WATERWORKS

OFFICIAL JOURNAL OF THE WATER INDUSTRY OPERATORS ASSOCIATION

W-I-O-A Australia EXCELLENCE IN OPERATIONS

DECEMBER 2006

WATERWORKS
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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. These can be emailed to a member of the editorial committee or mailed to the above address in handwritten, typed or printed form. Longer articles may need to be copied to CD and mailed also.experiences or longer articles describing detailed studies or events. These can be emailed to a member of the editorial committee or mailed to the above address in handwritten, typed or printed form. Longer articles may need to be copied to CD and mailed also.

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TRAINING - CAN YOU MEET THE CHALLENGE?

The importance of training can never be underestimated as we in the water industry grapple with a diverse range of responsibilities including operating reservoirs, delivering irrigation water and collecting drainage, treating and distributing safe drinking water and collecting, treating and ultimately reusing our wastewater. As we have seen in other countries, (both developed and third world), the consequences of mistakes or poor performance on our part can be catastrophic, and may be manifested in sickness and even deaths. A well trained and competent operational workforce is therefore essential to allow us to perform our various roles in the water industry adequately.

After some lengthy but unavoidable delays, the second stage of the Water Industry Training Package review has been completed and the Package is currently involved in the final approval processes from the Department of Education, Science & Training (DEST). The updated Package is likely to be endorsed and available for use in early 2007.

WIOA had representation on the Package Review Committee and we are confident in saying that there has been some outstanding work done at the Certificate II & III levels in particular. This includes the development of a number of new units of competence, breaking some pre-existing large units into two or more units, and a review and total rewrite of all the remaining units. We are certain that the 2007 package now contains units that better reflect the tasks our staff undertake. That is not to say that the new package is perfect and ongoing improvement will remain a high priority to meet new issues and technologies as they arise.

In our opinion, the only down side to the process relates to the "un-nesting" of the qualifications, forced on us by DEST for reasons only they understand. By definition, "un-nesting" means that trainees have the ability to move in or out of the qualification framework at any certificate level and there are no prerequisites at any level.

By way of example, the existing Package (NWP 2001) requires the completion of Certificate II prior to undertaking a Certificate III. To achieve a Certificate III, a total of 22 units of competence must be completed. It is recognised that in some cases this is a difficult process but it is generally considered an appropriate mechanism to ensure that a person with a Certificate III qualification is adequately trained in a broad range of competencies and can demonstrate their competence in the workplace over a period of say 3 to 5 years or longer.

Under the 2007 version of the package, a person can elect to enter at Certificate III level without having completed Certificate II (or any other water related studies) and is therefore only required to undertake eleven units to achieve the same qualification that someone under NWP 2001 was required to do 22 units to attain. The skills and experience sets of two people with the same qualification on paper are now going to be completely different. The abilities to competently operate may also be significantly different.

To us, this is a prime example of the education system dictating the rules at the expense of what the industry requires as an appropriate outcome and the value of a Certificate III has been seriously eroded. This situation is disappointing to WIOA when our primary goal is to do everything we can to increase the level of knowledge, skills and effective performance of "operators". We feel we have been let down by others with a lack of vision in relation to the importance of our industry and the tasks we perform.

So where does this leave us in relation to providing a trained and competent workforce?

The challenge is now firmly at the feet of employers right around the country. We live in an era of unprecedented regulation and controls over staff numbers and expenditure. It is possible that some employers will bow to these pressures and be tempted to save costs by adopting a minimalist training approach. To any

Our Cover: A small front end loader is lifted into a filter at a Gold Coast Water WTP. The loader was used to assist in the removal of the filter floor prior to its complete rebuild.

employers considering this approach, consideration must be given to the notion that “due diligence” requires the demonstration of ability across the board and not just in a few areas. Employers must ensure that they have staff capable of operating ALL their systems well. Training plans should be developed based on a skills review/audit for all staff. Our investigations show that in most cases, completion of only 11 Units of competence will not be sufficient to cover the necessary skills required.

While it is not absolutely necessary to model ourselves on what is done in other countries, it is appropriate to consider other models for comparison purposes. In California there are five grades of certification for Treatment and five grades of certification for Distribution. The treatment plant sites (and distribution systems) are also rated from 1 to 5. Each level of facility requires operators with the same level of training. That is, a T5 facility requires a number of T5 operators. Progression from one grade to another requires both training and experience. For grades one and two there is no site or grade specific experience required, however for T3 and T4 grades the applicant requires one year as a chief operator at the preceding level plant. So an applicant for T4 needs the experience at a T3 plant. A T5 operator, operating the highest category of WTP, requires two years of operator experience working as a chief operator while holding a valid T4 operator certificate at a T4 facility. The T5 assessment involves a 20 minute oral assessment by an interview panel. During the oral assessment the candidate is assumed to be the chief administrator of a WTP utilising both ground and surface water with all known quality problems. The candidate is required to look at the bigger picture to ensure the operation is safe and the actions proposed in dealing with problems is in the best interest of the public. The candidate is expected to “use his/her wit and not a screw driver” and based on the topics able to be examined, must have a very considerable practical and theoretical knowledge.

Contrast this to the progression now possible in Australia once NWP 07 is endorsed!!

WIOA strongly supports the requirement that we have a well trained, experienced and competent workforce without which public health and environment protection cannot be assured. It is also worth noting, in this time of nationwide drought, that the production of recycled water for possible direct potable reuse will require the highest level of operation and diligence. Does the new system ensure this?

Regardless of what the qualification rules in NWP 2007 allow, WIOA strongly recommends that Certificate II be completed prior to Certificate III. WIOA will also continue working to ensure that the water and wastewater treatment Units in Certificate IV are reviewed and updated to enable an operator to reach a “specialist technical” qualification as opposed to the front line management emphasis which currently exists.

We expect that attainment of this technical qualification, including the appropriate amount of job related experience, will be recognised as the highest level of technical certification for the operation of treatment plants in the future. The establishment of such a Certificate IV would help to provide a training and qualification pathway for operators in Australia and also provide operators with similar training and experience expected in other countries in the world.

In closing, the proof will be in the pudding and only time will tell if our concerns are justified or not. We just hope that if something does go wrong in the future, you are not the one in the “hot seat” trying to explain why it happened.

George Wall and Peter Mosse
December 2006

LETTER TO THE EDITOR

Dear Peter

Your Editorial in the last issue of WaterWorks was timely and reflects the importance of operator training in the days of emerging drinking water regulation in Australia.

As a training provider with many years of experience, we at the Water Industry Training Centre would like to think that operators do make use of the knowledge and skills they obtain through their training to improve the quality of their work and the optimum performance of their plants. Your assertion that operators might fail to implement key points of training back on the job is likely the result of a lack of motivation by the operator and/or the lack of support from supervisors and other employees who might have limited time or resources to assist them.

The Centre’s efforts to engage supervisors and managers in operator mentoring and motivation is achieved through the process of evidence collection as part of the operator’s assessment following the completion of training. This is an important aspect of skills assessment under the Australian Qualifications Framework.

The Centre maintains a close relationship with its client organisations through workplace assessment which promotes the involvement of supervisors and managers in the outcomes and effectiveness of training courses. It provides the impetus for regular work appraisals and would also highlight areas where the operator is either unable or is not meeting the standard of performance specified in the Water Industry Training Package.

Workplace assessment involves supervisors and managers collecting formal evidence of operator performance on behalf of the Training Centre. This evidence is tested against the elements and performance criteria outlined in the Training Package and is required before the operator can achieve competence for specified Units of Competence in the Package.

This arrangement achieves two important requirements. Firstly, training can ensure that operators learn the underpinning knowledge required for the application of a particular skill but in order to be competent to operate and control processes, the operator must provide demonstrated evidence on an actual treatment plant. The second requirement achieved is the involvement of the operator’s organisation in the training process which is necessary for quality assurance and occupational health and safety obligations.

The Centre agrees with you that training alone does not lead to implementation in the field. It is important that this does not imply that the training is inadequate. We are generally encouraged by the interest, motivation and personal development attained by our trainees, however, their ability to translate what is learned into action at the plant is dependent on the level of supervisor support and resourcing to enable the operator time to apply these newly acquired skills.

I take this opportunity to compliment you on the quality of WaterWorks. The range of articles and the practical nature of them is extremely useful to operators and it provides a great forum for them to promote some of their effective ways of overcoming local problems.

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NOT HAPPY LARRY! THE AFTERMATH OF CYCLONE LARRY

Shane Bandiera
Winner of the Actizyme Prize for Best Paper by an Operator at the 2006 Queensland Water Industry Operations Workshop

On the 20th March, 2006, Cardwell Shire, Cairns City and Johnstone Shire, suffered very destructive damage as a result of Cyclone Larry. Water and sewerage services became one of the primary focuses in supplying essential living needs back to its residents.

The Johnstone Shire covers an area of 1,634 km^2 with a population of about 20,000 and is located in Tropical North Queensland. 54% of the Shire is Wet Tropics World Heritage Listed. The major town in the Shire is Innisfail, with a population of about 10,000, and is located approximately 90 km south of Cairns. Economic and urban development in the Shire is built largely upon agricultural, minor tourism and business industries.

The Johnstone Shire has two water supply schemes. The North Area is fed by the North Johnstone River. Water from the river is pumped to the Water Treatment Plant, treated and then pumped to a main reservoir, then gravity fed through the reticulation system via trunk mains. The North Area also has three other secondary reservoirs and three small pressure systems that pump to smaller reservoirs in the outlying areas of the North. No water infrastructure has provision for permanent standby generators on site in case of power outage.

The South Area consists of a gravity fed system from Nyleta Creek with five reservoirs and chlorination as its only treatment. The system feeds a number of small towns like Silkwood, Elarish and down to the beaches of Kurrimine, Bingal Bay and Mission Beach.

The Johnstone Shire has one Sewerage Treatment Plant (STP) located in the town of Innisfail and has thirty Sewerage Pump Stations (SPS) throughout the town, five main pump stations and 25 secondary submersible pump stations. No sewerage infrastructure has provision for permanent standby generators on site in case of power outage.

Table 1. Extract of JSC Disaster Management Plan for Water and Sewerage

System	PRE - DISASTER CHECKS
Water	Check capacity of all reservoirs and fill where possible
	Check all pumping stations are operational
	Check water supply intakes (Nyleta, Jurs Ck. & Nth. Johnstone)
Sewerage	Check all sewage pumps are operational
	Check STP
	Check all overflow sites & close where necessary
	PRE - DISASTER ACTIONS
Reservoirs	Isolate Church St. and turn off power to station
	Isolate Flying Fish Point
	Isolate South Johnstone but maintain supply to Mena Creek Pump Station
	Isolate Fenby Gap N° 2 (2.2ML)
	Isolate Bingal Bay Reservoir (1ML)
	Isolate Bay Hill Reservoir (2.2ML) (at SV beside road)
Water Pump Stations	Isolate one low lift pump at river pump station
	Isolate one high lift pump at water Treatment Plant
	Isolate one pump at Merchetta's
	Isolate one pump at Flying Fish Point (To Maria Street)
	Isolate one pump at Fallon Road
	Isolate one pump at Jurs Creek
	Isolate one pump at Bicton Close
	Isolate one pump at Mena Creek (Sth. Johnstone Res.)
	Isolate both pumps at Church Street
	Isolate both pumps at Mundoo Booster
	Isolate both pumps at Etty Bay
	Isolate both pumps at Jubilee Grove
Sewage Pump Station	Isolate one pump at M.P.S.'s 1,2,3,4,5. (note times)
Isolation to be done	Isolate one pump at S.P.S.'s with 2 pumps (note times)
after first cyclone	Isolate power to Sewage Treatment Plant (except chlorinator)
alert	Isolate pump station at Etty Bay

Pre Disaster Preparation and Actions

Imminent Threat of Cyclone Larry

Sunday 19th March 2006

Johnstone Shire Council has a disaster management plan in place; part of this plan is the pre-disaster preparation for water and sewerage. Table 1 indicates actions to be taken prior to a disaster.

Persons nominated in the pre Disaster Management Plan are assigned to these actions.

Water Reservoirs - Isolate all Reservoirs North and South except main reservoir in the North Area.

Water Pump Stations - Isolate one pump at Pumping Stations

Sewerage - Isolate one pump at all dual pump stations.

Generator at Sewerage Pump Station No 5 at Innisfail.

Post Disaster Action

Severe Tropical Cyclone Larry Category 5

Monday 20th March 2006 Time: - 4-00am to 10-00am

After Larry had passed, the destructive force of the cyclone was evident with major damage to homes and other buildings, extensive damage to local crops, loss of power, limited water and no sewerage.

A coordination centre was set up to assess the damage, resurrect essential services, and handle public issues arising from the Cyclone, with the primary focus of public safety and reinstatement of water and sewerage.

Contacting water and sewerage personnel were a concern, however nearly everyone arrived at work during the course of the first day. The only communication was via two way radio channel UHF 16, as there was no power to the Council depot, there were no computers and no Council radios in operation. Power supply had to be reinstated to the Water and Sewerage assets. This was coordinated jointly by Ergon, Council, and the Council contract electrician.

A major oversight was the requirement of fuel for emergency uses, which included vehicles, generators, and clean up plant. No fuel station was commandeered until it was realised this had not been anticipated.

The water and sewerage department had a hard copy of water and sewerage pump stations which linked pumps to generators. This information was passed to Ergon to access suitable generators.

Water

Shortly after the cyclone, consumers started to use water to clean down houses and cars and driveways, which reduced the availability of water for drinking and personal hygiene. Information was provided in disaster preparation literature but was not heeded. The result of which was total drawdown (4.5 megalitre) on our main reservoir storage at Stoters Hill with a loss of water in certain areas of the reticulation system. This was less than 3 hours after the cyclone had passed. A second reservoir was brought on line and the flow directed to the Innisfail Hospital and to the Town Hall coordination centre. This action aided in prolonging the gravity feed of limited water and prevented unnecessary wastage of water. At this stage there was no idea as to the time frame for reconnection of power to the water intake and WTP plant, or whether there was a generator "big" enough to supply power.

As result of the drawdown, which was anticipated by Council, bottled drinking water, sufficient to supply the entire population of 20,000 at 5 litres/ person/ day was ordered within hours of the cyclone passing. Deliveries were received from 10pm on the day of the cyclone. This supply of bottled water continued for 2 weeks, although the quantities were reduced as the scheme came back on line.

Water was the first service to be reinstated. In the North Area, 2 x 500kva generators were transported in, one for the WTP and the second for the river pump station on the North Johnstone River. System checks were carried out before powering up both sites by Ergon and Council contract electrician. Water was back on to about 80% of consumers in the North Area by 7pm the day after the cyclone.

Most consumers had water, although those areas reliant on booster pump stations generally had low flow and low pressure. Although some stations suffered minor damage, by the end of the first week almost all consumers were reconnected with the aid of generators at these booster pump stations, the exception being a handful of consumers with severely damaged or destroyed homes.

In the South Area however, water supply was lost for a longer time due to problems with mains and service line breaks caused as a result of uprooted trees and very soft soil conditions. These breaks were not found or located until the rain had decreased and roads cleared. The supply was back on line within a few days with the only concern being the reinstating of the chlorinator and the disinfection process being up and running.

Access to Nyleta Creek was not possible for seven weeks after the cyclone due to the access roads being unpassable.

After the worst was over, inspection of the water assets revealed there was only a small amount of severe damage sustained as a result of Larry. What damage there was, was due mainly to vegetation falling on or uprooting infrastructure.

One issue that had not been anticipated, was the breaks and leaks caused by heavy machinery working on the very soft ground during cleaning up of vegetation and debris from footpath areas.

Sewerage

As a result of the sewerage pump stations not being operational, considerable overflows were occurring and the system was over capacity due to continued rain, inflow, and infiltration problems. The EPA has been very supportive and understanding of the problems faced by Council. In many cases toilets could not be flushed because of loss of water in higher areas, and or because the system was full and not able to flow properly (blocked overflows by debris). For this reason porta loos were brought in for various areas, but mainly for the evacuation centres and the SES workers.

The STP suffered only minor damage; however it took longer to be fully operational. Installation of a 200kVa generator had to be halted and the generator taken to high ground as a result of concerns over flooding. It was decided not to risk the generator. This flooding did not eventuate, with the generator being bought back in to allow the STP to be brought back on line.

Generators to provide power to the SPS's were difficult to source, some coming from Brisbane. Transport to Innisfail was made difficult due to highway flooding. Most of the generators were supplied, fuelled and maintained by Ergon, six were maintained by Council. Two of the major pump stations were operational from about day 4 and the others followed several days after that. Priority and sequential listing of generators were brought on line catchment by catchment by working upstream from the sewerage treatment plant. Reinstating upstream pump stations first would have created a "flooding" of unwanted sewerage downstream which is not desirable. Even in an automated system this should still be the process of the bringing sewage pump stations back on line.

Public Health

Boiled water notices were issued to all consumers in the North and South area supplies. In the South area the chlorinator had been damaged in the cyclone and repairs had to be made and suitable generator installed. This took some days. In the North area the boil water notice was only a precautionary measure as the WTP was up and running a day and half after the cyclone.

In the post cyclone days until power was restored there was the issue of sewage overflows from pump stations and manholes. In this specific disaster there was no flooding so this was contained to drains and the Johnstone River with a small number of back yard problems.

In the days immediately after the disaster, personnel went around and informed residents of public health issues, including the distribution of literature in relation to the overflows and having live sewage in their yards. An example of this is keeping children away from the affected area. Council staff then aided in cleaning yards where overflows occurred to ensure public hygiene was maintained without infection/sickness.

Generator at Fallon Road Water Pump Station.

Lessons Learnt

The following issues can be concluded from Cyclone Larry and are provided to help others prepare for natural disasters like LARRY.

a) Disaster manual needs to have distinct protocols in place for post disaster management of water and sewerage to the extent of requirements for getting infrastructure on line. The size and type of the disaster needs to be accounted for.

b) Water leaks in mains need to be traced quickly before significant water loss occurs due to the large quantity of debris scattered on the ground and hence over the supply infrastructure

c) Contractors cleaning up need to be aware of doing further damage to underground mains and services

d) Actions need to be taken to access all intakes and water infrastructure as quickly as possible i.e. Nyleta – 6 weeks later, still not able to get in to intake, vegetation damage and land slides along intake road.

e) Ensure alternative power supplies are readily available and matching the requirements of the system in both water and sewerage. The ultimate is having permanent stand by generators.

f) A reliable and totally sustainable fuel supply needs to be available for commandeering for emergency uses which includes generators for essential services.

g) A secure channel of communication, open channel UHF 16 is not good enough for Council emergencies.

h) More timely media saturation of the pitfalls of unnecessary use of water after a disaster. The disaster booklet mentioned this but there was no reinforcement of this requirement immediately before the cyclone.

i) Hard decision needs to be made as to the period the infrastructure will be out and whether water is limited to emergency services only, with other measures to cater for public.

The reason bananas were $15 a kilo.

Acknowledgements

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The Author

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2005 KWATYE PRIZE REPORT: COLOUR REMOVAL USING NANOFILTRATION

Eddy Ostarcevic

Colour is commonly used as a measure of the aesthetic quality of water. The organic chemicals that make up colour are only part of a much broader group of organic chemicals known collectively as Natural Organic Matter (NOM). NOM is found at different levels in both surface and ground water. The organic material comes from the decay of plants, animals and microbes in and above the soils in the catchment. As water passes over the decaying material the NOM is leached out and transported into the water. As such NOM includes proteins and amino acids from the breakdown of cells and polysaccharides, lignin, tannin and fulvic acids from the break down of cell walls. NOM may also include organic matter generated by domestic, industrial or agricultural sources. The end result is a

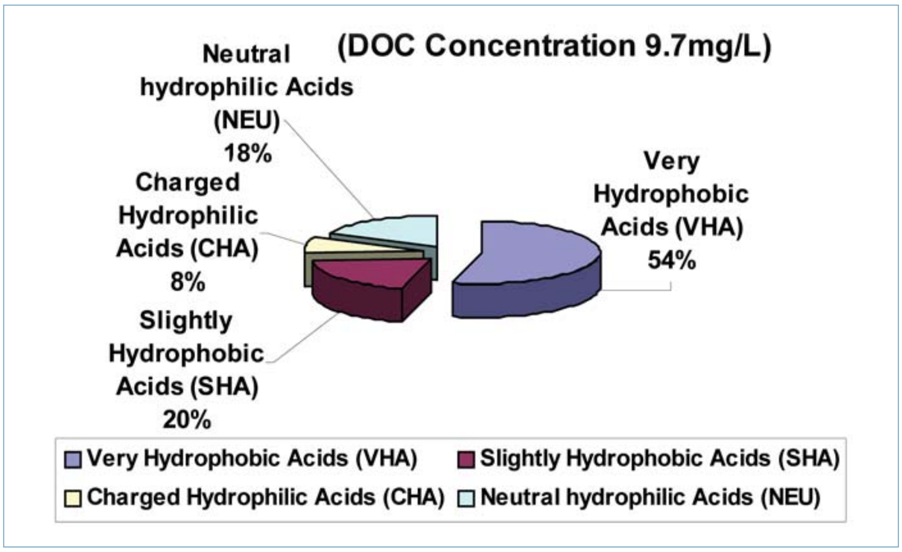

Figure 1. Mt Zero Raw Water DOC Fractions.

diverse range of organic materials that are unique for each water source and that can vary from season to season.

Some of the components of NOM such as tannins and fulvic acids contribute to the colour of water whereas other components such as polysaccharides do not affect the colour of the water.

NOM is difficult to measure. The Dissolved Organic Carbon (DOC) test is commonly used as a measure of the levels of NOM but it doesn't measure all of the NOM. In the laboratory, DOC can be further separated into 4 different parts VHA, SHA CHA and NEU. For example the raw water supplying the Mt Zero WTP in North Western Victoria has a DOC that averages around 9.7 mg/L. Figure 1 shows the breakdown of the Mt Zero DOC into the four different parts.

VHA represents over half of the DOC present in the raw water with SHA making up only 8% of the NOM. The VHA and SHA groups are generally responsible for the colour in water and, along with the CHA fraction, contain compounds that are most likely to be removed by conventional treatment processes using metal salt coagulants such as Alum or Ferric Sulphate. These conventional processes typically only remove 30 to 60% of the NOM in water. The actual removal rates are dependent on the character of NOM and the performance of the treatment process. Generally less than 10% of the NEU fraction can be removed using chemical coagulation.

NOM that remains in the treated water is able to combine with disinfectant thereby requiring higher doses to overcome the demand and inevitably form disinfection byproducts (DBPs). The remaining NOM also provides a continued supply of food for the production of biofilms in distribution networks, further increasing the disinfectant demand

Coloured water with little alkalinity and low turbidity is considered soft and aggressive and presents a challenge to water authorities to treat. Such water supplies currently require preconditioning using pH correction to ensure that the coagulation and flocculation processes are effective. However, no matter how well the water is preconditioned and chemically coagulated some of the DOC will remain in the water leading to problems with DBPs and biofilm growth. DBP levels may well exceed the Australian Drinking Water Guidelines. If the DOC can be reduced, biofilm growth can be reduced and disinfectant doses reduced thereby providing better water quality and reducing maintenance activities required within the distribution system.

The development of nanofiltration (NF) and 'tight' ultra filtration (UF) membranes has provided a new set of tools to remove DOC, including those that cause colour, from soft water without the need for coagulant chemicals. The NF and UF membranes also provide a significant improvement as a barrier against bacteria and viruses by removing microbial and viral contamination to several orders of magnitude greater than 'conventional' water treatment processes.

Another advantage of the use of membranes is that the large amounts of inorganic sludges produced during the treatment of coloured water supplies with traditional coagulants are not produced. This therefore greatly reduces the sludge disposal problem. Aluminum and iron sludges can lock up soil phosphorus and make it unavailable to plants, so beneficial use is severely limited. The potential to use the concentrated DOC rejected from the membrane process as a soil conditioner reverses the trend of disposal to one of beneficial reuse. NF and UF membrane systems can be considered chemical free because they do not require metal salt addition to reduce NOM. However, a conventional disinfectant may be added and membrane-cleaning processes do require small amounts of chemicals to clean the membranes at varying frequency throughout the year.

UF and NF membranes are available as either spiral wound elements, tubular membrane elements with an integral swabbing mechanism or sintered ceramics among other materials. Tubular NF elements are like oversized straws that are 10mm in diameter and usually about 4 metres long.

Nanofiltration has been used to deliver finished water with low NOM, and consequently colour, in various countries throughout the world. The Kwatye (Water) Prize awarded by WIOA in 2005 provided an opportunity to investigate an alternative treatment process to remove NOM, without the need to add metal salts.

Grampians Wimmera Mallee Water (GWM Water) has undertaken extensive community consultation throughout the North West region of Victoria. One of the key messages from our customers is that they want to reduce, or eliminate, the use of chemicals. GWM Water's customers are not unique in this, with many communities across the state and throughout Australia expressing similar desires.

Ultrafiltration (UF) and Nanofiltration (NF) membranes are now available from several suppliers that are capable of removing NOM reduce DOC by up to

MISSING IN ACTION

Sandy McGregor

"Hey Mike, do ya remember were we put the ladder last?"

"Na Mal".

"Well Mike, I can't find it."

"I put it in the shed Mal."

"Well it ain't there Mike."

"What's Jimmy laughin' about Mal?"

"Dunno Mike."

"Jimmy, what are ya laughin' about?"

"Me and me bro' found ya ladder"

"Where Jimmy?"

Editor's Note

One of the requisite skills for conducting filter inspections at Treatment Plants is to ensure that everything that is taken into the filter is taken out! Even the trusty ladder.

The Author

Sandy McGregor was a Water Treatment Technologist with Gippsland Water and has recently joined Water Corporation in Western Australia. He has been involved in many filter inspections.

90%. The study tour undertaken for the 2005 Kwatye Prize aimed to answer the following questions:

1. What recovery rate is sustainable for UF and NF using different DOC sources such as that typically found in Tasmania, tropical north Queensland and the Northern Territory and the mountain regions of Victoria and NSW.
2. Can NF and UF membrane system operate with recovery rates as high as 95%?
3. Can increasing raw water temperature enhance DOC removal?
4. What type of fouling problems will be generated?
5. Will these membranes be subject to increased microbial fouling because of the concentrated food source available?
6. What are the limitations in water quality with respect to the types of DOC and alkalinity concentrations as well as calcium hardness?
7. Can the concentrated DOC be used as a soil conditioner when the raw water supply is soft? Can this equally apply to hard coloured water sources?

The following case studies summarise some of the experiences with NF membranes around the world.

Irvine Ranch Water Treatment Plant

Southern California is growing so quickly that a coastline about the same length as Melbourne to Portland currently is home to the entire population of Australia, more than 20 million people. This population growth has placed tremendous strain on the available water resources and alternative water sources are being developed to cater to the ever-increasing demand.

One of the water districts that serve communities south of Los Angeles is the Irvine Ranch Water District (IRWD). IRWD have developed a water resource from an unused aquifer approximately 670 m deep to provide water to their growing community. The water is very old and has a colour of around 200 Hazen Units with a temperature of 30°C and 15 mg/L of methane. Chemical coagulation was not a viable option, as the character of the water did not lend itself to efficient DOC and colour removal.

IRWD designed and installed a three-stage NF membrane system in 2002. There are 36 pressure vessels in the first stage, 18 in the second stage and 7 in the third stage with a total of 1,381 eight-inch NF membrane elements. The existing three stage arrays have the capacity to continuously deliver just over 30 ML/d with an average recovery of 92%. Methane stripping towers were also installed after the membrane process to ensure that the water was free of dissolved methane. It is interesting to note that IRWD considered using the methane for the generation of power however in the end it was not considered financially viable.

Reject water from the plant is disposed to sewer, however the sewerage system belongs to another water authority and IRWD pay a trade waste disposal charge. The trade waste disposal charge prompted IRWD to design and install a fourth stage due for completion at the end of 2006. Incorporating the fourth stage will improve recovery to slightly more than 98%; this is a better recovery than most conventional water treatment processes, but it does come at a cost.

It is interesting to note that the NF membranes have had a Clean In Place (CIP) performed only once during the past four years of operation. This tends to indicate that this DOC does not support microbes because the fouling rate would be far greater if the DOC was readily degradable. The unusual anaerobic nature of this water source means that such performance cannot, in general, be expected.

Scottish Water

Scottish Water provides water and sewerage services to a population of 4.85 million people and covers an area approximately the same size as that covered by GWM Water, about 60,000 km^2. Scottish Water currently supplies water to over seventy communities using tubular NF membranes, and to a lesser degree spiral wound NF membranes varying in size from 10 m^3/d to 1.9 ML/d. Raw water throughout the highlands of Scotland is soft, aggressive and coloured (60 – 100 HU) and is often subject to extreme fluctuations in colour. When rain falls the colour of water in the Lochs can become very coloured, similar to the dark tea coloured waters in western Tasmania and southern Victoria, and the water temperature often drops below 2°C.

Scottish Water NF plants use Cellulose Acetate (CA) membrane materials rather than the polyamide thin film composite (TFC) material typically used in many of the NF plants in America. One of the perceived benefits that CA membranes provide is the ability to dose chlorine before the membranes on a daily basis for about an hour to help control biological fouling of the membranes. TFC membranes cannot tolerate oxidants like chlorine but they can tolerate chloramines addition and this is sometimes used to help control biofouling.

The tubular membranes have a significant advantage over spiral wound elements because pretreating the water to remove turbidity is not required. Turbid water is allowed to enter the tubular membranes and particulate fouling is controlled by using a foam ball that swabs the membrane surface. The foam ball is slightly smaller than the internal diameter of the NF membrane and the passage of foam swab induces turbulence that assists in controlling particulate material blinding the membrane surface. The swabbing operation takes about eight minutes to complete and occurs every four hours of operation, although this frequency is adjustable. A recirculation stream is required to ensure that sufficient cross flow is maintained to help control fouling and maintain the desired recovery.

Operators at Kilchrenan WTP Kyle of Lochalsh WTP both agreed that the tubular NF treatment plants were generally easier to operate because the automated swabbing helped to control the fouling and the NF membranes consistently produced excellent water quality with a "minimum of fuss".

Water temperature at the sites varied between 0.6°C and up to a maximum of 12.2°C. Recovery was between 65% and 75%. This extreme raw water temperature range certainly tests membrane processes but the Scottish experience shows that they can be employed to deliver excellent water quality even in the most trying of conditions.

The Norwegian Experience

Norwegian provincial councils own and operate water treatment plants, as is the case in NSW, Queensland and Tasmania. Nanofiltration processes are used to produce drinking water for over one hundred communities throughout Norway. Most of the Norwegian NF plants use cellulose acetate spiral wound membranes.

The Orkdal Water Treatment Plant, just south of Trondheim, represents a typical treatment plant and uses spiral wound CA nanofiltration membranes that can deliver 8ML/d. The raw water temperature was 2°C and can climb up to 8°C during the warmer periods of the year.

The molecular weight of NOM in Norwegian waters is higher than that experienced in Australia and therefore the larger molecules are generally easier to remove. This specific feature of the raw water character provides an opportunity to use an NF membrane with a higher molecular weight cut off (MWCO) or alternatively, a 'tight' UF membrane may provide satisfactory performance.

The raw water DOC is typically between 2 and 5 mg/L with pH in the range 7.1 to 7.5. Colour is generally relatively low, between 20 and 30 HU, with around 50 mg/L Calcium as $CaCO_3$ and an EC of 80 µS/cm.

At the Lello WTP the plant has failed to deliver the required flow rate of 10ML/d and can only produce 6 ML/d with daily maintenance cleans and a clean in place (CIP) every two weeks. The process design and configuration were not optimised for the raw water quality at Levanger and was a copy of a similarly sized plant. Professor Tor Ove Leiknes from Trondheim University (NTNU) recommends properly characterizing the raw water and undertake some pilot trials using a variety of membranes and conditions to optimise the design before construction rather than just blue printing a similar design.

Conclusion

It is clear that nanofiltration and to a limited extent 'tight' UF extend the range of tools that water authorities have at their disposal to deliver good quality drinking water. While there are currently no nanofiltration plants in use to produce drinking water in Australia there are a few plants in far north Queensland that use UF membranes to reduce DOC without the use of chemicals. Reports suggest that a 40% reduction in DOC concentration is consistently achieved.

The answers to some of the questions are very positive while some questions remain unanswered and require further research. Some of the things that have become clearer as a result of the study tour include:

1. Recovery rates ranging from 65% to 98% are possible for nanofiltration systems using different DOC sources. It is evident from the wide variety of raw water sources being treated overseas that raw water characteristics typical of those found in Tasmania, tropical north Queensland and the Northern Territory and the mountain regions of Victoria and NSW as well as parts of West Australia would be suitable candidates for treatment using NF.

2. Irvine Ranch WTP is evidence that recovery rates as high as 95% are possible but it is also clear that raw water characterisation and pilot scale testing are essential before implementation.

3. The effect that raw water temperature has on DOC removal is dependant on the raw water character but the water density will reduce and flux rates will increase as the water temperature increases.

4. Fouling is considered to be one of the most important factors when considering the application of NF membranes and is an area that needs careful attention during the pilot scale testing, design and operation phases.

5. Increased fouling rates are expected as the raw water temperature increases and special attention is required to determine what strategies should be employed to minimise the effect of fouling. Scheduled pre-chlorination of the NF feed water using cellulose acetate membranes could be one such strategy.

6. The concentrated food source available on the reject side of the membranes will certainly promote biofouling because it was evident at most treatment plants visited even at temperatures below 5°C.

7. The limitations of water quality with respect to the types of DOC and alkalinity concentrations as well as calcium hardness are dependant on the design parameters such as flux rate, recovery and cross flow. Raw water characteristics such as calcium hardness and alkalinity may be limiting and may reduce the likelihood of NF membrane applications.

8. The rejected concentrated DOC was returned to the source water and was not reused in any treatment facility visited. There appears to be no reason why the concentrated DOC cannot be used as a soil conditioner. The beneficial reuse of the concentrated DOC may still be viable where antiscalants are used to improve membrane performance to reduce fouling because antiscalant formulations may be suitable for such applications.

Acknowledgements

I am very grateful to the Water Industry Operators Association and the sponsors of the Prize, Environmental & Process Technologies, for the opportunity to undertake the extensive study tour. I am also honored to chosen as the inaugural recipient of the Kwatye (Water) Prize.

I would also like to thank Mr Peter McManamon, CEO of GWM Water, for his immediate support for the study tour which took me away from my management position for 5 weeks and Mr Gabriel Vigna of ITT Flygt Ltd who made the Scottish, Swedish and French legs of the trip memorable.

The experience of meeting a number of researchers, treatment plant operators, membrane manufacturers and membrane system designers and integrators was invaluable. The knowledge shared by the people visited was considerable and included some valuable insights when things don't go according to plan.

Finally, the Kwatye Prize has provided an opportunity to answer some of the questions posed at the beginning of this study and this may be the catalyst for the implementation of nanofiltration systems in Australia specifically targeted to produce high quality safe drinking water.

The Author

Eddie Ostarcevic is Treatment & Distribution Manager with GWMWater in North Western Victoria. Eddie was the recipient of the 2005 Kwatye (Water) Prize awarded by WIOA and sponsored by Environmental & Process Technologies. He can be contacted on 0427 819 847.

DETERMINATION OF COD, PROTEIN, BLOOD AND TOTAL SOLIDS IN MEAT PROCESSING WASTES

Rob Dexter

The accurate and rapid determination of waste strength in food processing wastes is important for many reasons:

- High strength wastes and uncontrolled variability in waste strength may represent a loss of valuable product
- Trade waste fees paid to a water authority are usually based on the strength of the waste discharged. Accurate and timely measurement ensures accurate charging
- Detailed knowledge of the composition and variability of the waste stream facilitates process optimisation
- Knowledge of the strength of incoming waste to a treatment plant allows operators to optimise treatment process and to verify that trade waste agreements are met.

Traditionally COD is used as a measure of the organic strength of a waste. Protein and blood can more directly indicate the location of a loss and allow quantification of its cost in terms of lost product and treatment/compliance costs. Protein also gives an indication of the amount of nitrogen coming from protein breakdown as opposed to cattle urine sources. Total solids are also a regulated parameter for compliance.

Laboratory measurement of COD, protein, haemoglobin and total solids all require more or less complex methods of determination. The s:can Spectrolyser, offers an opportunity to measure COD and other parameters directly on line without the use of other chemicals. There are no moving parts or messy calibration solutions. The unit has its own compressed air cleaning system that maintains a clean sample area in all but the most aggressive wastes. The Spectrolyser is a compact, fully submersible, on line UV Vis Spectrophotometer, capable of measuring absorbances at all wave lengths from 200nm to 750 nm at time intervals ≥ 1 minute. The unit is suitable for continuous online monitoring for regulatory compliance or for feed forward control of a process system in a treatment plant.

Blood entering the primary clarifier at a meat works.

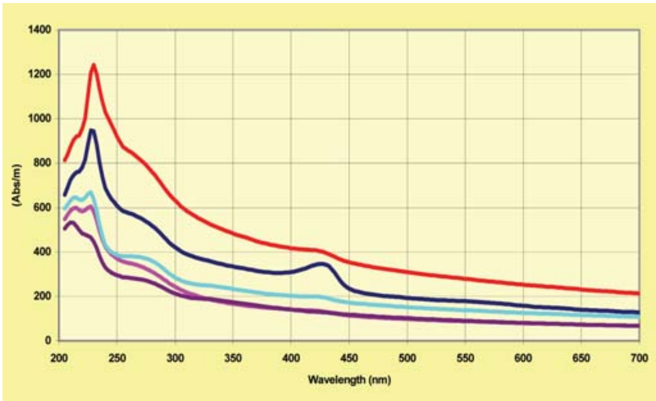

Figure 1. Range of absorption spectra obtained for the meat factory effluent showing variability at different times of the day.

The main buffer tank at a meat works.

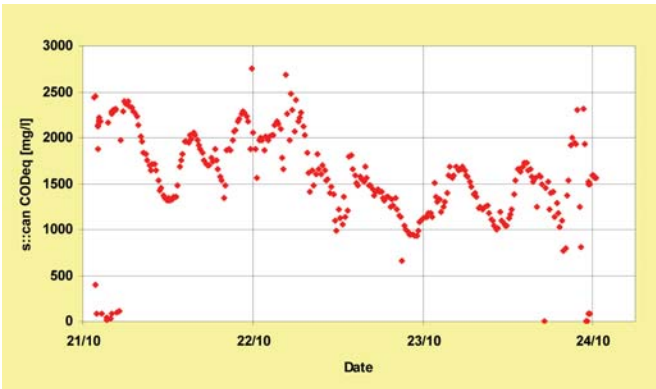

Figure 2. Variation in COD levels in the trade waste stream received at a domestic STP over a period of 3 days as determined by the Spectrolyser. Data are taken at 15 minute intervals.

The Spectrolyser in place in the inlet channel of an STP receiving meat processing waste.

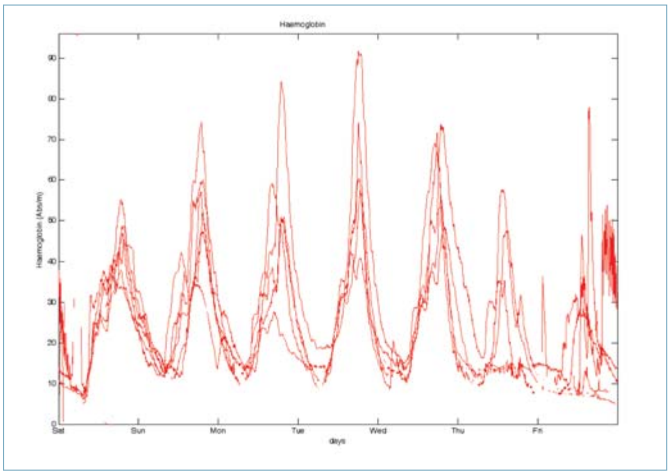

Figure 3: Variation in blood (Haemoglobin) levels. Several weeks of data have been overlaid to show the very regular and repeatable pattern.

This paper describes the use of the Spectrolyser to measure novel parameters in high strength meat processing wastes at a number of different sites. The Spectrolyser was either installed in the inlet to an STP receiving trade waste from a meat processing factory or directly in the effluent stream from a meat processing plant.

Results

Figure 1 shows a range of different absorption spectra for a trade waste entering an STP. The different shapes reflect subtle differences in the composition of the waste at different times of the day. Spectra similar to those shown in Figure 1 are used for the determination of COD.

Figure 2 shows the variation in COD concentration in the waste over a period of three days. The results obtained demonstrated an excellent correlation between COD determinations based on the Spectrolyser and the laboratory determinations for the same sample (R^2= 0.94).

It is also being utilised by the receiving authorities as the meat waste is distinctive enough to be separated out of a complex general wastewater matrix. This means that the contribution of the meat processor to the influent to the council wastewater treatment plant can be mathematically determined from a sensor in the WWTP inlet.

At another site, the Spectrolyser was located in a buffer tank and set up to measure blood and protein components in an attempt to determine what losses were occurring from different parts of the factory. Despite assurances from production areas that losses were low, Figures 3 and 4 clearly show that levels of blood and protein in the buffer tank vary considerably and in a repeatable fashion over several weeks. The patterns for blood and protein do not completely coincide. Figure 5 shows variations in the levels of total solids in the buffer tank.

This data is now being used to help operations locate the source of specific losses and to redirect high and low concentration waste to suitable treatment processes. The goal of the optimisation program is being to reduce treatment costs, minimise the risk of non compliance at the discharge point.

The source of the total solids levels was primarily found to be derived from manure from cattle yards. Identifying this source allowed the separation of this waste from processing wastes which has substantial potential benefits for treatment options.

The ability of the Spectrolyser to identify the nature of losses and to monitor key compliance criteria constitute a major step forward in the management of meat processing waste.

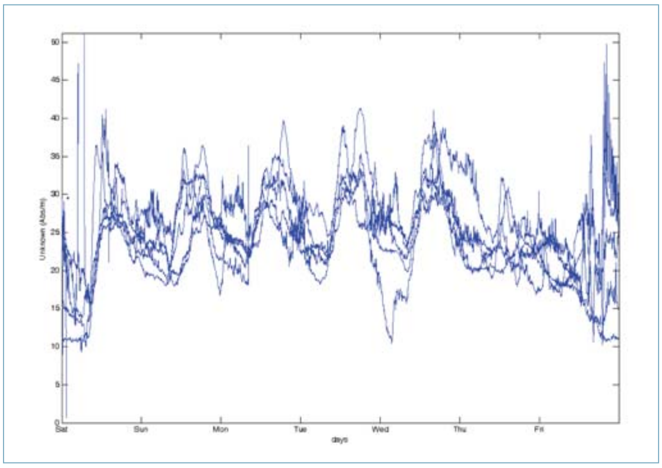

Figure 4: Variation in protein levels in the buffer tank at a meat processing factory. Several weeks of data have been overlaid to show some regularity and repeatability in the pattern of protein levels.

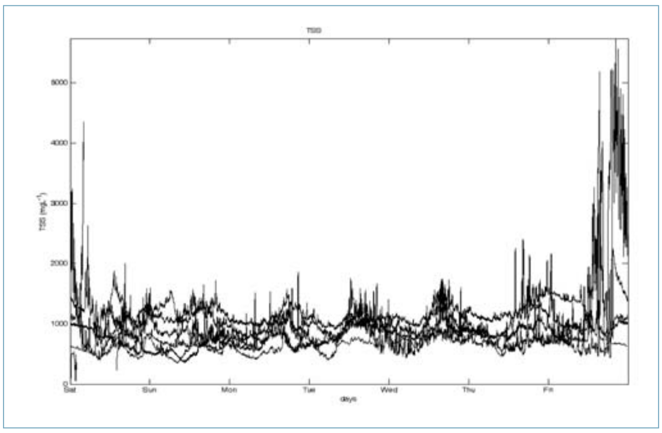

Figure 5: Variation in total solids in the buffer tank at a meat processing factory. Several weeks of data have been overlaid.

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FLUORIDATION IN THE FAR, FAR NORTH

Peter MacTaggart
Winner of the WITA Prize for Best Paper Overall at the Queensland Water Industry Operations Workshop

The Northern Peninsula Area (NPA) is located at the tip of Cape York in far north Queensland, and is comprised of three Aboriginal and two Torres Strait Islander communities that utilise a common water supply. Water is extracted from the Jardine River and pumped to the township of Bamaga where it is treated through a microfiltration process. Treated water is then pumped to a high level reservoir and gravity fed to each of the five communities.

An extensive consultation process led by Queensland Health and the Department of Aboriginal and Torres Strait Islander Policy (DATSIP), combined with dental surveys across the area conducted by the Department of Defence through the Army Aboriginal Community Assistance Program (AACAP), culminated in an agreement from each of the Councils to add fluoride to their water supply in 2003.

SunWater has operated the water treatment facility and reticulation area in the NPA under contract to DATSIP since it was constructed and commissioned in 2000. Following the decision to fluoridate, DATSIP commissioned SunWater to construct a suitable fluoride dosing facility as an augmentation to the existing treatment plant.

Initial planning activities revealed three commonly available sources of fluoride for application to water supplies, these being:

1. **Sodium fluoride (NaF)**. This is a powder-based form of fluoride, and is the most common source of fluoride utilised in Queensland water supplies.

2. **Sodium silicofluoride (Na_2SiF_6).** Another powder-based form of fluoride used utilised widely throughout Australia, although not currently used in Queensland.

3. **Fluorosilicic Acid (H_2SiF_6)**. A liquid based form of fluoride that is also commonly used throughout Australia.

The form of fluoride utilised in the water treatment process largely dictates the design of the dosing facility that must be adopted to apply the chemical, with notable differences between the powder based plants and acid (or liquid) based plants. As there are no quantifiable health benefits of one form of fluoride over another, the process for determining the form of fluoride to be utilised in the NPA was based on a number of key criteria:

1. *Reliability*. The majority of supplies and materials utilised in the NPA are shipped in from Cairns, The roads into the area are rugged and impassable during the wet season. Consequently there are significant delays associated with accessing spare parts and other inventory for corrective maintenance exercises. In addition, travel to the site by service technicians from major centres requires connecting flights from Cairns via a regional flight service with limited availability, and accommodation in the area is restricted and expensive. Subsequently reliability of the system was considered a critical factor in plant selection.

2. *Capital and operating costs*. Costs varied significantly depending on the form of fluoride used and the associated dosing equipment. For smaller systems such as the NPA, acid based plants tend to have lower capital costs (due to their simplistic design) and higher operating costs (due to the expense of the acid which is not commonly available in Queensland) in comparison to powder based plants.

3. *Operator health.* A major concern associated with the operation of a fluoridation facility is the exposure of operators to fluoride compounds. While fluoride compounds can cause acute poisoning, chronic poisoning is more likely from workplace exposure (QLD Health, 2000). A regular intake of fluoride above 6 mg/day is likely to result in toxic effects that are collectively known as fluorosis. In water treatment facilities this generally occurs through the regular intake of sodium fluoride dust via the lungs (QLD Health, 2000).

4. *Queensland Health Code of Practice for the Fluoridation of Public Water Supplies (the COP)*. The COP defines the operational criteria needed to meet the main technical, workplace health and safety, and environmental requirements of Queensland's fluoridation legislation. It also identifies how fluoridation plants are to be established and operated in a safe manner to satisfy these criteria (QLD Health, 2000). The COP was the most significant criteria in the design process, and was utilised in the establishment of the specification to the dosing equipment supplier and in the design and construction of the fluoride dosing room.

Based on these key criteria, fluorosilicic acid was selected for the NPA facility. The reasoning for this selection process was as follows:

1. *Reliability*. The system selected was comparatively simple and presented fewer mechanical processes that could potentially fail, notably through the absence of bag loaders and mechanical mixers typically associated with powder based plants.

2. Cost. Capital costs of acid plants were generally lower than powder based plants, again due in most part to the absence of bag loaders and mechanical mixers. Chemical costs of acid were higher than powder (approximately 20% more based on the quotes obtained during the planning phase), however the plant would need to be operated for 25 years before the combined operating/capital costs tipped in favour of a powder based facility given the relatively small volumes of water being treated (averaging 4 ML/day).

Powder based plants also present an additional cost in the disposal of the bags in which the chemical is supplied. Due to their contamination with fluoride powder, the bags are deemed a regulated waste, and would need to be transported to Brisbane for disposal.

3. *Operator Health.* The use of a liquid product avoided the dust issues associated with powder-based plants, and this was a major factor in plant selection. Acid fumes were a consideration, however this was effectively managed through the installation of appropriate mechanical ventilation.

4. *COP Compliance*. Given that the facility was being designed from scratch, achieving compliance with the COP was relatively straight forward for both powder and acid plants, with no advantage to either system.

The NPA Fluoridation System

The plant utilises 20% fluorosilicic acid which is delivered to the facility in 1000 L bulky bins. The bins are connected directly to the dosing skid, and 30 L batches of acid are transferred to a header tank via a transfer pump. This acid is then released to one of two 120 L day tanks (duty and standby) and filled with water to generate a 5% solution.

This dilution process was specifically designed into the facility to provide higher flow rates through the dosing pumps, thereby facilitating more accurate dosing at lower plant flows. Water demand in the NPA varies between 1 and 6 ML per day depending on the season, and problems have been experienced in the past with chlorine dosing pumps both priming and accurately dosing at lower flow rates.

Both day tanks are mounted on loss of weight scales required under the COP to measure the weight of chemicals used on a daily basis. Duty and standby dosing pumps deliver the diluted solution into the treated water main via a common suction line from both day tanks.

System operation is largely automated via an independent PLC which controls the batching process and transfer between day tanks, and fluoride dosing rates which are controlled from online analyser measurements. The only aspect of operations that is not automated is the filling of the header tank, which is controlled manually via the switchboard. This manual intervention has been built into the system to prevent possible overdosing resulting from PLC failure.

Problems Encountered

The following is a brief overview of some of the key problems that were encountered during commissioning and initial operation of the NPA fluoridation facility. Many of the issues outlined here are relatively simplistic in nature, however they resulted in disrupted operations and required considerable effort from both the supplier and operator to identify and resolve.

Problem 1: Fluoride concentration spikes during the plant backwash process

The NPA water treatment plant utilises a micro-filtration process that filters water through polypropylene fibres to remove contaminants. These fibres require relatively frequent backwashing in order to dislodge built up sediments, resulting in the plant stopping, backwashing, and recommencing operation every half hour or so.

During commissioning of the fluoridation facility, it became rapidly apparent that this intermittent operation was generating large fluctuations in fluoride concentrations. As the plant stopped to backwash, so too did the fluoride plant a short time later. Because the fluoride plant did not stop in the same instant that the primary treatment facility stopped, a small volume of concentrated fluoride entered the treated water main. When the plant operation recommenced, this spike was sent through to the on-line fluoride monitor, exceeding the safety threshold of 1 ppm, and subsequently shutting the fluoride plant down. When the fluoride levels had fallen to an acceptable concentration, the fluoridation unit recommenced operation, only to be shortly disrupted by another backwash cycle that set the same chain of events into motion once again.

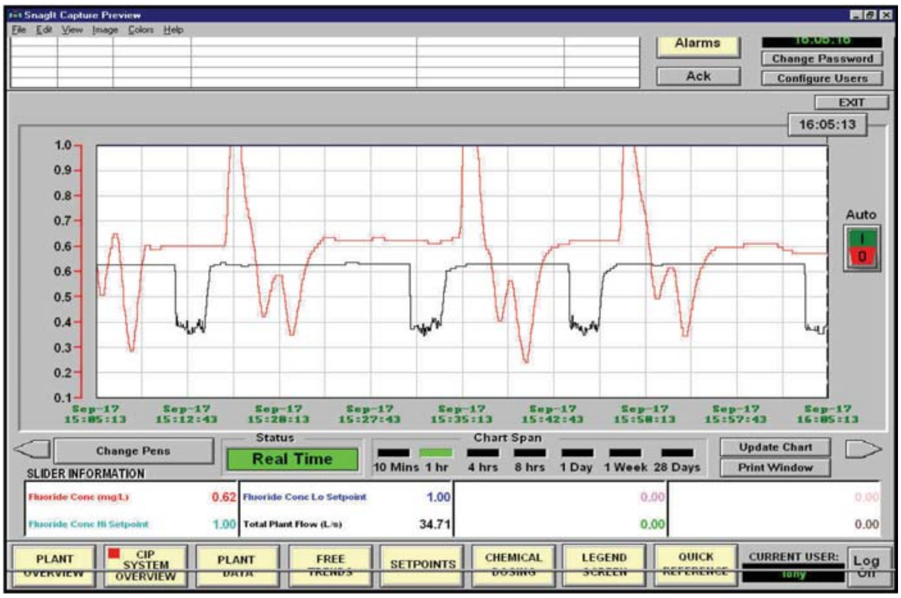

Figure 1. SCADA screen dump showing the plant flow rate (black line) and corresponding fluoride concentration spikes (red line) following the backwash process.

This process is graphically illustrated in Figure 1.

To negate the impacts associated with small spikes of fluoride travelling through to the online analyser, a contact tank and recirculation pump were installed. This tank receives all water from the sampling line and mixes it prior to entry into the analyser, delivering a homogeneous solution that eliminates small chemical concentration variations and provides an averaged (and more constant) measurement of chemical dosage rates.

This solution also eliminated a secondary issue of inadequate chemical mixing in the treated water main prior to extraction at the sampling point, which was later found to be compounding the fluctuations in the fluoride concentration. The installation of the contact tank not only resolved this issue, but also generated more constant results from the existing online pH and residual chlorine analysers that had been suffering from this same problem to a lesser extent since construction of the primary treatment plant.

Problem 2: Loss of online analyser calibration during shutdown periods

During the wet season, demand for water in the NPA can drop below 1 ML/day. As the distribution system is equipped with over 11 ML of storage capacity to cater for higher demand periods, this seasonally reduced demand can result in regular plant shutdowns exceeding 12 hours.

During the first wet season following commissioning of the plant, the online fluoride analyser started losing calibration. After some discussion with the supplier it was determined that the ion selective electrode utilised in the analyser required constant immersion in water, and as sampling of water does not occur unless the plant is operational, the shutdowns were drying out the electrode. The supplier had apparently never encountered this problem before, as this was the first treatment plant they had experienced with such a variable mode of operation.

To solve this problem, the newly established contact tank was equipped with a bypass valve that allowed water to be passed through the analyser when the treatment plant was not in operation, thereby perpetually submersing the electrode and eliminating the cause of calibration loss.

Problem 3: The chemical dilution process

To achieve the desired 5% solution of fluorosilicic acid, water is added to the 20% solution provided by the chemical supplier. The batching process utilised involves depositing the contents of the header tank (20% acid solution) into the day tank prior to filling the tank with water. Adding the water after the acid allows mixing of the day tank to provide a uniform solution for injection.

Following commissioning, Queensland Health pointed out that adding water to acid is not a desirable practice due to the exothermic reaction that results, and that the preferred process is to add acid to water. However reversing the process to cater for this change would have eliminated the source of mixing, thereby requiring the addition of mechanical mixers.

After some calculation it was determined that the risks associated with the mixing process were low, and agreement was obtained from Queensland Health to leave the process as it was designed. However as a result of this experience, Queensland Health has indicated that it will amend the COP to eliminate this practice in the future.

Problem 4: Leaking fittings and associated corrosion

The fluoride plant suffered from a number of leaks that became evident shortly after operation commenced. These leaks led to obvious safety hazards for the operators, but also caused damage to the skid on which the plant was built. The skid was constructed largely of galvanised steel, including the electrical conduits, which offers little in the way of acid resistance and is expected to degrade significantly over the next few years.

All that could be done to solve this problem was to repair the leaks by resealing all of the valves and fittings on the skid with Loctite 456. The specification to the supplier should have stipulated sealing of all joins with Loctite, and more importantly the construction of the skid in stainless steel and the provision of electrical conduits in PVC.

Conclusions

The selection of fluorosilicic acid as the source of fluoride for the NPA treatment facility overcame a number of the problems associated with powder based plants, notably the dust issues impacting operator health and the elimination of mechanical processes required to deliver the powder into solution. It also negated the regulated waste issues associated with disposal of powder bags, and kept capital costs to a minimum.

Aside from the leakage issues and associated corrosion, which could have been readily minimised through the use of appropriate construction materials and methods, there were no major drawbacks identified from the plant or disadvantages when compared to powder based options. To that end the selection of an acid based system proved to be the optimal decision for the small water supply in the NPA. However acid plants become less appealing as the size of the treatment facility increases due to the comparatively high chemical costs (particularly in Queensland), which would rapidly consume any capital cost savings that might be obtained where larger volumes of water are being treated.

References

Queensland Health (2000), *Code of Practice for the Fluoridation of Public Water Supplies,* Queensland Government, Brisbane.

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THE NORTH ADELAIDE TANK: WHAT A BEAUTIFUL STORAGE

Matthew Thompson

What architectural treasures lay hidden from sight? As we all know, many water industry assets lie below the ground and many have been in service for hundreds of years. Magnificently bricked sewers and water pipes and treated water storages are locked away from sight around the world. The North Adelaide Tank is surely one of these.

In the late 1800s the Hydraulic Engineers Office controlled water assets and services in South Australia. In a Public Works Report of the Hydraulic Engineers Office on October 9, 1878, it was reported that tenders had been invited for

> "the construction of a covered reservoir to hold 1,000,000 gallons, to be built on the Park Lands, at the corner of Barton Terrace and O'Connell St, North Adelaide. When this reservoir is completed it is anticipated that the pressure in the city will be improved by relieving the mains of the great draught now caused by the Port."

The 4.546 million litre reservoir was completed on February 25th 1879. It initially supplied the Port Adelaide area, relieving demand on the city and inner eastern suburbs. A Public Works Report on 25th September 1879 showed that "the reservoir is in excellent condition, and is tight as a bottle". The construction is brick arched, consisting of 48 columns with stepped bases and a concrete floor. The construction has remained largely unchanged over its 127 year history except for inlet/outlet pipework and associated controls. As can be seen in one of the original plans (Figure 1) it lies buried approximately two metres underground in the heart of North Adelaide. I wonder if all those who have visited the historic Piccadilly Theatre opposite ever walked out and thought that the grassy mound over the road supplied water to 60,000 people along the coast up to Le Fevre Peninsula?

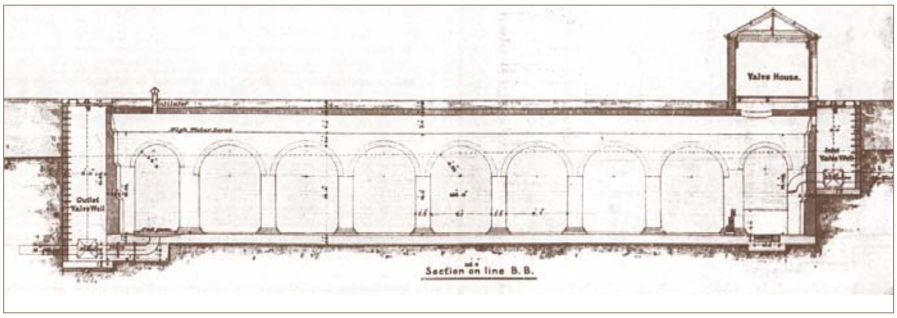

Figure 1: One of the original plans (1878).

The Hydraulic Engineers Office was renamed and known as the Engineering Water and Supply Department SA for the majority of the 20th century and finally in 1994 became the South Australian Water Corporation. This year SA Water are celebrating their 150th year. Since 1996, United Water International Pty Ltd have operated and maintained SA Water's Adelaide metropolitan water and wastewater infrastructure.

All storages at one time or another require cleaning to help maintain water quality throughout the distribution system. The North Adelaide tank is no exception. Tanks such as these were cleaned manually by

Continued over page

Figure 2: High pressure cleaning - the divers predecessor (1963).

Figure 3: Gothic castle or water storage tank (1978)?

TURBIDITY METERS ON TRIAL!

Peter Woodrow,

Winner of the WIOA prize for Best Paper by an Operator presented at the South Australian Operators Conference 2006

Background

Accurate measurements of low level turbidity are an important part of water treatment necessary to ensure the protection of public health. United Water is faced with the need to replace 20 turbidity analysers over the next two years. Consequently, we set out to determine the most appropriate analyser for the purpose of measuring turbidity of filter outlet and treated water.

Traditionally these instruments have been ranged from 0 to 2 NTU. This range provides suitable accuracy and resolution around the nominal measurement range of 0.1 to 0.2 NTU while having enough 'headroom' to provide important data on non-conformances. This range became the first specification for the test requirements. Our QA dictates required accuracy and also some requirements for calibration. These additional requirements resulted in the final specification used in this test.

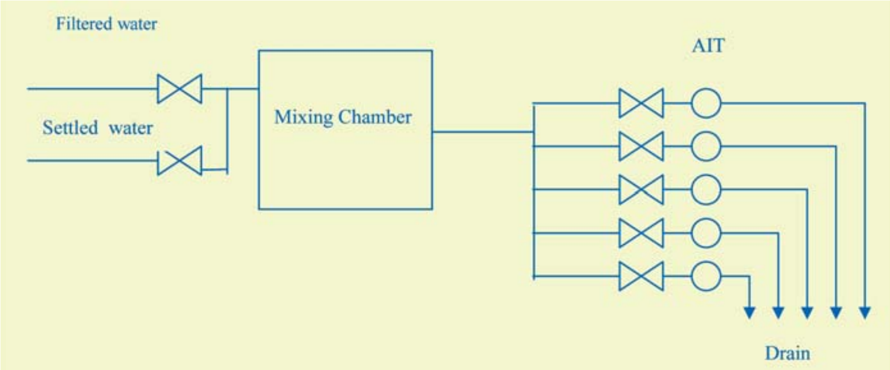

Figure 1. The setup used to provide variable water quality to trial the meters.

What is Turbidity?

Turbidity is the measure of the light scattering properties of water. It is measured in Nephelometric Turbidity Units (NTU).

Calibration of turbidity measurement devices is based on a standard suspension of Formazin. This is made up using solutions of hexamethylenetetramine $[(CH_2)_6N_4]$ and hydrazine sulphate $[(NH_2)_2.H_2SO4]$. A 4000 NTU primary standard suspension is made using a standard recipe and diluted to an appropriate strength.

So how are Low Range turbidity meters calibrated? The primary Formazin standard is diluted for calibration of low range instruments, however there are limitations to how far Formazin can be diluted. The following factors affect how much the primary standard can be diluted and still be regarded as being an accurate standard:

- the turbidity of distilled water used for dilution;

Continued from previous page

draining the tanks and then using high pressure hoses and brooms (Figure 2). A comparison of Figure 3 taken in 1978 with the photograph in Figure 2 shows it is still in spectacular condition.

Prior to United Water's involvement with diving contractors in 2000, tanks such as North Adelaide EL51 continued to be cleaned manually. United Water now contracts commercial diving companies to clean the tank with vacuum hoses whilst the tank is kept online. This has resulted in less water wastage and disruption to customers. The historic tank was cleaned most recently in May 2006 by Nordical Diving Services P/L (Figure 4). The divers reported up to 5 millimetres of sediment on the bottom. The tank was last cleaned in 1993 indicating that sediment is building up at about 0.5 mm/year.

Figure 4: Divers cleaning the storage 2006.

The divers wore thick neoprene dry suits and were only able to work for two hours at a time in the cold 8°C water. The tank took about 12 hours to clean. While the water was "quite chilly" the divers were understandably somewhat reluctant to leave the water and the exquisite sight of the old architecture.

The Author

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Editor's Note. Any time there is a chance to dive this one, let me know. What an experience. And yes I do have the necessary qualifications!!!

- atmospheric contaminants; and
- the shelf life of the resultant suspension.

For these reasons we calibrate (or check calibration) at much higher levels than we measure at. We generally calibrate above 10 NTU, yet measure below 0.2 NTU and we rely on an accurate zero and the linearity of the instrument to provide low turbidity accuracy.

Turbidity meters are typically zeroed by one of the following methods:

- calibrate in air;
- turn off the light source; or
- filter process water to 1 micron or less.

There is NO true test for absolute zero NTU.

For the trial some assumptions needed to be made, the major one being that our Hach 2100N laboratory turbidity meter is accurate. This assumption is reasonable because the meter is:

- calibrated at, 20, 200, 1000, 4000 NTU every 3 months by the Australian Water Quality Centre;
- zeroed in air; and
- verified by "blind" tests administered by the Australian Water Quality Centre every 4 weeks.

Method

A range of suppliers were contacted and invited to provide turbidity analysers for trial based on the following specification:

Range:	0 to 2 NTU
Accuracy:	0.02 NTU
Repeatability:	0.02 NTU
Resolution:	0.01 NTU
Light source:	White light
Process connection: connected	Pipe/tube

The following six instruments were offered:

- Endress & Hauser Turbimax CUE21
- Yokogawa TB750G
- Sigris
- Hach 1720E series 2
- ABB 4670series
- Rosemount Clarity 11 Model T1055

These instruments shall be referred to as units A, B, C, D, E, & F (in no specific order) in this paper, so that the results remain anonymous.

The instruments were installed at Happy Valley Water Filtration Plant and connected to the discharge of a filter outlet sample stream. All instruments were either delivered calibrated or were calibrated on site upon installation.

A process connection to settled water was later made and a 20 litre vessel installed as a mixing chamber as shown in Figure 1. This allowed mixtures of settled water

Table 1. Results of the turbidity comparisons for the six turbidity analysers.

	A	B	C	D	E	F	Lab
	0.11	Not yet received	Not yet received	Not yet received	0.0115	0.11	0.096
	0.11				0.109	0.11	0.094
Error	-0.024				0.020	0.015	
	0.080	0.092	0.128	0.123	0.101	0.140	0.105
	0.080	0.090	0.122	0.124	0.104	0.130	0.103
Error	-0.024	-0.013	0.021	0.020	-0.001	0.031	
	0.320	1.698	0.360	0.358	0.361	0.360	0.318
	0.320	1.321	0.355	0.354	0.360	0.350	0.322
Error	0.000	1.190	0.038	0.036	0.041	0.035	
	0.22	0.267	0.277	0.277	0.23	0.26	0.266
	0.21	0.267	0.273	0.273	0.226	0.25	0.267
Error	-0.052	0.001	0.009	0.009	-0.039	-0.012	
	0.22	0.195	0.164	0.213	0.168	0.2	0.203
	0.21	0.195	0.167	0.21	0.174	0.2	0.204
Error	0.0115	-0.0085	-0.038	0.008	-0.0325	-0.0035	
	0.17	0.166	0.111	0.165	0.219	0.15	0.168
	0.17	0.159	0.109	0.161	0.128	0.15	0.173
Error	0.000	-0.008	-0.061	-0.007	0.003	-0.021	
	0.1	0.07	0.08	0.08	0.062	0.08	0.087
	0.1	0.072	0.081	0.081	0.066	0.08	0.084
Error	0.015	-0.015	-0.005	-0.005	-0.022	-0.005	
	0.11	0.068	0.082	0.085	0.071	0.09	0.084
	0.12	0.066	0.082	0.087	0.072	0.09	0.087
Error	0.030	-0.019	-0.003	0.001	-0.014	0.005	
	0.17	0.156	0.173	0.169	0.132	0.16	0.172
	0.17	0.058	0.164	0.169	0.135	0.16	0.178
Error	-0.005	-0.068	-0.007	-0.006	-0.042	-0.015	
	0.1	0.069	0.085	0.138	0.064	0.08	0.094
	0.11	0.069	0.085	0.082	0.06	0.08	0.092
Error	0.012	-0.024	-0.008	0.017	-0.031	-0.013	
	0.61	0.762	0.665	0.694	0.579	0.66	0.67
	0.6	0.738	0.651	0.692	0.57	0.66	0.655
Error	-0.058	0.087	-0.005	0.030	-0.088	-0.003	
	0.68	0.693	0.687	0.724	0.632	0.7	0.705
	0.69	0.678	0.705	0.736	0.66	0.71	0.7
Error	-0.017	-0.017	-0.006	0.028	-0.056	0.003	

Table 2. Summary of calculated errors for each of the meters.

Meter	Average Error (NTU)
A	0.020
B	0.025
C	0.018
D	0.016
E	0.031
F	0.013

Table 3. Instrument cost summary.

Instrument:	A	B	C	D	E	F
Purchase Cost:	$3,000	$2,590	$4,445	$3,480	$9,895	$2,950
Replacement Light Source:	TBA	$290	$90	$394	$260	$725

Table 4. Calibration and maintenance times.

Instrument:	A	B	C	D	E	F
Calibration	20 min	60 min	30 min	**90 min	N/A	30 min
Maintenance	10 min	15 min	30 min	20 min	30 min	15 min

***Unit 'D' requires a 1 micron in line filter to provide "zero" NTU Water, when installed this will greatly reduce calibration time (est 40-60 min)* and filtered water to be used to produce variations in the sample water turbidity.

The instruments were kept on line and samples were taken for laboratory tests daily. These laboratory tested samples provide a measure of accuracy for our tests. When an instrument deviated from the laboratory reading by 0.05 NTU or more an adjustment was made in accordance with our operations QA methods.

Sampling Method

Samples were taken from the discharge of each of the test instruments. In each case two samples were taken for each test. Readings were recorded from each test instrument before and after sampling to ensure a steady consistent reading during sampling. The sample bottles were cleaned, then double rinsed with the sample prior to sample collection. Care was taken to ensure no movement or disturbance to sample pipe work before or during sampling since this can cause variations in turbidity. Where the two readings varied by more than 0.05NTU the results were discarded and the sampling was repeated.

Comparison with Lab Tests

Comparisons between laboratory tests on grab samples and test instrument readings are based on the average of the two readings collected as described above. The raw results are shown in Table 1 and summarised in Table 2.

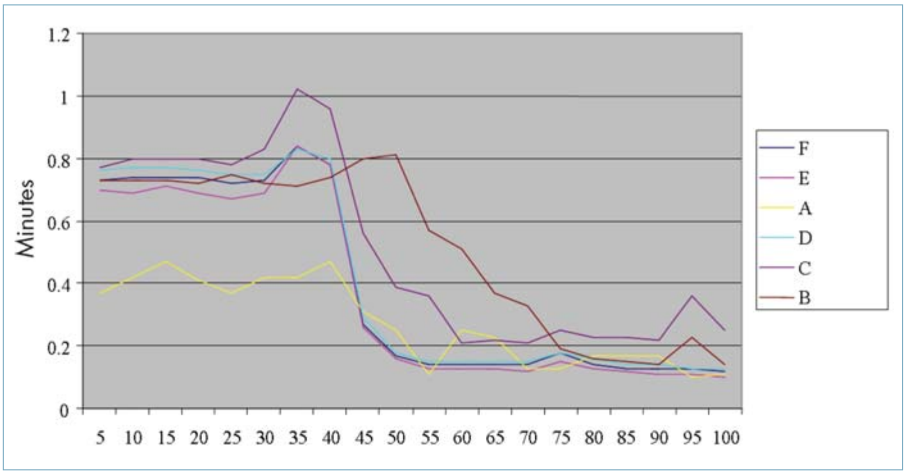
Cost

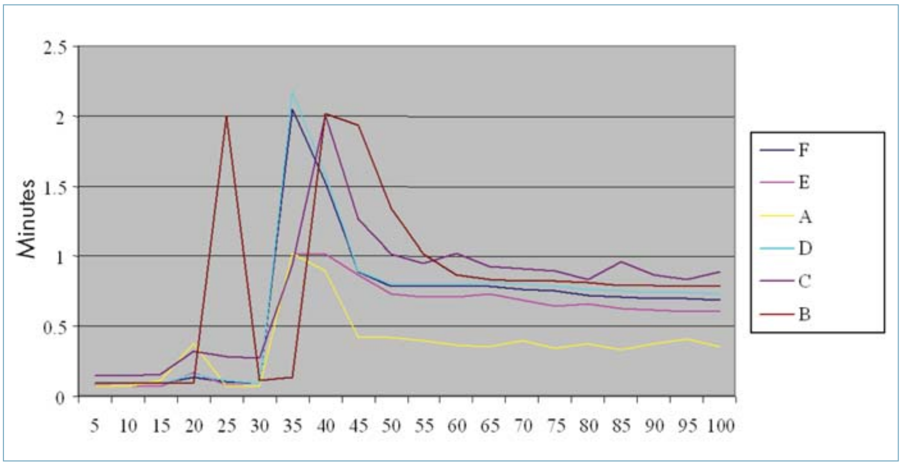
The cost of each instrument together with the cost of a replacement light source (one of the few wearing components) is provided in Table 3. Pricing is based on the supply of one instrument only.

Maintenance Requirements

Maintenance requirements vary from instrument to instrument. In each case the manufacturer recommends a specific frequency of periodic maintenance and often suggests regulating this based on operator experience. United Water has its own QA requirements which override recommendations for maintenance frequencies lower than ours. The resultant frequency of maintenance is therefore similar for all instruments. The approximate time taken to carry out this maintenance is tabulated below. Times are based on my personal experience during the trial and may differ once experience with each instrument is gained.

The frequency of two point calibration is also recommended by the manufacturer, although frequencies less than three monthly are over ridden by United Water's QA requirement for quarterly calibration. As a consequence all instruments tested can be regarded as requiring two point calibration every three months, with the exception of one instrument which self calibrates daily. Times taken to complete a calibration are also shown in Table 4.





Figures 2 and 3. Typical responses to water quality changes.

Speed of Response

During the test period a number of step changes were made by introducing settled water. This typically produced a short duration spike in turbidity as biofilm/sediment in the sample lines is disturbed. The turbidity then settles to the new value. Because each instrument has differing sample flow rates and detention times each has a different response characteristic. Typical response to change is indicated in Figures 2 and 3. In each case Unit 'F' and 'D' responded most quickly while unit 'B' was consistently the slowest to respond.

Conclusions

These are all 'top-end' instruments and all perform similarly.

- Unit E was most expensive, had no means of comparative calibration and was the least accurate.
- Unit D had the least efficient (for time) zero method, which required filtering the sample stream and laboratory testing the resultant water. Yet the supplier suggests they have the only true zero calibration.
- Of the others you can take your pick based on experience, pricing (for the project at hand), etc.

…. Which is precisely what we did

The Author

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BULACE DYEING MINIMISES TRADE WASTE

Jason McGregor
Winner of both the Hepburn Prize and Actizyme Prize for Best Paper at the Victorian Operators Conference 2006

In September 2004, Central Highlands Water and the Environment Protection Authority established a cleaner production partnership in an effort to minimise trade waste generation and to maximise resource efficiency. Bulace Dyeing has been operating out of Ballarat for 30 years, servicing both local and international clothing manufacturers with a short run and quick turn around dyeing service. Bulace Dyeing was invited to participate in the partnership in the hope of minimising the amount of sodium discharged into the sewer and reducing potable water demand through process optimisation.

In consultation with Central Highlands Water, Bulace Dyeing developed a comprehensive understanding of its environmental footprint, including the potential to impact on Central Highlands Water's "SmartCycle®" water reuse project through the use of sodium based products. Central Highlands Water has committed to delivering a 15% reduction in unrestricted potable water demand over the next 50 years, through its Demand Management Strategy. The SmartCycle project is part of this.

Bulace Dyeing's participation as a cleaner production partner led to a major rethink of long-term historical practices and perhaps not surprisingly, a thorough review of processes revealed some exciting opportunities to significantly reduce the business's environmental footprint.

Following a period of investigation, three separate projects were identified as having potential to significantly improve Bulace Dyeing's water consumption and trade waste contaminant load.

Project 1. Dye Bath Reuse

The first project involved the collection and reuse of wastewater from the business's largest dye bath. This bath typically contains 100 kilograms of sodium chloride, 20 kilograms of sodium carbonate, 3 kilograms of sodium hydroxide and 1000 litres of potable water.

Initial trials indicated that the dyeing solution in this bath could be reused up to six times without affecting product quality; however it was apparent that the quality of the dyeing began to be compromised during each subsequent cycle.

In an effort to further increase the potential for dye bath recycling, a flocculation & filtering system was built to remove the hydrolysed dye from the dye bath prior to reuse, as this was causing lower colourfastness in the finished fabric. Although any number of "off the shelf" filters would have sufficed, a more sustainable option was sought. In keeping with the cleaner production theme, Bulace Dyeing constructed a purpose built filter, which comprised of a stainless steel gravity deck lined with recycled paper. Importantly, this system relied on gravity rather than pumps and filter paper that had already been used in production that was previously disposed of to landfill.

Filtering the recycled water prior to its reuse was profoundly effective; enabling the same water to be reused more than 100 times. This trial alone demonstrated capacity for reducing the total trade waste sodium load by up to 20% in addition to the obvious water savings.

Project 2. Chemical Substitution

During the cotton dyeing process, fabric will develop a negative electrical charge when immersed in water. Unfortunately most commercial dyes are anionic (negatively charged) and as a result most fabric will naturally tend to repel the dyestuff. This is overcome on an atomic level by adding an electrolyte to the dye bath which floods the fabric with positively charged molecules. As a result, the dyestuff combines with the fabric to form covalent bonds which are then secured by the addition of a strong alkali.

Unfortunately, the most commonly used chemicals in this process contain large amounts of sodium, which is widely recognised for its ability to impact the sustainability of reclaimed water reuse schemes. Encouraged by an obscure mention of potassium salt whilst researching alternative low salt dyestuff on the internet, Bulace Dyeing Managing Director, John Bulluss conducted laboratory trials to determine if potassium could be substituted for sodium and if so, how efficiently would it work in Bulace Dyeing's process. While chemical substitution does not necessarily reduce total dissolved solids (TDS) loads, potassium is considered to be much less harmful than sodium and can benefit some land based irrigation schemes, i.e. vegetable crops.

Having previously used sodium chloride (NaCl) and sodium sulphate (Na_2SO_4) in reactive dyeing processes, John theorised that potassium chloride (KCl) and potassium sulphate (K_2SO_4) had equivalent chemical properties. In addition, as potassium is more electro-positive and molecularly heavier than sodium, it is reasonable to expect KCl and K_2SO_4 to be more efficient than NaCL and Na_2SO_4.

To the delight of the cleaner production partners, trials showed that product quality using potassium is equal to that of sodium! In fact, the increased efficiency of KCl reduced the need to filter the recycled dye bath solution from one in every six cycles to one in every twenty cycles. This meant that despite KCl being around three times the price of NaCl, the cost benefits of using KCl meant that production trials could still be justified financially.

As a direct consequence of potassium substitution, Bulace Dyeing's trade waste sodium concentration has dropped enormously (see Figure 1).

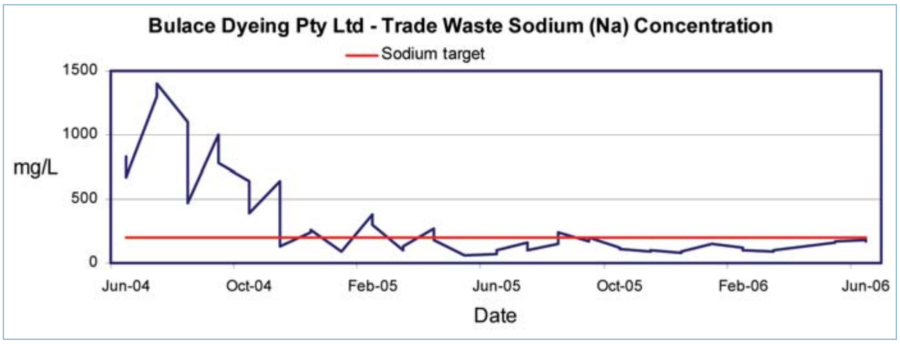

Figure 1. Sodium concentration in trade waste form Bulace Dyeing P/L over the period June 2004 to June 2006.

Project 3. Water Conservation

After optimising the chemical processes and having clearly established the success of recycling within the dyeing process, the partnership focused efforts toward water conservation in the hope of being able to minimise demand on drought affected water resources.

Based on the results of Central Highlands Water's laboratory tests and onsite monitoring by Bulace Dyeing, it was estimated that up to 80% of the total daily volume of trade waste could be collected and treated to a quality suitable for onsite reuse. Of course the effective removal of residual colour is critical where light coloured fabrics may be impacted.

After another series of bench trials a chemical coagulant product was identified that would remove 100% of the residual colour for $3.00 per kilolitre, however it was agreed that this did not offer a financially sustainable outcome. Upon further investigation, it was found that by reducing the amount of coagulant that was added and utilising overnight dwell times, it was possible to reduce the cost to $1.00 per kilolitre. This provided an affordable substitute to potable water that was suitable for the majority of Bulace Dyeing's systems.

Together with support from its cleaner production partners and funding from the "Stormwater and Urban Water Conservation Fund", Bulace Dyeing designed and constructed a water recycling system capable of recycling 42 kilolitres of trade waste each day. Since commissioning its water reclamation system in September 2005, Bulace Dyeing can now recycle up to 80% of the water used in dyeing operations. This equates to a reduction of up to 80% in potable water demand (see Figure 2).

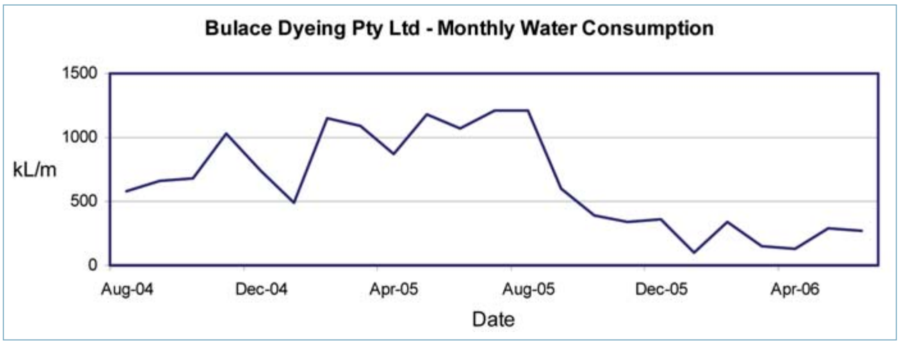

Figure 2. Potable water demand by Bulace Dyeing over the period August 2004 to May 2006.

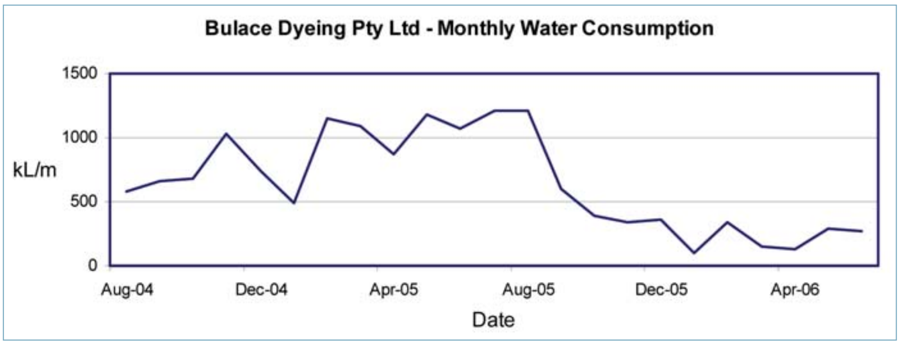

Figure 3. Reduction in sodium load from Bulace Dyeing.

Conclusion

With only 18 employees, Bulace Dyeing could have easily argued that the business lacked the resources necessary to investigate and implement innovative environmental solutions. Fortunately, the combination of Bulace Dyeing's enthusiasm, limited government funding and a cleaner production partnership, all resulted in significantly improved environmental outcomes.

Since June 2004, with support from a both EPA and Central Highlands Water, Bulace Dyeing has reduced its trade wasted sodium concentration from a maximum of 1400 mg/L, to less than 200 mg/L. This equates to an impressive 86% reduction in sodium load (see Figure 3). Importantly, these reductions were achieved through genuine cleaner production methods and did not result from an increase in dilution.

Acknowledgements

I would like to thank Bulace Dyeing for its commitment to the cleaner production partnership and its unwavering enthusiasm towards resource efficiency and environmental improvement. In particular, I would like to sincerely thank Mr John Bulluss for his ongoing assistance and support.

I would also like to acknowledge Central Highlands Water and the Environment Protection Authority for establishing the cleaner production partnership.

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