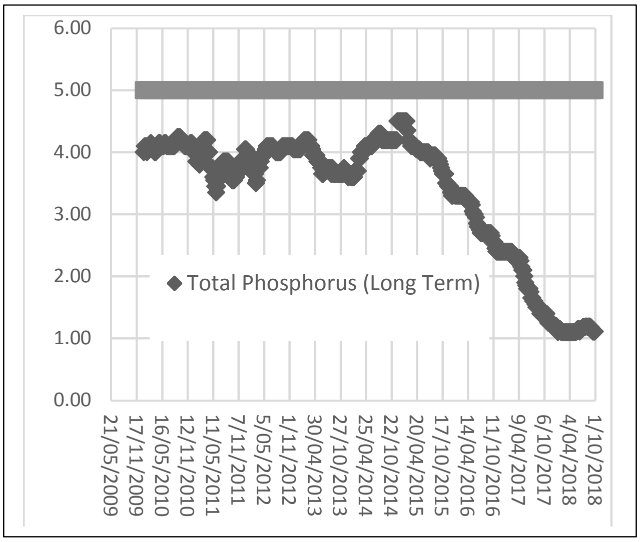
6.0 PERMANENT FERROUS CHLORIDE DOSING

As mentioned above, the original chemical dosing system was first trialled from 07 May 2014 to 22 Sept 2014 and identified the requirement of a major overhaul to the chemical dosing system at that time. The major overhaul to the process was completed in September/October 2016, and full commissioning of dosing facility was done on 26 October 2016. The chemical dosing process is efficiently operational since then with minor disruption. Before commencing the Ferrous Chloride dosing on 26 October 2016, the dosing system consisted of following process components:

- Dosing point 1: at the inlet channel splitter box located just upstream of the settled sewage valve
- Dosing point 2: two parallel dosing points in mixed liquor lines located upstream of secondary clarifiers of plant A and Plant B
- Chemical storage and transfer pumps encompassing three storage tanks and
- two dosing pumps
- SCADA control for flow paced chemical dosing with operator adjustable dosing rate

Ferrous Chloride was first commenced at dosing point 1 (at the inlet channel splitter box) on 26 October 2016 and was operational only for two weeks. One of the key lessons learned during this trial was ferrous metal deposition on Magflow meter tube. Therefore, the second dosing point was used for permanent chemical dosing. Dosing point 1 was fully decommissioned in the first week of May 2017. The outcomes of this trial will be discussed in the following sections.

Since the beginning of Ferrous Chloride dosing, the total phosphorus (TP) in the final effluent is consistently below target long term concentration of 1.5 mg/L and currently maintaining long term TP of 1.2 mg/L. This resulted in a significant reduction of TP discharge to Logan River in 2017/18 compared to 2014/15. Total nitrogen removal was also positively affected by an improvement of about 20%.



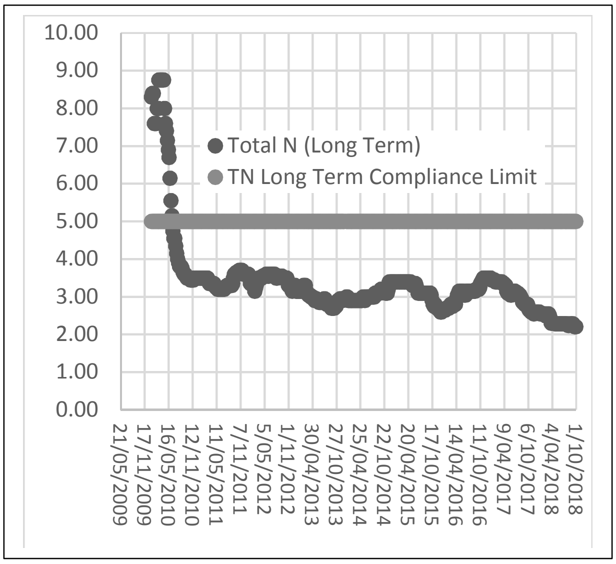
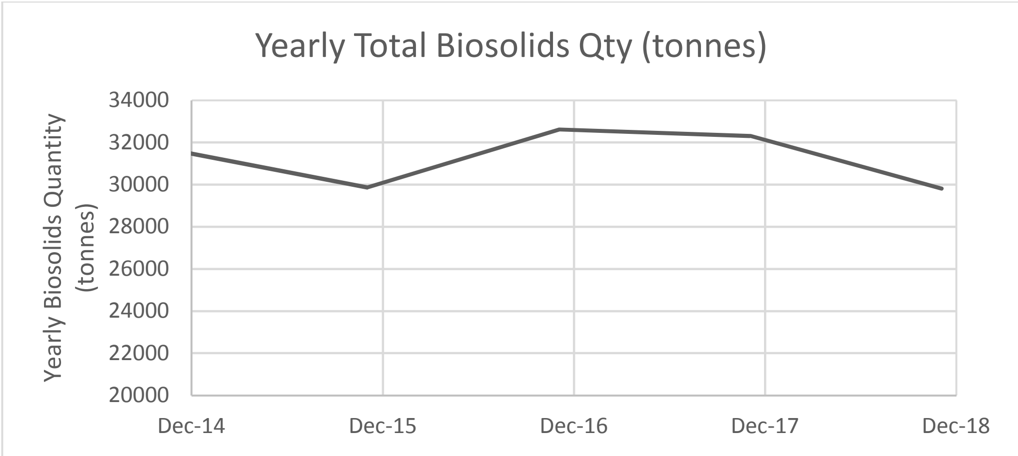
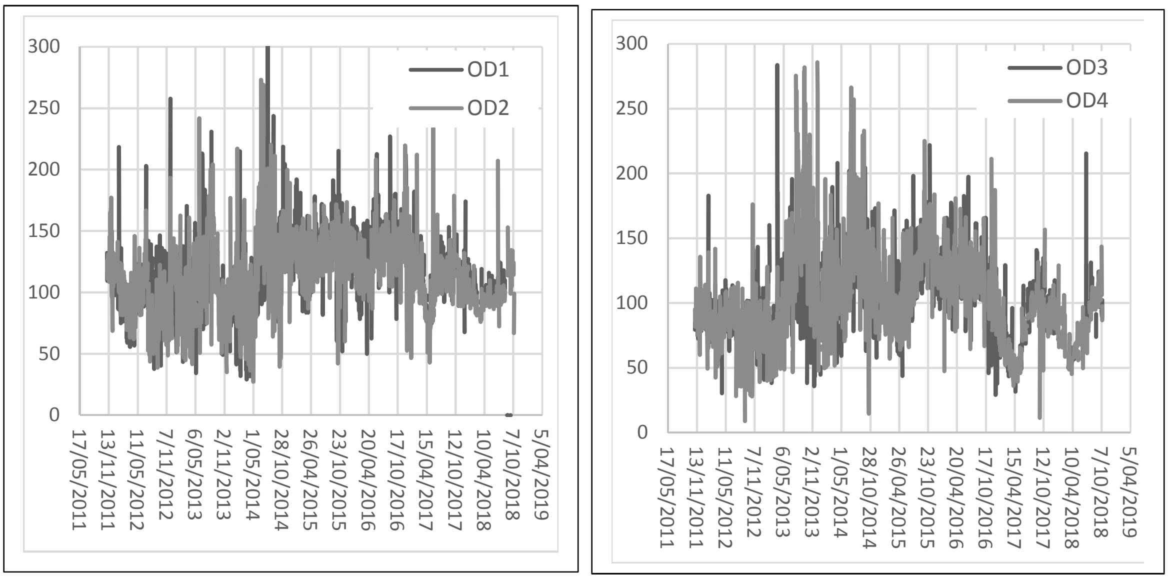


Figure 3: ***Long term TP and TN concentrations (mg/L) in treated effluent***

The mass of Biosolids generated at the plant was also positively affected. The previous assumption (trial described in Section 5) of 13 – 34% increase of biosolid quantity was proven wrong. Ferrous chloride dosing produced drier Biosolids cake (on average 1.5 % drier).



<u>Figure 4</u>: **Generation of biosolids per year**



<u>Figure 5</u>: ***Sludge Volume Index (mL/g) in oxidation ditches***

7.0 CONCLUSION

Ferrous Chloride dosing at Loganholme Wastewater Treatment Plant has been proven effective. With 0.005% v/v chemical dosing, long term TP of 1.5 mg/L can be maintained efficiently. To achieve efficient results, controlled flow paced dosing with flow capping are proven important to avoid overdosing of chemicals, maintaining pH in biological process and prevent corrosion in concrete structure and mechanical units. Ferrous chloride also showed a positive impact on sludge dryness because it improves sludge settleability. As ferrous ion deposits on magflow meter tube, it is recommended to use Ferrous/Ferric Chloride dosing downstream of magflow meter and should not be adjacent to magflow meter.

8.0 ACKNOWLEDGEMENT

Loganholme operators and maintenance staff who assisted happily during the trial and ongoing operations. We would like to thank Logan Water Infrastructure Alliance (LWIA) for their good works on upgrading the system based on the trial report prepared by Treatment Program. A special thanks to Water Business Manager for support and encouragement.

CONTROLLING THE ODOURS AND MINIMIZING THE HYDROGEN SULPHIDE AT THE BUNDAMBA SEWAGE TREATMENT PLANT

Paper Presented by:

Martin Coromandel

Author:

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Queensland Urban Utilities

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Bundaberg Multiplex Centre, Bundaberg
5 & 6 June, 2019

CONTROLLING THE ODOURS AND MINIMIZING THE HYDROGEN SULPHIDE AT THE BUNDAMBA SEWAGE TREATMENT PLANT

Martin Coromandel, *Treatment Team Leader*, Queensland Urban Utilities

ABSTRACT

The Bundamba sewage treatment plant provides wastewater treatment to the majority of the Ipswich region. Queensland Urban Utilities (QUU) operates and maintains the treatment plant for the Ipswich City Council. The treatment plant is a biological nutrient removal plant which also services the advanced water treatment plant which is part of the recycled water grid.

Odour complaints have been received from staff and high levels of hydrogen sulphide (H_2S) were measured on data loggers. A thorough study of the environment, plant and equipment was done to look at the source of the H_2S. This insight was a way to identify the issues and improve the working environment for our staff. The operators monitored various times, locations, operational trends, and odour control equipment. They also implemented a misting dosing system and tracked the results.

It was found that there were some minor cost effective operational changes that were needed to improve the working environment for the staff, and reduce the effects of the odour and H_2S. QUU plan to construct a new inlet works to improve the inlet process and reduce the odours and H_2S.

<u>Figure 1:</u> ***The Bundamba Sewage Treatment Plant***

1.0 INTRODUCTION

The Ipswich region has grown from 141,000 in population in 2006 to 206,459 people in 2017. Over the years we had three operators became ill, and have since returned to work at QUU. This prompted an investigation by the operators to improve the working conditions. The environment was monitored by a data logger and the data extracted for analysis.

The operators found various trends and high levels of H_2S in the lunch room, laboratory, and around the main building. There were levels of H_2S as high as 200ppm recorded. The majority of the H2S was coming from the inlet. So a study was done to identify the issues and operations planned to identify ways to reduce the effects of the H_2S and improve the odour control unit reliability. There are many options with dosing ferrous into the network, or look at what can be done at the wastewater treatment plants.

Figure 2: ***The inlet works and lunch room locations***

2.0 DISCUSSION

To identify the levels of hydrogen sulphide coming into the plant through the influent and to assess potential ferrous dosing rates SAS Laboratory tested dissolved sulphides to help operations make decisions using the data. The dissolved sulphides were high during the early hours of the morning as found in our results.

Table 1: ***Dissolved Sulphides testing at Bundamba***

Method	Test	Units	20/7/2018 0800	20/7/2018 1000	20/7/2018 1200
F.002	pH- Field	pH unit	6.88	7.46	7.82
F.005	Temperature	Degrees Celsius	20.9	21.0	19.0
1.609	Dissolved Sulphides as S	mg/l	19	7.7	9.8

2.1 Hydrogen Sulphide Monitoring

To gather some data on the working environment, the operators not only tested for dissolved sulphides but data loggers were placed in four locations to identify the levels of H_2S in the atmosphere.

Locations

1. In the Lunch room at Bundamba STP.
2. The back of the Control room near the septic pump station.
3. The inlet building.
4. Outside the control room building.

It was identified that the inlet works was the most affected by the H_2S, so procedures were improved to ensure the operators were protected from the high levels of H_2S.

Gas monitoring devices are now essential when accessing the inlet building and a full face mask must be worn. According to the data we have collected and in reference to the Government of Western Australia department of health it was found our levels in the lunch room were in the range from 0.008ppm-2ppm which at 2.0ppm can cause bronchial restrictions.

Table 2: ***The exposure and effect levels for hydrogen sulphide in the air.***

Level in the Air (ppm)	Impacts and Health effects
0.008	Increase possibility of annoyance and headache, nausea, and fatigue
2	Bronchial restrictions
4	Increased eye complaints
5-10	Minor metabolic effects
20	Neurological effects including memory loss and dizziness

According to the Western Australian Department of Health recommends exposure limits of hydrogen sulfide air quality guidelines developed by the World Health Organization as shown in Table 3.

Table 3: ***Recommended standard exposure limits to H_2S***

Limit (ppm)	Average timeframe
2	30 mins
0.1	24 hours
0.014	90 days

2.2 The Lunch Room Monitoring

The lunch room and SCADA room was monitored to look at ways to reduce the H_2S. This is where the operators spend a lot of their time. They do a lot of their meetings, tool box talks, inductions and complete permits to work for all contractors. The exhaust of the odour control units were tested to identify how much H_2S was being released from the odour units and to check their efficiency. The normal reading coming from the exhaust of the odour units should be zero.

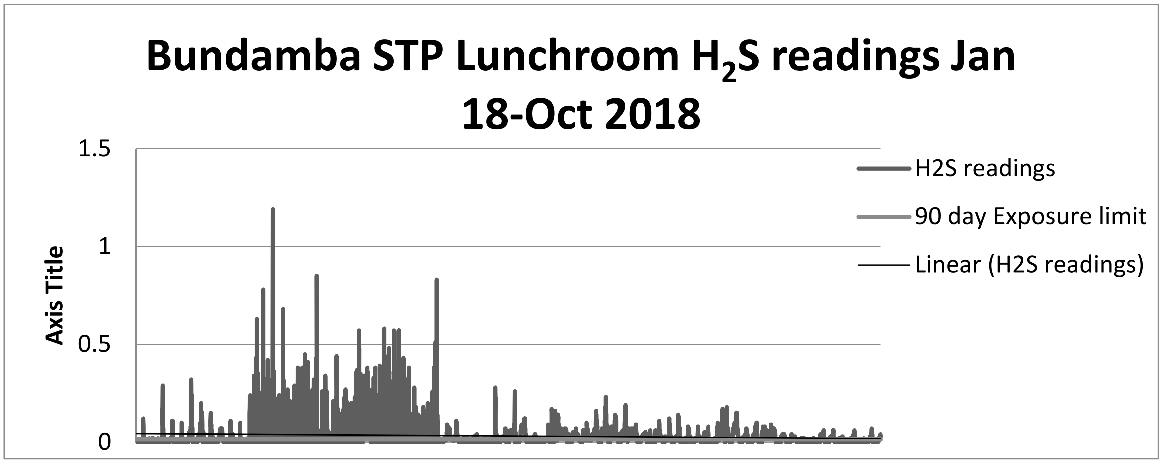
Table 4: ***H_2S samples taken from the odour control units***

Dates	Odour Unit 1 (ppm)	Odour Unit 2 (ppm)
21 May 2018	7.6	5.2
22 May 2018	6.8	12.9
23 May 2018	5.4	10.4
24 May 2018	6.9	7.8
25 May 2018	7.0	9.8
28 May 2018	5.8	7.6
29 May 2018	6.3	4.1

The H2S in the lunch room peaked on average at 1.2ppm and it was found that the odour control units needed new carbon installed to be more efficient with the H_2S reduction.

A majority of the labour was done by the operators, and unused carbon from Oxley Creek STP was used to refurbish one unit which saved $4,500 in carbon costs. The total cost to QUU was $6,580 to refurbish the carbon in both odour control units and with the operators doing 90% of the work. By the operators completing this task and recycling unused carbon we saved $9,040.

We identified the average ppm drop from 0.2ppm to 0.03ppm in the lunch room almost immediately. On most occasions readings of 0.00 ppm were recorded.



<u>Graph 1:</u> ***Data taken from an odour logger positioned in the Lunch room***

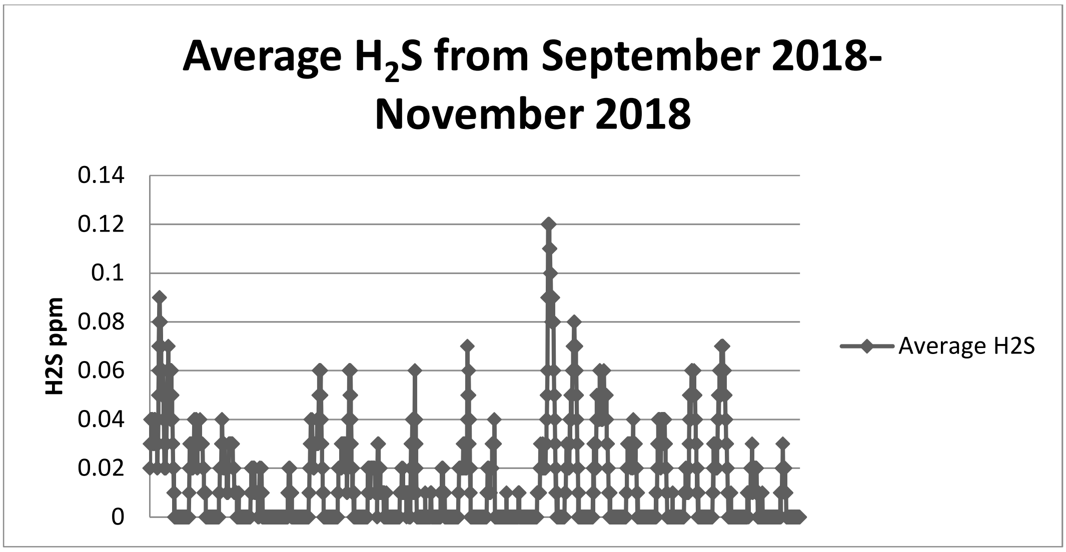
2.3 Reducing the H_2S Through a Misting System

During the mornings and upon arrival to the treatment plant the lunch room would still have occasional readings of H_2S so we implemented a fine misting system at the inlet which dosed a supressing agent that reduces the H2S and also deodorises the work area. This chemical is called Atmosphere and has been found to remove and eliminate some hydrogen sulphide in the atmosphere and results can vary between 98%-99% as found in a study at the Sydney University by Dr Jeffery Shi FRACI C Chemical Manager and Chief Consultant Analytical and Testing Laboratory.

A trial was initiated to identify how much more H2S we could look at reducing by implementing this misting system. The system consisted of a Dema dosing pump which does not need electricity. It is connected to potable water and has a valve with an automatic timer to open at set times. The atmosphere chemical is then pumped and mixed by the Dema pump and distributed to a misting system. To install this trial system cost QUU $1,153 and an additional $2,662 for plumbing to get the potable water up to the inlet screen level.

<u>Figure 3:</u> ***Misting pump set up*** **<u>Figure 4:</u>** ***Fine mist over grit channel***

The operators managed to reduce the 90-day exposure average to 0.0125ppm from September 2018 to November 2018 it is recommended that the 90-day exposure limit is 0.014ppm or below. Concerns were still raised that further work is needed to reduce the H2S and constantly monitor the environment. The ultimate goal was to provide a better work place for our staff.



<u>Graph 2:</u> ***Average H_2S results from the lunch room after implementing misting system***

3.0 CONCLUSION

It was identified that there were some very simple solutions to some of the issues the team at Bundamba encountered. Through a thorough in-house study of our working environment we had some great data to make some informed decisions. The refurbishment of the odour control units completed by our operational staff was a step forward to getting our plant working correctly. Through this work we were able to reduce the 90-day exposure limit. Operations saved $9,040 doing all the labour and reusing unused carbon.

It was important to the team that all staff and contractors need to wear an H_2S monitor when accessing the inlet works. A full face mask was also implemented when entering the building to ensure extra protection.

The atmosphere misting system was a very affordable solution towards reducing some of the H_2S and also creating a pleasant odour around the inlet works. We identified immediate results from starting the trial in August 2018. The initial set up only cost $1,153 for the pump and misting system and $5,000 a year on chemical costs.

Options to dose ferrous are also available to reduce H_2S and a thorough trial was needed to identify the impact it will have on the process. QUU currently dose ferrous into the network in various locations and also at the Luggage point sewage treatment plant.

The H_2S reduction at Bundamba still requires more remedial work needed to improve the working environment but has steered in the right direction to look at possible solutions.

Funding for the new inlet works and a new staff building was approved with a project delivery in 2020. This upgrade will provide greater serviceability for the growing city of Ipswich, increase process reliability, improve working conditions and provide a safe and pleasant work place for all QUU staff, contractors and visitors.

4.0 ACKNOWLEDGEMENTS

I want to acknowledge the staff in the Ipswich team that helped in this study, and everyone who implemented changes and repairs to improve the working environment, and especially the team at the Bundamba STP.

5.0 REFERENCES

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PERFORMANCE STUDY: REMOVAL OF PFAS CONTAMINANTS WITH POWDERED ACTIVATED CARBON

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PERFORMANCE STUDY: REMOVAL OF PFAS CONTAMINANTS WITH POWDERED ACTIVATED CARBON

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ABSTRACT

The presence of per- and polyfluorinated alkyl substances (PFAS), in particular PFOA and PFOS, in many raw water sources is of increasing concern across water treatment and regulatory bodies and consumer communities. This study aimed to investigate the ability of a range of PACs to remove PFOA and PFOS from a wide range of water matrices, with varying total PFAS concentrations, DOC levels and in the presence of taste and odour compounds MIB and geosmin.
It was found that the majority of PACs tested could simultaneously remove in excess of 95% of PFOA, PFOS and MIB/geosmin, although performance was hindered in high DOC waters, highlighting the importance of PAC performance testing to provide operational certainty for a given application. These findings enable water treatment plant operators to assess whether their current PAC product and dosing systems are well suited for use for removal of PFAS contaminants, or if an alternative PAC product can improve performance and better manage PFAS risks in raw water supplies.

1.0 INTRODUCTION

With per- and polyfluorinated alkyl substances (PFAS), in particular perfluorooctanoic acid (PFOA) and perfluoro octane sulfonate (PFOS), currently dominating the list of microcontaminants of concern for water and waste water treatment plant operation, there is increasing interest in treatment options to manage the risks posed by these compounds. Given granular activated carbon (GAC) has been successfully used as a filter medium for adsorption of PFAS contaminants, it stands to reason that powdered activated carbon (PAC) should also be effective. This study aimed to investigate the use of a range of PACs to remove both industrial PFAS contaminants and individual compounds (PFOA and PFOS) from low DOC (potable) waters, and a higher DOC raw water analogous to a surface water. In order to simulate real world conditions, a final scenario was studied in which PFOA and PFOS were introduced to raw waters containing MIB/geosmin, to provide an indication of performance where PAC is currently being dosed for taste and odour (T&O) removal.

2.0 DISCUSSION

2.1 Materials and Method

PAC samples were provided by Activated Carbon Technologies Pty Ltd. The material properties of the PACs used in this study are given in Table 1. Test water matrices (M1 – M6) are given in Table 2. 10 g/L working stock samples of each PAC were prepared by dissolving 1g of dried PAC in 100 mL of MilliQ water.

PFOA and PFOS spiking (M1 & M2) was carried out with working stocks prepared from pure reagents provided by Sigma-Aldrich, and an industrial waste water (approximately 3.3 mg/L total PFAS; 210 µg/L PFOA; 950 µg/L PFOS) was used to spike a broader range of PFAS contaminants (M3 – M5). MIB and geosmin spiking was carried out using in house samples (M5 & M6).

Table 1: ***Raw Material Properties for PAC samples used in performance study Note – SAC refers to Steam Activated Coal; SACo refers to steam activated coconut***

Material Properties	Acticarb PS800	Acticarb PS1000	Acticarb PS1000F	Acticarb PS1300F	Acticarb 1:1 PS1300F/PC1000
Raw Material	SAC	SAC	SAC	SAC	SAC/SACo
Iodine Number	888	1006	1012	1214	991
Tannin Value	260	259	217	128	240
Methylene Blue Adsorption (g/100 g)	17.9	19.6	22.7	24.3	18.0
Ash Content (%)	10.0	10.3	10.8	13.7	8.5
Volatile Content (%)	6.9	3.1	3.3	3.5	2.8
D_{50} (µm)	17.5	18.6	13.5	13.8	16.4

Table 2: ***Raw Water Matrix data for PAC performance studies***

Raw Water Properties	M1	M2	M3	M4	M5	M6	M7
DOC, mg/L	1.7	7.2	1.7	1.7	1.8	2.8	2.8
True Colour (CPU)			3	3	3		
UV254 absorbance (abs/cm)			0.05	0.05	0.05		
MIB (ng/L)					20	115	87
Geosmin (ng/L)					28	107	118
PFOA (µg/L)	9.3	13	0.7	8.2	0.7	9.7	
PFOS (µg/L)	10	11	2.4	27	1.8	6.5	
Total PFAS (28 analytes) (µg/L)			9.1	102.4	9.8	16.3	

The test water matrices were created to assess the following scenarios:

- Maximum removal levels of PFOA/PFOS in a low DOC water with no other PFAS contaminants present (M1)
- DOC blinding effects on PFOA/PFOS removal with no other PFAS contaminants present, in a high DOC water (M2)
- Selective removal of PFOA/PFOS in low and high PFAS water matrices (M3 & M4)
- Continued removal of PFOA/PFOS in a low PFAS water matrix, with MIB/geosmin introduced as per seasonal events (M5)
- Continued removal of MIB/geosmin in a low DOC water matrix when PFOA/PFOS are introduced (M6), and comparison with removal of high levels of MIB/geosmin only (M7)

Jar testing was conducted in 1 L jars with 1 L of the appropriate test water matrix. Dose rates of 10, 25 and 50 mg/L of PAC were used. Jars were initially slow mixed (60 rpm), followed by PAC addition, 15 minutes of continued slow mixing, and 45 minutes of settling time. Following settling, samples were filtered through a Whatman #1 filter paper and collected in an appropriate sample bottle for external analysis.

PFAS analysis was conducted by Eurofins MGT using the 28 analyte PFAS suite (LC-MS). MIB and geosmin analysis (SPME) was conducted by the Australian Water Quality Centre.

2.2 PFOS and PFOA Removal

Performance data for PFOA and PFOS removal in M1, M3 and M4 are given in Table 3. Considering the 25 and 50 mg/L dose rate data, there is little difference in PAC performance in M1 (PFOA/PFOS only, low DOC) and M4 (PFOA/PFOS with other 100 µg/L PFAS contaminants, low DOC) for PS800, PS1000, PS1000F and PS1300F.

This suggests these PACs have excellent selectivity for PFOA/PFOS. Figure 1 shows the consistency of PFOA/PFAS removal across the range of conditions at 50 mg/L. All PACs generally removed the most PFOA/PFAS in M3, where the initial concentrations of each was low, (0.7 and 2.4 µg/L respectively). The PS1300F/PC1000 blend was trialled as it was thought the coconut based PAC may have a greater selectivity for PFAS based on its microporous structure. However, it did not perform better than the comparable coal based PAC, PS1000, and was not tested with M3 and M4.

Table 3: ***PFOA and PFOS removal, matrices M1, M3 and M4***

PAC Dose (mg/L)	PFOA (Left) and PFOS (Right) Removal (%) – M1									
	PS800		PS1000		PS1000F		PS1300F		PS1300F/PC1000	
10										
25	57.0	77.0	64.5	78.0	75.3	90.0	86.0	95.6	52.7	75.0
50	81.7	97.0	94.3	98.0	97.0	98.6	98.1	99.3	91.8	96.7
	PFOA (Left) and PFOS (Right) Removal (%) – M3									
10	37.3	63.3	41.8	69.6	47.8	74.2	55.2	82.5		
25	65.7	85.8	74.6	91.3	77.6	93.3	88.1	97.1		
50	89.6	97.1	95.5	98.3	95.5	98.3	97.0	97.9		
	PFOA (Left) and PFOS (Right) Removal (%) – M4									
10			31.7	48.1	34.1	51.9	45.1	70.4		
25	56.1	77.4	65.9	79.6	73.2	88.5	82.9	94.4		
50	86.6	95.6	93.3	97.2	94.6	97.3	96.8	98.4		

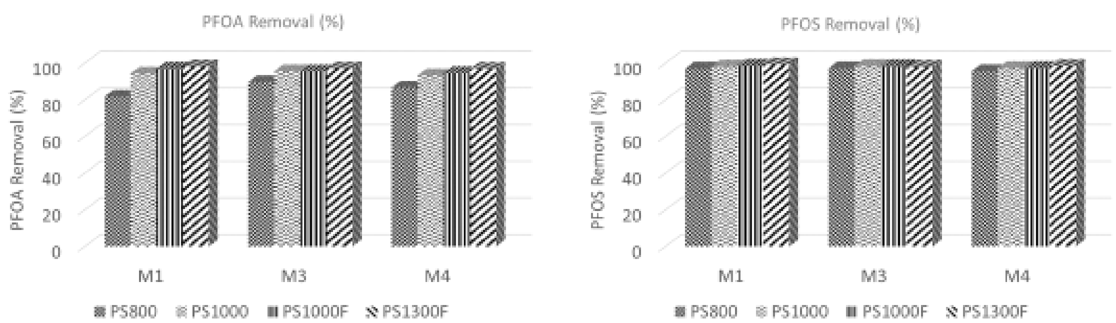


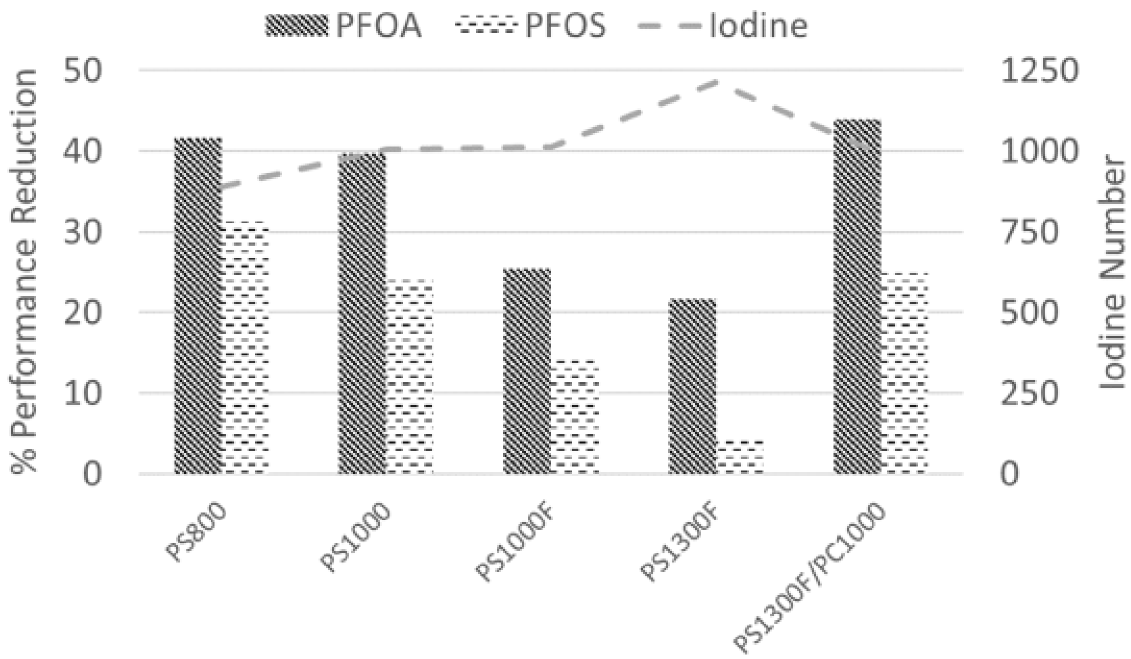
Figure 1: ***PFOA (left) and PFOS (right) removal, M1, M3 and M4, 50 mg/L dose rates***

2.3 DOC Blinding Effects

DOC blinding effects are apparent when comparing performance of PACs between M1 & M2. This data is given in Table 4. All PACs saw a reduction in the ability to absorb PFOA/PFOS in higher DOC water. Figure 2 shows the performance reduction for all PACs. For all PACs, the reduction in PFOA removal performance in high DOC water was higher than that for PFOS, and the magnitude of the performance reduction decreased with increasing iodine number. One exception was again the PS1300F/PC1000 blend, which had comparable performance reduction to PS800 for PFOA removal, suggesting that coconut based PACs do not perform as well as coal based in this application. These results highlight the complexity of DOC effects on PAC performance, and the need for comprehensive performance testing to increase certainty in a given application.

<u>Table 4:</u> ***PFOA and PFOS removal, matrices M1 and M2***

PAC Dose (mg/L)	PFOA (Left) and PFOS (Right) Removal (%) – M1									
	PS800		PS1000		PS1000F		PS1300F		PS1300F/PC1000	
25	57.0	77.0	64.5	78.0	75.3	90.0	86.0	95.6	52.7	75.0
50	81.7	97.0	94.3	98.0	97.0	98.6	98.1	99.3	91.8	96.7
	PFOA (Left) and PFOS (Right) Removal (%) – M2									
25	25.4	38.2	33.8	41.8	43.1	55.5	37.7	70.9	27.7	52.7
50	47.7	66.4	56.9	74.5	72.3	84.5	76.9	95.1	51.5	72.7



<u>Figure 2:</u> ***Performance reduction for adsorption of PFOA and PFOS between M1 and M2, 50 mg/L dose rate, with iodine number***

2.4 Simultaneous PFAS/MIB/Geosmin Removal

Performance data for PFOA, PFOS, and MIB/Geosmin removal in M5 and M6 are given in Table 5. PS1300F, as the best performing PAC for PFOA/PFOS removal, was selected for these trials, with PS1300F/PC1000 included to investigate the performance of coconut based PAC in this scenario. Following 100% removals of T&O compounds in M5, PS13000F was tested with M6, with higher levels of MIB, geosmin, PFOA and PFOS.
The data in Table 5 shows that both PACs removed 100% of T&O compounds in M5, when T&O compounds were spiked at typical levels of approximately 20 – 30 ng/L. At 50 mg/L doses, both PACs also selectively removed in excess of 95% of PFOA and PFOS from a range of PFAS contaminants, again highlighting excellent selectivity for these compounds.

When dosed at 30 mg/L in M6, PS1300F removed almost 95% of PFOA and MIB, 98% of PFOS and 100% of geosmin. The T&O removal performance in M6 was similar to that in M7, indicating that performance has not been compromised by the introduction of PFAS contaminants.

Given the magnitude difference of concentration between T&O compounds (ng/L) and PFOA/PFOS (µg/L), high levels of removal of both contaminants, especially when T&O were present at very high levels of approximately 100 ng/L in M6, suggest that these contaminants are adsorbed at different active sites or pores within the PAC, and removal performance was maintained across both scenarios. This is displayed graphically in Figure 3.

<u>Table 5:</u> ***PFOA, PFOS, MIB and Geosmin removal, matrices M5, M6 and M7***

PAC Dose (mg/L)	PFOA (Left) and PFOS (Right) Removal, M5				MIB (Left) and Geosmin (Right) Removal, M5			
	PS1300F		PS1300F/PC1000		PS1300F		PS1300F/PC1000	
25	87.7	95.0	78.5	85.6	100.0	100.0	100.0	100.0
50	98.5	98.9	95.4	96.7	100.0	100.0	100.0	100.0
	PFOA (Left) and PFOS (Right) Removal, M6				MIB (Left) and Geosmin (Right) Removal, M6			
10	51.5	70.8			77.4	88.8		
30	94.3	97.8			94.4	100.0		
					MIB (Left) and Geosmin (Right) Removal, M7			
10					77.0	90.7		
30					95.4	96.6		

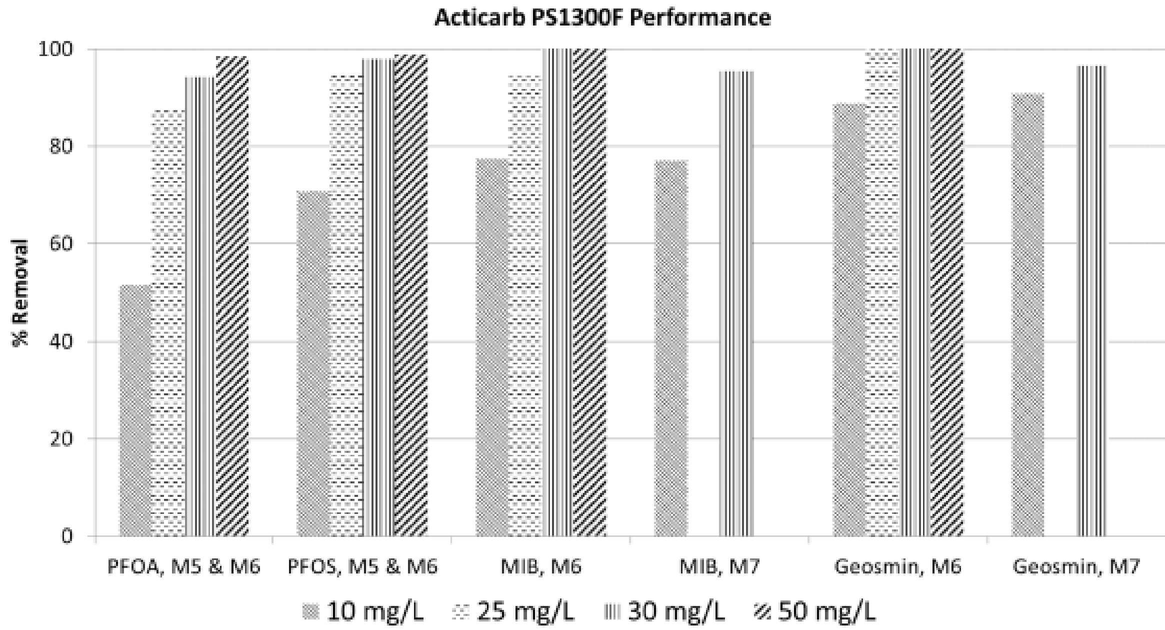


Figure 3: ***Percent removal of PFOA, PFOS, MIB, Geosmin, matrices M6 and M7***

3.0 CONCLUSION

The jar testing showed that all PACs used in the test work program performed well in a range of scenarios for removal of PFOA, PFOS, other PFAS contaminants, and T&O compounds. In general, PAC performance in terms of contaminant removal increased with increasing iodine number and methylene blue adsorption, and decreasing tannin value (tannin value being an inverse performance indicator). Finer PACs also performed better where iodine number was comparable. The steam activated coal and steam activated coconut blended PAC (PS1300F/PC1000) did not perform as well as a comparable steam activated coal PAC (PS1000), indicating that steam activated coconut PACs are not as effective as steam activated coal in these applications.

The performance of all PACs increased with dose rate, as expected. It is interesting to note that when dosed at 50 mg/L, all PACs with the exception of PS800 and the PS1300F/PC1000 blend removed high levels of PFOA and PFOS, suggesting that a more adsorptive (and hence more expensive) PAC is not necessarily required to remove these contaminants; an existing PAC can be dosed at higher rates to achieve the same result. This will however have implications for powder handling, PAC dosing, and sludge generation and handling, and should be carefully investigated prior to implementation at full scale.

The DOC blinding effects show that increased DOC strongly effects PAC performance. DOC fluctuations in raw water sources are common and may occur due to natural seasonal variations in raw water quality or as the result of rainfall events. The best means of ensuring that a given PAC can perform across the range of expected conditions is via a thorough jar testing program with appropriate water matrices and contaminant spikes. Such a testing program is an essential tool in risk management frameworks and allows operators to respond to a range of scenarios whilst maintaining confidence in finished water quality.

REDUCING WATER QUALITY RISKS DURING HIGH SOURCE WATER BROMIDE AND SALT EVENTS

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REDUCING WATER QUALITY RISKS DURING HIGH SOURCE WATER BROMIDE AND SALT EVENTS

Duncan Shillito, *Operations Coordinator Water Treatment Central Region, Seqwater*

ABSTRACT

Seqwater's largest Water Treatment Plants (WTPs), Mt Crosby East Bank and West Bank, produce up to 800 ML/d combined that supplies the majority of drinking water for the South East Queensland (SEQ) region associated with The Water Grid. The raw water source 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. Without intervention (outside of normal operations), risks passed onto Queensland Urban Utilities and Logan City Council and their consumers include disinfection by-products, measured as total trihalomethanes (THM) exceeding Australian Drinking water Guidelines (ADWG) guideline values and the potential for taste and odour complaints due to the higher salt levels.

This paper provides background and discusses Seqwater's application of its Bromide Management Plan following inflows of high levels of salt and bromide into the raw water from the Black Snake Creek in October – November 2018.

1.0 INTRODUCTION

In recent years, the SEQ drinking water supply entities have been developing improvements to the disinfection regime across the regions that receive drinking water from the Water Grid. It's been decided that the central region comprising; Brisbane, Ipswich and Logan will retain a chloramine regime, whereas Gold Coast, Redland and Sunshine Coast regions will continue using free-chlorine. The Water Grid converts the disinfection state between these regions, via break-point chlorination and chloramination at three dosing facilities. In a chloramine environment disinfection by-products (THM) are considered a low risk with the THM formation post treatment remaining low. In a free-chlorine environment, THM continue to increase depending on; bromide and organic levels post treatment, free-chlorine residual, the water age and number of doses on free-chlorine. Although THM can leave the WTPs at low levels <100 µg/L, the ADWG guideline value of 250 µg/L can still be realised in free-chlorine systems, especially with organics >3.5 mg/L Total Organic Carbon elevated bromide. This is the case of the Water Grid operating in break-point mode and where retail entities break-point chlorinate the extremities of their chloramine systems to maintain safe drinking water.

The focus of this event is that with increased bromide in the raw water, three out of the four THM fractions will be increased.

2.0 DISCUSSION

Following an investigation into a 2015 incident where high THM levels (290 µg/L) were observed in the drinking water supplied by the Water Grid (Southern Regional Pipeline), a linkage was established between increased salt and bromide levels in the MBR and the potential for high levels of THM in free chlorine environments. Seqwater water quality and process engineering staff developed the Bromide Management Plan which focusses on reducing organic levels in the drinking water to mitigate excessive THM formation when elevated levels of bromide and/or organics are recorded in Mt Crosby WTPs raw water.

The Bromide Management Plan follows Seqwater's Incident & Emergency philosophy and covers; establishment of a cross-sectional team with defined responsibilities, communication protocols, triggers for activation and de-activation of the Plan and review for improvement. The key elements of the Plan are to; understand the impacts of changes in the raw water (peaks and durations of salt and bromide) through intensive water sampling and monitoring in the raw water, WTPs and the Water Grid, apply mitigations such as increasing coagulation performance to reduce organics, consider reducing impact zones by changing the direction of the Water Grid and clear communication within Seqwater and water quality representatives of Queensland Urban Utilities and Logan City Council.

The 2018 Incident was formally activated from 22 October to 5 November, where the raw water conductivity and bromide levels at the WTPs were triggered (>450 µS/cm and 0.18 mg/L respectfully). An incident alert was raised prior to this, and the Plan was introduced following alerts of high levels of conductivity observed in the upper parts of the MBR.

The following sections provide background information and performance for the key elements of the Incident management; Catchment, Treatment Responses, River Flush, and Impacts.

2.1 Catchment

The catchment area supplying Mt Crosby WTPs covers approximately 10,473 km^2, which incorporates Lake Somerset and Lake Wivenhoe catchments (7,020 km^2) and the Lockyer Creek / MBR catchments (3,465 km^2). The predominant land use is classified as 'grazing & native vegetation' (66%). From a microbial pathogen perspective, the catchment is described as 'unprotected' and presents a high risk for bacteria, viruses and protozoa. In normal operation, water is released via multi-level baulks at Wivenhoe Dam. The water then travels along 60 km of MBR to Mt Crosby weir / raw water intake.

In dry weather periods, raw water at Mt Crosby weir / raw water intake is essentially supplied from Lake Wivenhoe (typically 90-100%). Water quality observed at Mt Crosby WTPs 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.

The Black Snake Creek catchment is well-known for its flooding and salinity issues. Wide-scale historical land clearing and farming from the late 1800s have altered the landscape vegetation and hydrology. During the millennium drought, continued pumping of water caused the groundwater levels to lower to a point whereby bedrock water rose into the alluvium. Following the 2011 flooding, the groundwater levels rose upwards causing brackish water to connect with the alluvial creeks. In addition, the geology of the catchment changed and results in 'catena form salinity' and 'saline seepages'.

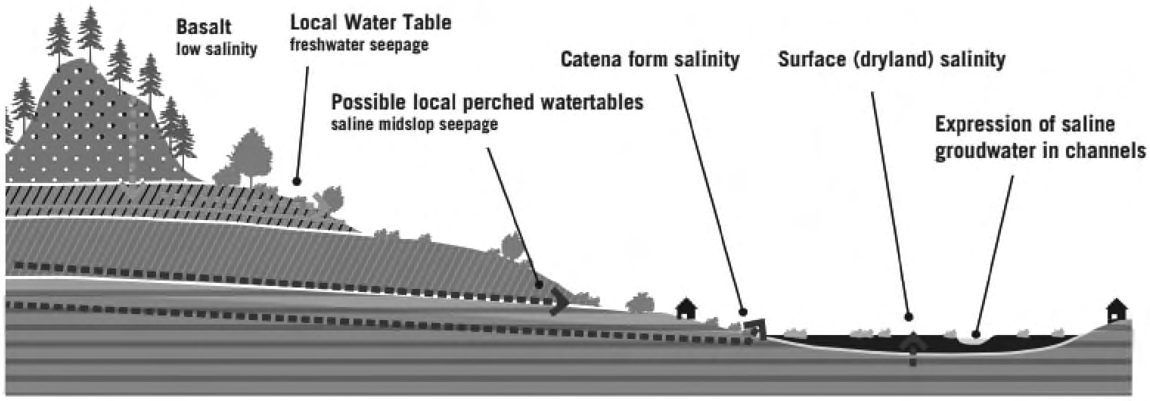

Figure 1: ***Salinity processes in Black Snake Creek***

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 conductivity. This event in October 2018 saw 2 separate injections of Black Snake Creek into the MBR of approximately 12,000 µS/cm. The volume was unquantified however, the effects of these injections raised the background levels in the MBR from 450 µS/cm to approximately 1,200 µS/cm in the upper sections, which indicates a potential large increase at Mt Crosby. Significant water quality grab sampling and analysis along the MBR during the event assisted online data to assist in predicting the salt / bromide levels for the event. Supporting staff from the Water Quality and Laboratory teams reprioritised their workload to provide results every few days. It was established that the correlation of conductivity to bromide was strong.

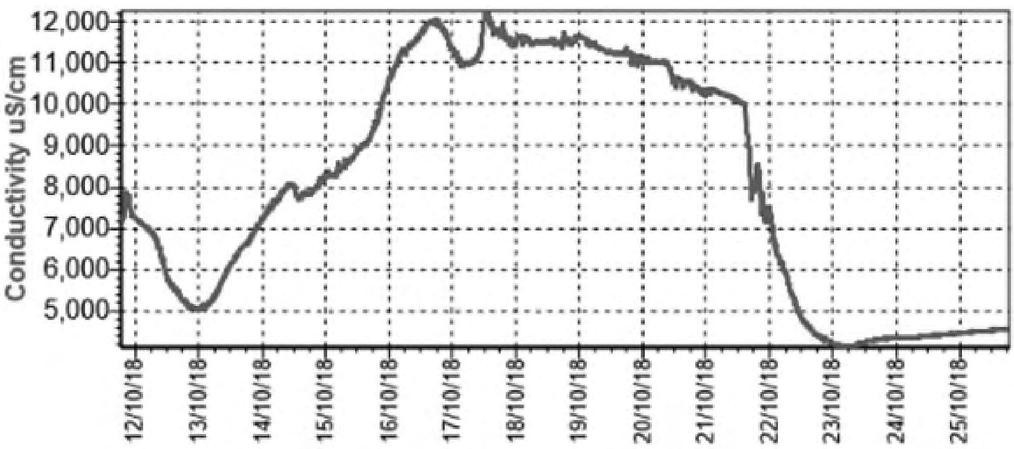

Figure 2: ***Black Snake Creek salinity – measured as conductivity***

2.2 Treatment Responses

Mt Crosby WTPs operate under Seqwater's Drinking Water Quality and Environmental Management Plans. Both 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. Typically, the normal operating objective for coagulation and sedimentation processes is to reduce turbidity and colour to assist the filtration performance requirements of the HACCP Plans are met.

The main operational challenges for the WTPs relate to typical raw water quality changes from the river-based source water such as high levels of turbidity following heavy rainfall / flooding and high supply demands which can be managed by the existing treatment processes.

Neither salt nor bromide can be removed by the existing processes, therefore the Plan's strategy is to enhance the reduction of THM precursors such as Natural Organic Matter (NOM) with higher alum doses to offset the increased THM formation potential of higher bromide concentrations. Operationally, a change in the regime and performance targets are employed; from typical settled water colour and turbidity - to settled water organics levels. The operational treatment target derived 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 the actual and potential THMs produced. A coagulation pH of 5.8 is adopted.

Some introduced risks of significantly increasing alum doses include; reconfiguration of the HACCP Plan and adjustments of control systems, increased alum consumption (maintain sufficient stocks and cost), increased sludge production (handling and cost), addition of higher lime doses and sodium hydroxide (to offset low coagulation pH levels from increased alum doses), increased monitoring (jar tests, settled water) and the potential for reduced filtered water performance (poor settling floc).

A series of jar tests from various sections of MBR were routinely 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 target were met. Refer to Table 1.

<u>Table 1:</u> ***Operational targets based on Raw Water Changes***

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

Upon application of the target Bromide Factor Value, operational limitations were realised. With the high doses of alum (from background of 8 mg/L Al_2O_3 to 27 mg/L), the sodium hydroxide dosing system was engaged to raise the pH. The lowest dosed water pH and settled water UV245 achievable at both WTPs was 5.8 and 0.036 cm^{-1} respectively. The floc was observed to be very light and excess carryover was evident. At this point, filtered water quality was unstable (although in specification). Any further efforts to reduce organics without compromising filtration was considered a high risk.

During the event, treated water from both WTPs were analysed for THM (total and individual) as well as testing the THM formation potential. The background THM range under normal raw water quality and operations 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 half of the maximum observed under the THM formation potential testing due to water age and dose rates applied in the test. Refer to Table 2.

Table 2: ***Mt Crosby WTPs THM results***

Mt Crosby WTPs	Min	Max	Average	Formation Potential
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

2.3 River Flush – Additional Dam Releases

In dry weather conditions nearly 100% of raw water requirements for Mt Crosby WTPs is supplied by releases through Wivenhoe Dam. Some minor losses are incurred through the MBR by irrigation schemes, evaporation and sub-surface flows. River level targets are set at Mt Crosby weir to guide Wivenhoe releases to provide sufficient supply for raw water pumping and environmental flows. Although not explicitly referred to in the Plan, an option exists to reduce / dilute the salt and bromide levels in the MBR by additional releases from Lake Wivenhoe. Seqwater has undertaken this option in recent similar events and for this event, it was determined that the levels of salt and bromide would be outside the capabilities of management through current treatment processes. Additional releases from Lake Wivenhoe to dilute the peak and duration the event would be active was 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 reduce the peak and duration of the event significantly (thick line vs thin line).

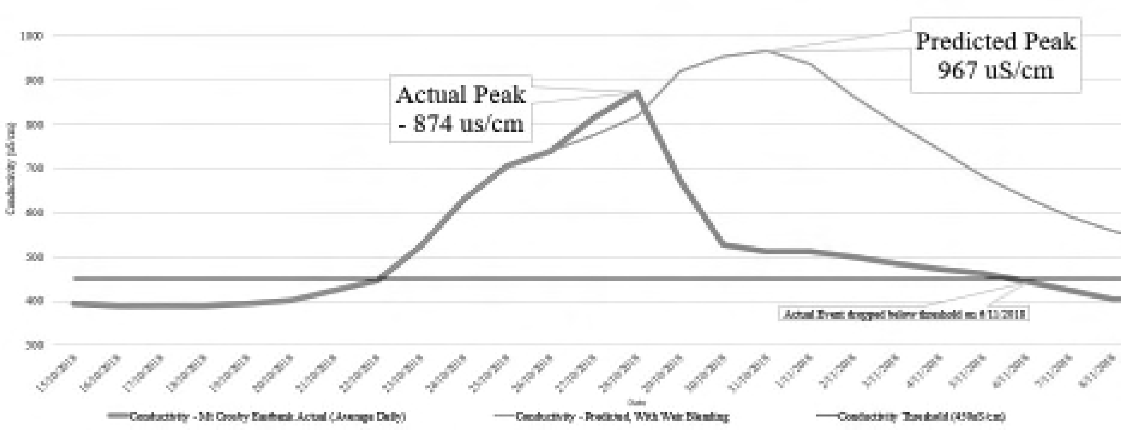

Figure 3: ***Conductivity at Mt Crosby. thick line = actual, thin line = predicted***

2.4 Potential Impacts – Disinfection By-Products, Taste & Odour complaints

Seqwater's most likely supply system to observe high levels of THM 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, this highest level of THMs observed in this system was 160 µg/L.

Reports from Queensland Urban Utilities and Logan City Council indicate that all results for THM were >250 µg/L, which is vast improvement on the last high salt and bromide event (2017). It is relevant to add that both utilities have recently worked with the Water Unit of the Queensland Department of Health to implement management plans to identify and reduce THM. The plans are similar in nature and employee techniques such as; trigger-based monitoring, reduction of water age by flushing dead ends, reduction in additional free chlorine doses and aeration of reservoirs to drive off chloroform.

According to the ADWG, taste & odour complaints can be experienced from salty water at levels around 600 mg/L total dissolved solids (equivalent to 1,000 µS/cm conductivity). During the event, no water quality complaints of this nature were reported to Queensland Urban Utilities or Logan City Council.

3.0 CONCLUSION

The mitigations of significantly increasing alum doses (reduce THM formation by reducing organics) and additional releases from Wivenhoe Dam (reduce peak and duration of event) were successful in managing this raw water salt and bromide inflow event. All THM results across Seqwater and retail systems were under the ADWG guideline value and no customer complaints were recorded.

An internal review of the Incident and application of Bromide Management Plan was undertaken by key staff involved in the event. It was determined that the Plan was followed effectively including; adherence to the Incident & Emergency process, internal and external communications and ownership of roles and responsibilities. Improvements to the Plan were identified such as earlier formal activation of the Plan based on upstream river data and the inclusion of river flushes / dilution activities.

The overwhelming improvement required to mitigate 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. Although conductivity is currently measured by online instruments, accurate flow measurement of injections into the MBR would provide more warning of similar events.

4.0 ACKNOWLEDGEMENTS

Managing water quality events that cover catchments, stored water, dams, treatment, bulk transport and retail entities takes considerable coordination and agreement. Seqwater Operations staff are blessed to have knowledgeable, reliable and dedicated support teams that are eager to assist. Thanks to the Process Engineering and Water Quality (Advisors, Sampling, Laboratory) teams. Also, thanks to water quality representatives from Queensland Urban Utilities and Logan City Council who continue to work together with Seqwater during these challenging events.

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CYBER SECURITY OF CRITICAL INFRASTRUCTURE IN QUEENSLAND WATER SERVICES

Paper Presented by:

Mandy Downes

Authors:

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Department of Natural Resources, Mines and Energy

44th Annual WIOA
Queensland Water Industry Operations Conference and Exhibition
Bundaberg Multiplex Centre, Bundaberg
5 & 6 June, 2019

CYBER SECURITY OF CRITICAL INFRASTRUCTURE IN QUEENSLAND WATER SERVICES

Mandy Downes, *Executive Director Operations Support,* Department of Natural Resources, Mines and Energy (DNRME)
Tracy Vincent, *A/Director Water Supply Regulation,* DNRME
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ABSTRACT

Cyber security requirements have been integrated into Queensland's regulatory framework for drinking and recycled water service providers. The new requirements are in response to recommendations made in the Queensland Audit Office's (QAO) report on the Security of Critical Infrastructure (Report 19:2016-17).

QAO's audit aimed to determine the vulnerability of critical infrastructure to information technology and cyber security hazards. The investigation was conducted with a small number of large entities that provide water and sewerage services. However, as approximately 44 per cent of service providers in Queensland supply communities of less than 1000 connections and with enormous variability in terms of resources and operations, the Department of Natural Resources, Mines and Energy (DNRME) subsequently conducted case studies within five medium to small organisations.

These case studies found a range of security issues which, in most cases, were easily addressed. Through the incorporation of cyber security in DNRME's regulatory framework we expect to create awareness of these issues, encourage monitoring for incidents and promote planning for responding and recovering from incidents.

1.0 INTRODUCTION

The Queensland government recognises the importance of maintaining continuity of drinking water and sewerage services for the community. These services generally use computer systems to control operations of critical infrastructure such as water treatment plants and related facilities and assets. Like all computerised systems, these control systems are at risk of cyber threats which may originate from internal or external sources and can be intentional/malicious or unintentional.

In 2016-17 the Queensland Audit Office (QAO) investigated a small number of large water service providers responsible for critical water infrastructure to determine if the entities had processes in place to protect their water controls systems. The QAO undertook penetration testing to identify and exploit security vulnerabilities. It also assessed whether entities had security detection and restoration protocols in place to identify security breaches and restore the systems in the event of an attack. The QAO found that the water control systems assessed were not as secure as they could have been at the time of testing.

The Department of Natural Resources, Mines and Energy (DNRME) was responsible for implementing two of the recommendations of the QAO report:

1. Integrate information technology risks and cyber threats into the existing risk management framework for drinking water services and in the Queensland water and sewage service provider performance reports, and
2. Facilitate information sharing about adopting standards for securing information technology amongst entities that manage water control systems.

In order to address QAO's audit recommendations, DNRME built on the report findings by conducting case studies within five medium to small organisations. This broader cohort could better inform DNRME's response to the recommendations.

2.0 DISCUSSION

2.1 DNRME Case Study Design

There is enormous variability among service providers in Queensland in terms of the degree of automation of drinking water operations, the technical integration of their drinking water operations into broader Council systems, the capability and capacity of operators, and the size and location of water services and assets.

In recognition of this diversity, DNRME contracted an external organisation to conduct a project that ultimately broadens the sample of service providers and provides additional learnings that enable our industry to better understand, and therefore more effectively respond to, cyber security threats. More specifically, the project aimed to establish a base line of the potential for cyber security breaches using a sample of five smaller service providers, with the findings adding to the knowledge base from QAO's audit of large service providers. These five service providers volunteered to participate in the trial through an expression of interest sent to all providers.

The project involved conducting initial vulnerability assessments at each site followed by the installation of appropriate devices or honeypots containing software/programs that replicate drinking water operations control systems (SCADA). These devices monitored any potential cyber security 'attacks' coming from internal threats and provided information to help determine the extent to which systems were vulnerable to such threats.

Figure 1: ***Insider threat detection device - Honeypot***

Honeypots were installed and monitored over a six-month period with monthly reports provided to the service providers and DNRME. Any issues of concern were immediately communicated to the organisation.

2.2 Case Study Findings – Vulnerability Assessments

Vulnerabilities identified during the assessment were consistent with what is seen in other industries with people identified as the main cause of problems. These include genuine human errors, inadvertently compromising the security through participation in an email scam or social call or a disgruntled employee trying to get back at their employer and sabotaging infrastructure.

Vulnerabilities are also a result of the greater connectivity we now have within our systems, for example, field devices are directly connected to the internet and operational environments converge with corporate environments.

Common weaknesses identified for the service providers were:

- Lack of application patching – leading to vulnerable systems
- Using outdated systems that are not vendor supported anymore
- Default credentials used across a vast majority of infrastructure – leading to simple system access (e.g. admin/admin password)
- Credentials written on Post-It notes in plain view
- Increased attack surface due to unnecessary applications being installed – and also not patched
- Lack of system hardening – leading to simple system access (tighter coding)
- Some physical findings – leading to simple access to infrastructure (e.g. security) – links between other operational technology – access to one operational technology provides a connection through to another (e.g. enter by online security cameras into water operations).

The vulnerability assessments highlighted the need to take the principle of 'least privilege' and aim to reduce the overall attack surface constantly. Recommendations included:

- Implement a password/credential storage service
- Change default credentials on all infrastructure where it is used
- Implement application whitelisting (as opposed to blacklisting)
- Implement firewalling where appropriate
- Implement system hardening techniques / disable services that are not necessary to operational tasks.

These strategies are also included in the Essential Eight mitigation strategies recommended by the Australian Government to use as a baseline to make it harder for people to compromise systems. 'Furthermore, implementing the Essential Eight pro-actively can be more cost-effective in terms of time, money and effort than having to respond to a large-scale cyber security incident' (Australian Government).

2.3 Case Study Findings – Honeypot Monitoring

Honeypots were installed at each of the five selected sites. A honeypot can be thought of as a smoke alarm; it sits quietly when everything is fine, but if it starts alerting there is a problem somewhere that needs attention. A honeypot is an impersonation device that can be configured to look and feel like a real field device, attracting malicious attention. In summary, these devices are:

- targeted at operational technology infrastructure
- small machines running a Linux operating system
- emulating a real world device – variants available for different OT type networks
- able to interact with the honeypot – it will respond like the device it's built to emulate
- for detection, not defence.

Table 1 is a summary of the activity recorded over the six month trial period. The shaded boxes indicate that some sort of activity has occurred across the sites. As service providers were contacted when activities were detected, the resulting improvement is evident in subsequent months' results for most providers. None of these events were considered critical.

Table 1: ***Summary of threat activity recorded (Sept 2018 to Feb 2019)***

Site	September	October	November	December	January	February
A	Six (6) counts of IP tables event recorded	Zero (0) counts recorded	Zero (0) counts recorded	Zero (0) counts recorded	Zero (0) counts recorded	Zero (0) counts recorded
B	Two (2) counts of IP tables event recorded	Zero (0) counts recorded	Zero (0) counts recorded	Zero (0) counts recorded	One (1) count of Sensor missing recorded	Zero (0) counts recorded
C	Ten (10) counts of IP tables event recorded	Zero (0) counts recorded	Zero (0) counts recorded	One (1) count of Sensor missing and one (1) count of SSH login attempt recorded	One (1) count of Sensor missing recorded	Zero (0) counts recorded
D	Zero (0) counts of IP tables event recorded	One (1) count of Sensor missing recorded	One (1) count of Sensor missing recorded	Zero (0) counts recorded	One (1) count of Sensor missing recorded	Two (2) counts of Sensor missing and one (1) count of ICS Ports events recorded
E	One (1) count of Sensor missing recorded	Zero (0) counts recorded	Zero (0) counts recorded	Zero (0) counts recorded	Zero (0) counts recorded	Zero (0) counts recorded

For the purpose of this study, IP (internet protocol) tables events are when a device attempts to communicate with the honeypot on any available service port; Missing sensor is when the honeypot goes offline for 15 minutes or longer (usually due to internet connection dropouts); and ICS (Industrial Control System) ports events are when a device connects to the emulated ICS services on the honeypot.

2.4 Development of the Regulatory Framework

The findings from the case study research, combined with input from information technology experts from individual service providers, peak bodies and the Queensland Government Chief Information Office (QGCIO) was used to develop a set of questions on which service providers are to report. The five reporting indicators are specified in the Key Performance Indicators for Annual Performance Reporting for Queensland Urban Water Service Providers Definitions Guide and include:

- Governance structure implemented
- Vulnerability/ risk assessment of water/ sewerage assets implemented
- Cyber security safeguards implemented
- Cyber security detection process implemented
- Cyber security response and recovery plan implemented.

In addition, cyber security threats and breaches to water quality are to be included as an additional whole of service hazardous event in the risk assessments within each registered drinking water service provider's existing Drinking Water Quality Management Plan (DWQMP). Cyber security incidents must also be included in the drinking water quality incident response process.

3.0 CONCLUSION

Cyber security is a potential threat to the operation of critical infrastructure including water and sewage operations. Tasked with the responsibility of incorporating cyber security into the drinking water regulatory framework, DNRME has undertaken research to help develop an approach that is relevant to the real environment experienced by water service providers and which will initiate changes in how cyber security is addressed in the operations of these organisations.

Providing information to help service providers implement these changes is required as specified in the second recommendation of the QAO report. Implementing this recommendation will help create awareness and develop an understanding amongst water operators so they can work collaboratively with their information technology co-workers to initiate the required changes.

4.0 ACKNOWLEDGEMENTS

DNRME acknowledges the assistance provided by RIoT Solutions in implementing the case studies and providing advice about the broader environment and context to help amend the regulatory framework to best capture the requirements that will enable service providers to implement appropriate strategies.

DNRME also acknowledges the Queensland Water Directorate, Local Government Association of Queensland and water service providers for providing timely and informative input to the DNRME project.

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GIN GIN WATER TREATMENT PLANT (WTP) UPGRADE

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44th Annual WIOA
Queensland Water Industry Operations Conference and Exhibition
Bundaberg Multiplex Centre, Bundaberg
5 & 6 June, 2019

GIN GIN WATER TREATMENT PLANT (WTP) UPGRADE

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ABSTRACT

Gin Gin township is located about 50 km southwest of Bundaberg. The Gin Gin Water Treatment Plant (WTP) supplies potable water to the Gin Gin township with a total connected population of approximately 1,600. The Gin Gin WTP is a package conventional treatment plant that was commissioned by Aquagenics in December 2002. It has a nominal treatment capacity of 25 L/s, or 2 ML/day of treated water if operated on a 24-hour basis.

Gin Gin WTP has three (3) water sources –

- Gin Gin Creek
- SunWater irrigation channel
- Damascus Rd Dam

During dry conditions, the volume and water quality of the Gin Gin Creek degrade. Due to the small nature of the catchment, the creek water quality is very reactive to rainfall and can experience fluctuations in turbidity, pH, manganese and organics.

The SunWater irrigation channel approximately two (2) km north of the treatment plant is the main and more secure source for the Gin Gin WTP due to the reliability and consistency of the water supply and quality. However, the channel does undergo periodic herbicide spraying and water is transferred to the Damascus Rd Dam prior to the spraying.

The Damascus Rd Dam is a small holding dam (providing about 2 – 3 weeks' storage) and is only used for 3 – 4 weeks a year during maintenance activities in the SunWater irrigation channel. The dam has a number of water quality risks.

Bundaberg Regional Council (BRC) identified the need to upgrade the Gin Gin WTP in order to maintain a supply of safe potable water and meet the predicted population growth of the Gin Gin Township. A WTP Capability Review and Source Water Quality Review was initially undertaken that recommended key process upgrades for the Gin Gin WTP.

1.0 INTRODUCTION

The Gin Gin WTP consists of the following major unit processes:

- Inlet works for raw water pumping
- Coagulation with ferric chloride
- Flocculation with polymer
- Clarification using inclined tube settler
- Constant rate filtration using dual media filtration (filter coal and sand)
- Post pH adjustment using caustic soda
- Disinfection using sodium hypochlorite.

The original Gin Gin WTP had a reasonably high level of online instrumentation for plant automation. However, despite a nominal treatment capacity of 25 L/s, the plant was only capable of treating raw water flows up to 12.5 L/s, due to limitations with the existing filter media configuration and raw water pump capacity.

The plant typically sources its water primarily from the Gin Gin Creek and the SunWater irrigation channel, with Damascus Rd Dam providing supply for 3 – 4 weeks a year when the SunWater irrigation channel is off-line during maintenance activities such as herbicide spraying.

All three (3) water sources gravitate to the Raw Water Inlet Box located in the Gin Gin Creek. Two submersible pumps (duty/standby) are used to deliver the raw water from the Inlet Box to the WTP at a fixed speed of approximately 12.5 L/s.

At the WTP the raw water is dosed with Ferric Chloride. An inline static mixer is used to ensure rapid mixing for effective coagulation. Raw water turbidity and dosed water pH are monitored online. The coagulated water then enters a two-stage flocculation process with dosing of a non-ionic polymer (LT20) into the 2nd flocculation chamber.

The flocculated water is clarified in a high rate inclined tube settler. Sodium hypochlorite is added to the settled water just prior to filtration to initiate the coated media process in the dual media filters. Turbidity, pH and free chlorine residual of the filtered water are monitored online (sampled from the common filter outlet line.

The filtered water is then pH corrected using caustic soda and further dosed with Sodium hypochlorite for disinfection in the onsite clearwater tank. The pH, free chlorine residual and turbidity of the treated water (i.e., post chemical correction) are also measured online.

Sludge from the clarifier and filter backwash water gravitate to the wash water storage tanks. This waste stream is then dosed with polymer (LT20) and pumped to a thickening unit. Supernatant from the thickener returned to the 1st flocculation chamber, while the thickened sludge is typically desludged every 12 hours for a period of 60mins.

Treatment plant performance is constantly monitored by on-line quality instrumentation for turbidity, pH and chlorine residual.

The plant operates automatically 7 days a week. It runs on average 14 hours per day at normal water demand and 22 hours per day during dry/hot periods. The filters are backwashed automatically on run time (typically 10 hours when treating the irrigation channel water and 8 hours with the creek water) or filter headloss.

2.0 DISCUSSION

A treatment capability and source water quality review identified opportunities to improve plant performance and treated water quality. Amongst the key aspects of the review were removal efficiencies for difficult to remove organic material, iron and manganese and the effective removal of taste and odour compounds, along with improving the reliability of treatment to produce safe and aesthetically pleasing drinking water.

Gin Gin WTP raw water supply summary of key raw water quality parameters are shown in Table 1.0 – Summary of Raw Water Characteristics.

Table 1: ***Summary of Raw Water Characteristics***

	No. of Data Points	Min	Max	Average	Median	95%ile
Turbidity (NTU)	1,036	1.2	183	9.1	5.2	26.3
Apparent Colour (HU)	1,003	25	1,919	120	93	278
pH	1,022	5.59	8.10	7.02	7.02	7.43
Alkalinity (mg/L as $CaCO_3$)	16	57	200	119	112	189
Total Hardness (mg/L as $CaCO_3$)	13	65	172	112	110	171
Total Iron (mg/L)	80	0.100	3.870	1.269	1.155	2.732
Total Manganese (mg/L)	52	0.004	1.513	0.125	0.070	0.271
TOC (mg/L)	3	10	16	12	10	15.4
DOC (mg/L)	3	10	15	11.7	10	14.5
Conductivity (µS/cm)	420	143	900	401	389	623

2.1 Treatment Capability Review and Source Water Review

The treatment capacity of the major process units of the Gin Gin WTP were assessed and the outcome is shown in Figure 1.0 - Treatment Capability of Major Process Units.

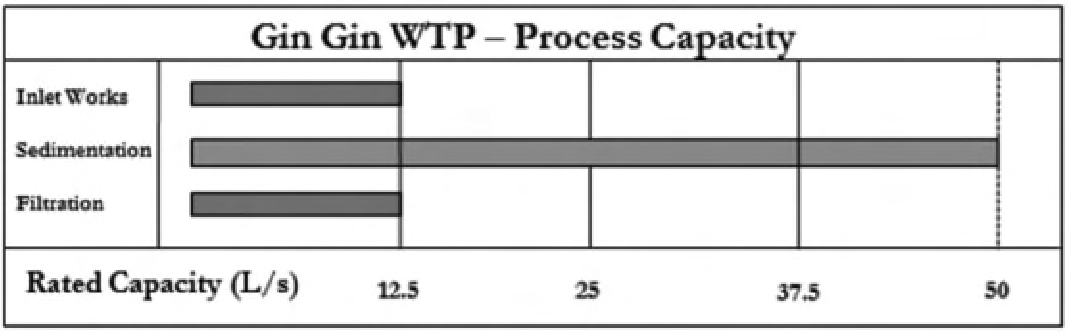

Figure 1: ***Treatment Capability of the Major Process Units***

The review identified that the filtration process as the main process bottleneck along with the raw water pump capacity being limited to about 12.5 L/s. The following key issues were identified from the review:

- Access to the Raw Water Inlet Box – (during flood events in the Gin Gin Creek access impacted as the Raw Water Inlet Box can be completely submerged. This represents a risk to the reliability of raw water supply to the treatment plant).

- Sludge build-up in sedimentation sludge hoppers – (issues with desludging from the sludge hoppers in the high rate settling tank due to formation of rattle holes around the slot openings on the sludge collection pipes. Operators had to periodically hose out the settling tank to get rid of the accumulated sludge).

- Filter media configuration – (unsatisfactory with an undersized L/d ratio, where L is the filter media depth and d is the filter media diameter. The undersized L/d ratio was limiting the plant from operating at its design capacity of 25 L/s).

- Algal bloom risks – (SunWater channel and Damascus Rd Dam source water experienced seasonal algal blooms with taste and odour impacts from MIB / Geosmin and other algal metabolites such as algal toxins. During seasonal taste and odour events the Gin Gin WTP was not equipped to remove MIB and geosmin or other extracellular algal metabolites such as algal toxins.

2.2 Gin Gin WTP Upgrade Project

Gin Gin WTP upgrade project works was completed in 2017 and major elements consisted of the following activities;

- Construction of additional section of pipeline to by-pass the raw water pump station and deliver water directly to the treatment plant from the SunWater channel and Damascus Road dam.

- Upgrades to the Raw Water Inlet Box and laterals in Gin Gin Creek;

- Addition of powdered activated carbon (PAC) contact tank, including PAC storage, preparation and dosing facility.

- Upgrade of filter media to accommodate an increase in the instantaneous flow through the plant from 12.5 L/s to 25 L/s.

- Construction of sludge beds to accommodate high solids loading during PAC dosing.

2.3 Project Innovations

Historically Gin Gin WTP source water selection was governed by water level in the Raw Water Inlet Box. Source water would flow directly into the Raw Water Inlet Box from either Gin Gin Creek or flow via a control valve from the SunWater Irrigation Channel. Essentially the maintenance of the water level in the Raw Water Inlet Box provided a shandy mix of source waters. Operators had no capability of selecting or controlling source water.

The installation of the new PAC contact tank brought about opportunity to have dedicated pipework and flow metering for each source water providing process control and historic records. Innovation implemented was that prioritisation of source water control by level control function in the PAC contact tank. This meant that if Gin Gin Creek source water was of superior quality it could be preferentially harvested over SunWater Irrigation Channel water and vice versa. Operators could also exclude a source water if it was of poor quality such as high in turbidity, iron, manganese, algae and/or organics.

Laterals in the creek bed were (3m x 6m) bore screens covered in 6mm pea size gravel, located at bottom, middle and top of Raw Water Inlet Box. Inside each bore screen we installed stainless tubing with small holes equally positioned along it to allow connections to valving inside the Raw Water Inlet Box to allow an air blast at regular occasions dispersing iron bacteria that builds up in creek bed. So basically we have our own filter bed in the Gin Gin Creek. Refer to Figure 2.0 - Schematic of the Upgraded Gin Gin WTP Process.

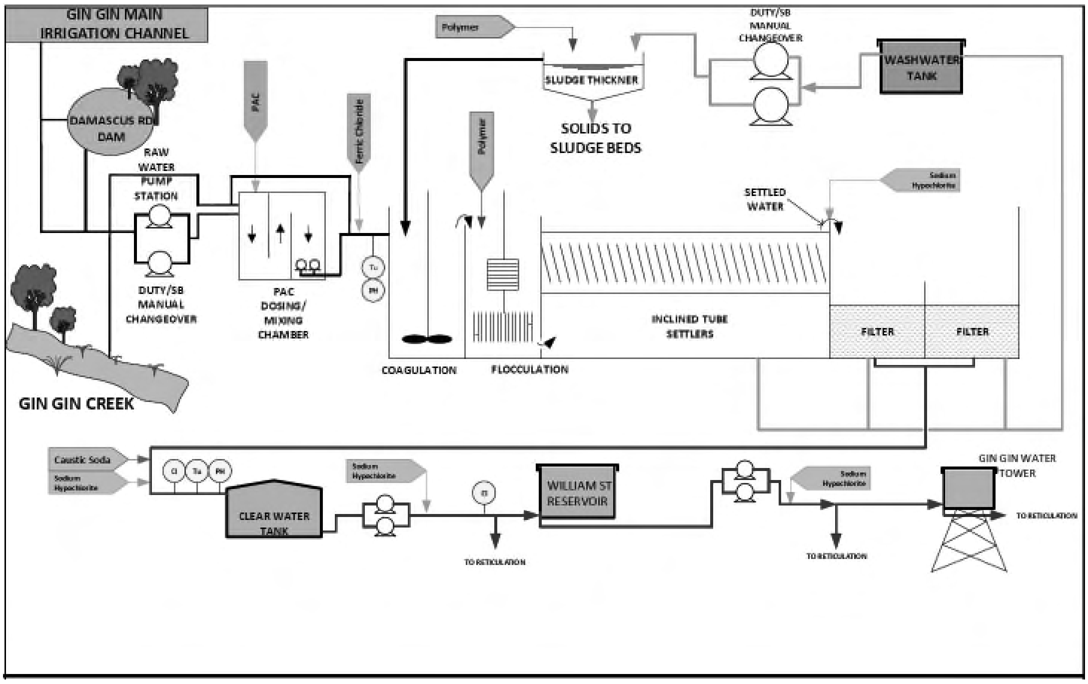

Figure 2: ***Schematic of the Upgraded Gin Gin WTP Process***

2.4 Operations and Performance Monitoring

The 2017 upgraded Gin Gin WTP has now been operating for a little over two (2) years, performing really well. Being able to now select raw source water from either Gin Gin Creek and/or SunWater Irrigation Channel has meant we can harvest the best available raw water quality minimising chemical dosing and treatment.

The addition of PAC has greatly improved water quality aesthetics reducing taste and odour complaints along with improved filter water dissolved organic carbon (DOC) content, now achieving less than < 2 mg/L DOC to reduce disinfection by-products such as THMs.

Gin Gin WTP raw source water experienced a DOC spiked in February 2019 and with PAC dosing the filtered water quality with regard to reduced DOC levels are shown in Table 2.0 – Summary of Filtered Water DOC.

Table 2: ***Summary of Filtered Water DOC***

Date	Raw Water DOC (mg/L)	WTP Filtered Water DOC (mg/L)	PAC Dose (mg/L)
7/02/2019	6.35	1.14	25
18/02/2019	6.91	1.30	12
28/02/2019	7.27	1.63	12
7/03/2019	10.18	1.60	8

The new sludge beds are functioning well accommodating the increased solids loading during addition of PAC dosing. Also a change in desludging from the plant thickener to a more frequent regime from 12 hours for 60mins to every 25mins for 60sec or selected by operator depending on visual inspection of sludge draw off. This has also improved settled water quality by reducing carry-over of solids onto the filters.

Upgrade of the filter media with addition of an extra 400mm layer of filter coal has resulted in improved filtered water quality with an average of 0.063 NTU since the upgrade.

Gin Gin WTP treated water supply summary of key treated water quality parameters are shown in Table 3.0 – Summary of Treated Water Characteristics.

Table 3: ***Summary of Treated Water Characteristics***

	No. of Data Points	Min	Max	Average	Median	95%ile
Turbidity (NTU)	283	0.035	0.162	0.063	0.060	0.091
True Colour (HU)	283	0.0	1.0	0.04	0.03	0.04
pH	283	6.00	7.74	7.03	7.03	7.47
Alkalinity (mg/L as $CaCO_3$)	36	25	142	79	81	128
Total Hardness (mg/L as $CaCO_3$)	36	41	197	96	105	174
Total Iron (mg/L)	37	0.01	0.14	0.05	0.05	0.012
Total Manganese (mg/L)	37	0.001	0.019	0.003	0.002	0.013
DOC (mg/L)	110	0.7	7.3	3.6	3.2	6.8
Conductivity (µS/cm)	283	64	890	491	530	754

3.0 CONCLUSION

The upgrade of the Gin Gin WTP was implemented in-house by Bundaberg Regional Council (BRC) providing staff with opportunities to have input with design and operating modes. The outcome being the transfer of knowledge and learnings to assist with operations and process management. Gin Gin WTP now has higher reliability and robustness producing a better and more consistent quality of treated water for the Gin Gin township.

4.0 ACKNOWLEDGEMENTS

Wish to thank the Bundaberg Regional Council (BRC) – Water Services team for their support and opportunity to present at the Queensland Water Industry Operations Conference and Exhibition. Thanks to Jeff Rohdmann Process Manager for input and information in preparing the paper. Also pass on my appreciation to the BRC Gin Gin WTP Project Manager Paul Viljoen, Project Team, Technicians and Electrical / Mechanical trade teams for their active participation in delivering the successful implementation of the Gin Gin WTP upgrade.

5.0 REFERENCES

Capability Review and Water Quality Enhancement: Kalkie, Gregory & Gin Gin Water Treatment Plants, Yaode Yan, Hunter Water Australia, 2012.

POSTER PAPERS SUBMITTED FOR JUDGING

Judging from 1.10pm on Thursday, 6 June 2019

- **Mr Shane Bambrick & Mr Andre Tubert,** *(Queensland Urban Utilities)*
  - *"Leak Detective"*
- **Mr Paul Campbell-Cowie,** *(Logan City Council)*
  - *"Dechlorination Process at Loganholme Wastewater Treatment Plant"*
- **Mr Mark Tosh,** *(Queensland Urban Utilities)*
  - *"Gibson Island Picket Fence Thickener's (PFT's) Optimisation Polymer Dosing Trial"*
- **Mr Charndeep Chahal,** *(Bundaberg Regional Council)*
  - *"Biosolids – The Changing Trends"*
- **Mr Lee Wieden,** *(Bundaberg Regional Council)*
  - *"Bundaberg Regional Council Water Services Solar Projects"*
- **Mr Jeff Rohdmann,** *(Bundaberg Regional Council)*
  - *"Sewer Catchment* - *Corrosion and Odour Management"*
- **Ms Leah Jones,** *(Queensland Urban Utilities)*
  - *"The Best Job in the World"*
- **Mr Luke Ayres & Mr Matthew Alderwick,** *(Seqwater)*
  - *"The new Canungra Water Treatment Plant"*
- **Mr Craig Mathisen & Mr George Wall,** *(WIOA)*
  - *"You Can Save a Life"*

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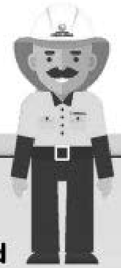


LEAK DETECTIVE

PROBLEM

A percentage of water provided by water utilities is lost in leaks and bursts.
Not all leaks are above ground gushers. Some can be concealed underground and be difficult to identify and locate.

SOLUTION

When water pipes leak, the water gushing out under pressure creates a vibration sound.
This "hiss" or "whoosh" sound can be detected by leak noise correlators.

Queensland Urban Utilities use compact Gutermann leak noise correlators and ground microphones.

DEPLOYMENT

Two wireless sensors are deployed on the pipe or fittings either side of the suspected leak location. The noise created by the leak is picked up by the sensors and the information is sent via bluetooth to the computer or tablet.

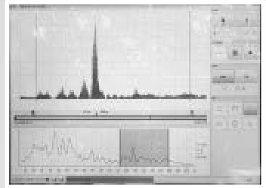
Factors producing good quality leak noise

High Water Pressure
Hard Backfill
Small Leaks
Clean Pipes
Metallic Pipes
Small Diameter Pipes

Factors producing poor quality leak noise

Low Water Pressure
Soft Backfill
Split Mains
Encrusted Pipes
Soft/Lined Pipes
Large Diameter Pipes

OPERATION AND RESULTS



The distance between the sensors, pipe material and pipe size details are entered into the computer app.

If a leak is detected, the distance from each sensor is indicated. Depending on the environmental conditions, accuracy of leak locating can be within centimetres.

Pinpointing the leak is usually completed using a very sensitive ground microphone.

Deployment and correct use of this precise technology can produce significant results.

- *Resolution on first visit*
- *Unseen leak identification*
- *Significant water savings*
- *Minimised customer interruptions*
- *Employees professional development*

Correlating…..
An effective approach,
giving great results.

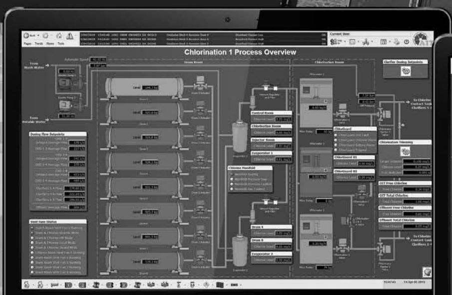
Dechlorination Process
at Loganholme Wastewater Treatment Plant

Project drivers

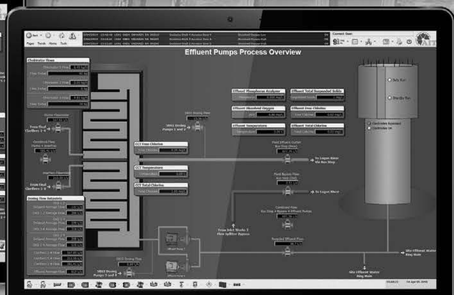
- Ineffective disinfection of effluent
- Limited time in the contact tanks during wet weather events
- High cost to deliver a new chlorine contact tank
- Limited land within the treatment plant
- Super-chlorination and dechlorination known to be cost-effective

History of the project

A new dechlorination unit (sodium bisulfite dosing) was completed and commissioned in 2016. Council's Logan Water Infrastructure Alliance and Treatment Program staff worked collaboratively to design, construct and commission the project. A trial of the new unit was conducted for six months. Since May 2017, the unit has operated full-time with the target total chlorine of 0.35 mg/L present in the final effluent.



Chlorination process



Chlorine contact tank and process monitors

The process

Final effluent is chlorinated using a chlorine contact tank, process monitors and a control accessory. Once the final effluent passes through the chlorine contact tank, dechlorination is achieved by applying a sodium bisulfite solution.

Chlorination

The main process components are: eight liquefied chlorine drums (920 kg each), two evaporators, three chlorinators, two booster pumps for carrying water, a chlorine contact tank and chlorine monitors.

One drum supplies chlorine at a time and automatically changes over when the weight of the drum is 10 kg. Chlorine is drawn through the evaporators and turned into a gas, with recycled water used to convey it to two dosing points.

Two chlorine analysers at the chlorine contact tank and two at the final effluent chamber measure free and total chlorine. They take readings every 2.5 minutes, giving reduced free and total chlorine readings before and after sodium bisulfite dosing.

Dosing is based on the total chlorine reading at the contact tank via a closed loop control (to a set point of 0.35 mg/L of total chlorine at the final effluent chamber).

Dechlorination

The system comprises two sets of sodium bisulfite dosing pumps; the first including one standby/duty arrangement with capping at 24 L/h. This is for dosing chlorinated effluent discharged to the Logan River. The second set is a standby/duty arrangement for recycled effluent water that is used around the plant including as dilution water for the odour scrubber. This is capped at 4.9 L/h. Refer to graphs on this poster showing the quality of treated effluent discharged into Logan River.

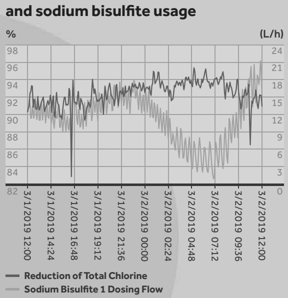
Trial results

During the six-month trial, the total chlorine target was 2 mg/L, 1.5 mg/L, 0.5 mg/L and 0.3 mg/L at the final effluent chamber (located about 60 m downstream of the chlorine contact tank). Sodium bisulfite dosing was efficient in knocking down the total and free chlorine levels entering the Logan River.

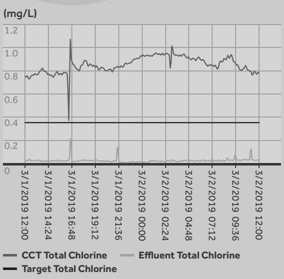
Full-time operation results

Results achieved since May 2017 are shown in the graphs below.

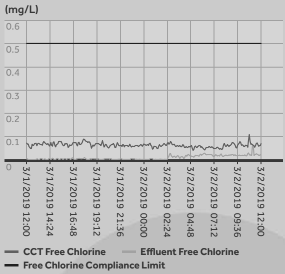
% Reduction of total chlorine and sodium bisulfite usage



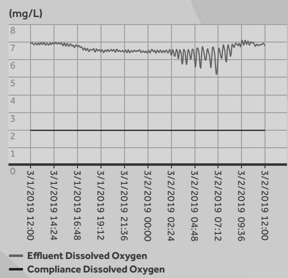
Total chlorine concentrations before and after dechlorination

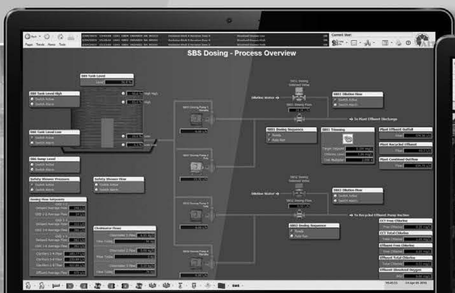


Free chlorine concentrations before and after dechlorination

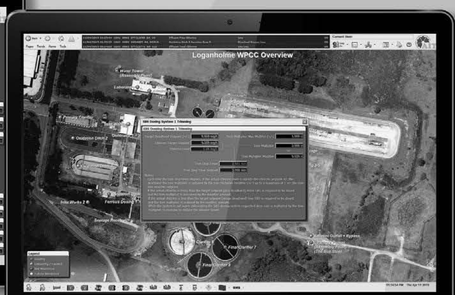


Final effluent dissolved oxygen





Dechlorination (sodium bisulfite) process



Sodium bisulfite dosing: trimming of chlorine

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Operator, Loganholme Wastewater Treatment Plant
Logan City Council
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Imtiaj Ali
Senior Process Engineer, Wastewater Treatment Program
Logan City Council
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Conclusion

The dechlorination process at Loganholme Wastewater Treatment Plant has maintained a sustainable level of total chlorine in the final effluent discharged to the Logan River. With a capped dosing rate of 24 L/h and 0.35 mg/L of target total chlorine concentrations, it is possible to maintain a yearly 70 percentile total chlorine concentration of 0.1 mg/L at a cost of $105,000 per year. A target total chlorine of zero will put pressure on operational costs and will potentially be difficult to maintain. This is due to process uncertainty and the inability to measure very low concentrations of chlorine using existing monitors and handheld instruments.

LOGAN
CITY COUNCIL

Acknowledgements We would like to thank the Logan Water Infrastructure Alliance team for leading the design, construction and commissioning of this project. We are indebted to co-operators and maintenance staff for the maintenance, operation and monitoring of the new process. Special thanks to Andrew Stevenson (Program Leader Treatment) and Stephen Walters (Plant Supervisor) for their encouragement and support.

Gibson Island Picket Fence Thickener (PFT's) Optimisation Polymer Dosing Trial

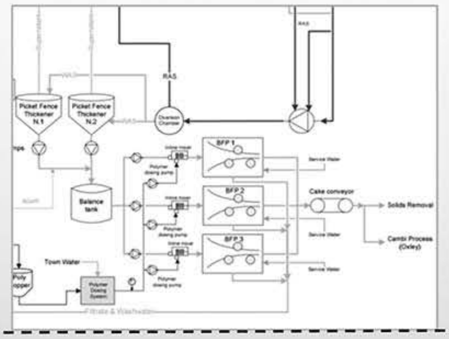
Mark Tosh, Senior Operator for Queensland Urban Utilities. Mark.Tosh@urbanutilities.com.au Mob. 0459803552

Acknowledgements: Clinton Barnes from SNF, Queensland Urban Utilities Treatment and Production Team & Queensland Urban Utilities Research and Development Team

Project Overview

Gibson Island Reclamation Plant (GI) Waste Activated Sludge (WAS) utilises two PFT'S to thicken it's WAS prior to being sent to the Belt Filter Presses (BFP's) for bio solid's beneficial reuse.

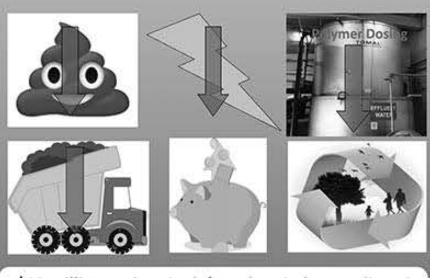
It has been recognised that the PFT's cause a "bottle neck" in the operation of the WAS process and that further efficiencies could possibly be achieved in bio-solids management through enhancing the efficiency of the PFT'S, this could provide possible improvement in sludge age, increased dryness of solids



Direct Cost Savings

Polymer	0 ppm	8 ppm	
BFP polymer cost	$301.32	$200.88	$/day
PFT polymer cost	$0.00	$70.71	$/day
Total Polymer **Cost**	**$301.32**	**$270.71**	$/day
Transport			
Total Transport Cost	**$1,908.00**	**$1,606.74**	**$/day**
BFT Energy Usage			
Total Energy Cost	**$94.33**	**$70.17**	**$/day**
Dewatering			
Total Dewatering Cost	**$2,303.65**	**$1,948.50**	**$/day**

% Direct cost savings	15%	
Total direct cost savings	$355.15	$/day



$12 million savings in deferred capital expenditure!

Savings of up to **$20,400 per month!**

Environmental Benefits

- → Optimisation in BFP performance having less loading back to Bio reactors through better capture rates
- → More efficient transportation of Bio solids and reuse has better impact on the environment
- → Reduction in energy costs via the reduction of BFP run time saving on kWh
- → Reduced transportation, easing on congestion on the roads and reduced CO2 admissions

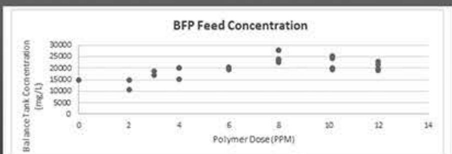
Community Benefits

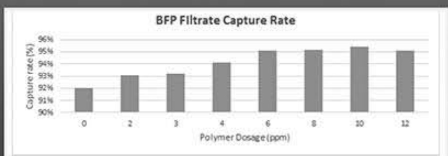
- → Cost savings in bio solids transportation
- → Costs savings on reduced chemical dosing
- → Further whole of life expectancy on BFP's due to reduced running time.
- → Delayed need for future BFP upgrades via more effective use of the PFT'S

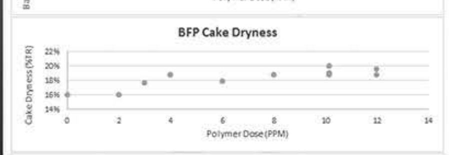
Reputational Benefits

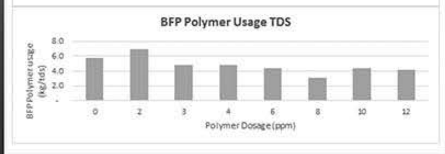
- → Delivery of a more economical and efficient service to the community who we serve
- → This project provided additional PFT capacity hence, higher sludge age by up to 18 days and higher biosolids cake dryness by up to 18% without causing operational issues (eg. FST syphon)

Trial Results









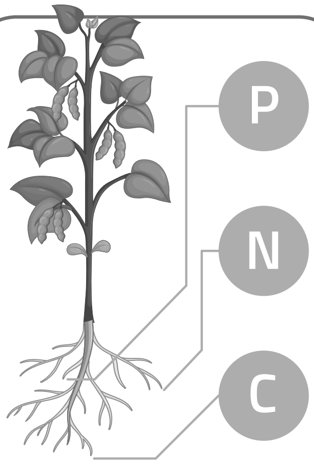
QUEENSLAND UrbanUtilities

BUNDABERG REGIONAL COUNCIL

Building Australia's best regional council

Biosolids

the changing trends



Regulated

Location is important

- Water table
- Nearby receptors
- Soil type

Emerging concerns

- Quality criteria
- Contaminants (PFAS)
- Code/laws

Enhanced crop production

Different crop types:

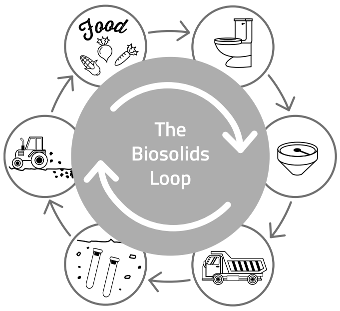
- Soybeans
- Sugarcane
- Macadamias

We deliver

- Soil analysis
- GPS tracking results
- Summary of quantity of material applied to land

The future

- Portfolio of land
- Compost
- Different plant types *(fodder)*
- Treatment - stabilisation
- Landfill ⃠
- Sustainability



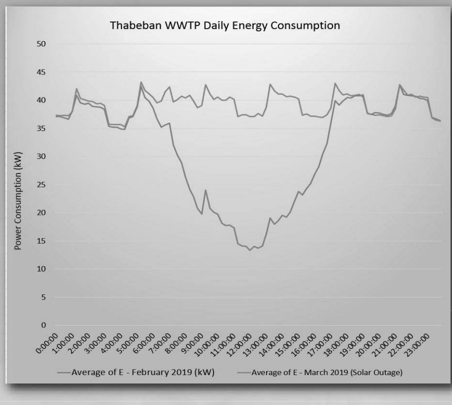
Beneficial Reuse Program

Charndeep Chahal- Senior Teachnical Officer-Water Services
Email: www.admin@bundaberg.qld.gov.au
Telephone: 1300 883 699

bundaberg.qld.gov.au/biosolids

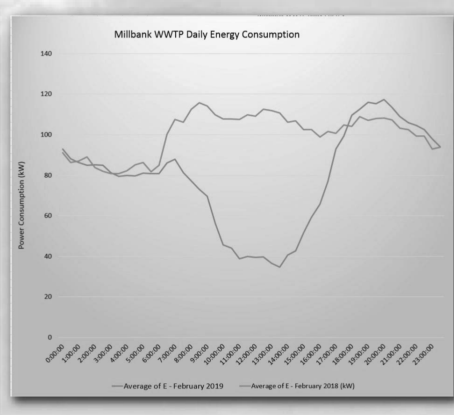
BRC WATER SERVICES
SOLAR PROJECTS

Thabeban WWTP 39.4kW



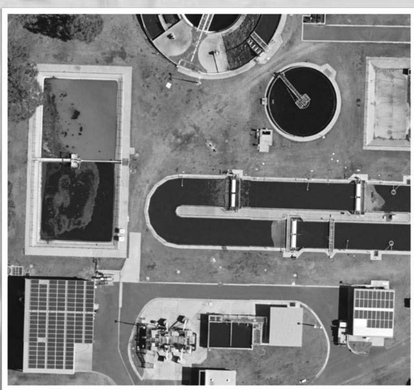
- Average of 179.6kWh/day (= 4.6 x DC Rating)
- Billing Reduction of $668.60/ month
- Ground mounted array.
- **$0.12/kWh**

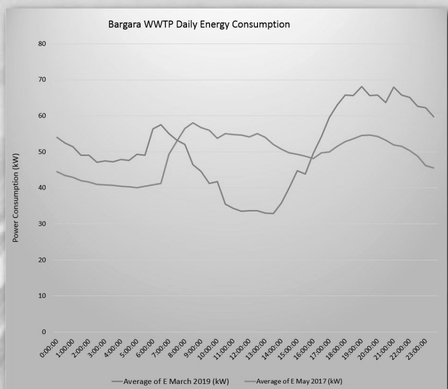
Millbank WWTP 87.7kW



- Average of 450.5kWh/day (= 5.13 x DC Rating)
- Billing Reduction of $1675/ month.
- LGC income of $840.00/ month.
- Roof mounted array.
- New shed for additional roof space.

Bargara WWTP 63.24kW





- Average of 290kWh/day (= 4.6 x DC Rating)
- Billing Reduction of $1042/ month.
- Roof Mounted Array
- **$0.116/kWh**

LESSONS LEARNT:

- Roof mounted arrays are far more cost effective. Consider roof condition and repair/replacement requirements.
- Systems less than 30kW AC can be full export, this saves on export controls and complexity of the installation.
- Payback dependant on the cost of daytime power which is offset. Cheaper energy = less payback.
- LGC (>100kW AC) system is complicated and invoicing requires administration.

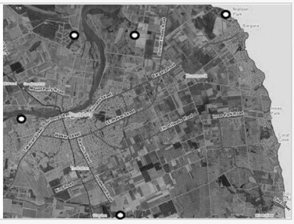
Lee Wieden, Principal Electrical Engineer, Water Services, Bundaberg Regional Council

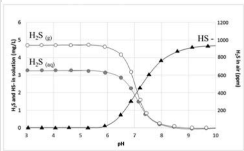
Email - www.admin@bundaberg.qld.gov.au

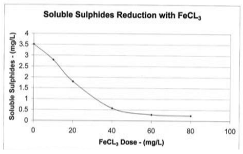
Sewer Catchment- Corrosion and Odour Management

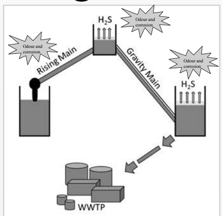
Background

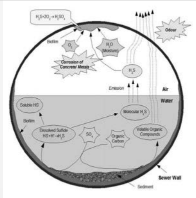
- 5 Treatment Plants
- 482.6 Km of sewer mains
- 112 pump stations



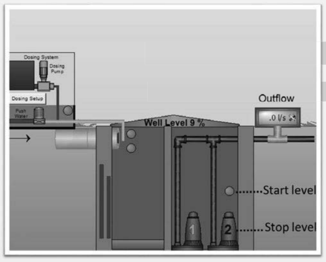








Chemical Dosing – Pump Level Control



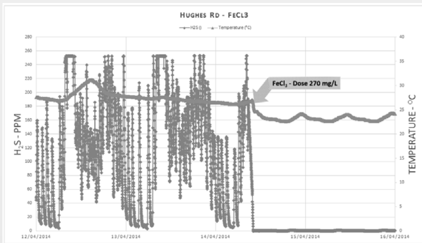
Methods

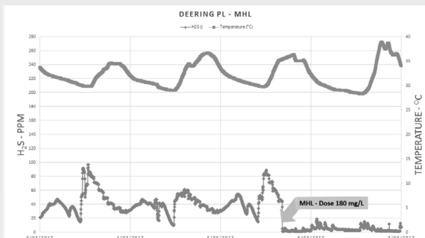
Prevention
- Calcium Nitrate
- Ferric Nitrite
- Oxygen injection
- Biological

Containment
- Magnesium Hydroxide
- Sodium Hydroxide
- Ferric Chloride

Treatment
- Carbon filters
- Bio-filters
- Chemical Scrubbers

Results





Lessons Learnt:

BRC initially adopted the practice of dosing chemical into the pressure main on the discharge side of the sewage pumps. BRC experienced some difficulties in controlling the dosed quantity and with the injection point arrangement. As a consequence, BRC altered the point of chemical addition to each sewage pumping station's wet well so that the chemical dosing procedure is a batch process.

The desired chemical batch dosing quantity is based on a selected dosing rate times the dry weather duty sewage pump cycle volume (duty pump start volume less the duty pump stop volume). The chemical dosing pump rate delivers the desired chemical batch dosing quantity in the shortest dry weather duty pump off time. The chemical dosing pump is initiated when the duty sewage pump stops. As a result, the required volume of chemical is added to the wet well during the non-pumping period.

Advantage of this batch dose arrangement is that the chemical dosing rate tends to follow the diurnal pattern of the dry weather flow and in wet weather the duty sewage pump as well as the standby sewage pump (acting as an assist unit) would start and the sewage pump stop level would not be activated for some time, with the result that the chemical dosing would be delayed until the sewage flows return to a cyclic "off-on" pattern. If the duty sewage pump stop level is less frequently activated (such as would occur during a wet weather event), then less chemical dosing would occur.

This dosing procedure provides a simple, but generally effective, method of modulating chemical dosing to the flow conditions in the pressure main from each SPS. It adds the greatest quantity of chemical (when hydrogen sulfide formation is at its maximum) and the least quantity of chemical during wet weather or high flow conditions (when hydrogen sulfide formation is at its minimum).

Jeff Rohdmann, Process Operations Manager – Water Services, Bundaberg Regional Council
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Telephone: 1300 883 699

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REGIONAL COUNCIL

THE BEST JOB IN THE WORLD

Be part of an innovative industry

Wastewater Treatment Plant Operator

School recruitment poster

WE WANT YOU

1. We want you to consider a career as a Wastewater Treatment Plant Operator.

WHAT DO WE DO?

2. Wastewater is generated by Domestic, Commercial and Industrial Customers.

FROM THIS

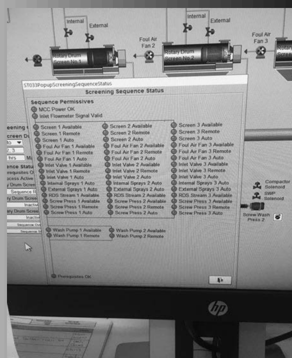
3. It travels through the Sewer Network and arrives at the Sewage Treatment Plant.

TO US AT THE TREATMENT PLANT

Where we…….

- → Ensure environmental licencing conditions are met
- → Monitor environmental discharges
- → Record and track plant data
- → Maintain and repair plant and equipment
- → Order plant consumables e.g. chemicals, rubber gloves.
- → Work safely at all times
- → Collect and test wastewater samples
- → Operate equipment to treat water
- → Clean and maintain equipment
- → Use high tech computer systems
- → Learn to read technical drawings
- → Conduct site tours for visitors
- → Write procedures
- → Some manual labouring
- → Use chemicals safely
- → Fault Analysis

4. We treat the raw wastewater through a biological process to ensure regulatory requirements are met. We undertake a broad range of daily duties to ensure this. We also have innovative sidelines i.e. Power & Gas Generation, Effluent and Biosolids Re-use.



TO THE ENVIRONMENT

5. Once the wastewater has been treated and meets license requirements it is discharged to the environment.

Leah Jones, Treatment Plant Operator for Queensland Urban Utilities. leah.jones@urbanutilities.com.au Ph. 0427 031465

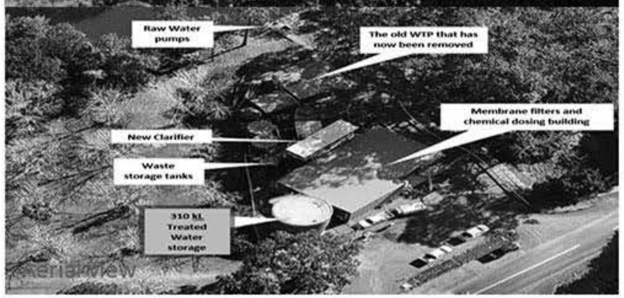
The new Canungra Water Treatment Plant

Delivering a modern water treatment plant for future population growth of Canungra and surrounds.

The redesign and upgrade the previous water treatment plant was certainly needed as it had been operating for almost 50 years and some of its structural components had reached the end of their service life. Construction involved progressively decommissioning and removing existing structural components of the old plant as well as installing the new facility.

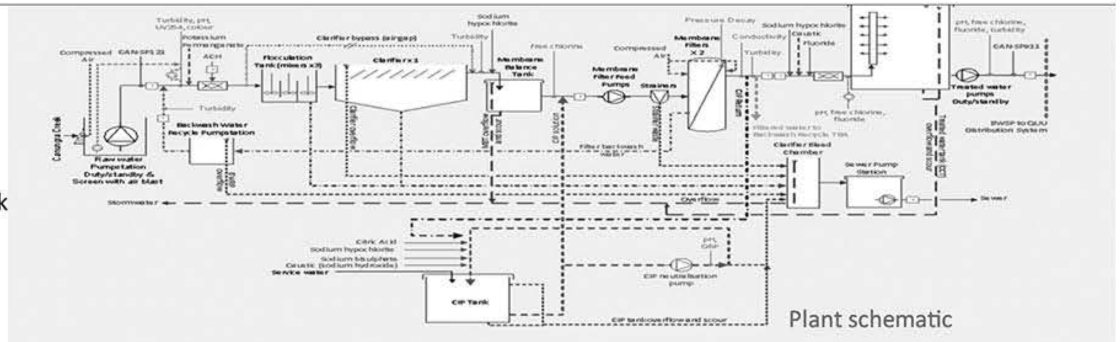
A secure and reliable water supply is critical to Canungra's continued prosperity and the health of its residents and environment. The new plant will be able to produce 1.5 million litres of treated drinking water each day, which is almost four times the production capability of the old plant, ensuring we can meet the community's future water needs.


Excavation of clear water tank



The new Canungra water treatment plant can treat raw water with **turbidity up to 1000 NTU** at a reduced flow rate. Under "normal" raw water conditions it can treat at **21.3 L/S** which equates to 1.53 ML/D with **onsite storage of 310KL**. That onsite storage alone gives us an **increase of 250 KL** onsite available for transfer to Appel St reservoir when required. Previously, with limited storage, in times of dirty water from rain events or maintenance issues this could leave us in a precarious position. Having the limited capability to treat a maximum of 5L/s at times it could take days to fill up the Appel St reservoir again if the demand was high.

A brief overview of the treatment process: Screening and pumping at the raw water inlet structure, with 2 submersible pumps that are presently run in a duty/ standby arrangement. From there we dose ACH, **Aluminium Chloralhydrate;** this is a change from the previous coagulant and is recommended with the use of the membrane filtration. The use of ACH also provides other benefits such as giving us a broader dose range which, when treating ever changing creek water, is of a great benefit. The dosed water is pumped into the inlet structure and proceeds through the flocculation and clarification process where a large percentage of the solids, heavy metals and organics are removed prior to filtration with the addition of pre-chlorination after clarification. From this point the fun starts, with **ultra-membrane filtration**. There are 2 membrane filtration trains, again operated in a duty / standby arrangement ,which filter the clarified water. Ancillary systems include backwashing, chemical cleaning and neutralization and membrane testing to verify the integrity of the membranes. After filtration **sodium hydroxide** is dosed for pH adjustment, **sodium hypochlorite** for disinfection and **sodium fluoride**. From there water is pumped from onsite storage to the Appel St reservoir on demand basis determined by the reservoir level.


Plant schematic

seqwater WATER FOR LIFE

Luke Ayres & Matthew Alderwick
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Luke.ayres@seqwater.com.au

YOU CAN SAVE A LIFE

Checking your skin is as easy as ABC…DE

Your skin check card simplifies the abcde rule of melanoma detection, the clinical best practice employed by skin specialists worldwide and helps you detect potentially deadly melanoma before it is too late.

Skin cancer warning signs

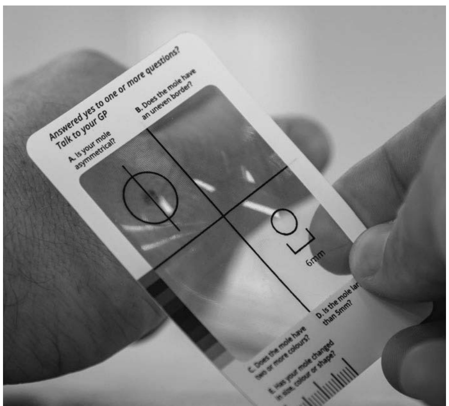
A — **ASYMMETRY**
Is your mole have an asymmetrical shape?

B — **BORDER**
Does your mole have an irregular border?

C — **COLOUR**
Does your mole have two or more colours?

D — **DIAMETER**
Is your mole larger than 5mm?

E — **EVOLUTION**
Has your mole changed size, colour or shape?



For more information
iamskincancer.com.au/education

Poster by Craig Mathisen & George Wall
Water industry Operators Association of Austrlaia
info@wioa.org.au