WATER WORKS

OFFICIAL JOURNAL OF THE WATER INDUSTRY OPERATORS ASSOCIATION OF AUSTRALIA

MAY 2017

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Contributions Wanted
WaterWorks welcomes the submission of articles relating to any operations area associated with the water industry. Articles can include brief accounts of one-off experiences or longer articles describing detailed studies or events. Submissions may be emailed to peter.mosse@gmail.com or info@wioa.org.au

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QUENCHING THE THIRST FOR INFORMATION

George Wall

In December 2016, WIOA surveyed our members to obtain their thoughts on the range of services provided by the Association, including our publications. With responses received from almost 400 members, the overall results indicated a high level of satisfaction with the services, communications and publications provided.

Interestingly, almost 90% of respondents advised that they regularly read the WIOA publications, including *WaterWorks*. When describing what information members were most interested in, the three most popular responses included new technology, technical information, and research and development items.

In line with member expectations, sourcing, locating and distributing quality and relevant information to the operational side of the water industry is, and always has been, one of WIOA's primary goals. We have developed a suite of initiatives over the years to help meet this aim.

WIOA has engaged and worked with a number of industry experts to develop a range of Practical Guides on the operation and optimisation of water and wastewater treatment plants, along with the distribution system. The Guides provide the latest in operational practices and optimisation ideas relating to each of the process steps. Many one day seminars have been successfully staged around the country where the information in the Guides is explained in greater detail.

The WIOA website contains the technical papers and posters from each of our Victorian, New South Wales and Queensland conferences, going as far back as 1998 in the case of Victoria. There is a search engine on the Home page of the website that allows website visitors to unlock a treasure trove of information potentially relating to their particular issue.

Our Technical Journal *WaterWorks* has been produced twice each year since 2001 and contains operationally focused articles. In sourcing material for *WaterWorks*, along with publishing the best papers from our conferences, the editorial team attempts to provide information that is practical and operationally useful, rather than hypothetical in nature.

We are finding that it is becoming increasingly more difficult to obtain articles from people in the operational side of the water industry. Although most Water Utilities are open in their approach and do not want others to make the same mistakes, there is a developing trend to not talk openly about issues where things have gone wrong or not 100% to plan. Sharing actual information and lessons learnt is the best way to keep the industry informed, help us all avoid making the same errors and reduce risk to our customers. We hope that Water Utilities will review their position on what material they approve for public release so that all relevant information can be provided for the betterment of the industry.

In recent months, WIOA has made a formal relationship with Water Research Australia (WaterRA). Like WIOA, providing quality and relevant information is a priority for WaterRA, given that they generate a significant amount of technical material on a regular basis.

OUR COVER

Our cover shot shows Torres Strait Island Regional Council Water Operations Manager, Mark David and Water Operator, Manuel Kepa replacing an RO membrane module on Yam Island in the Torres Strait.

Developing the relationship will allow WIOA to distribute operationally relevant material to our members and our operational stakeholders.

By way of example, WIOA has been actively distributing hard copies of the "Good Practice Guide to the Operation of Drinking Water Supply Systems for the Management of Microbial Risk – Research Project 1074" as it contains information specifically relevant to water treatment and distribution system operators.

An article highlighting the existence of the Good Practice Guide was published in the November 2015 edition of *WaterWorks*, yet we find it amazing how few operators are aware of its existence. An electronic copy can be downloaded from www.waterra.com.au/project-details/167.

Additionally, some articles from HealthStream have been reproduced in past WIOA publications. We plan to continue making appropriate linkages in the future with like-minded organisations to ensure that access to the best possible information is available for our members.

Finally, the member survey also provided useful feedback that we have used as part of a project currently underway to revitalise the association's online environment. We eagerly anticipate the launch of the new look WIOA website towards the middle of 2017.

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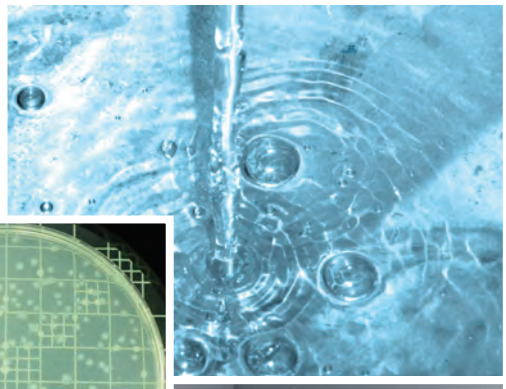
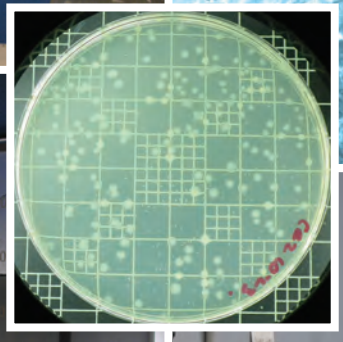



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WHAT YOU DON'T KNOW CAN HURT YOU

Winner of the Best Operator Paper at the 2016 WIOA Victorian Operations Conference

John deBoer

On the 12th of May 2015, a sequence of events began that, 10 days later, would culminate in a major hydraulic incident leaving the Yering Gorge Pumping Station (YGPS) critically damaged and exposing the operator on the site to significant risk. This event would result in the station being out of operation for two months before partial pumping could be reinstated, and a total of eight months would pass before the station would again operate at its full capacity.

The YGPS delivers water from the Maroondah Aqueduct and the Yarra River into the Sugarloaf Reservoir and is the primary source of inflow to Sugarloaf. In turn, Sugarloaf Reservoir feeds the Winneke WTP, which services the northern suburbs of Melbourne.

The total pump station capacity is approximately 1100 ML/day and comprises 4 main pumps – each with a capacity of 250ML/day – and 2 additional supplementary pumps – each with a capacity of 40 ML/day. The station is operated to harvest approximately 200 ML/day from the aqueduct together with the maximum available river flow, excluding the minimum required environmental passing flow of 350 ML/day.

The pump well is situated approximately 3 metres below the river bed and 55 meters below the Maroondah Aqueduct, with the station delivering water into Sugarloaf Reservoir, which is approximately 120 meters above the pumping station. The aqueduct suction main is an 1100mm diameter pipeline that drops almost vertically from the aqueduct into the station below (Figure 1). There is a manually operated diversion valve at the aqueduct, an actuated isolation valve on ground level 17 meters above the pump well, and an 1100mm actuated suction valve at each of the 2 aqueduct duty pumps.

The station draws water from the aqueduct suction main to supply critical station services, such as motor cooling, bearing cooling and seal ring flushing systems. Whenever the aqueduct is taken out of service, the station's services supply

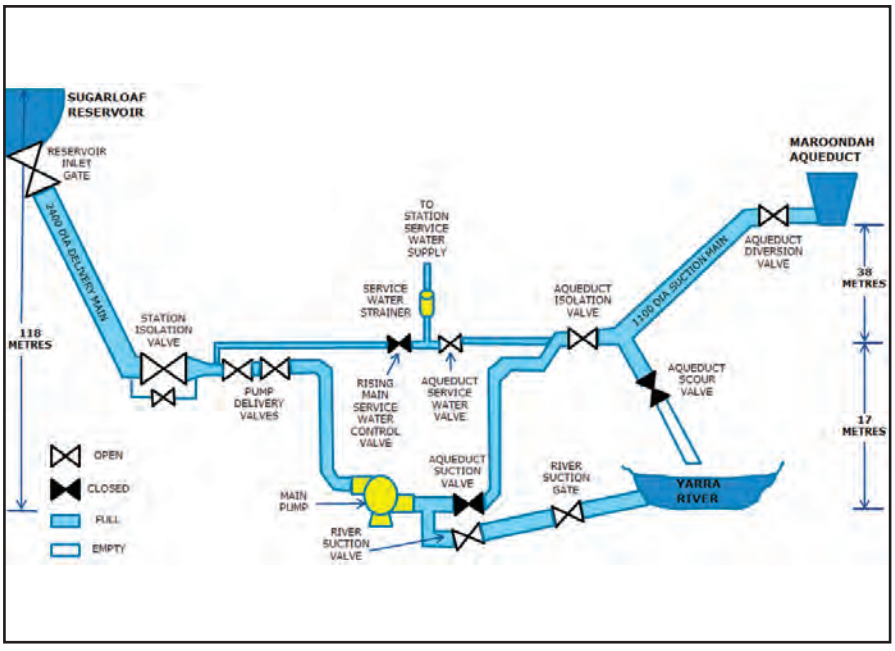

Figure 1. Normal operating configuration of the YGPS during river duty

is revalved to be supplied from the pump delivery main via a pressure-reducing service water control valve (Figure 1).

In order to protect the station against critical flooding events, the control system includes a "Station Shutdown" function. When this occurs,all pumps are stopped and the station isolation valve, river suction gate and the aqueduct isolation valve immediatley close to protect the station from external sources of stored energy. Critical faults that initiate a station shutdown include:

- Delivery main reverse flow
- Pump well flooded alarm
- 110-volt DC system failure
- Pressing the m anual "Station Shutdown" E-stop button.

Event 1: May 12–13

On May 12th, the Maroondah aqueduct was dewatered to the Yarra River to enable structural repairs to take place upstream of the pump station. The Aqueduct Scour Valve (Figure 1) was opened to dewater the aqueduct and the suction main down to the same level as the aqueduct isolation valve. During this time, the station was offline as the river flow was too low to allow pumping and the aqueduct supply was unavailable. The following day, river levels had risen sufficiently to allow river harvesting to resume. To facilitate this, the station services supply was transferred to the rising main and one of the main pumps was started on river duty.

Event 2: May 19

During the 6 days between May 13 and May 19, the remaining section of the aqueduct suction main gradually dewatered a further 17 meters to river level, through what was later discovered to be a leaking suction valve on one of the main pumps. With the Aqueduct Service Water Valve now closed, there was no means to ensure that the suction main remained fully charged, and there was no online pressure monitoring available to alert the operator that the main was now empty.

On the afternoon of May 19, operators shut down the pump station, as river flows had once again decreased to below minimum environmental levels. During the pump stopping sequence, a minor "reverse flow" was detected in the rising main.

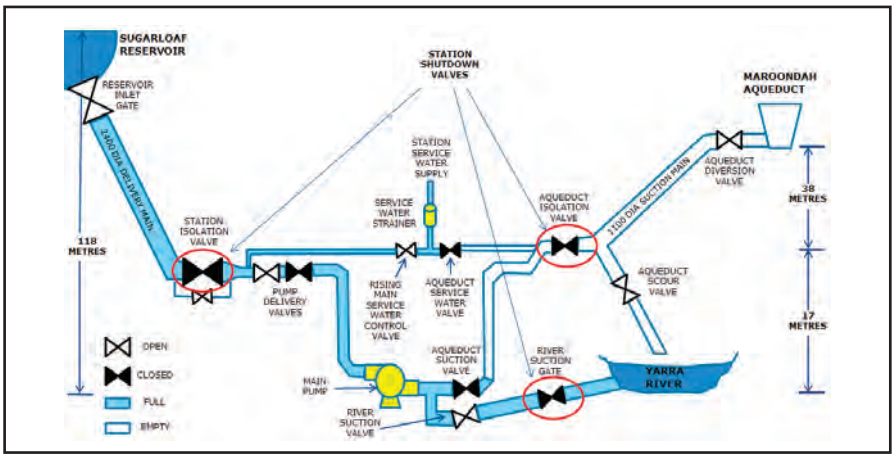

Figure 2. "Emergency Shutdown" configuration of the YGPS with the Aqueduct Suction Main dewatered

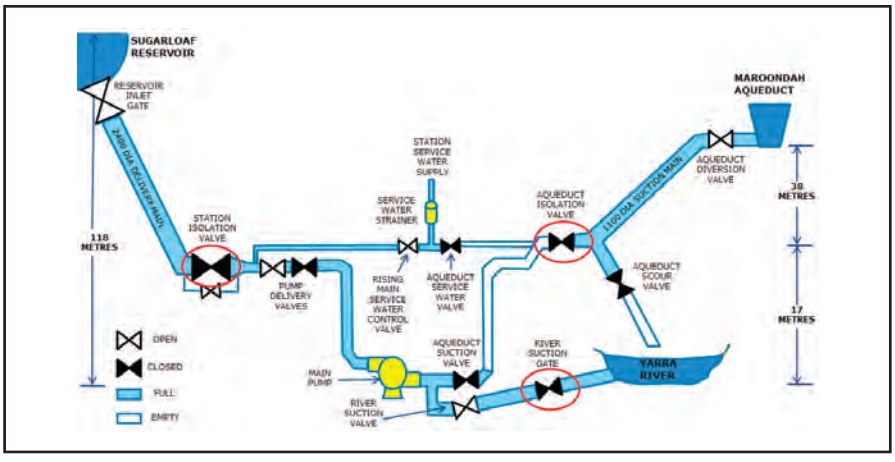

Figure 3. YGPS with the Aqueduct main recharged

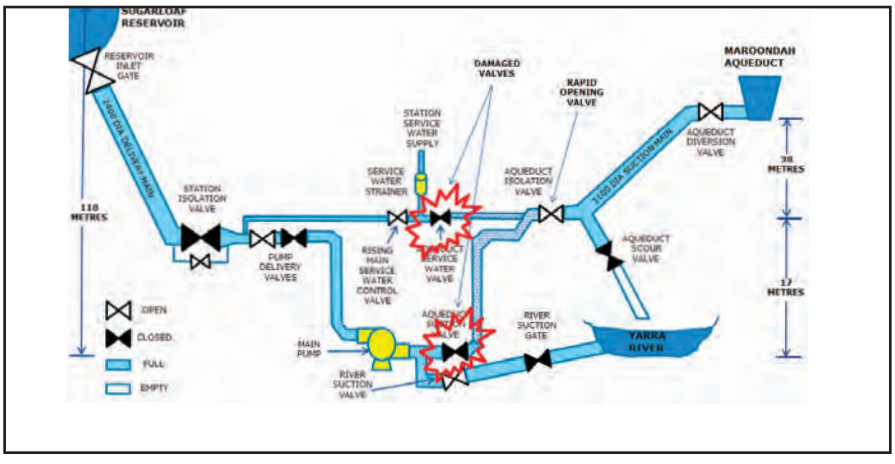

Figure 4. Location of damaged valves at the YGPS

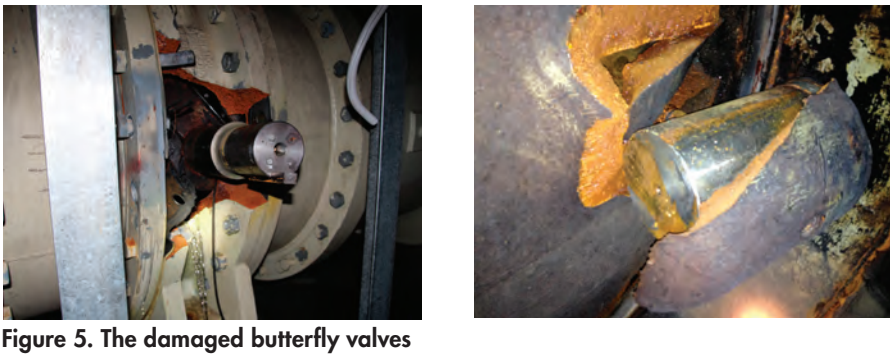

Figure 5. The damaged butterfly valves

This alarm initiated a "Station Shutdown" sequence that automatically closed the Station Isolation Valve, River Suction Gate and Aqueduct Isolation Valve. The reverse flow alarm during a pump stop sequence was not uncommon and was known to occur periodically. As the pumping station was no longer required to operate, it was left offline in "Shutdown" mode with the major isolation valves remaining closed (Figure 2).

Event 3: May 21

With the aqueduct maintenance works now complete, the aqueduct was slowly recharged, but only filled as far as the closed Aqueduct Isolation Valve, leaving approximately 17 meters of empty 1100mm diameter suction main beneath it (Figure 3).

Event 4: May 22

The Operator attended the site to prepare the station to resume pumping from the now recharged aqueduct supply. He initiated a "Station Reset" command. This control function returned the Aqueduct Isolation Valve to its pre-shutdown condition, and immediately opened the valve. The opening travel time of the 1100mm diameter butterfly valve is less than three seconds, and the rapid opening of this valve allowed the 40 tonnes of stored water above the valve to drop rapidly into the empty void below. The resulting pressure shock split the housing of the 250mm service water valve, causing water to flood from the ground floor into the station below. This showered the high-voltage pump drives with water and caused an electrical fault that turned off all station lighting except for minimal emergency lighting. The shock also hit the 2 closed, 1100mm diameter, Aqueduct Pump suction valves, tearing the butterflys from their cast housings and punching a 300mm hole into the side of one of the valves (Figures 4 and 5). Water flowing from these valves knocked down a blockwork wall and flooded into the pump well at a much greater rate than the sump pumps could manage.

In the Line of Fire

The Operator Interface Unit used for station control is situated on "C" floor at the bottom of the pump well, 1 level above the main pumps. With water flooding over high-voltage equipment from above, the pump well flooding from below and the station in total darkness, the operator was trapped in a precarious position.

To add to the operator's predicament, an emergency escape ladder adjacent to the operator interface had been recently deemed noncompliant and was barricaded pending further investigation. This left the operator with no choice but to remain in this location (Figure 6) until help arrived to safely isolate the electrical supply.

One of the alarm conditions that initiates the "Station Shutdown" sequence is a 110V DC supply failure. The water flooding in from the failed Service Water Valve above faulted the 110V system initiating a Station Shutdown, which closed the Aqueduct Isolation Valve preventing any further flooding. With the station power supply now faulted leaving the sump pumps no longer operational, the safety measure that initially led to this incident was the same measure that ultimately protected the station from being totally flooded.

Recovery Works

With all personnel now safe, and the station safely isolated, work began immediately to repair the station to an operational state. Transfer of water from the Maroondah Aqueduct was ceased, and 10 gigalitres of river water flowed past the station, unable to be pumped into Sugarloaf Reservoir. The Winneke Treatment Plant continued to supply water to Melbourne, but with no inflow, the level in Sugarloaf Reservoir began to decline steadily.

A team of operations, asset management and project engineering representatives worked tirelessly to implement the recovery project in as short a time as possible. Orders were immediately placed for replacement valves. Meanwhile, detailed isolation risk assessments and implementation plans were developed to allow the safe removal of the damaged valves and installation of blank flanges to enable the station to harvest from the Yarra River until the new valves arrived. A second shutdown was then conducted to remove the blank flanges and install the new valves, returning the station to its full operating capacity. These restoration works were conducted over a period of 8 months at a cost in excess of $1.2 million.

Post Event Investigation and Key Learnings

Following this incident, a lengthy investigation was conducted. Several key focus areas were investigated:

- Organisational Factors
- Task/Environmental Factors
- Individual Actions
- Absent or Failed Defences.

While there were many key factors associated with this incident, the root cause was ultimately determined to be that "the hazard of the Aqueduct Suction Pipe becoming dewatered was not identified in the design and subsequent operation of the YGPS."

The hazard was not identified in the relevant manuals, training or procedures, nor had it been observed in the operating experience of the pump station, and no mitigation measures were installed or implemented at the pump station.

The key learnings from this investigation include the importance of:

- Risk assessment processes during the design stage (HAZOP, CHAZOP & Safety in Design) to identify this type of hazard.
- Understanding hydraulic gradients and potential stored energy in pipes and pump stations.
- Monitoring and managing the differential pressure across control or reducing valves when de-isolating, recharging or resetting the plant.
- Understanding how the loss of control of stored energy can lead to asset failure with the potential to impact personal safety.
- Selecting the correct engineering controls, such as bypass valves, control interlocks and permissive alarms, to prevent the plant from operating in an unsafe condition.
- Ensuring that asset risk assessments include consideration of process safety risks and the effectiveness of existing engineering controls that manage these risks.
- Ensuring that risk assessments of operational or asset changes include a whole-of-system review of the potential impact of each change, and ensuring that those risk assessments are appropriately documented.
- Proactively reviewing local operations that may expose people to "line-of-fire" hazards in the event of an asset/technical integrity failure, including evaluating egress from these locations in the event of an emergency.
- Ensuring that core risks are identified for each operational site, and that effective controls are in place and appropriately documented in procedures.

The ripple effect from this incident spread to all corners of Melbourne Water's Service Delivery arm as management teams from both the water and sewer sides of the business took a fresh look at process safety at their key assets and asked themselves the question "could something we don't know about be waiting to harm us on our site?"

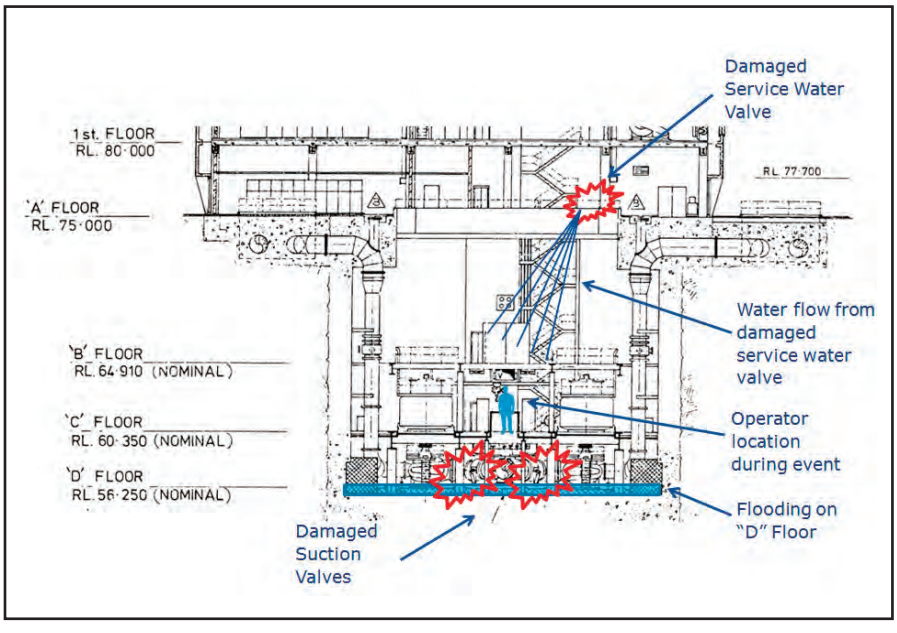

Figure 6. Operator location during the incident

The Author

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INNOVATIVE SOLUTION TO SEWAGE PUMP STATION UPGRADE

The asset owner at the Mount Piper Power Station, Rainer Scheurer, was looking for a solution to the maintenance issues associated with his submersible sewage pump stations on the site. The problems were: lifting chains breaking, pumps becoming stuck on their rails, and general reliability. Operators were also exposed to a seven-metre fall into the pit when lifting submersible pumps.

Scheurer went to Hydro Innovations, who suggested the use of Gorman-Rupp self-priming sewage pumps, which meant that any work could be done without opening wet well covers. Rainer liked the idea, but the pit was so deep that self-priming pumps could not be located at ground level.

Hydro Innovations suggested putting the pumps into the existing valve vault – to get pumps closer to water level – and Gorman-Rupp's V3B60-B pumps were chosen for the job, to deliver the 15 litres per second flow rate, but most importantly, were capable of re-priming the required 7.6-metre suction lift.

Hydro Innovations designed a system that could comfortably fit in the valve vault. A compact but practical design was approved and the project delivered.

Mount Piper Power Station now has a sewage pump station that is under cover (inside the valve vault), is easily accessed without the need for lifting apparatus, and can be safely maintained by one operator.

HIGH-PERFORMANCE, BEST-IN-CLASS TECHNOLOGIES

Managing water properly is a challenge for any supplier, and the bigger the area – and the harsher the environment – the bigger the challenge becomes. The Swan Hill Irrigation Region encompasses the established districts of Nyah, Tyntynder, Tresco, Flowerdays and Kerang; it covers some 31,480 hectares and services a range of agricultural enterprises, including horticulture, cropping, dairy, vines, cattle and lamb production.

Since the system was built, changes in irrigation methods, land use, and channel decommissioning and modernisation works have reduced overall system demand, and as a result, the existing infrastructure was struggling to cater to the reduced demand.

With costs of pumping becoming excessive, Goulburn–Murray Water, in conjunction with Envirotech Water Solutions, engineered a suitable solution to increase efficiencies, lower utility costs and reduce overall pump maintenance.

New pumps have been installed, and the major upgrades that have been implemented, including improved control systems, have contributed to overall improvement of pump station capacity and energy efficiency.

The district employs a number of 'reclaim' pump stations to both discharge groundwater to the Murray River and function as flood mitigation.

All sites consisted of vertical lineshaft-driven pumps of differing outlet and control configurations that had been in continual service since their installation 30–40 years ago.

Envirotech developed a simple, robust and cost-effective solution by replacing all units with custom-built submersible pumps and cable-support system, enabling the new pumps to be installed directly into the existing wet wells without modifications to surrounding earthworks and associated civil construction.

The pumps were also fitted with water-ingress probes, and thermal monitoring for the bearings and stator that, through the upgraded switchboard telemetry, warn of any problems before pump damage can occur.

By providing a submersible option, considerable costs were saved compared to the originally specified vertical lineshaft-driven pumps – with better pumping efficiency thus saving on energy consumption. Apart from the capital cost of the pumps, there are significant savings in maintenance costs, as the pumps can easily be lifted up and out of the wells by the cable system, which also improved safety as personnel no longer had to enter the wet well to perform routine maintenance as they did previously.

Envirotech Water Solutions has extensive experience with pumping stations, water storage and irrigation systems of all sizes and applications.

Their specialist knowledge and expertise has provided a solution that is not only acceptable to local authorities, but also to the many residents who rely on water in this rural environment. With more than 35 years of experience and hundreds of successful installations throughout Victoria and interstate, Envirotech Water Solutions is uniquely positioned to provide cutting-edge solutions to any brief.

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FISH AND SEWAGE LAGOON SLUDGE

Winner of the Hepburn Prize for Best Paper Overall at the 2016 WIOA Victorian Operations Conference

Ben Pohlner

Background

De-sludging sewage treatment lagoons is a costly and messy process, and it can cause a lengthy disruption to the operation of the sewage treatment facility.

Wannon Water in South-Western Victoria initially became interested in the concept of using fish to improve sewage treatment through earlier work undertaken by the Victorian Department of Primary Industries.

In 2008, Wannon Water invited Deakin University to investigate the possibility of aquaculture in sewage lagoons. The Hamilton Water Reclamation Plant (WRP) was chosen as the preferred site to undertake the research, as the relevant licences and permits were able to be obtained, and the effluent quality was deemed suitable for the purpose. A research facilty was constructed on the banks of the Hamilton WRP primary lagoon, and trials were set up to to assess fish growth, sludge accumulation and characteristics and water quality.

Establishing the Science : 2010–2013

Wannon Water has supported a number of Deakin University's Honors student projects to establish the basic science of using fish to improve the sewage treatment process.

The experiments were carried out in tubs on the banks of the lagoons (Figures 1 and 2) at 3 stocking densities. The fish survived well at each density; however, the growth rate of the fish was highest at the lower stocking density (Figures 3 and 4).

Figure 1. Control tank with no fish showing a heavy accumulation of sludge

Figure 2. Test tank with goldfish showing zero accumulation of sludge

The initial project was to determine the impact of common goldfish (*Carassius auratus*) culture on Total Nitrogen (TN) and Total Phosphorous (TP) in primary effluent lagoon water. The trial also examined goldfish survival at different stocking densities, and fish flesh was tested for any accumulation of pesticides and heavy metals. The early results showed very little impact on water quality, including TN and TP concentration over the duration of the trial. No accumulation of heavy metals in fish flesh was detected. An extension of this trial also showed no accumulation of pesticides.

One major point of significance was noted in this trial. Approximately 50 to 100mm of sludge accumulation was observed in the control tanks at the conclusion of the trial (Figure 1); however, almost zero sludge accumulation was noted in the tubs containing fish (Figure 2). This observation prompted further research focusing on the potential for fish to reduce sludge volumes in sewage lagoons.

Figure 3. Goldfish at the time of stocking the experimental tanks

Figure 4. Goldfish after 5 months in primary effluent

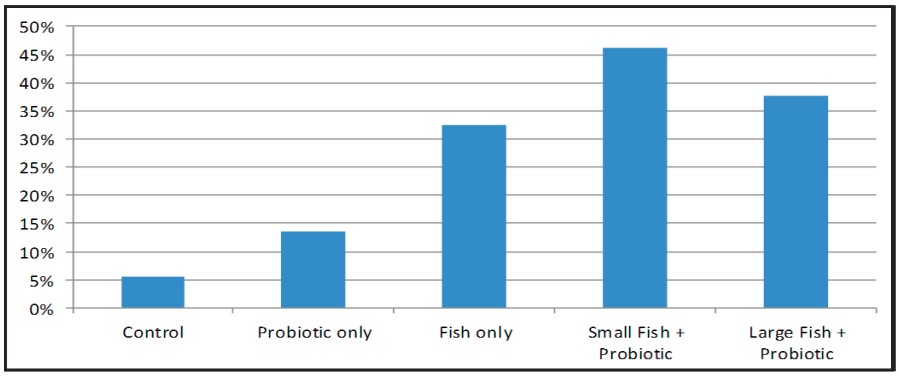

Figure 5. Sludge reduction over a 70 day period in static trial tanks

In an effort to identify a suitable native fish species for sludge remediation, a project was undertaken to assess a range of potential fish species, including 2 species of mullet, silver perch and tench.

These species were assessed for survival and their ability to remove sludge from the trial tanks. The results showed that there were no native species suitable for sludge remediation and that goldfish were the best performers in the trial. These new trials also found a significant decrease in accumulated sludge in tanks with goldfish, confirming the earlier results.

A subsequent trial assessed the impact of goldfish on a set volume of sludge in a static tank with no inflow or outflow. The trial used sludge and water directly from the Hamilton primary effluent lagoon. A probiotic was also included in these trials as a comparison. The probiotic was promoted as being able to significantly reduce sludge volume by enhancing the natural bacteria populations in a sewage treatment system, and thereby contribute significantly to the decomposition of sludge.

Results over 70 days showed fish survival of 89–93% and rapid early growth. All treatments containing fish displayed significant decreases in sludge and treatments without fish showed very minor decreases that were not significant (Figure 5).

Our results showed an average of 13.5% reduction in sludge volume when probiotic was used alone compared to goldfish, which recorded an average of 32.4% reduction in sludge volume. Of most interest was the combination of fish and probiotics, which recorded from 37.6% to 46.2% reduction in sludge volume.

This trial demonstrated that fish are very effective at removing solids; however, utilising fish in combination with probiotics appears to be a more effective technique for sludge reduction.

Growing our own fish: 2013–2015

Based on the trial results, Wannon Water secured an unused commercial aquaculture facility in Warrnambool (Victoria), capable of producing up to 2M fry (young fish) annually. This facility is now producing goldfish specifically reared for sewage sludge treatment.

Wannon Water also invested in the development of a Juvenile Fish Production Facility in Hamilton. This involved the conversion of an obsolete biosolids drying bed facility comprising 16 cells. This facility is currently used to grow 15 mm fry from the Warrnambool hatchery up to 50 mm in size ready for stocking into operational sewage treatment plants.

Finding the ultimate sludge sucker –Goldfish x Carp hybrids

Common carp (*Cyprinus carpio*) are seen as superior to goldfish for the purpose of sludge remediation, as they grow faster, grow bigger, and are able to tolerate extremely harsh water quality environments. Carp are classified as noxious and invasive in Victoria, meaning that the biosecurity requirements for culturing carp would be so restrictive that any proposal to use them in sewage treatment could not practically proceed.

During 2013, Wannon Water investigated goldfish x carp hybrids, which are cultured overseas as a food fish. This fish (when crossed correctly) presents significant advantages over both carp and goldfish in that it grows faster and to a much larger size (15kg+). It is very hardy and able to tolerate very poor water quality conditions (much tougher than both carp and goldfish). It also has enhanced disease resistance and it is almost sterile.

Deakin University undertook a literature review into the fertility status of goldfish x carp hybrids. This review found that male hybrids are sterile, however, there is a slight chance that female hybrids may be fertile. It is not known if hybrids could develop a self-sustaining population in the wild if inadvertently released.

In 2015, Wannon Water received the appropriate DPI licences and commenced a program to breed goldfish x carp hybrids in Warrnambool, to develop hatchery methods (in conjunction with a commercial hybrid hatchery in America). As a result of this work, successful spawning, larval rearing, and grow out of hybrids was achieved. Further work is now being undertaken to demonstrate acceptable levels of sterility using different larval rearing techniques in an effort to gain DPI approval to stock this fish in primary effluent lagoons.

Implementation at Hamilton and Port Campbell

Initial lagoon stocking using goldfish was undertaken at the Hamilton WRP in 2015/16 to investigate the impact on sludge on a full lagoon scale. Approximately 150,000 fish were raised by Wannon Water and stocked into the primary lagoon. The assessment of their impact is ongoing, with sludge surveys using sonar technology undertaken at 6-monthly intervals to determine impact on sludge volumes.

A more structured research trial was also recently implemented at the Port Campbell WRP. Port Campbell has a twin primary lagoon system, with influent distributed evenly between the 2 lagoons. One primary lagoon at Port Campbell was stocked with goldfish to enable a direct comparison between the primary lagoons and the impact of fish on sludge volumes. Monitoring of fish and water quality is undertaken on a weekly basis, and sludge volume monitoring is undertaken on a 6-monthly basis. The trial will also assess overall treatment plant efficiency and any implications for EPA licencing.

To date, this trial is going well, with sampled fish showing good growth and no symptoms of disease or stress. Fish are able to tolerate the primary effluent lagoon enviornment and have no impact on the daily operation of the facility. This trial is due for completion in mid 2017.

The Author

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PORTABLE MAINS DISINFECTION AFTER REPAIR

Peter Mosse and Derek Braden

In 2014, a joint publication entitled Effective Microbial Control Strategies for Mains Repair and Depressurisation was released by the American Water Research Foundation and the United Kingdom Drinking Water Inspectorate (WRF 2014). This definitive guide provides a sound scientific basis for works practices, flushing and disinfection during and after repair of water mains. If you don't already have a copy, it can be downloaded from www.wioa.org.au/operator_resources/tools.htm

One of the recommendations relates to the need to disinfect high-risk breaks to achieve a Ct of 100 for the whole section of pipe, along with associated valve faces and hydrants that were dewatered. Very simply, this means that chlorinated water needs to be held in the pipe section. Ct 100 can be most easily achieved by dosing at 10mg/L and holding for 10 minutes (10 x 10 = 100), or dosing to achieve 5mg/L and holding for 20 minutes (5 x 20 = 100).

Additional support for the need for disinfection of mains repairs comes from the study reported by Nygaard et al in 2007. The authors reported that when flushing and disinfection is carried out after a mains repair that required isolation and dewatering, there was a reduced risk that people living downstream of the repair site would become ill.

Figure 1. The portable disinfection unit deployed in the field attached to two hydrants

How can this be done easily?

A small portable unit has been developed to facilitate mains disinfection.

The unit consists of a metal box (D:740mm x W:700mm x H:1000mm and weight ~45 kg) mounted on wheels with all the necessary equipment to facilitate disinfection (Figure 1).

The unit is set up as shown in Figure 2. Water is passed around a closed valve through a bypass pipe that is situated between the source water and an entry point into a water main to be treated.

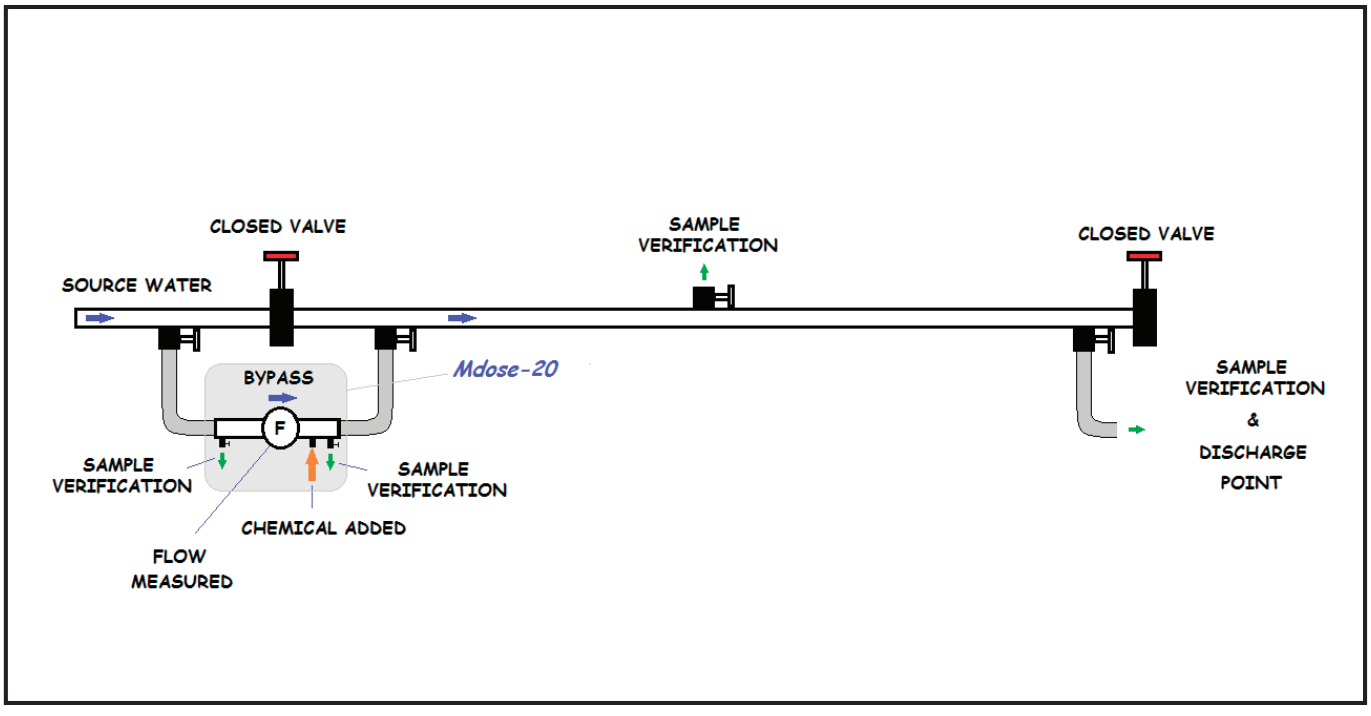

Figure 2. Schematic showing how the portable disinfection unit is deployed in the field for chlorination

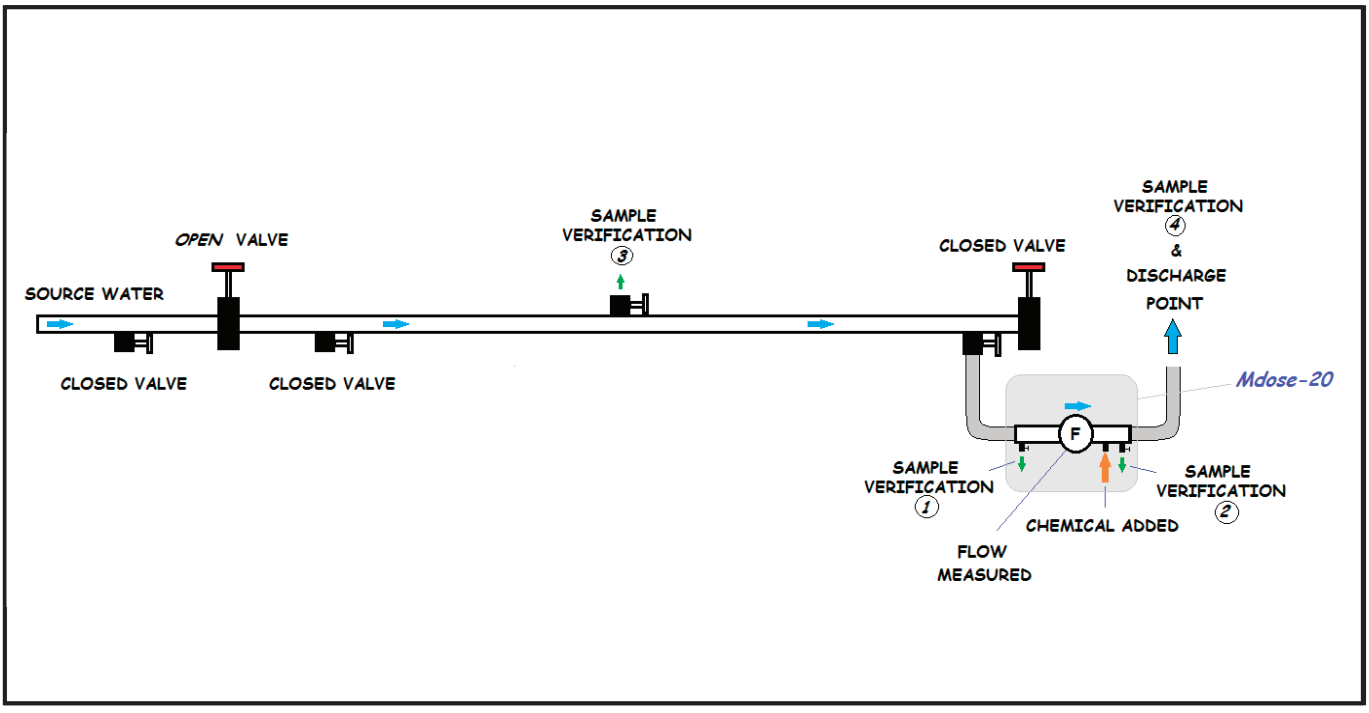

Figure 3. Schematic showing how the portable disinfection unit is deployed in the field for dechlorination

A flow meter measures and displays the flow rate in the bypass pipe. Based upon the flow rate, a metering pump in the unit doses a controlled amount of disinfectant (usually Sodium Hypochlorite), into the water stream prior to leaving the bypass pipe. A free chlorine residual analyser can also be incorporated into the unit to verify the actual dose being applied.

The treated water then passes through the section of main to meet the disinfection criteria specified. Verification of free chlorine residual levels are taken manually at various locations along the pipeline, usually at hydrants or fire plugs. On arrival of the chemically treated water at the discharge point, all dosing is stopped and the water is "captured" between closed valves at each end and held for enough time to achieve a minimum Ct of 100.

Is disinfection required for all mains breaks repairs?

Absolutely not; however, in a situation where contamination of the inside of the pipe could or has occurred, then the answer is definitely yes. The need for disinfection can be reduced by meticulous attention to hygienic work practices before, during and after the repair. However, it is prudent to recognise that contamination may occur, and to be prepared for what to do when it does.

What happens to the super chlorinated water in the pipe?

The same portable unit can be used to dechlorinate the water as it leaves the pipe (Figure 3).

On completion of the disinfection stage described above, the unit is flushed out and transferred to the discharge location where the pipeline water is de-chlorinated as it is discharged to waste (Figure 3). This uses the same equipment with a saturated Sodium Thiosulphate solution.

Alternatively, a dechlorination mat system can be used as described by Denny Anderson on page 18 in this edition of *WaterWorks*.

Other uses

The portable system described above can also be used for disinfection of new mains according to the requirements specified in WSA 03-2011-3.1.

The Authors

Peter Mosse (peter.mosse@gmail.com) is the owner of Hydrological P/L. Derek Braden (derek@c-techservices.com.au) is the Managing Director of C-Tech services in Melbourne.

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DECHLORINATING AFTER MAINS DISINFECTION

Denny Anderson

Once a main has been disinfected after a high-risk repair, or indeed a new main that has been installed, the question has always been what to do with the chlorinated water. It is generally not acceptable to the EPA to discharge this water directly to the environment.

Possibilities include:

- Use a hydrant to aerate the water up into the air to dissipate the chlorine
- Let the highly chlorinated water run over grass or the road surface to again dissipate the chlorine
- Run the chlorinated water over and through hay bales
- Collect the flushed water in a tanker.

These are all poorly controlled strategies.

Central Highlands Water (CHW) have used a technique involving a dechlorination mat and a dechlorination diffuser hydrant.

In both cases, sodium sulphite tablets are used (Figure 1). Sodium sulphite (and sodium metabisulphite) react with chlorine to produce environmentally harmless chemicals.

Dechlorination System

The dechlorination system consists of a dechlorination mat (Figure 2) and a dechlorination diffuser hydrant (Figure 3). The mat system consists of a fabric mat with pockets sewn into it. The sodium sulphite tablets are simply fitted into the pockets.

The mat is placed on the ground and water from the hydrant is allowed to flow onto, through and over the mat (Figure 5).

Alternatively, in situations where superchlorination is carried out, the diffuser hydrant is generally used without the mats.

The system has been in use at CHW for about 5 years and the field teams find them very simple to use and effective.

The Author

Denny Anderson (denny.anderson@chw.net.au) is Team Leader, Civil Maintenance Delivery with Central Highland Water in central Victoria.

Figure 1. A drum of sodium sulfite tablets

Figure 2. The dechlorination mat showing the pockets with sodium sulfite tablets in them

Figure 3. The dechlorination diffuser hydrant showing the position of the sodium sulfite tablets

Figure 4. The projection end of the dechlorination diffuser hydrant

Figure 5. The dechlorination system in situ

FLUSHING AT 1 M/SEC

Neville Whittaker and the GVW Central O&M Team

In the November 2016 edition of *WaterWorks*, an account of the development of Goulburn Valley Water's (GVW) Safe Water, Mains Repair Procedure was published. GVW's Safe Work Instruction (SWI) requires repaired mains to be flushed at a rate of 1 m/sec for 3 pipe volumes.

Before being able to apply this requirement, the flow of 1 m/sec needed to be converted to a meaningful L/sec figure. The Flushing Velocity Calculator, available on the WIOA website www.wioa.org.au/operator_resources/tools.htm was used to calculate the flow rate. So for example, for a 150 mm pipe, the required velocity is 17.7 L/sec.

While there are ways to calculate the flow velocity from the way the water flows out of a hydrant, the Central O&M crew elected to use a direct reading hydrant. As a result, digital flow hydrants which provide both totaliser and instantaneous flow rate (L/sec) have been purchased. The hydrants are painted hot pink to make it very clear that they belong to Goulburn Valley Water and are only to be used for Safe Water projects. Figures 1 and 2 show examples of the hydrant in use at 6.8 L/sec and 30.3 L/sec. The flow rates are easily dialled up by simply opening the hydrant until the required flow velocity registers on the output screen.

In addition, all shovels used on water main bursts in the Central O&M district have been painted hot pink (Figure 3)

As you can imagine, the O&M team is "extremely pleased" to use these hot pink items!

With the arrival of these hydrants, the pink shovels and a portable disinfection unit allowing us to chlor nate after high risk main repairs (see page 17 of this edition), we now feel more confident that we can deliver best practice management of any mains repair.

Figure 3. THE "shovels"

The Author

Neville Whittaker (nevillew@gvwater.vic.gov.au) is District Manager Central O&M at Goulburn Valley Water in Victoria.

Figure 1. Hydrant flow and instantaneous readout at 6.8 L/sec

Figure 2. Hydrant flow and instantaneous readout at 30.3 L/sec

A BETTER WAY OF CLEANING WATER MAINS

It's been a little more than 10 months since the Detection Services NO-DES unit rolled out of the Morayfield workshop of Brisbane Isuzu. Since then, it has worked its way across Queensland, New South Wales, Victoria and South Australia, working with various utilities to clean and disinfect water mains of various sizes. We have cleaned, to date, more than 100 kilometres of water mains, and as the unit becomes accepted by progressive utilities as a viable and effective alternative method of cleaning water mains, the NO-DES unit has become increasingly productive and effective. Initially, we were flushing around two kilometres per day; however, we are continuing to make significant strides in outputs without compromising quality.

We have certainly learnt a lot about its capabilities; for example, we know that by supporting the planning of a mains flush and working with clients to understand the locations of valves and hydrants, we can achieve significant rates of cleaning per day. This has been a significant learning curve for us and our clients, and we have reaped significant benefits when using such a collaborative approach. Our average daily clean using the loop approach, as depicted above, can see around 5.5–6 kilometres cleaned daily.

We have removed significant levels of sediment and biofilms from water mains of varying sizes, and have seen great results removing turbidity and increasing chlorine residuals, as the NO-DES unit can also add a residual back into the network safely and methodically.

The use of the NO-DES unit provides significant benefits: no water is wasted during the process; there is no environmental discharge to plan and cater for; the system remains online, keeping customers in supply; and the unit is portable and simple enough to establish without significant traffic control and customer interface.

With support from the client, the NO-DES unit can easily achieve flows of more than 120 litres per second; it's able to clean water mains at a velocity of more than 1.5 metres per second. A recent project at a busy airport in Queensland saw flows of 122 lires per second removing sediment and biofilm from a 415-millimetre water main and providing a chlorine residual upon completion. The unit was so successful in removing the biofilms that it's due back in a few weeks to flush more assets for the client.

The technology and our collaborative approach to mains cleaning is now becoming accepted by forward-thinking utilities as a useful and effective tool when dealing with issues such as nitrification, elevated turbidity and low chlorines. The unit itself can be mobilised very quickly, and is completely self-sufficient. We can be on site within 24 hours of your call, and in most cases, even less.

If you would like a presentation on our approach, or even a demonstration showing how the NO-DES unit can support your efforts and reduce waste and environmental discharge more effectively than traditional methods, please give us a call on 1300 772 835.

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RED DISCS AT MORGAN WTP

James Gorman

A number of waterborne illness outbreaks around the world (including in Australia) have been caused by valves being left in the wrong position after servicing. One of the best known is Nokia in Sweden in 2007, where a valve separating potable water from recycled water was left open after servicing, allowing 450 kL of treated effluent to enter the potable system. This resulted in 6500 people falling ill. There was also an event in central Victoria in Australia at a cheese factory, which had a truck wash down bay. By altering a position of a valve, either drinking water or bore water could be used for wash down. The problem was that the bore was about 20 m from the factory septic tank drain system. On the occasion of the event, the valve was left open, allowing the higher pressure contaminated bore water containing pathogenic bugs to flow into the factory system.

Clearly it is important to ensure that valves are always in the correct position and that the position of the valves is known.

A system has been in place at the Morgan WTP for many years. It consists of a Valve Hook Board which has a hook for each valve. The Board also indicates the valve position in normal operation (Figure 1). The abbreviations on the Board are NO = Normally Open or NC = Normally Closed. There is a red disc tag for each valve.

Figure 1. Two of the hooks on the Valve Hook Board showing the two possible orientations "NO" and "NC" of the valve

The red disc tag for the valve remains on the valve when the valve is in its normal operating state (Figure 2).

If the valve state is changed during service, the red disc tag is removed and hung on the Valve Hook Board (Figure 3 and Figure 4)

This then gives a visual representation of what valves are not in their normal operating state.

Figure 5. A clear Board at the end of a task clearly shows all the valves have been returned to their correct normal operating position

When the maintenance task is completed, the Board will have no tags left on it, indicating that all valves have been returned to their normal operating state and the tags will be back on the valves.

The Author

James Gorman (james.gorman@sawater.com.au) is the Water Treatment Coordinator at the Morgan WTP at Morgan in South Australia.

Figure 2. The red disc tag on the valve shows the valve is in its correct "normal" operating position

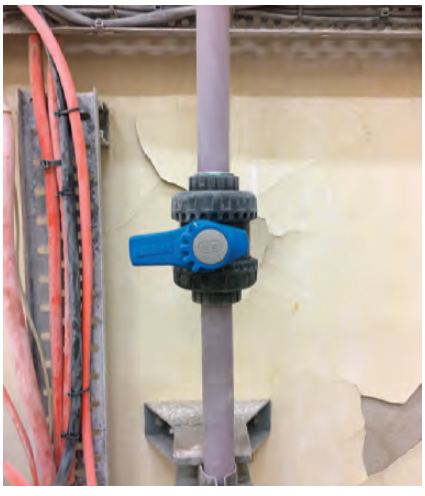

Figure 3. The valve position has been changed and the red tag is placed on the Valve Hook Board

Figure 4. A quick look at the Valve Hook Board reveals which valves are not in their normal operating position

SOLIDS INCINERATION AT LOWER MOLONGLO

Shane Dyson and Eric Nielsen

The Lower Molonglo Water Quality Control Centre (LMWQCC) biosolids handling process is unique in that it processes solids using the only large sewage sludge incinerator in Australia.

The system was designed in the early 1970s and installed from 1974 to 1978 as part the construction of the larger LMWQCC WWTP. Incineration was seen as favourable over other methods of solids handling due to a number of factors:

- While the location of LMWQCC meant that flows could be gravitated to the plant, it placed challenges on removal of large quantities of solids from site and increased demand onto landfill sites on a growing city.
- Incineration allowed for solids to be reduced by a third, with an average of 45 tonnes of dry solids per day reduced to 15 tonnes of ash material.
- It also created an opportunity to reuse the ash from site, and to be on sold as a lime-enrichened agricultural soil conditioner under the name "Agri Ash".
- Incineration also offered the option of energy recovery by heated scrubber filter water being returned to the screened wastewater flow. This is extremely useful to the biological process during the cold Canberra winter months, where the difference between 15ºC and 17ºC results in an almost exponential amount of biological activity.

Overview of the Solids Handling Process

Figure 1 outlines the solids handling process at LMWQCC. The typical treatment processes, such as screening and grit collection, are employed; however, unlike the majority of WWTPs in Australia, these products are not disposed of at landfill sites. They are instead incinerated with the other solid waste streams, such as settled primary solids and waste streams from the biological nutrient removal process.

Combined thickened sludge and macerated screenings are pumped from the sludge holding tank to one of three centrifuges. Dewatered sludge, or "Cake", is fed via a series of conveyors to the online furnaces; centrate is piped to the building's drainage sump and from there pumped back to the screened wastewater flow at the head of the plant.

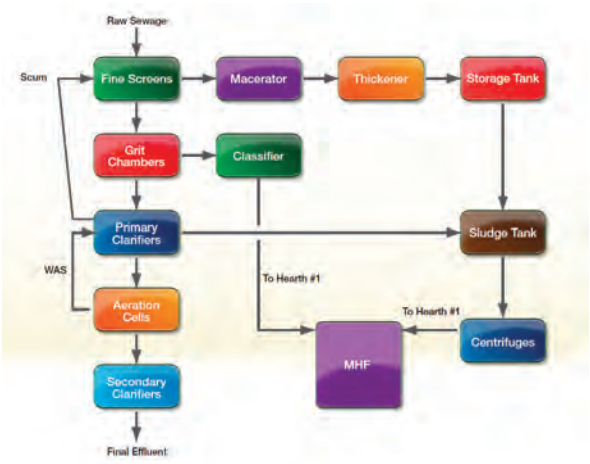

Figure 1. Overview of LMWQCC Solids Handling Process

The Incinerator

The incineration system consists of two identical Multi Hearth Furnace (MHF) combustion trains comprising of:

- 2 x 6.8 m outside diameter – 9 hearth Incinerators, both 13 m tall
- A multi-clone cyclone system for separation of heavy particulates
- A wet scrubber exhaust system with pre-cooler and impingement plates for capture of fine particulates
- An induced draft fan and butterfly valve air dampers to maintain negative pressure conditions within the furnace
- Multiple types of stack emission instrumentation
- Ash cooling and handling system
- 6 x auxiliary fuel oil burners in hearths 5, 6 and 7

These are presented diagrammatically in Figure 2.

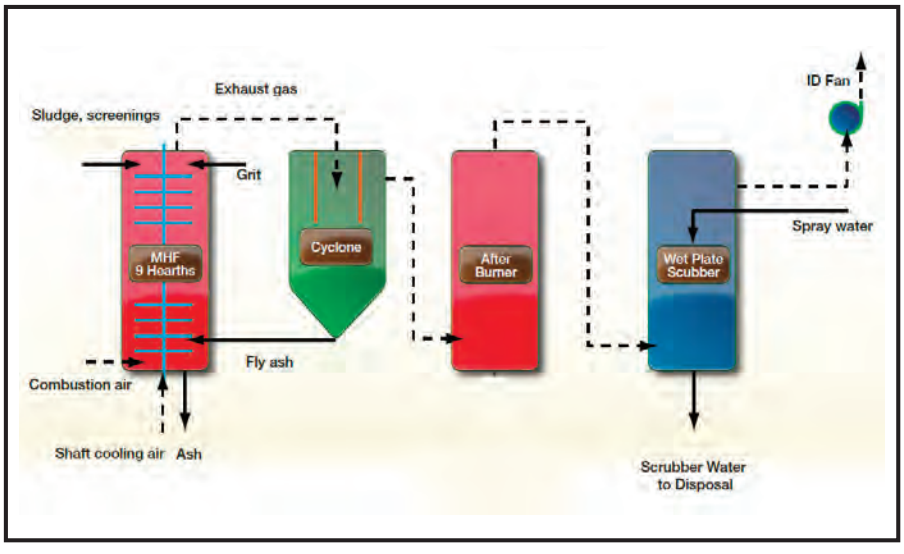

Figure 2. Overview of MHF process

The MHF (Figure 3) can be divided into three zones. The first zone, which consists of the upper hearths, is the drying zone. Most of the water is evaporated in this zone. The second zone, generally consisting of the central hearths, is the combustion zone. In this zone, the majority of combustible material is burned, and temperatures reach 760–1150ºC. The third zone includes the lowest hearths and is the cooling zone before ash is conveyed to storage bins.

Operation of the System

Operating this dynamic process is a task that requires considerable training and operational experience.

The MHF is operated, monitored and controlled 24 hrs a day, 7 days a week. Due to the constantly changing characteristics of sludge feed to the furnace, operation could not always be described as being in a stable condition, and can dive and climb rapidly (Figure 4).

This requires an immense amount of interaction and fine tuning to changing conditions. For example, the control room can't be left without someone monitoring trends and alarms because of the likely possibility of rapid changes. Typical operating conditions have evolved substantially compared to those when it was designed and built some 40 years ago. Following is an outline of the main factors that affect operability.

Variability of feed characteristics

The furnace was originally designed to burn sludge at approximately 8 L/s at a sludge density of 12–17%. Typical operating conditions today, 40 years on, are 10–12 L/s at 30–40% solids. This change in sludge density (being twice as dry as design) has resulted in the burn or onset of combustion occurring in the upper hearths, so instead of combustion taking place in hearth three, it occurs in hearth one or two. These values have changed because of population increase and a secondary augmentation to the process, adding an anoxic bioreactor which has resulted in tonnes of additional biomass in circulation. Additionally, density has been affected by competing economies – lime reuse vs combustion costs. Lime was originally reclaimed and recycled through the incineration process, as at the time lime was more expensive than fuel. More so, feed density has increased because of more efficient dewatering equipment. During a shift, proportion of volatiles in the feed can change dramatically, which affects overall burn and furnace stability. This is because of a daily flush of the plant's inflow structure. Grit loadings on the furnace are constant but due to poor grit classifier performance, water can be transferred through to the furnace, resulting in high emissions and temperature drops, all making the operation of the furnace more challenging.

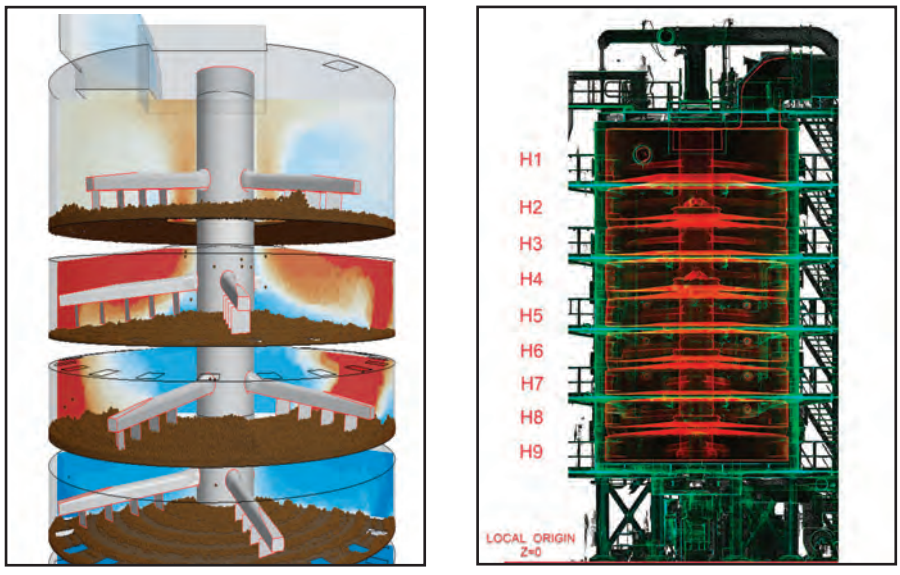

Figure 3. Cut away schematic of the Multi Hearth Furnace and diagrammatic representation of the process

Inherent risks associated with incineration

As can be expected with any incineration process, there are a multitude of interlocks associated with protecting the asset and personal safety of employees. These range from pressure drops on a fuel line, whether or not a scrubber water supply pump is running, fire detection alarms and many more. These examples and many other interlocks – some 24 in total – are all capable of tripping feed to the furnace, causing an unstable environment to "burn out" the furnace.

Of course, some safety measures are put in place from lessons learnt. For example, on the 10th of May 1995 the screenings and incineration building caught fire due to ignition of combustible material in a foul air duct. As a result, all fibreglass in the furnace hall was replaced with steel and more importantly a hot work permit system was put in place.

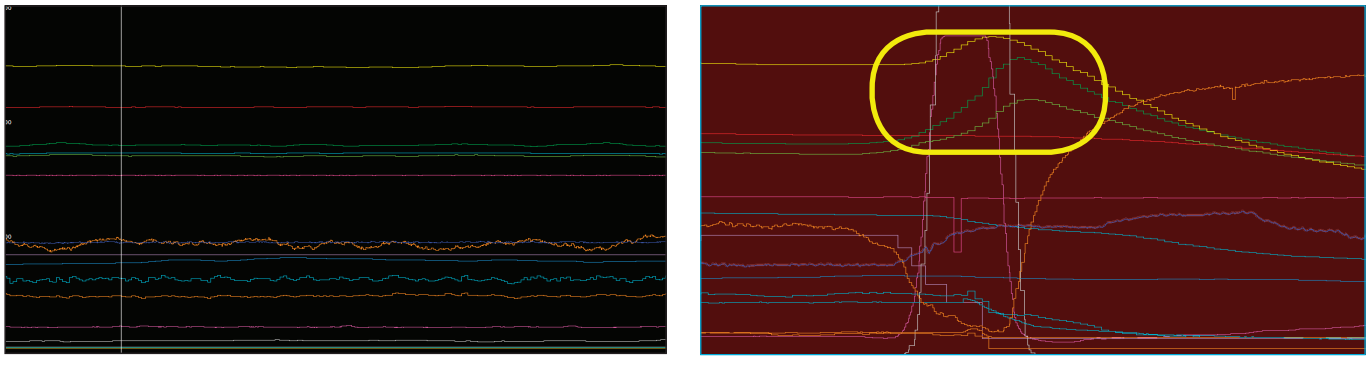

Figure 4. Examples of stable furnace operation on the left and unstable operation on the right where temperatures varied by about 300°C over a period of about 3 minutes

Others can be general nuisance from alarms due to smoke and ash, which are not uncommon. This can be managed reasonably during normal conditions, but when projects or major maintenance is occurring, the operator's focus is not only devoted to furnace monitoring and shutdown but also site management procedures. During an emergency, all site work ceases and site personnel muster, with operators acting as site safety wardens.

Sludge inventory

As sludge from the primary settling tanks is the main feed source for the furnace, whether or not the furnace is running bears great influence over sludge inventory and variables, such as WAS rate. Inversely, sludge inventory is a main driver for sludge feed rates to the furnace. Prolonged periods of high inventories must be combated with high feed rates to the furnace sometimes running dual centrifuges at rates of 14 L/s. Although this is achievable, the furnace requires even closer monitoring of hearth temperatures, oxygen demands and emission parameters as it operates in an even more meta-stable condition.

Design legacies

The successful operation of the furnace depends on obtaining accurate, reliable and, most importantly, truly representative combustion temperatures. Gaining truly representative temperatures from the furnace is just about impossible; the thermocouples on an IN hearth (where the gases flow OUT) give a representative reading. However, the thermocouples on an OUT hearth (where the gases flow IN towards the shaft) read a combination of the temperature of the flue gases coming up through the drop holes from the hearth below and flame radiation from the hearth below, especially in the combustion zone. A compounding issue is that each hearth contains only one thermocouple, reducing operator feedback and resulting in difficulty to pre-empt the "burn" moving from one hearth to another, which can cause flare ups as combustion rapidly moves to material not yet burnt.

The burners are as they were installed 40 years ago and can be hard to start, which happens when they are generally needed the most, which is in a rapid temperature loss situation. Furthermore, they cannot be controlled automatically or to set point as the thermocouples do not return reliable information about conductive heat transfer.

While not truly representative, at least temperature is reported to the operator in real time whereas time lag from the stack emissions analysers can be between 5 and 15 minutes. This essentially means that by the time emissions readings are out of specification relative to our atmospheric licence parameters, the conditions within the furnace causing the issue have already occurred. This is more often than not overcome by the intuitiveness of operators piecing together multiple other inputs and pre-empting changing conditions.

Ageing infrastructure and equipment

As the plant was built some 40 years ago with equipment generally replaced as necessary, ageing infrastructure begins to present issues as equipment failures become more frequent, resulting in more scheduled shutdowns.

While condition monitoring can predict certain equipment failures, others are unpredictable. For example, loss of a core in a multi-core cable causing an Induced Draft Fan trip and a prolonged shut for fault finding. These planned or unplanned shutdowns result in situations where maintaining the atmospheric licence is difficult. Also, the loss of production and increased sludge age in primary and secondary clarifiers put other stresses on the rest of the plant.

Upgrade Works to Improve Operability

Development of a Computational Fluid Dynamics (CFD) model of the incineration process has allowed assessments to be made of different upgrade options for the MHF.

The projects identified are summarised below.

- Equipment upgrade of the furnace and exhaust system, including new additional thermocouples, new dual fuel burners, new natural gas supply for these burners and a new drop chute to allow cake to be fed directly into hearth 3 moving the combustion zone down into hearths 3 and 4 as originally designed.
- A complete electrical, instrumentation and control upgrade.
- Installation of 3 new centrifuges and associated polymer dosing systems, new and modified centrifuge diverter chutes and a centrifuge hot swap changeover tank to enable centrifuges to be run in different modes simultaneously.
- Installation of a new Sludge Holding Tank, which anticipates spreading the load of percentage of solids in the feed to create a more consistent sludge feed. This consistent feed should eliminate the peaks and troughs of temperatures throughout the shift, and will provide capacity to 2030 and allow improved management of sludge age.
- Provision of increased capacity for the inlet screens and macerators, and increased performance and stability in the grit dewatering process reducing the moisture content of material being fed into the furnace.

Agri-ash Reuse

The Agri-ash product is spread on paddocks in much the same way as lime or other fertiliser. A local contractor, Fertspread, manages the sales of the product.

The following information is taken from the Fertspread website (www.fertspread.com/agri-ash)

Agri-ash is a soil-ameliorant/soil-conditioner. It is produced at the Icon Water Lower Molonglo Water Quality Control Centre in the ACT. It is not produced to any specification and the composition may vary. Fertspread are the sole distributers and although the product is readily available, from time to time demand outstrips supply

Sewage ash is a complex and variable combination of materials resulting from the combustion of organic material and added chemicals. Many of these elements emanate from within the sewage collection system; others are added as part of the sewage treatment process.

Sewage ash is produced at temperatures above 650°C and is sterile. It contains no carbon or nitrogenous fertiliser value. The major constituents are calcium carbonate (limestone) and calcium phosphate.

Sewage ash has about half the neutralising value of lime, the neutralising value is around 60%. The phosphate level is around 6.6% and there are many trace elements in the product. 1.12% of the total phosphate is citrate soluble and 5.48% is citrate insoluble in a slow release form. Agri-ash is a light brown, sterile, dusty product that is has similar handling characteristics to superfine lime. The product is best handled by professional contractors because of the difficulties in spreading the product.

Agri-ash is delivered in bulk only, in approximately 31 tonne loads. Upon delivery, it should be left uncovered in the paddock throughout all types of weather.
Agri-ash allows you to apply a capital application of phosphorus at a low price while still achieving your liming requirements. Most farmers have been exceptionally pleased with results from Agri-ash and have become repeat users.

The Authors

Shane Dyson (shane.dyson@iconwater.com.au) is a Water Industry Operator Technical Officer, and Eric Nielsen is a Water Distribution Engineer/Water Industry Operator, both with Icon Water in the ACT.

Editor's Comment

A few years ago I had the opportunity to tour the LMWQCC Multi Hearth Furnace up close. Until you do so, you cannot really appreciate the size and complexity of the installation. I remember thinking at the time that this plant would take some time to master the operation of the system. So well done to the team that operates it.

If you are in the Canberra area and would like to see it, contact Shane and see if you can organise a visit.

THE AUSTRALIAN WATER QUALITY CENTRE

The Australian Water Quality Centre (AWQC) is dedicated to ensuring, and responding to, the public health requirements relating to the provision of water and wastewater services for communities in Australia and around the world.

We are committed to maintaining our position at the forefront of water science, working hard to improve the effectiveness and efficiency of water quality management, analysis and testing.

Our specific water industry focus drives our comprehensive service, which is tailored to all aspects of the water cycle, including catchment, source, treatment, distribution, wastewater, re-use and alternative sources, such as desalination.

Backed by a passionate team that can assess the effectiveness of various treatment options, the AWQC is often engaged to provide testing and advice during major water quality incidents, and on major infrastructure and environmental projects across Australia and internationally.

Our promise to the water industry is that we will always strive to maintain the highest standards of public health, while constantly improving the effectiveness and efficiency of our service. We aim to proactively partner with you to avoid safety or supply issues before they happen, but should a crisis or problem occur, you can be confident that the expertise and commitment of the AWQC team will support you, and we will work to overcome challenges as quickly as possible.

From managing our partnership relationship through our dedicated account managers and 24/7 incident and emergency response, through to reporting solutions tailored to our partners' specific needs, the AWQC has a proven track record of supporting the water industry in the optimal delivery of drinking water and wastewater services.

We help to improve effectiveness through AWQC's advanced Laboratory Information Management System (LIMS), supported by field tablets for the timely entry of field data, and our WaterScope system providing 24/7 online reporting of results configured to our client's specific reporting requirements.

The AWQC provides water quality training professionals to ensure that our partners are kept up to date with leading-edge technologies and reporting tools. Further training is offered to support clients in field sampling, testing, and taste and odour panels.

AWQC specialist areas include:

- specialised pathogen assays
- disinfection by-products
- algal management
- molecular source tracking
- commissioning and monitoring of treatment plants
- water treatment advisory services
- testing products to AS/NZS 4020.

The AWQC has been at the forefront of many of the advances in laboratory testing and water treatment technology over the last 40 years, leading research and method development of the tests that are now standard practice – for example, Colilert, algal toxins, disinfection by-products, *Cryptosporidium* and *Naegleria fowleri*.

SUSTAINABLE ODOUR SOLUTIONS

CleanTeQ Aromatrix is at the forefront of environmental air quality management, and our company's innovations and technologies are based on more than 25 years of research and experience. Our technology suite comprises biological air treatment systems, activated carbon scrubbers and regenerative thermal oxidisers (RTOs) together with fibreglass ducting and cover systems. We can meet the needs of the simplest odour reduction problem to the most complex of emissions for strict environmental compliance.

We've recently completed the installation of an odour control system for Melbourne Water's Eastern Drop Structure, a regenerative thermal oxidiser for Nestlé and are currently in the design phase for a chemical scrubber at Sydney Water's North Head Wastewater Treatment Plant. Our experience will give you the confidence that your odour or fume problem will be dealt with using the latest technologies, and to a high performance and quality standard.

PAC AND MEMBRANES AT TWEED

Peta Thiel and Marty Hancock

Powdered Activated Carbon (PAC) has been used for many years to remove algal metabolites during drinking water treatment both in Australia and overseas. The PAC is typically dosed into the raw water and removed through coagulation, flocculation, clarification and media filtration.

More recently, membranes have been used in water treatment and there have been concerns expressed about using PAC in conjunction with membrane filtration. The concerns are based on:

- Potential fouling due to the increased particulate load in the feed water and the specific particles of PAC being of similar size to the pores of the membrane, leading to blockages
- Damage to the membranes due to the potential abrasiveness of the PAC.

Tweed Shire Council's Bray Park WTP sources its raw water from the Tweed River catchment in North East NSW immediately adjacent to the Queensland border. The catchment is unprotected and potentially prone to blue green algal blooms. The raw water for Bray Park WTP is characterised by having relatively low levels of organics with seasonal algae blooms and storm events. During storm events, the turbidity, colour and organics increase. There are also seasonal increases in manganese concentration, which are treated using potassium permanganate.

The plant was upgraded in 2010 to the process train shown in Figure 1, which included a PAC contact tank (for removal of algal metabolites), and ultrafiltration membranes for pathogen control.

At the time of the upgrade, a number of types of membranes were considered. GE Immersed Ultrafiltration ZeeWeed 500D Module Membranes were selected as they could operate in conditions with higher solids loadings (they have been used quite widely in MBR applications in wastewater treatment), such as the Bray WTP which has no clarifier prior to the membranes.

PAC Selection

Although the literature shows that PAC dosing can improve the flux rate across membranes by reducing organic fouling (Nie, 2010; Hatt JW, 2013; Londono; Sabina, 2008), membrane companies are typically risk averse and usually recommend not dosing PAC due to the higher solids loading, potential fouling and the potential for the abrasion of the membranes.

Solids loading

This issue had already been addressed by the initial selection of the Zeeweed membrane product, which is capable of continuing to operate in a high solids environment.

Membrane fouling and PAC abrasiveness

GE provided recommendations for a type of PAC for use with their membranes. The PAC was to be wood based, with a low Gold's Number and with particles that were not the same size as the pores in the membrane (Alam and Keiser, 2014).

Membrane performance testing has shown that membrane fouling occurs mostly with particles finer than 5 µm. Therefore, a PAC with a low lower percentage of fine particles (<8% by volume) has been shown to result in comparatively lower membrane fouling (Alam and Keiser, 2014).

The relative abrasiveness of PAC can be measured using an accredited testing procedure (ASTM G075-07), which provides an abrasiveness value referred to as the "Gold's Number" (GN). A lower GN correlates to a less abrasive product.

To ensure security of supply, Tweed Shire Council required a locally sourced carbon with a Gold's Number <6, which is suitable for membranes with backwash aeration, and a low fines (<5 µm) content. The PAC also had to have a high efficiency for removal of the algal taste and odour metabolites MIB and Geosmin. A higher efficiency of removal means a lower dose and therefore lower solids loading to the membranes.

Four PACs were selected for independent jar testing to determine the ability of the PACs to remove MIB and Geosmin. Raw water to the WTP was spiked with MIB and Geosmin, and the percentage removed at 5 different dose rates was evaluated. The results are shown in Figures 2 and 3.

Based on these performance results, the Acticarb PS1300 was tested for its Gold's Number and particle size distribution.

The particle size distribution curve (Figure 4) showed that 5.3% of particles were finer than 5 µm well under the required 8%.

The Gold's Number came back at 2.1 – a very low figure, and therefore suggesting very low abrasiveness.

Based on the above results, the Acticarb PS 1300 product was selected for use at the Bray WTP. The product is now in routine use.

Weekly in-house, raw water quality monitoring for MIB and Geosmin is conducted to ensure PAC dosing can begin prior to a significant taste and odour event.

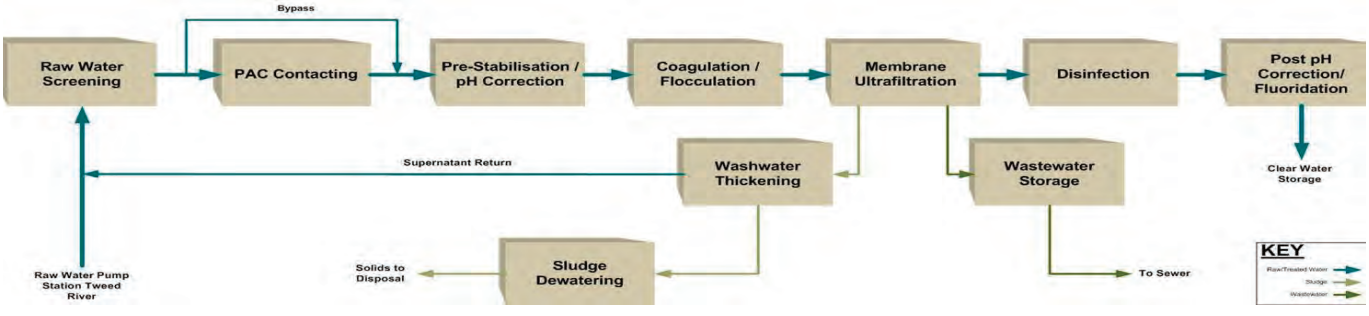

Figure 1. The process train at the Bray Park WTP

The PAC dose is selected to ensure a concentration of less than 5 ng/L of MIB/ Geosmin in the treated water. PAC is also dosed to reduce chlorine demand by removing background organics.

The PAC contact time is typically 60 minutes and then alum is dosed prior to the membranes. There is no clarification step and this is the water that is in contact with the membranes.

Membrane operations require the following maintenance:

- Air and water backwash approximately every 60 minutes (airscour/ backwash), plus chemical cleans (hypo + citric) once a month
- Hypo to combat biological fouling (more frequent when dosing PAC)
- Citric acid to combat alum scaling.

Initially, there was a large sludge build-up within the membranes (Figure 5) containing alum sludge and PAC.

The tension/slack of the membranes was adjusted (tightened), and the backwash frequency increased to combat this build-up. Figure 6 shows the small amounts of PAC that can accumulate in the membranes. This PAC build-up can be minimised by running additional hypo cleans while dosing PAC.

Membrane autopsies can be used to determine what is contributing to fouling and damage. Autopsies of the Bray WTP membranes was conducted after 1 year of operation and have shown some damage to the membranes; however, Figure 7 shows more physical damagew than abrasion from PAC.

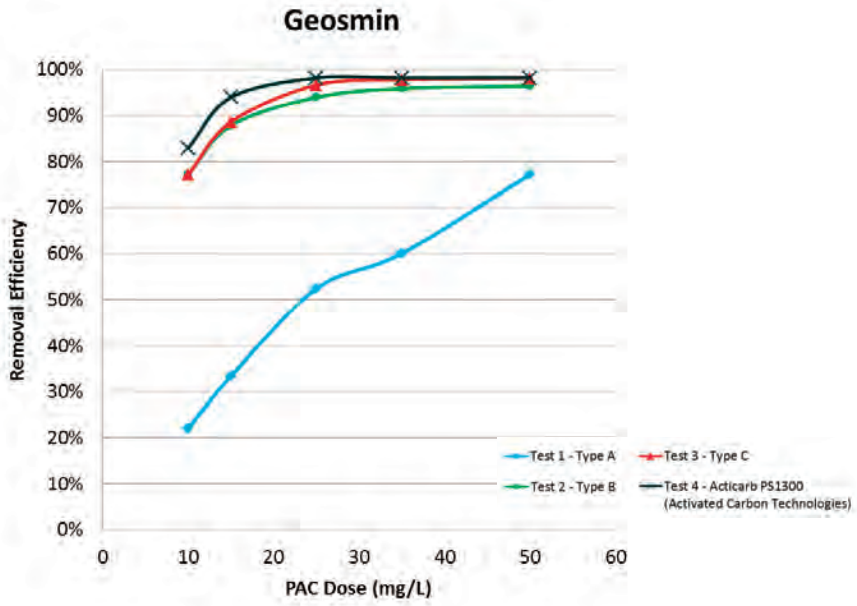

Figure 2. Removal efficiency for Geosmin for the four PAC products

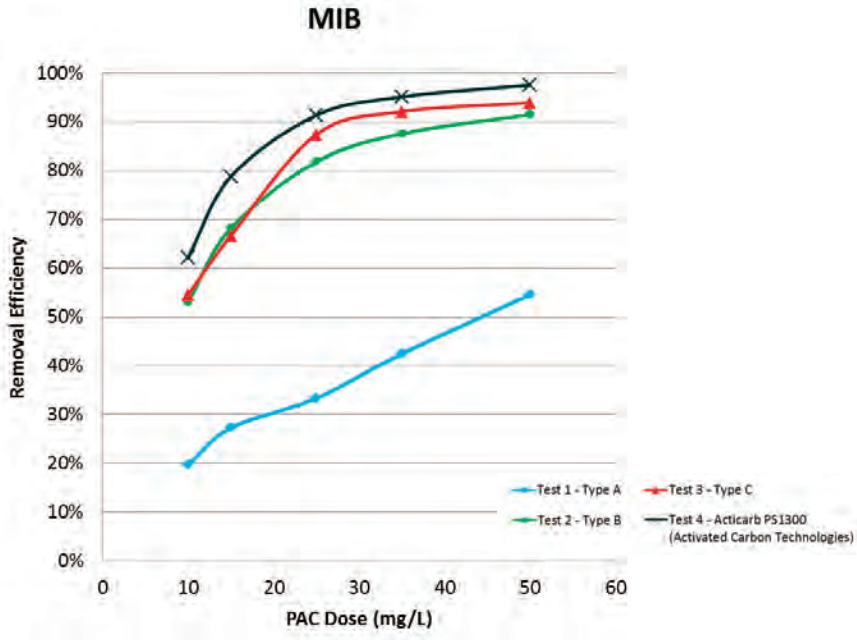

Figure 3. Removal Efficiency for Geosmin for the 4 PAC products

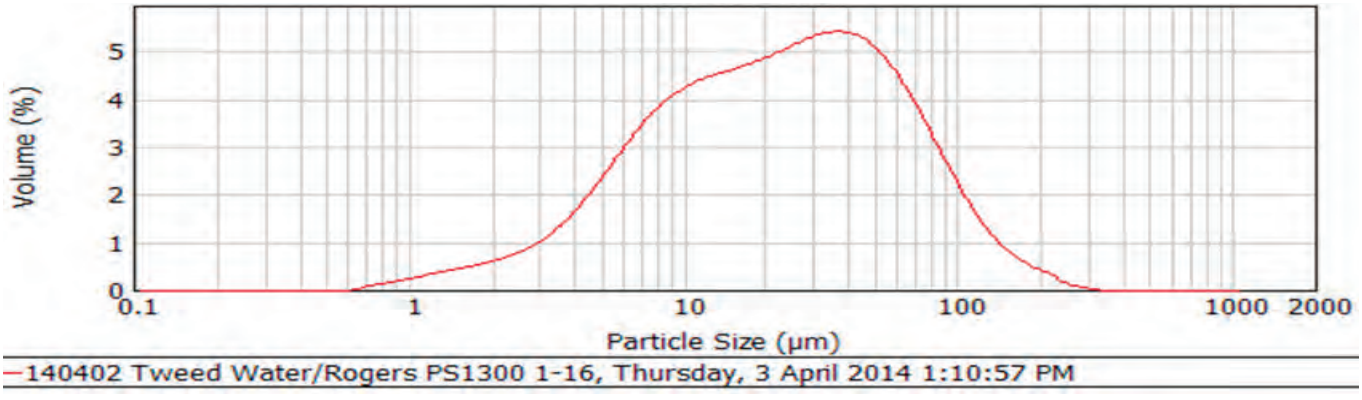

Figure 4. Particle Size Distribution Curve for Acticarb PS1300

The Author

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Figure 5. Sludge build-up within the membranes during the early trials

Figure 6. Evidence of PAC within the membranes

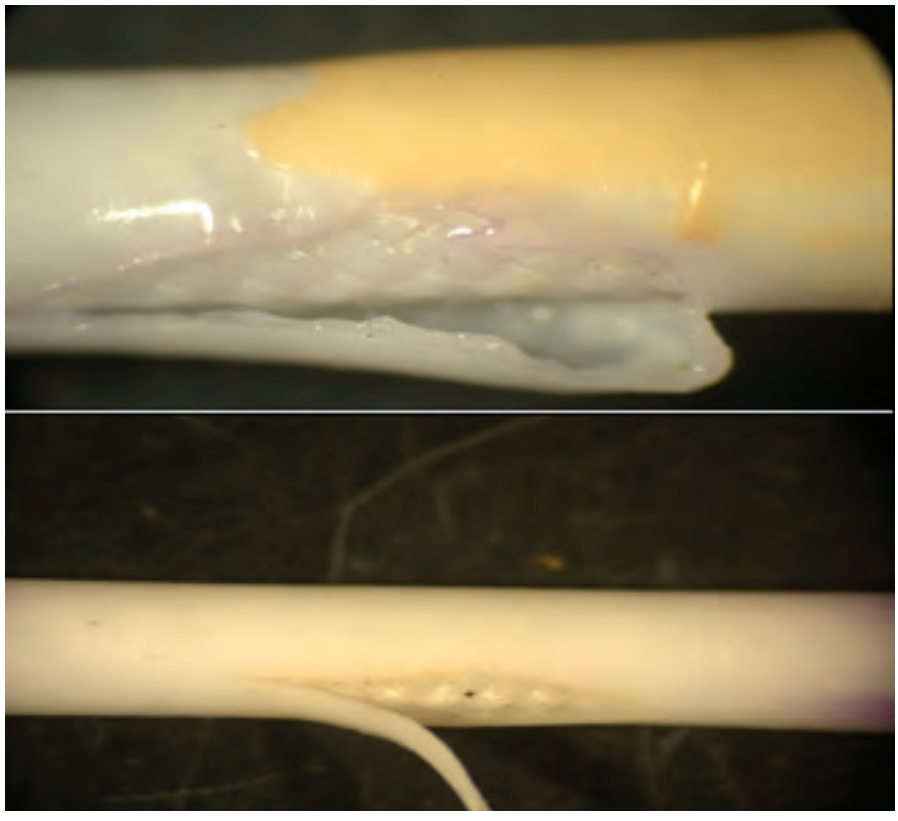

Figure 7. Evidence of mechanical damage to the membranes. There is no evidence of abrasion of the membranes

THE BENEFITS OF MECHANICALLY JOINED HDPE PIPE

Australia's population is expected to increase by eight million people by 2030, adding to existing pressure on infrastructure for transport, water and wastewater. With the implementation of the 15-year Australian Infrastructure Plan, both private and state-owned companies are encouraged to "place a high priority on productivity growth. This can be achieved through efficient management of existing infrastructure…and efficient delivery of new assets".[1] The plan also looks specifically at workforce productivity, stating that labour costs can account for up to 39 per cent of overall infrastructure project costs. Improving efficiency can free up funds for other areas of a project.[2]

The future of water infrastructure

From regional towns and growing cities, to manufacturing and mining operations, water supply and wastewater infrastructure are critical services required to meet Australia's growing population. High-density polyethylene (HDPE) or "poly" is the fastest-growing piping material in civil works and water transport infrastructure applications, with adoption expected to increase by five per cent per year.

Lightweight, economical and erosion-resistant, HDPE is the ideal material for underground buried and outdoor exposed pipelines. In response to this trend, Victaulic, the world's leading producer of mechanical pipe joining solutions, has developed a Watermark™-certified mechanical joint for HDPE piping. While butt fusion and electrofusion are currently the standard joining practices for HDPE pipe, these methods of installation are frequently delayed or compromised due to site conditions. Weather conditions (like extreme heat, humidity, rain and wind) can not only affect the time required to fuse a joint, but also the integrity of the joint itself by creating a sub-par fuse.

The Victaulic solution

With the Victaulic mechanical Refuse-to-Fuse™ system, joints can be completed regardless of site conditions, reducing risky variables and providing greater efficiency. Joints can be installed up to 10 times faster than fusing, while providing a consistent joint every time. Through the simple act of tightening two bolts and nuts, there is no need for expensive fusing equipment, power sources or certified fusion installers. This means that skilled workers can be deployed to more demanding areas of complex infrastructure projects. Ultimately, the Victaulic Refuse-to-Fuse system allows for an installer to know how many joints can be completed per day, regardless of site conditions, which, in turn, allows for better planning, allocation of workforce and investment.

WaterMark™-approved

With successful uptake in the mining and commercial building markets in Australia, the Victaulic Refuse-to-Fuse system is already helping installers save time and reduce the cost of their projects. Now, with the recent addition of a WaterMark™-certified version of the Victaulic product, the benefits can be shared across the water and infrastructure markets. Specifically formulated to meet the Australian water industry's WaterMark™ standard of excellence, the coupling is designed to ensure protection against corrosion in underground buried water lines and outdoor lines exposed to the elements.

[1] Australian Infrastructure Plan, Infrastructure Australia, February 2016, Page 15.

[2] Australian Infrastructure Plan, Infrastructure Australia, February 2016, Page 20.

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