WATERWORKS

PUBLISHED BY THE AWA AND THE AUSTRALIAN WATER & WASTEWATER OPERATORS ASSOCIATION

WELCOME TO WATERWORKS

Pictured is the south aeration basin at the Morwell Wastewater Treatment Plant. See the article on page 44 by Mick Cook for more information about the upgrade of the Morwell STP.

Welcome to the first edition of *WaterWorks*. As the name suggests, this magazine is dedicated to daily operational activities within the water industry.

Over the last ten years the water industry has experienced a lot of change. Customers have become more aware of drinking water quality and now expect a consistent high quality product. This expectation places increasing demands on Water Treatment Plants. In many cases construction of new treatment plants or major upgrades have been necessary. Operations staff have had to master new more complicated plants or juggle the operation of the old plant while modifications have been made to their plants. The new focus on the management of distribution systems recognises that the water distribution system is more than just a system of pipes and has a profound effect on water quality.

Similarly, environmental expectations require greater emphasis on the management of sewer reticulation systems to prevent spills and limit infiltration. Sewage Treatment Plants have also faced the need to meet higher effluent quality requirements and regulators are placing increased pressure on the development and implementation of sustainable operational systems including reuse.

To meet this changed focus, both water and wastewater treatment plants are becoming increasingly complicated with on line instrumentation, have sophisticated monitoring including SCADA systems and are computer or PLC controlled. Plant laboratories are being used for a greater number and variety of tests, and data is now being managed in databases rather than the old plant run sheets. New equipment is released at such a rapid rate that it is difficult for operators to be aware of the instrumentation available or to trial new equipment.

All these changes have placed increasing demands on the skills and knowledge of field operation staff and technical support staff.

This magazine is an idea I have had for some time to provide a means whereby real life operational experience can be made available to others involved in water industry operations. Many different and exciting things are happening in different parts of Australia. The magazine will offer the opportunity to report on the actual experiences of operational staff and allow a transfer of knowledge in a format that should be easier to understand than some other more technically based publications.

We will produce 2 editions per year to start with, and the aim is for papers and reports to be contributed by field and technical support staff on any topic associated with the day to day operations of treatment plants and distribution or sewer reticulation systems.

Since the concept of the magazine originated in Victoria the first edition reflects a bias to this area of Gippsland. Initially, we expect contributions to the magazine to be slow however we have access to a range of articles and also to papers and posters from the Vic AWWOA conferences. These will be used to supplement the content of the magazine from time to time.

We would like to encourage operations staff to submit articles from the out set. We will also identify potential authors and encourage them to contribute. Ultimately the ongoing success of the venture will depend on support from operational staff.

The magazine will attempt to provide a balance between water and sewage and between treatment and pipes however at times it may appear to be skewed to one mode or the other. I hope the articles will be of sufficient interest for all, regardless of their particular discipline at this stage.

And so with one bold step and the production of this the first edition, onwards into the future.

Peter Mosse
Editor

CONTENTS


CASE


CAT


AUSTRALIAN POLLUTION
ENGINEERING
BENDIGO
(054) 488.317
Dewatering Unit

I would like to congratulate Peter Mosse for his initiative and efforts in starting this important magazine. A publication such as this, with an operator focus, has been discussed at AWWOA Committee level for quite some time but until now has not been possible. We are pleased that Peter has taken up the challenge as inaugural Editor, and we look forward to assisting him in the production of future editions.

In this first edition, I'd like to take the opportunity to introduce you to the AWWOA - Australian Water and Wastewater Operators Association. Historically, in 1973 a small, but enthusiastic group, intent on increasing the knowledge and skills base of wastewater operators, formed the AWWOA. In those days there were no training courses for operators and, after much hard work, the efforts of this group was rewarded with the formation of the Victorian Water Training Centre.

The link with the development of training has been maintained and one of our Committee Members, Mr John Harris, is the current vice Chair of WIETTA-Water Industry Education Training Association of Australia. As with the early days, much hard work has been done over a number of years to develop a Water Industry Training Program and to gain its National accreditation. This program incorporates study modules covering numerous tasks associated within the water industry including water and wastewater treatment, catchment management, headworks and supply, reticulation system construction and maintenance, and irrigation management to name but a few. These courses are now up and running and some Certificates have already presented to operators under the new system.

The membership criteria and services offered has been significantly expanded by the Association since the early days and we now offer membership to any person within Australia undertaking a role in ANY part of the water cycle.

The AWWOA has constitutional goals of information transfer and development of member skills. To facilitate this, activities such as seminars and conferences are organised, a quarterly newsletter entitled *Operator* is produced, job advertisements for position vacant are distributed, and a website is maintained. Please take the time to look over the website at www.awwoa.org.au next time you are surfing the net. It contains much information including copies of past conference papers and newsletters, links to corporate members and other websites, a copy of our Constitution, and a membership application form for those so inclined. AWWOA Members get all these benefits plus now 2 editions of this magazine, for the exorbitant fee of $10 + GST = $11 per year.

In relation to this magazine, its success will depend entirely on the contribution of you - the operators. From my observations over a number of years, a lot of operators sell themselves short when it comes to communicating what they do, or more importantly what they have achieved.

You need to consider that we all work in the same industry with similar issues relating to our jobs no matter what function we undertake within the water cycle. Everyone, including reservoir managers, water or wastewater plant operators or reticulation maintenance staff, have problems with plant, equipment, shortages of time, money and labour and are under the same pressure to deliver quality products or services at all times.

A problem worrying you right now may be exactly the same as one facing a number of operators across the breadth of Australia. Someone else may have already fixed this problem and it may be beneficial to you if you knew how they did it. Conversely, it would be great for others to read how you fixed a problem no matter how big or small. Sometimes the simplest solutions are overlooked in the urge to generate a high-tech or more complex fix.

I urge you to take up the challenge and get involved by writing an article and look forward to reading contributions from water industry practitioners located all over Australia.

Russell Mack
AWWOA President

AWA COMMENT

I am really glad to see this publication hit the streets, thanks to the energy of Peter Mosse and his colleagues, the collaboration between the Operators' Association in Victoria and the Australian Water Association and, of course, the support of Hallmark Editions.

Although we are told repeatedly that today's is a wired world, the truth is that most people, given half a chance, prefer to read something in hard copy, preferably nicely laid out, colourful and interesting. This magazine is intended to fill that gap for Australia's water operators.

The journal, *Water*, that includes this magazine has a long, proud tradition of bringing high quality technical papers to Australia's water industry. Not many of those papers have appealed to the people at the coalface, though, because they tend to be theoretical and complex, rather than straightforward and practical. What operators need is information that talks about their daily challenges - how they can work better, smarter, more safely, and improve their prospects of advancement in the workplace. I hope that the articles collected here are going to answer those needs.

My own, specific area of interest on the operations front is training, as I have a long involvement with WIETAA, the association that represents the training interests of the water industry. After many years of struggle, a new national Training Package for the water industry is about to be formally adopted, freeing up training resources across the country. Once the Package is signed and sealed, the challenge is to see its contents implemented; that will be hard because operators are spread thinly across Australia and there are not that many training providers.

For WIETAA to be effective in getting training implemented, it needs to know what people in water operations want and need in the way of training and qualifications. A very helpful step there will be direct feedback from operators in the field. Please contact me on the phone (02 9413 1288) or by e-mail cdavis@awa.asn.au if you would like to spell out any training need, concern or idea.

Enjoy this first issue of *WaterWorks* and I hope we can bring you many more issues, designed in your interest.

Chris Davis
Executive Director, AWA

Floated Sludge Removal - Shepparton Water Treatment Plant

by Neal Collins,
Goulburn Valley Water

Sheppartons' Plant No. 1 is the newest plant on site and was constructed in 1997. This new plant is a dissolved air floatation filtration (D.A.F.F.) water plant which is comprised of three 13 ML cells. The nominal capacity of Plant No. 1 is 40ML./day.

The D.A.F. process involves the introduction of air saturated water (water with micro bubbles) to the coagulated water as it enters the filter cell. This effectively does away with the sedimentation stage of conventional treatment and causes the flocculated particles to rise to the surface with the assistance of micro air bubbles. The clear water then descends through the filter bed, below each cell.

The aerated sludge forming on the surface of each cell then needs to be periodically drawn off. The process of sludge removal is performed by flooding the cell above the spillway, which is at the opposite end of the cell inlet. This process is referred to as a *float off*. It is this process we looked at improving, as it uses a large volume of water, which was being sent to **waste**.

At the time of commissioning the float off occurred every two hours, for a duration of 6 minutes. It was calculated the water **wasted** during this 6 minute period was 42,480 litres.

Our operators found that by using a hose to assist the sludge towards the spillway, during the float off, it would shorten the duration of the float off. This led us to investigate the possibility of sprays, as a permanent fixture, to assist with the sludge float off.

The main objective of this spray system is to reduce the time of 'float off' which in turn minimises water wastage.

It has seen the sludge float times reduced from 6 minutes to 2 minutes.

We have calculated the water used in a float off, with the sprays in operation, to be 14,160 litres. A saving of 28,320 litres per float. When you multiply this by the number of floats in 20 hours of operating time (typical run time per day), then multiply that by 3, being the number of cells. It adds up to a saving of *849,600 litres per day*.

This wasted water was sent to Shepparton de-watering plant. It has made huge savings on the operating cost of this plant.

'Launder Scrubba'

by Trevor Gordon,
Goulburn Valley Water

In the past the cleaning of the de-cant troughs was done manually with oversized toilet brushes. This involved walking out in each trough and physically scrubbing them. This method was physically demanding and time consuming.

A better way was needed ....

At Shepparton we are currently developing a new piece of machinery. 'The Dirty Scrubba.' It involves the cleaning of the water collection (de-canting) troughs on the sedimentation tanks of our conventional Water Treatment Plants 3 and 4.

With ongoing emphases on health and safety in the workplace and with the risk involved in this balancing act it was suggested we come up with a fall arrest system for our operators to use while carrying out the cleaning task. There were funds in the budget allocated to this project.

After some investigation into cost and feasibility of this high wire act we discussed the possibility of building a machine to do the cleaning job for us and so the 'dirty scrubba' was created. A local engineering firm who have worked with us on the development of the dirty scrubba made the prototype.

The cost of this project will come in well below the amount budgeted originally for the first suggestion of a fall arrest system. The manual labour has been all but eliminated as the dirty scrubba works as a stand alone cleaner with rotating brushes self propelling it along the troughs.

Although it still needs some work to maximise its cleaning ability and improve its user-friendly aspects we are very happy with the outcome.

Still on the drawing board is the internal trough scrubba and the feedback from the engineer suggests this will be the simpler of the scrubbas and we hope to have this fully operational in the next month or so.

WATERWORKS

Editorial Committee

Peter Mosse, Editor
mossep@gippswater.com.au

Russell Mack
mackr@gippswater.com.au

George Wall
GeorgeW@gvwater.vic.gov.au

Direct mail to:
WaterWorks Editor
c/-Peter Mosse, Gippsland Water
PO Box 348, Traralgon, Vic 3844

Advertising

Brian Rault, National Sales Manager
Hallmark Editions
PO Box 84, Hampton, Vic 3188
Level 1, 99 Bay Street, Brighton, Vic 3186
Tel (03) 9530 8900 Fax (03) 9530 8911
Mobile 0411 354 050
Email brault@halledit.com.au

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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 e mailed 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.

HELP !!!!!!
Any Ideas???

This section is available for readers to raise issues or ask direct questions relating to unsolved operational problems. Readers are invited to respond directly to the author of the help article and also through the pages of the magazine so that others may benefit from the experience.

Alum Problems

Gippsland Water has for some time now been experiencing problems with crystals present in alum in the dosing system at several of its WTPs. The crystals don't seem to be present in the delivered product or in the tank but are appearing in dosing pumps and back pressure valves on the dosing lines. Are any other operators experiencing this. If so how have they solved the problems. Michelle Colwell (51 774 600 or colwellm@gippswater.com.au).

This unit was manufactured by **Goulburn Valley Engineering**.

For further information, contact Trevor Seccull on 035821 2266.

Propeller Blades at the Moe STP?

by Paul Keating, Treatment Plant Operator, Gippsland Water

No, not propeller blades but two stainless steel pipes that are now crushed flat, and all it took was 2.7 metres of head pressure.

Moe STP has three treatment cells (5m x 4m x 4m), each holding on average four million litres. The raw sewage is introduced into each cell by its own manifold which is a 370mm stainless steel pipe with four 370mm droppers. Cell No3's manifold is fed by a 370mm stainless steel pipe which runs through Cell No1, at 1.6 meters above the floor of the cell.

Cell No3 was the first cell to be drained for modifications to be carried out. After draining and cleaning, inspection took place. When we looked up the inside of the empty pipe we didn't like what we thought we saw; and poked a torch up and had a better look.

What we first thought was that the top of the pipe roof had collapsed to half way and the rest was sludge. Out with the hose and another look revealed that the top had collapsed 50% but also the bottom had collapsed 50% as well - a completely blocked pipe.

After a few expletives(#$%^&0) the questions flew quick and fast. First thought was to determine how much of the pipe was squashed and how badly. A camera inspection from either end was a possible option, but we located a piece of 50mm pvc and probed the damaged pipe from the surface. It felt like 13 metres out of 20 metres with problems, forget the camera!!

This raised a lot of questions and a lot of possible answers. Thinking vacuum was the cause of our problem, we decided to fabricate a new pipe (to original specifications, which turned out to be all custom made,) and then get divers to remove the damaged pipe and install the new pipe. We allowed two weeks for the delivery of parts and to organize every thing we thought we needed, and then we were into it. The work took 12hrs but every thing went to plan and we were back in action. This was a Thursday. Friday every thing was still OK - BUT on Monday the cell that was supposed to be empty was now 3/4 full.

The pipe had failed again...... Bugger!

This time concerned phone calls to frantic engineers confirmed that an empty 270mm stainless steel pipe with 1.5mm wall thickness can only withstand 2.7meters of head pressure.

A lot more questions and possible answers flew everywhere, and this time we decided to stay with 270mm stainless steel but with a wall thickness of 2.5mm (5.2 meters head pressure).

Two-and-a-half weeks wait for parts, eight hours this time to replace the damaged pipe (getting good at this) and so far no problems with stainless steel pipes reducing in diameter.

So if someone can explain to the engineers (they are the ones scratching their heads) and the rest of us, why a 13 metre length of pipe would completely collapse flat one way for 6 metres and then the rest of its length collapse at 90º to the first half please feel free to enlighten us.

• Paul Keating (keatingp@gippswater.com.au) is a Sewage Treatment Plant Operator at Gippsland Water and has operated the Moe STP for 5 years.

BRAIN TEASER

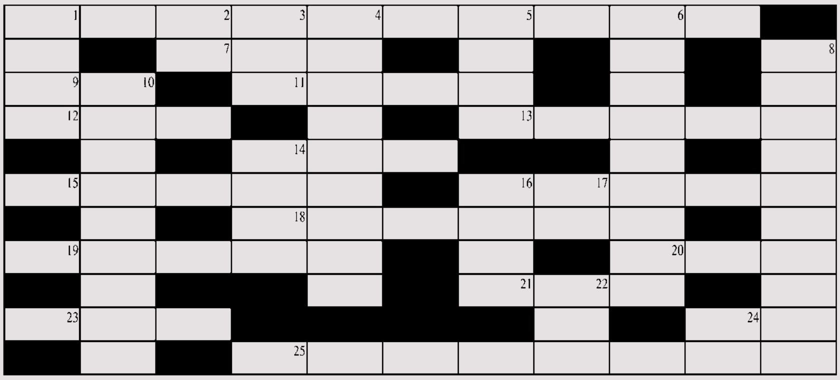
Much of what we do relies on calculations. In this segment we will pose some real life operations problems and give you the chance to have a go at working out the answer.

The workings will be provided in the next edition of the newsletter.

Blacks Block!!

You need to disinfect water flowing in a 750 mm diameter main at a constant rate of 80 l/sec. You have a stock solution of 3% (w/v) hypo.

- What flow rate is required from the dosing pump to deliver hypo to the main to achieve a total chlorine residual of 0.6 mg/l?
- How much hypo will be used per day assuming the water flows in the pipe for 12 hrs/day?
- How long would it take for an increased dose of chlorine to be detected 2 km away along the same pipe?



ACROSS

1 Next step after 4 down
7 Excrement
9 This helps the pay packet
11 Type of water treatment (abbreviation)
12 Water is _ _ _
13 Brekky food
14 Important for brew
15 Flat
16 Copy
18 Salty
19 Not the most
20 Nothing
21 Do this to your I's
23 Have a go
24 Information technology (initials)
25 Added to water for dental health

DOWN

1 The movement of liquid through a pipe
2 Short for operator
3 Chemical version of B.O.D.
4 Change the surface charge of colloidal particles
5 High _ _ _ _ pump
6 What the water and wastewater plant are used for
8 To move water through a system of pipework
10 A method used to send and receive information and control items of plant
14 Place where armed forces eat
16 Look after
17 Put _ _, To work hard
22 Used to propel a boat
24 Identification (initials)

BALANCING THE WASTEWATER EQUATION

George Wall – Wastewater Specialist, Goulburn Valley Water, Vic; Secretary, Australian Water & Wastewater Operators Association (AWWOA)

Lagoon based systems are used for many purposes at Wastewater Management Facilities (WMF), including primary or secondary treatment through to maturation/irrigation storage.

Ask yourself the following:

- Have you ever been caught with too much water in your lagoons due to heavy rain or unusual events?
- Are you able to identify problems or malfunctions with your plant or equipment early?
- Are you able to predict in advance when to take action or do you rely on crisis management?
- Would you know the hydraulic impact of accepting effluent from a new industry?

If you answered 'No' to any of these questions, I suggest you consider the development of a mass water balance model.

I can hear some operators mumbling – "yeah sure, how hard is that going to be?". There have been models designed for everything under the sun but most of time the model designer overcomplicates things, making them unattractive for operators to use. The key is to go back to the basics and provide a simple model that all operators with access to a PC can easily understand and use. A simple model has been used at a number of Goulburn Valley Water WMF's for many years. This model has proven reliable at different plants, both large and small, and is used to predict potential operational problems, allowing operators to develop appropriate water management plans well in advance of any need for action.

What information do we need to develop a mass water balance model?

Effective models rely on quantifiable inputs and outputs. Inputs include raw waste inflow to the plant, rainfall collected in the lagoons and returns to the plant (such as runoff collected in re-use dams following irrigation). Outputs include reclaimed water for irrigation, evaporation losses, and offsite discharges.

In addition, we need some physical information on the lagoons. Surface area is important to calculate evaporation; design freeboard or 'air space' to ensure the stability of the embankments and avoid overtopping by wave action; a means of measuring the actual volume held in storage to allow predictions by the model to be cross checked against real data; and access to weather data – primarily rainfall and evaporation.

Model

Figure 1 shows a simple mass water balance model for the fictitious Muddy Creek WMF. We can use this model to track flows in and out of the plant and, more importantly, to determine when and for how long, we need to discharge to the Muddy Creek.

What do the terms in the model mean and where do you collect the necessary data?

The figures entered into the model are normally monthly values, with all flows recorded in megalitres. If an operator wished to run the model on any particular day during a month, cumulative values from the start of the month to that day are required for **all parameters** otherwise the model outcomes may not be sensible.

Evaporation and rainfall

Ring the Bureau of Meteorology in your State. There will be a location somewhere in your area recording weather details. Evaporation data is

Figure 1. Sample Spreadsheet

Muddy Creek Wastewater Management Facility

		2000							2001						
		JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUNE	Totals
	UNITS														
EVAPORATION	mm	30.8	36.6	46.2	68.7	109.2	160	202.5	244	172	176.3	94.3	51.5	30.8	1,392
RAINFALL	mm	41.3	44.7	42.3	51.3	67.7	90	10.7	46.7	80	18	32.8	46.8	39.5	570
PAN COEFFICIENT		0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
INITIAL STORAGE AVAILABLE	ML	136.57	141.30	91.36	77.68	53.14	34.96	27.18	106.00	134.63	133.90	171.82	172.47	130.33	
LAGOON SURFAC AREA UTILISED	Ha.	13.56	13.56	13.56	13.56	13.56	13.56	13.56	13.56	13.56	13.56	13.56	13.56	13.56	
NET EVAPORATIVE LOSS	ML	-3.60	-2.34	-0.72	0.50	2.67	5.15	20.52	20.14	7.81	16.68	5.78	-0.76	-2.02	73.66
INFLOW VOLUME	ML	38.45	39.87	43.75	42.68	45.14	44.79	38.85	40.52	42.62	39.87	35.13	42.75	38.00	493.96
IRRIGATION VOLUME (our site)	ML	0.00	0.00	0.00	10.68	21.43	22.03	47.80	23.70	35.19	30.00	20.00	0.00	0.00	210.83
OFF-SITE IRRIGATION (Joe's Farm)	ML	0.00	0.00	0.00	0.00	11.55	12.16	3.60	19.89	12.63	10.00	0.00	0.00	0.00	69.83
DISCHARGE TO MUDDY CREEK	ML	0.00	30.00	30.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	30.00	130.00
PREDICTED STORAGE	ML	97.78	88.72	76.89	76.17	72.03	68.15	103.63	129.20	147.64	150.72	141.37	107.86	97.85	
ACTUAL STORAGE	ML	100.68	91.36	77.68	81.52	73.60	70.56	106.00	134.63	133.90					

Notes:
1. Values for Evaporation and Rainfall as recorded from (wherever you get the data)
2. Inflow volume recorded from the totalised inflow meter at the plant.
3. Irrigation volumes to our site are as recorded on the meter (irrigation pump, water wheel etc).
4. Off-site Irrigation volumes to Joe's site are as recorded on the meter (irrigation pump, water wheel etc).
5. Discharge off-site to (Muddy Creek) as per outflow meter.
6. Actual Storage Volume is calculated at the end of each month for comparison with the Predicted Storage Volume.
7. Figures are accurate to the end of each month where an actual storage value has been entered.
8. Colours Used in model: Unshaded reserved for values calculated by the model. Blue or mauve is used for fields requiring the operator to input raw data.

limited and you need to find a site with similar characteristics to your plant. Alternatively, collect your own data on site with a calibrated rainfall gauge and evaporation pan. This will give much better data and is inexpensive to set up.

Pan Co-efficient

Pan co-efficient is necessary to allow determination of net water loss or gain from the ponds due to evaporation and rainfall. Evaporation of water from the surface of a water body is a function of a number of factors affected by the surface area. An evaporation pan has a small surface area and, as air passes quickly over the pan, it is not likely to become saturated with water vapour. Lagoons are much bigger and air passing over them may become saturated by water vapour by the time it has travelled only part of the distance over the lagoon. Thus, the volume of water evaporated from a pan may be higher than for a larger water body such as a lagoon. Most literature suggest a uniform monthly pan coefficient of 80%, although in windy, inland or arid regions, it is possible for the co-efficient to be much higher due to the drier air.

Initial storage available

To start the model, we require the actual storage volume, as measured on the last day of the previous month. Each month, the operator manually replaces the predicted storage at the start of the next month with the 'Actual' storage at the end of the previous month.

To obtain consistent 'actual' storage data, some type of permanent marker system needs to be installed into each lagoon from which the water level can be recorded. Graduated depth markers can be attached to structures or to posts driven into the banks, or even flow distribution pits. The top (zero value) of the marker must coincide with the top of the lagoon embankment. If the top of a pit is chosen as the measuring point, the level of the pit above or below the top of bank must be determined. This allows a measurement to be recorded even if the lagoon has been filled slightly above its design freeboard limit.

Record the water level weekly with the measurement taken from the same point each time. A spreadsheet can be developed to calculate storage available. To do this we need:

- lagoon surface area (average),
- design or required freeboard,
- height above freeboard level to the top of the marker point or bank, and
- actual depth to water from the marker point.

Surface area is required in hectares and all levels in millimetres.

Assuming that the measuring points are set to be level with the top of the lagoon embankment, use the following formula to determine storage available:

Storage Avail (ML) = (Depth to water – required freeboard [mm]) x Surface area/0.01 (ha)

If the result is positive then there is capacity available for more water, if it is negative then the lagoon has been filled above its design freeboard level and steps should be taken to reduce the water level. A description of how to determine average surface area is included below.

Lagoon surface area utilised

The lagoon surface area (average) utilised is necessary to allow determination of net gain or loss of water in the ponds due to rainfall and evaporation.

Undertake survey of the lagoons to determine average surface area. Use a measuring wheel or tape to determine the length and width of the lagoon banks at the top. Lagoons are usually constructed with batters of 3:1 and unless the banks are very steep, assume this value. Measure the average water depth in the pond by using a boat and measuring stick to determine the water depth at a number of points in the pond on a uniform grid pattern. Around 16 locations for a lagoon of approx 4ha in area should be enough.

These depths establish whether the floor of the pond is level and allow an average depth to be calculated for use in the surface area calculation. Measure the air space between the current water level and the top of the lagoon bank to give an overall depth. Attempt to pick the lowest point of the bank for this measurement, as this is where the pond would overtop first if overfilled.

Assuming a pond is 50m long and 30m wide at the top, and the average depth of water the day it was surveyed was 1.6m plus 0.4m from water level to top of bank, giving an overall depth of 2m.

Base Length = Surface length - 2 x (Depth x Slope)
= 50 - 2 (2 x 3)
= 50 - 12 = 38m

Therefore Average Length = (50 + 38)/2 = 44m.

Base Width = Surface width - 2 x (Depth x Slope)
= 30 - 2 (2 x 3)
= 30 - 12 = 18m

Therefore Average Width = (30 + 18)/2 = 24m.

Average Surface Area = Ave Length x Ave width
= 44m x 24m
= 1,056 m^2 or 1.056 ha

Assume that the design freeboard is 0.3m. To determine the average usable volume of this lagoon : 1.056ha x 1.7m deep = 1.79 ML. The depth used in calculating the volume is 1.7m as this is working depth taking into account the desired freeboard. It is possible to fill the lagoon to 2m, which would take the overall capacity of the lagoon to 2.112ML but it is undesirable operationally.

For odd shaped lagoons the best approach to determine average surface area is to dissect the lengths and widths to form squares, rectangles or triangles wherever possible. The area of squares and rectangles can be calculated relatively easily as above.

Average surface area applies when the lagoons are exactly half full. The margin for error as the ponds fill or empty is usually not excessive and therefore we do not need to adjust the average surface area of the ponds in the model as we update it.

The exception to this is when lagoons are taken totally offline for works or are emptied completely, as this will impact on overall evaporation area. Remove the area of these lagoons from the model and add again once they are refilled.

Net evaporative loss

This is a calculation performed by the model taking into account pan evaporation, rainfall, pan coefficient and lagoon surface area. The model calculates net loss or gain of water at the plant in megalitres.

Inflow volume

This is the monthly total of raw waste entering the plant and is essential for any plant. Some form of raw waste metering is usually required in the WMF's EPA License. Normally only monthly totals are required, except for special updates.

Irrigation volume

In our example, there are two areas utilising reclaimed water from the plant for irrigation. The first is 'our site' which is land owned, operated and irrigated by staff from the Muddy Creek Water Authority. The second is 'off-site reuse' on a neighbouring property - 'Joe's', with volumes applied to both sites recorded by flow meters.

Discharge volume

Surplus reclaimed water not able to be irrigated can be discharged to the Muddy Creek under an EPA License. The volume discharged is recorded by a flow meter. In this case the daily discharge limit is 1ML.

Predicted storage

At the end of each month, the net inflow and outflow volumes are calculated taking into account the initial storage capacity available. The model then predicts the volume of storage capacity likely to be available at the end of the month.

Actual storage

This is calculated by physically measuring the water depth in each pond as described earlier. The 'actual' storage volume is entered into the model and compared with the 'predicted' volume. This value can be used to indicate that all data to the end of this particular month are accurate - for the rest of the year, where there is no value in the 'Actual storage' step, all values are understood to be predicted.

Balance figure

There will be a difference between the 'Predicted' and 'Actual' storage volume on a monthly basis. Any discrepancies plus or minus 10% should be immediately investigated.

Items likely to cause a discrepancy include faults due to the accuracy of data such as the actual storage capacity measured; the calculated surface area or evaporation volume; isolated or locally heavy rain events not recorded at the weather monitoring site; problems with flow meters etc.

Interpreting the data and results

It is necessary to enter average inflow and outflow figures into ALL fields in the model when attempting to predict future balances. Inflow and outflow volumes should be readily available at all plants, therefore the only difficult data to source are likely to be rainfall and evaporation. If long term reliable flow data aren't available, enter actual values from immediate past months and estimate values for the remainder of the current year.

The Bureau of Meteorology should be able to supply weather data for a site with a climate similar to yours. If data for are not available, use the next closest data to get you started and consider setting up your own pan. As the model is updated with actual data each month, it becomes progressively more accurate. In the absence of long term data, actual figures from this year can be entered as predicted figures for next year.

The model can be used to provide data on 'what if' scenarios. It is possible to check the impact of certain events by altering the values in a row of the model and then looking at overall effects. Some examples of how you might use the model are:

- Assume we are experiencing a really wet year. By entering 90th percentile data for rainfall and evaporation (instead of average data), we can review the likely impacts on balances if the weather is wet for the rest of the year. Alternatively, it is possible to check on the availability of reclaimed water for irrigation on a monthly basis in a dry year. Entering higher evaporation and irrigation demand, coupled with lower rainfall, may indicate whether rationing of reclaimed water for irrigation will be required.
- Assume we want to take a lagoon off line and empty to do some work in it. Once empty, reduce the total lagoon surface area and the initial storage available by the area and volume of the pond off line. This allows us to see how long the pond can stay off-line to allow the works to be completed, and when or if we need to discharge due to reduced storage capacity.
- Assume that a new industry wants to start up in town. Add their predicted effluent volume to the monthly inflow figures and, leaving all other factors the same, see what impact this has. The model indicates the need for more irrigation areas, increased discharge, or more storage ponds. Alternatively it might demonstrate that in normal years we can handle the extra volume.
- Assume that we have lots of Blue-green algae in our lagoons and it is too wet to irrigate. If we estimate how much we could possibly irrigate for the rest of the season (which may be none), the model indicates how much storage room is left and the latest date to start discharges. This information may be important in determining the most appropriate course of action chosen to lower the algal levels.

As demonstrated, entering data to cover various scenarios alerts the plant operator to the possibility of future events and the operator can then develop necessary contingency plans well in advance

Further refinement - development of target draw down curves

Once data from a few years have been collected, the operator can easily develop a target draw down curve for the WMF. This curve alerts operators to minimum and maximum volumes of water that should be retained within the lagoons on a monthly basis.

After updating the mass balance model, the operator can check the available storage against the target curve. This will indicate if there is more or less water in the lagoons than normal. Appropriate site management decisions can then be made.

Use of a simple model such as this is a step forward in allowing WMF operators to adopt pro-active management systems at their plants. This type of model has been successfully operated at a number of Goulburn Valley Water WMF's for many years and is being introduced as a standard management tool for all plants.

Two versions of the spreadsheet model can be downloaded from the Australian Water and Wastewater Operator's Association (AWWOA) website at www.awwoa.org.au. – an Excel 5.0/95 and Excel 97/2000 workbook depending on what computer system you use. Copy the blank model and then modify it to suit your own WMF by adding or deleting rows. If you have any queries on the operation of the model send me a note at waterbalance@awwoa.org.au and I'll try to help you out.

Good luck and good balancing !!!

UPGRADING THE MORWELL SEWAGE TREATMENT PLANT

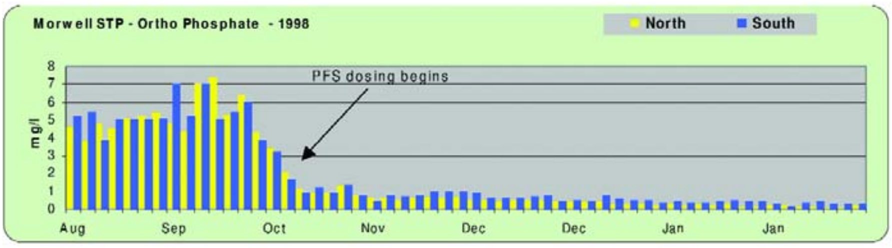
Mick Cook, Gippsland Water Operator

The Morwell Sewage Treatment Plant (STP) consists of 2 separate extended aeration plants. Each plant has an aeration basin with 2 low speed aerators, a circular clarifier (see Fig. 1), RAS and WAS pumps. There is a common raw sewage feed via 2 Archimedean screw pumps. South plant has a larger basin (2130 m^3) than North plant (1313 m^3) with both having the same size clarifiers. Both clarifiers discharge into a common lagoon system which discharges to the Morwell River. At present a new UV disinfection system is being installed on the plant discharge, at which point the lagoon system as it now stands will be decommissioned, keeping two for sludge lagoons and two for emergency storage (Fig 5).

The problems faced at the plant over the last 5 years and the solutions to the problems are described below.

Problem No 1 - High Phosphorous

The EPA discharge licence requires a median total phosphorous (T-P) of 0.5mg/L and a 90th percentile of 1 mg/L. There was no dedicated removal of phosphorous from the raw sewage other than what normally occurred in the conversion of food to biomass within the activated sludge plants. The N and S clarifier effluent T-P's were 5 mg/L with final discharge from the lagoon system to the Morwell River ranging from 5 - 9 mg/L. The increase through the lagoon system was attributed to P release from the anaerobic sludge layer in the lagoons. Further to this, the lagoon system was presenting major blue green algae problems in relation to the E.P.A. licence.



Graph 1. Phosphorous levels in the effluent from the Morwell STP before and after the introduction of PFS to the raw sewage.

Solution

- Dosing of raw sewage with Poly Ferric Sulphate (PFS) for P removal.
- pH correction using caustic. The caustic is dosed after the PFS.
- Installation of a new UV disinfection unit on the effluent from the clarifiers to eliminate the lagoons from the normal process and allow discharge directly into Morwell River.
- Set up 2 lagoons for emergency storage in the event of plant breakdowns or high turbidity. The lagoon effluent can be pumped back to head of plant.
- After a substantial on-site trial period using temporary equipment supplied by Aluminates Chemical Industries, the required P results were achieved. Aluminates were commissioned to install a permanent dosing facility of 1x 10,000 litre PFS tank, 1x 10,000L Caustic tank and variable speed diaphragm pumps with the PFS pump flow paced to inflow and Caustic pump controlled by an in-situ pH meter in the south basin. Due to physical constraints the PFS injection point was mounted in the inlet channel only 4 meters before the caustic injection. The solution to the lagoon problems involved a longer time frame and at the writing of this report the UV disinfection unit was almost ready for commissioning.

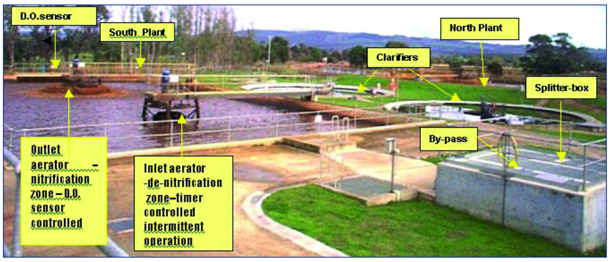
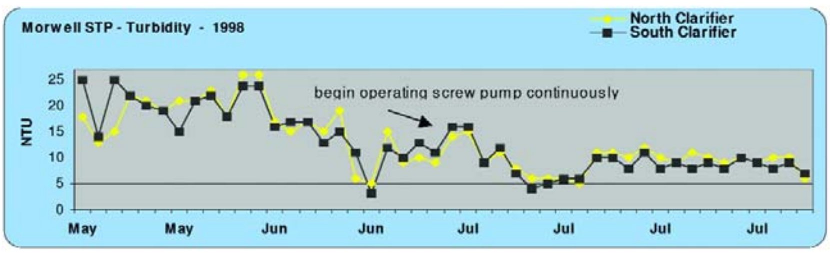


Figure 1. Activated Sludge Plant overview.

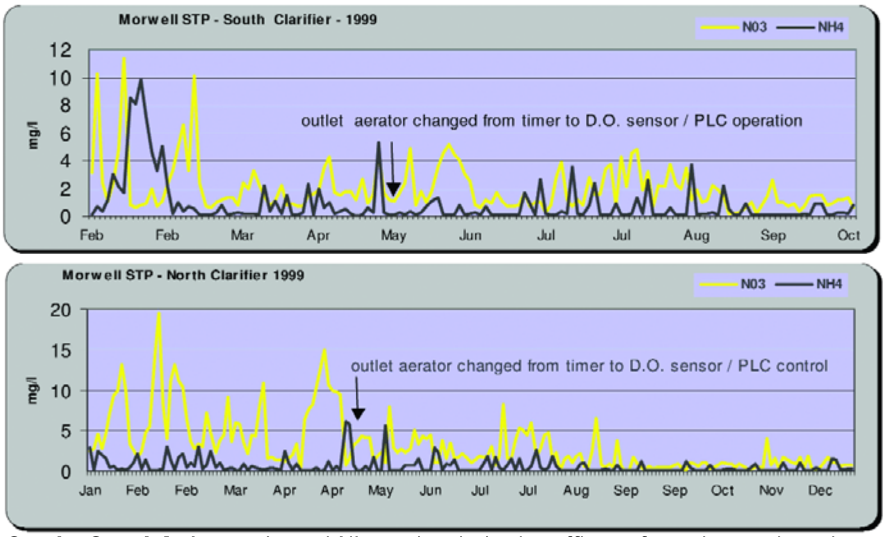
Results

- P levels at the discharge of the clarifiers now average 0.5 mg/L, fluctuating between 0.3 - 0.6 mg/L (see graph below)
- The effluent from the south clarifier is slightly more turbid than the effluent from the north clarifier. The turbidity is due to ferric hydroxide/ferric phosphate floc, resulting in the P level from the south clarifier being 0.1- 0.2 mg/L higher. Both plants are fed common raw sewage, dosed with PFS at 180 mL/kL, so we are currently looking into areas where floc shearing may occur such as the RAS pumps and check valves. The RAS flow rates in the south plant are higher than those from the north plant due to clarifier design and intermittent operation (explained later).
- There were doubts as to the position of the PFS injection point providing a good mixing zone so it has been relocated further upstream before the screw pumps, to aid mixing.
- Flow pacing of the variable speed PFS pump has not been as accurate as desired,



Graph 2. Turbidity in the clarifier effluent from the Morwell STP before and after modifications to the operation of the influent screw pumps.

due to the inability of the pump to cover the flow range adequately e.g. @ 20 L/sec = 225 mL/kL, @ 40 L/sec = 135 mL/kL. A new, more accurate pulse pump is currently being installed.



Graphs 3 and 4. Ammonia and Nitrate levels in the effluent from the north and south clarifiers showing the effect of the modified aeration controls.

Problem No 2 - Hydraulic overload of clarifiers

Initially there were two Archimedean screw pumps with one on duty and one on standby. They were controlled by a multitrode level sensor which allowed the pump well to fill to TWL before the pump operated, at which point it delivered approximately 200 L/sec (17000 m^3/d). This caused hydraulic overloading of both clarifiers resulting in solids wash-over.

Solution

Operate the duty pump on continuous manual run to eliminate the build-up of raw sewage in the pump well and remove the associated hydraulic peaks to the north and south plants.

Results

Solids wash-over from the north and south clarifiers is now not an issue resulting in higher quality effluent (Graph 2).

Problem No 3 - More accurate control over aeration to achieve consistent N removal

The north and south basin aerators were controlled by timers so that the two aerators in each basin were connected to a common timer and operated intermittently to achieve conversion of food to biomass and Nitrogen removal. The EPA licence requires ammonia reduction to 2mg/L median (5mg/L maximum), and nitrate to a level so as not to exceed a Total Nitrogen level of 10 mg/L. With no dedicated mixing zone for denitrification and the chance of under or over aerating due to varying organic loading over a 24 hr period, it was very difficult to reach and sustain the above requirements given the restriction of manually set timer operation.

Solution

Install a D.O. sensor on each outlet aerator for automatic control via the plant PLC to achieve food conversion and nitrification (ammonia removal) whilst leaving each inlet aerator operating intermittently via timers (4 min on 40 min off). The intermittent operation of the inlet aerator creates a denitrification zone (refer Figure 2) where raw sewerage is mixed with the biomass thereby encouraging nitrate reduction.

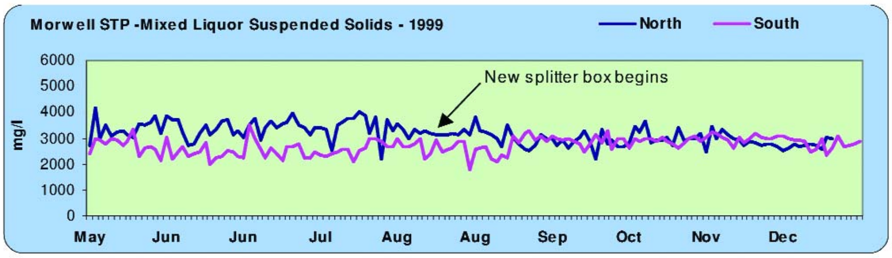
Figure 2. Intermittent aerator/mixer in foreground.

Result

The modifications to the DO and mixing control has stabilised N removal at the plant, with ammonia and nitrogen levels staying well within licence limits (Graphs 3 and 4). However, given that the bulk of nitrification/denitrification is occurring at opposite ends of the basin (excepting simultaneous nitrification/denitrification in the nitrification zone) it doesn't take much of a shift in operating parameters to upset the balance. There is still work to be done to trim up the process in this area to reduce some of the ammonia/nitrate peaks as shown in the graphs and thereby achieve more reliable operation. Further areas to consider are:

Figure 3. Splitter-box (foreground) and screw pumps and inlet works (rear).

- Determining the most effective position for the D.O sensor in regards to distance from the aerator and depth under the surface. At the moment the D.O. probe is surface mounted and is approx. 8 meters from the edge of the aerator impeller. The intention is to move closer to the aerator (approx 3 metres from edge of impeller) and deeper under the surface (approx. 2.5 metres/1 metre from the bottom). Hopefully this position will result in more sensitive control over ammonia/nitrate removal by



Graph 5. Stabilisation of MLSS in the north and south basins after commissioning of the flow splitter box.

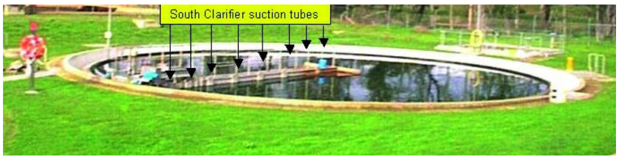


Figure 4. South Clarifier.

having the aerators switch off at an earlier stage when the D.O. would indicate completion of nitrification (thus not over aerating and destroying denitrification) and switch back on earlier as D.O.'s begin to fall. Hopefully this will also save some power usage.

• Style of D.O. probe. At this stage membrane style probes are used and in our application they seem to require regular cleaning (1/week) and calibration (1/mth). Biomass adheres to the surface of the membrane and if not removed, it begins to affect the performance of the membrane. A Zullig probe with a motor driven grindstone will be trailed to see if it can provide more accurate results over longer maintenance intervals (supposedly 1/yr other than occasional visual inspection).

• Trial a VSD on the inlet aerators in the de-nitrification zone to slow down the speed to 15 – 45 rpm, thereby reducing the D.O. input and increasing their potential as a continuous mixer/ stirrer.

The final speed is very much dependent on the gearbox design of the aerators e.g. the north aerator has oil immersed gears and can turn down to 5 rpm, while the south aerator has oil pump lubrication and can only turn down to 15 rpm.

Problem No 4 - Stabilisation of solids in aeration basins

During periods of low flow there was a partial transfer of the contents from one basin to the other. This transfer caused an imbalance in the mixed liquor solids as well as a drop of up to 400mm in the clarifier TWL. This was caused by the north and south basins (both at different TWL's), being interconnected via a common raw sewage inlet pipe.

Solution

A raw sewage flow splitter box was constructed to isolate the north and south basins from each other. The box was constructed so that a choice of splits was available e.g. 50/50 or 60/40. The design also included an overflow weir to re-direct flows in excess of 6 ML to the lagoon system (see Fig. 3) thereby eliminating hydraulic overload of the activated sludge plant.

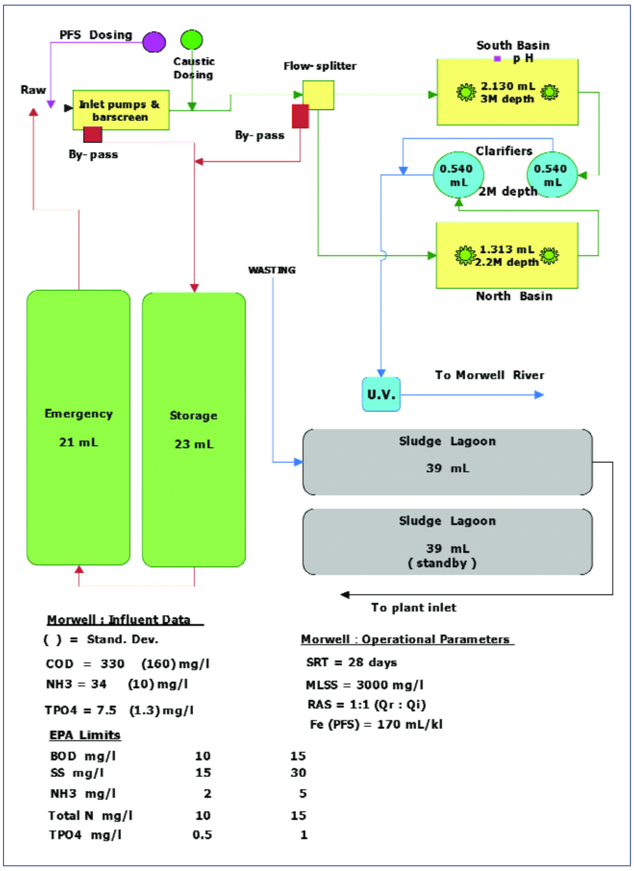


Figure 5. Morwell Plant Layout with the U.V. unit operating.

Result

As a result of these changes the clarifier water levels do not fluctuate relative to each other, solids transfer has stopped and the MLSS in the basins has stabilised (Graph 5). The high flow bypass has also assisted in reducing clarifier turbidity levels during periods of high rainfall.

Problem No 5 - Poor removal of sludge from south clarifier

Settled sludge in the bottom of the south clarifier was not being removed uniformly due to the suction tubes in the clarifier bridge (see Fig. 4) blocking off when a lower flow rate was selected.

Solution

The RAS pump rate was changed from a continuous 11 L /sec (950 kL/d), to intermittent pumping by reconfiguring the existing timers and setting them at 20 min off/6 min on. This setting still achieved the required 950 kL/d over 24 hrs, but when operating, the pump delivers 29 L /sec thus keeping the suction tubes flushed clean.

Results

Sludge is now removed in a uniform manner across the full width of the clarifier floor. However, the timer controlled method will not be long term, since during the RAS pump operating period there is a flow surge created by the higher return rate to the south basin and back to the clarifier. To overcome this, the intention is to program the PLC to ramp the VSD up to a maximum flow rate of 29 L /sec but for only 30 seconds and at 30 min intervals, thus eliminating the extra surging.

Author

Mick Cook (cookm@gippswater.com.au) is a sewage treatment plant operator with Gippsland Water. He has operated the Morwell STP for 3½ years. Prior to joining Gippsland Water, Mick worked at a number of South East Water STP's.

Acknowledgements

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PRACTICAL EXPERIENCES WITH PARTICLE COUNTERS

Michelle Colwell – Water Treatment Technologist, Gippsland Water

Particle counters are useful tools for optimising and monitoring the overall performance of treatment plants. However, their usefulness depends upon careful maintenance, correct set-up, and being aware of their limitations. This article provides an insight into some of the exciting things that can be done with particle counters, but also details some of the operational difficulties that may be encountered when using particle counters, and offers some advice on how to overcome these problems. Further, this article will explain in practical terms, how to use the information provided by a particle counter to optimise filtration performance.

What is a Particle Counter?

Conventional water treatment relies upon turbidity measurements to determine how well filters are performing. While turbidity measurements are useful, the information received from a turbidity meter is limited. A turbidity meter can tell you how 'cloudy' the water is, but it can't tell you whether the 'cloudiness' is caused by lots of small particles, a few large particles, or any combination of the two.

A particle counter is an instrument that can measure both the number of and size of particles in a water sample. A laser beam passes through the water sample, and the 'shadow' cast by particles in the sample falls onto a sensor. Each 'shadow' is counted, and the size of the 'shadow' is directly related to the size of the particle. Particle counters are therefore more versatile tools for monitoring filtration performance than turbidity meters.

The particle counters used by Gippsland Water have been configured to measure the total number of particles in the 2-15µm size range in the filtered water. By measuring this size range, we can count particles the same size as *Cryptosporidium* (4-6µm) and *Giardia* (8-12µm)[1]. *Cryptosporidium* and *Giardia* are both protozoan (single celled animal) pathogens that are extremely resistant to conventional methods of disinfection. They are capable of causing moderate to severe gastrointestinal illnesses. Filtration provides a physical barrier, which is the most effective way to reduce the risk of these organisms entering the reticulation where they may cause disease.

Log reduction

Log reduction is a term often used when describing the effectiveness of a WTP in removing particles. However, given that many raw waters have relatively low particle counts to begin with (less than 20,000 particles/ml in the 2-15µm size range), and measuring particle counts in raw water can be difficult and unreliable, measuring log reductions does not give a true indicator of the filter's performance. Achieving a good log reduction is dependant upon high raw water counts, and takes no account of the actual quality of the water exiting the filters.

A particle counter will generate real time particle count information on the actual particle counts exiting a filter, and these are a more reliable indicator of filtration performance. Gippsland Water aims to achieve less than 200 particles/ml (in the 2-15µm size range) for 95% of the time.[2]

Using actual particle counts requires no complex mathematics. However, for the mathematically inclined, the following formula can be used to calculate a log removal.

$$\text{Log reduction} = -\log_{10} \frac{\text{(Filtered water particle count)}}{\text{(Raw water particle count)}}$$

Example

Particle count exiting Filter 4 (Filtered water particle count) = 80 counts/ml
Raw water particle count = 7,000 counts/ml
Using formula,

$$\begin{aligned} \text{Log reduction} &= -\log_{10}(80/7000) \\ &= -\log_{10}(0.011) \\ &= -(-1.942) \\ &= 1.942 \\ &= 1.9 \end{aligned}$$

Table 1 illustrates the problems associated with reporting log reductions versus absolute counts exiting a filter. The table illustrates that although Filter 4 is producing the best quality water, it is the worst performer with respect to log removal of particles. When using a particle counter to optimise performance, the lower the particle count achieved, the better the quality of water being produced.

Table 1. Comparison of log reduction and absolute counts (all figures are counts/ml in the 2-15µm size range)

	Raw water counts	Filtered water counts	Log Reduction	Rank based on log reduction	Rank based on outlet counts
Filter 1	1,000,000	100	4	1	3
Filter 2	20,000	95	2.3	2	2
Filter 3	10,000	100	2	3	3
Filter 4	7,000	80	1.9	4	1

How to use the Particle Counter to Improve Filtration Performance

With common sense, and a methodical approach, significant improvements to the particle counts exiting the filters can be achieved. Patience and self-control is required to achieve these results, but the process is challenging and exciting, and the outcomes are intensely rewarding and satisfying.

Record Initial Conditions

Once jar testing has been used to determine an optimal chemical dosing regime, the particle counter should be left to monitor existing conditions. Without this preliminary information, you will never be able to tell whether any changes you have made have improved or adversely affected the overall operation of the filter. Several stop/start sequences, various plant run times and several backwashing sequences should be observed. It is important to record all chemical dose rates, backwash times, filter run times and plant stop/start trigger levels. Do not attempt to make any changes to your plant without first gaining this preliminary information. Figure 1 illustrates a typical particle count profile prior to making any operational changes. Notice the very high particle counts occurring when a primary and secondary filter come back on line after a backwash. These particle counts are orders of magnitude greater than the counts experienced during normal operation, and attempts should be made to significantly reduce or eliminate these particle peaks, in order to achieve the target of less than 200 particles/ml in the 2-15μm-size range, for 95% of the time.

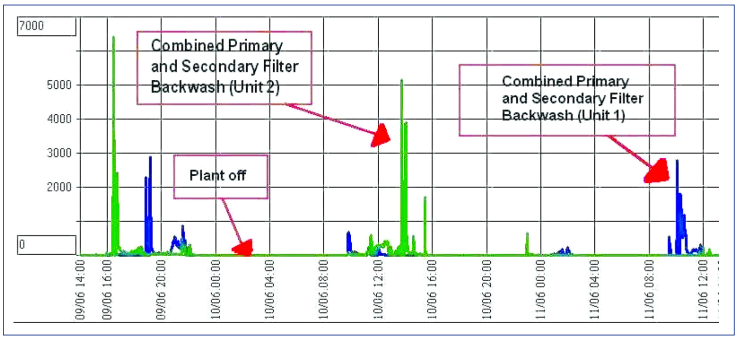

Figure 1. Particle counts/ml in the 2-15μm-size range before making operational changes.

Start by using gross visual means to optimise plant performance

The first thing to check is whether your filters are cleaning up effectively during backwashing. Watch and time several backwashes under existing conditions. Record your observations, and also record backwash rates by measuring the rise rate of water in the filter during backwashing. A plot of level versus time will allow you to calculate backwash rates.

Your observations may indicate a need to increase or decrease either the backwash rate or duration. Exercise caution if changing the backwash rate, as the rate must be high enough to fluidise the bed, but not so high as to risk media loss over the launders. A long handled rake inserted into the sand bed during a backwash will give a good indication of whether the bed is fluidising. If the rake does not fall to the bottom of the filter under its own weight (but remember to hold onto the handle!), then the bed is not effectively fluidising.

If you decide to make changes, it is important to make only one change at a time, and WAIT and use the particle counter to observe the effects of each change. Compare the results after making a change with previous results to determine whether the change has improved the filtered water quality.

Determine the maximum run time of your filters

- How long can your filter run before particle breakthrough occurs?
- Can you still backwash the filter effectively if the filter reaches breakthrough?

To determine the answers to these questions (under relatively stable raw water conditions) requires patience, simple mathematics, and the discipline not to alter more than one parameter at a time.

You will need to understand the physical limitations of your treatment plant. Simple mathematics is required to calculate the following:

- The capacity of your backwash tank(s)
- The capacity of your sludge handling facilities
- The backwash rate(s)
- The supernatant return rate

Once these figures are understood for each component of the plant, you know the boundaries that you are working within. Entering information into a spreadsheet is a useful way to represent this information. For example, if your backwash tank capacity is 25000L and the backwash rate is 150l/s, then you know that the maximum time that you can backwash your filters is 2.75 minutes. Similarly, if the supernatant return rate is 4 l/s, then it is going to take just over an hour and a half to empty the sludge handling facility if you backwash for 2.75 minutes, so you will have to wait at least this long before backwashing again. Depending upon the quality of water entering your plant, you may or may not be able to wait this long before another backwash is required. You must understand these physical limitations before you make any changes to the process. Without this knowledge, the process or the filters could be affected detrimentally, and it may take some time to recover.

If you already have filter outlet turbidity trended at your plant, you should have an idea of when filter outlet turbidity begins to rise. This has traditionally been the trigger for backwashing. However, particle breakthrough occurs BEFORE turbidity breakthrough. It makes sense therefore to determine when particle breakthrough begins to occur, and initiate backwashes just prior to this. If you do not have filter outlet turbidity trended, or the filter outlet turbidity trend does not show a characteristic breakthrough curve, then 'pushing the limits' is required. To do this without introducing confounding variables requires careful coordination. Ideally, the plant should be allowed to run uninterrupted for as long as possible, and normal backwashing (on time) should be inhibited. Plant shutdown on filter outlet turbidity or head loss should be activated to prevent turbid water carrying through to the reticulation. Careful planning is also required in order to ensure that any turbid water exiting the filters is disposed of to waste, and not to the reticulation, where it may pose a health threat to consumers. Experience indicates that it is often difficult to effectively dump water, as existing control mechanisms and flow paths are generally not designed to cater for this kind of activity.

Compromises may be required

Once a filter has been allowed to proceed to particle breakthrough, you may find that a single backwash is insufficient to clean it effectively. If this occurs, the filter should be backwashed again until is comes clean, and a reduced maximum filter run time should be estimated based on the plant's ability to clean the filter in a single backwash. You will find that compromises such as this are required in order to produce the highest quality water. Do not be overly surprised if the operating conditions that you eventually decide upon are far removed from the original design characteristics of the plant. Achieving design capacity may also be difficult, given that backwashing may either consume more water, take longer to complete, or be more frequent than before. Running at lower flow rates will also impact the plant's capacity to produce the maximum amount of water, especially if the plant already runs for extended periods of time each day.

Be patient - Eradicate or minimise rapid flow changes

It is really important to make only one change at a time, and make small changes. Use common sense to determine where the 'big wins' are likely to be. If you make changes, carefully note down the date and time of the change, then sit back and wait, and watch the trends to see what they tell you. Don't be tempted to 'fiddle' and make other changes at the plant until at least two complete filtration cycles have elapsed. A filtration cycle is the time from one backwash to the next of all filters under normal operating conditions.

When the particle counts exiting the filter suddenly increase, the filter is said to be 'shedding' particles. Most particle shedding events are likely to be attributed to rapid changes in flow, and the most dramatic changes in flow occur during plant start up, when components of the plant come back on line after backwashing, or when a filter backwashes and the flow through the plant does not reduce accordingly.

If the number of plant starts can be minimised, overall water quality should improve. Consider running the plant for longer at a lower flow rate, or allow storage basin levels to fall lower than before to allow the plant to run for longer. Consider combining these two strategies to allow the plant to run continuously.

One of the most disruptive influences on filtration performance is the change in flow rate through a filter. If plant inflow does not reduce proportionally when one or more units go off-line, then during this time, the remaining in-service filters effectively take more load. The fewer the number of filters at your plant, the greater the load applied to the remaining filters during the backwash of a single unit if flow does not reduce proportionally.

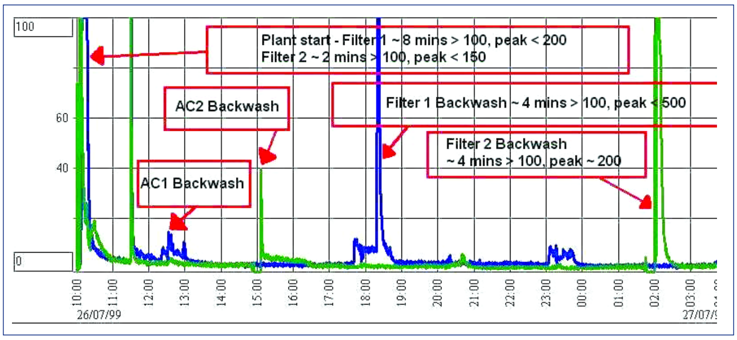

Figure 2. Particle counts/ml in the 2-15μm size range achieved after making operational changes.

The assistance of a PLC programmer may be required to achieve proportional inflow reduction, and variable speed flow depending upon operating conditions if it does not already exist. Allowing the plant to come back up to full production slowly after a filter backwash, or when the plant starts up from stopped will improve the water quality exiting the filters.

Fine Tuning

Once plant run times, filter run times and backwashing intervals and durations have been determined, other factors contributing to particle shedding (the increase in particle counts from normal operating levels) can be hunted down and controlled in an attempt to fine tune the performance of the plant. Once again, the minimisation of hydraulic shocks, which can be associated with rapid changes in flow, is a key driver. A significant contributor to rapid flow changes, particularly during backwashes and plant start/stop routines is the speed that valves open and close. If alterations can be made to make the transition from open to closed and vice versa as smooth as possible, then significant improvements in particle counts will be seen. Slowing down the rate that valves ramp open or close is an easy way to achieve better water quality, but may require the assistance of a PLC programmer, and must be done in a manner that does not adversely affect other parts of the treatment process. Figure 2 below shows the particle counts that were achieved by fine-tuning the operation of valves at a water treatment plant. Comparing the scale of Figures 1 and 2 gives a clear indication of the magnitude of improvement in particle counts that can be achieved.

Traps for the Uninitiated

Before embarking upon any particle counting exercise, a number of key points should be addressed. To avoid falling into some common traps, the following advice is offered.

Location

Correct location of the particle counter is vital in order to achieve worthwhile results. Particle counters are generally not suited to untreated or partially treated waters. Raw water particle numbers are generally high, and counting of particles in raw water is likely to be unreliable. The reason for this is that the sensor becomes 'swamped'. For example, if dirty water enters the unit, there may be so many particles passing by the sensor that individual particles are unable to be distinguished. Instead, the sensor incorrectly counts many particles as one large 'blob', effectively underestimating the total number of particles, and overestimating the size of the particles.

Air and slime

The relatively low flow rates through the particle-counting unit may encourage biological growths in the sample tubing and sensor. Biological growths can fall off the sample tubing without warning and provide a misleading 'particle event', or may contribute to poor results due to intermittent changes in flow. Partially treated water can also foul the unit, as small flocs can aggregate and restrict flow through the unit. It is therefore important to locate the unit where there is no likelihood of backflow or syphoning of untreated water. Slime growths can be controlled by backflushing the unit with a weak hypochlorite solution.

Entrapped air can also cause spurious results, as the unit cannot distinguish between air bubbles and real particles. Care must be taken to avoid air entering the unit, and pipework should be designed to avoid air entrapment. Constant head devices supplied with some particle counters have breather pipes at the highest point to purge air from the system, but if not well designed, they can contribute to operational difficulties such as acting like a venturi and sucking air into the system, or allowing all the flow to escape via the breather pipe. If the breather pipe is of larger diameter than the sample pipe, and the breather pipe outlet height is higher than the maximum hydraulic level of the system, the system should operate properly.

Movement

Particle counters are sensitive pieces of scientific equipment, and should be treated with care. Some brands are more sensitive to movement or bumps than others, or 'bumping' of components during cleaning. Over zealous cleaning can move internal components only fractions of a millimetre, but this can significantly affect the internal calibration of some particle counters.

Flow

Another important factor contributing to unreliable results is flow. To provide reliable results, the particle counter requires constant flow. Most units are designed to operate with flows between 70 and 100 mls/min. To ensure constant flow through the unit, a constant head device should be installed. Constant head devices are generally supplied with the particle counters. Flow through the unit should be checked at various times of day and at various stages of the filter run. Flow meters supplied with some commercially available units can be unreliable. Manual checks with a measuring cylinder and stopwatch are essential to verify actual flow through the unit.

Maintenance

As with all instruments, a particle counter will not provide reliable results if it is poorly maintained. The unit must be regularly cleaned, either by manually inserting a miniature bottle-brush, back flushing the unit or both. Periodic flushing with a cleaning fluid may be necessary in some cases, but it is wise to check with the manufacturer prior to introducing any type of chemical cleaner into the unit.

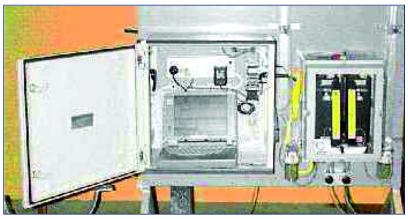

Figure 3. Example of a particle counter with supporting software on laptop computer.

Software and power failures

Sometimes the software programs that accompany the particle-counting instrument can cause difficulties. If power to the computer is interrupted, when power is restored, often the unit will either fail to resume data capture or capture incorrect data as pre-set flow rates and sampling times have been replaced by default settings. It is important to ensure a constant power supply to the unit to avoid these data capture problems. Surge protection of the entire unit is also highly recommended.

Sample line layout and materials

The length and layout of sample tubing, and the type of material used for the sample lines can also contribute to poor results. Where possible, sample tubing should be as short as possible to minimise hydraulic losses, and contain long sweeping bends in preference to 90-degree bends.

The tubing should also be constructed of a material that does not have a tendency for particles to accumulate on internal surfaces, and then fall off the walls without warning. It is wise to use tubing that complies with the manufacturer's recommendation.

Sweeping bends minimise turbulence, which can cause any accumulated particles to fall off the internal walls of the sample tubing. Similarly, horizontal pipework is preferred over vertical pipework, as more even flow dynamics can be attained in horizontal pipework.

Solenoid valves on sample lines should also be avoided where possible, as their sudden action may incite a spurious particle peak due to the 'shedding' of particles that may have accumulated in the line behind the closed valve. The use of incompatible metals in pipework and fittings should also be avoided, as even minute corrosion will be detected as particles.

Record keeping

Manual

A factor vital to event monitoring is the availability of an accurate record of the plant's activities. To interpret the data correctly, knowledge of plant activities and the time that it takes for the sample to travel from its origin to the sensor is vital. You must be able to correlate a 'particle event' detected by the particle counter to an operational activity (such as a backwash) at the plant. You must be able to track filter backwashes for all plant components (not just the filter you are looking at), plant stop times, plant start up times, and any changes in raw water flow or quality. Without this information, collecting particle counts is a waste of time.

Electronic

The ability to trend particle counts in parallel with other plant related information is invaluable. A picture tells a thousand words, and being able to graphically represent plant flow, turbidity, particle count, head loss, filter levels and valve positions all on the one graph is extremely useful. If the particle counter that you choose is likely to be a permanent installation, it is worthwhile checking whether the particle counter has the ability to send out a 4-20mA signal that can be picked up by a SCADA system. It is preferable to be able to trend all relevant plant information on the one system, and the one graph, rather than attempting to 'marry' incompatible software systems.

If correctly located and maintained, particle counters are valuable monitoring tools to assist in the full optimisation of filtration plant performance and ensure that the highest quality water is produced at all times.

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The Author

Michelle Colwell (colwellm@gippswater.com.au) is a Water Treatment Technologist at Gippsland Water. Prior to this she worked as a senior Microbiologist in the Gippsland Water laboratory.