USING PARTICLE COUNTERS TO OPTIMISE WATER TREATMENT PLANTS

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USING PARTICLE COUNTERS TO OPTIMISE WATER TREATMENT PLANT FILTRATION PERFORMANCE

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ABSTRACT

Gippsland Water is using particle counters to monitor and optimise the filtration performance at various water treatment plants. Working closely with the manufacturer of the Heyfield WTP, Gippsland Water used a portable particle counter to monitor the effects of operational changes at the plant. Valve ramping speeds, backwash interval and duration, and plant run times were altered to achieve a significant reduction in filtered water particle counts in the 2-15µm size range. Major changes to the initial plant design have been undertaken in light of particle count results. Particle counters are progressively being used at all Gippsland Water WTPs to optimise final water quality.

1.0 INTRODUCTION

Heyfield is located approximately 200km east of Melbourne. Heyfield draws its water supply from the Thomson River when river water quality is relatively good, and the irrigation channel fed by Lake Glenmaggie, when river water quality deteriorates. In November 1997, the design and construct contract to build the Heyfield WTP was awarded to Water Treatment Solutions P/L, a consortium comprised of Latrobe Valley companies Latrobe Valley Engineering Services (LVES), and Aluminates, and New Zealand based company Works Filter Systems. The plant commenced production in October 1998.

Figure 1 - ***Heyfield Water Treatment Plant***

The Heyfield WTP is a stand alone package plant consisting of two 1.5 ML/d modules (Figure 1). Each module consists of in line chemical dosing, a flocculation tank, adsorption clarifier (primary filter) and a secondary filter. The primary filter allows greater flexibility of operation in the event of varying raw water quality than a conventional clarifier / sedimentation tank. Rainfall events in the Heyfield WTP catchment can lead to rapid deterioration of raw water quality.

Sludge is settled by gravity in a primary sludge tank. The settled sludge is pumped to a secondary sludge tank where polymer is added to promote sludge thickening. The thickened sludge is then trucked off site and disposed of to a sewage treatment facility.

In May 1999, a PMS Liquilaz E-20 particle counter was set up at the Heyfield WTP. The unit was made portable by custom mounting the particle counter and another weatherproof cubicle onto a board. The board was then attached to a frame and connected to detatchable legs possessing all terrain inflatable wheels. The purpose of the particle counter was to monitor existing conditions, and to check to see what effect changes to the plant operation had on particle counts. The aim was to optimise the performance of the filters at the treatment plant in order to minimise the risk of the protozoans *Giardia* and *Cryptosporidium* entering the reticulation.

Figure 2 - ***Portable particle counter***

The concept of using particle counters to monitor and control water treatment plant performance is relatively new. 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 can tell you how many particles are passing through a filter and what size they are. Particle counters are therefore more effective tools for monitoring filtration performance than turbidity meters.

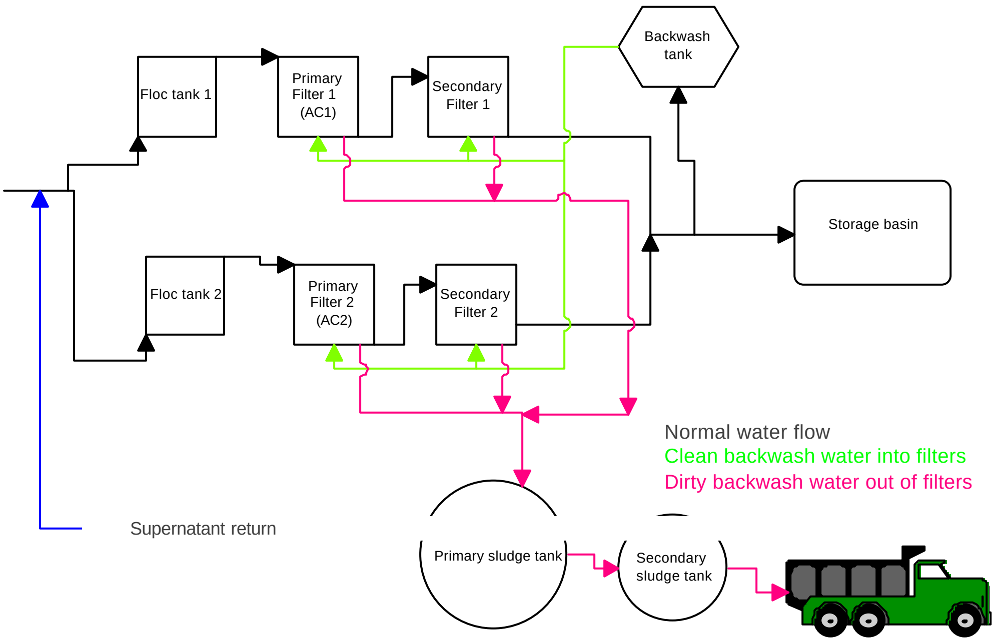
The particle counter at Heyfield was set up to measure the total number of particles in the 2-15µm size range in the filtered water. By measuring this size range, we can count particles the same size as *Cryptosporidium* (4-6µm) and *Giardia* (8-12µm) (Anon 1996).

Murray (1995) states that even during periods of poor raw water quality, 200 particles/ml for 95% of samples is a readily achievable target. With high quality raw water, 20 particles/ml should be able to be achieved. Our aim was to consistently achieve less than 200 particles/ml during normal operation, and approach the 20 particles/ml suggested by Murray. If we achieved this aim, we could be reasonably satisfied that we were doing our very best to minimise the risk of *Giardia* and *Cryptosporidium* entering the reticulation.

2.0 INITIAL CONDITIONS

Below is a schematic representation of the Heyfield WTP as originally constructed.

Figure 3 - ***Schematic of Heyfield WTP as originally constructed***



The raw water is dosed with PFS (polymerised Ferric Sulphate), with typical doses between 20 and 40 ppmv. There is no pre dose pH correction, and the floc tank typically operates at around pH 5.4. Polymer 1115 (a Betz Dearborn product) is added prior to the primary filter at a dose rate of around 0.08ppm. At commissioning, the plant passed its performance requirements based on primary filter run times of 5 hours, and secondary filter run times of 11.7 hours. The primary filters backwashed for 3 minutes, the secondary filters backwashed for 3.5 minutes, and the plant typically ran for approximately six hours at a time, based on the level in the storage basin. Filter design characteristics are shown in Table 1.

Table 1 – ***Filter design characteristics***

	Primary filter		**Secondary filter**	
Nozzles	1.5mm slotted plastic		Porous Ceramic Disc Media (PCDM) tiles	
Gravel	6-3 mm diameter	100 mm depth	6-3 mm diameter	100 mm depth
Sand	None	None	18/40 mesh (1.0-0.7 mm diameter) 30/60 mesh (0.7-0.25 mm diameter)	300 mm depth
Pumice	2.6-1.5 mm diameter	1000 mm depth	2.6-1.5 mm diameter	500 mm depth
Total media depth		1100 mm		900 mm
Filter area	2.4m x 2.4m		2.4m x 2.4m	
Filtration rate	-		18m/h	
Backwash rate	-		20m/h (adjustable to 36m/h)	

3.0 INITIAL PARTICLE COUNTS

Under the operating conditions listed above, the particle counts were as shown in Figure 4. During the trials, the plant operated at a rate of 28L/s, which is typical for the Heyfield WTP.

Figure 4 - ***Heyfield WTP Particle Counts before process modifications.***

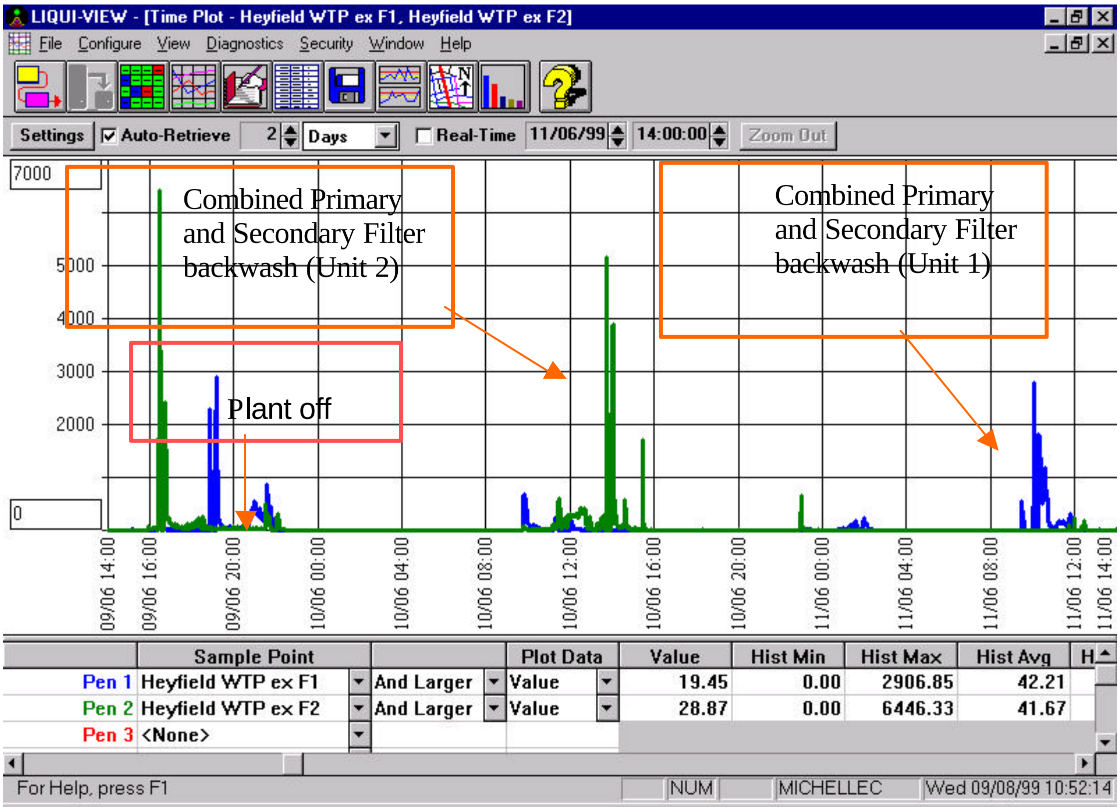


Figure 4 shows a marked deterioration in water quality immediately following a combined primary and secondary filter backwash, with particle counts soaring to as high as 5000 counts/mL from the "normal" operating level of between 30 and 60 counts/mL. These particle spikes also occurred during plant start up. From the graph, it can be seen that Unit 2 experienced particle spikes that were almost twice as high as Unit 1. Visual observation of the top of secondary filter 2 indicated considerable floc carryover from primary filter 2.

4.0 CHANGES MADE

The following changes were made in an attempt to minimise particle spikes.

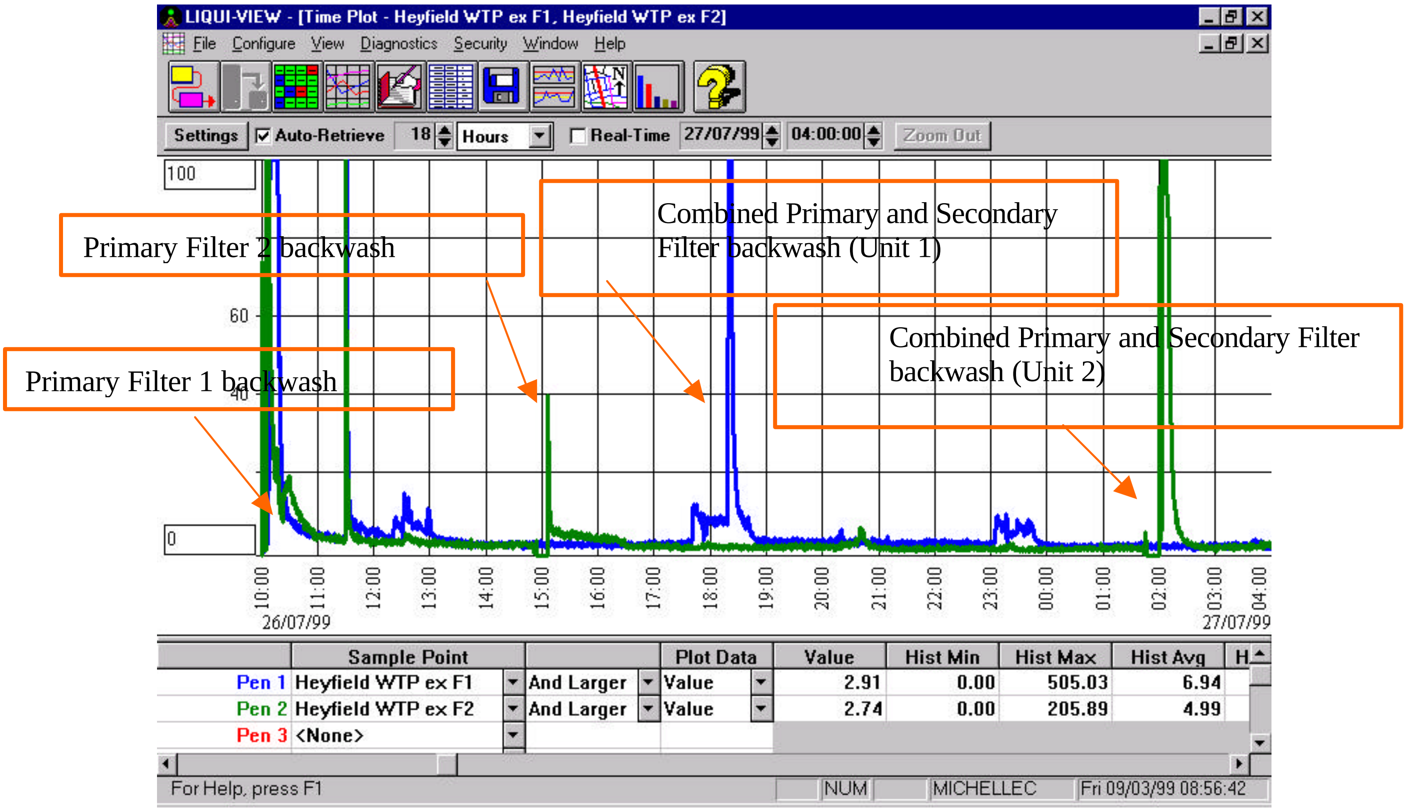
- Reducing the number of plant starts by allowing the basin to drop lower than was previously the case, which in turn allowed the plant to run for longer periods each day,
- Smoothing out rapid changes in flow by slowing down the opening and closing speeds of the filter inlet and outlet valves,
- Increasing the backwash times,
- Decreasing the primary filter run time. This had the effect of reducing the carryover of floc from the primary filter to the secondary filter, which subsequently reduced the load on the secondary filter, and
- Increasing the secondary filter run time.

The optimised primary filter run times were now 4 hours, and the secondary filter run times were now 15 hours. The duration of the primary filter backwash was extended to 4 minutes, and the duration of the secondary filter backwash was extended to 5.5 minutes.

5.0 IMPROVEMENT IN PARTICLE COUNTS

Following the abovementioned changes, a marked reduction in particle counts in the filtered water was noticed. These improvements can be shown in Figure 5.

Figure 5 ***- Heyfield WTP Particle Counts after process modifications (note change in vertical scale from Figure 4.***



Initial filter ripening curves were of extended height and duration (see Figure 4). Filter 1 exhibited counts of greater than 1000 particles/mL for approximately 55 minutes, with the peak count being more than 2500 particles/mL. Filter 2 exhibited counts of greater than 1000 particles/mL for approximately 45 minutes, with a peak count of more than 5000 particles/mL. After making operational changes to the Heyfield WTP, filter ripening periods were significantly improved. Filter 1 exhibited counts greater than100 particles/mL for approximately 4 minutes, with a peak of less than 500 particles/mL after a backwash, and Filter 2 exhibited counts of greater than100 particles/mL for approximately 4 minutes, with the peak being approximately 200 particles/mL following a backwash. When the plant started Filter 1 had counts of more than 100 particles/mL for approximately 8 minutes, with a peak of less than 200 particles/mL, and Filter 2 had counts of more than 100 particles/mL for approximately 2 minutes with the peak count being less than 150 particles/mL. The improvements in particle counts are summarised in Table 2.

Table 2 – ***Summary of improvement in particle counts***

	Before operational changes	After operational changes
Filter Unit 1 Ripening time (mins)	55	4
Filter Unit 2 Ripening time (mins)	45	4
Filter Unit 1 Peak particle count/mL	>2500	<500
Filter Unit 2 Peak particle count/mL	>5000	~200

6.0 FULL PLANT OPTIMISATION NOT ACHIEVED

Although the modifications performed were able to significantly improve the quality of water that the plant produced, full optimisation of the process was unable to be achieved. Constraints included a lack of available water to backwash with, and a lack of available storage volume to accommodate dirty backwash water. Further difficulties were encountered with programming interlocks in the Programmable Logic Controller (PLC).

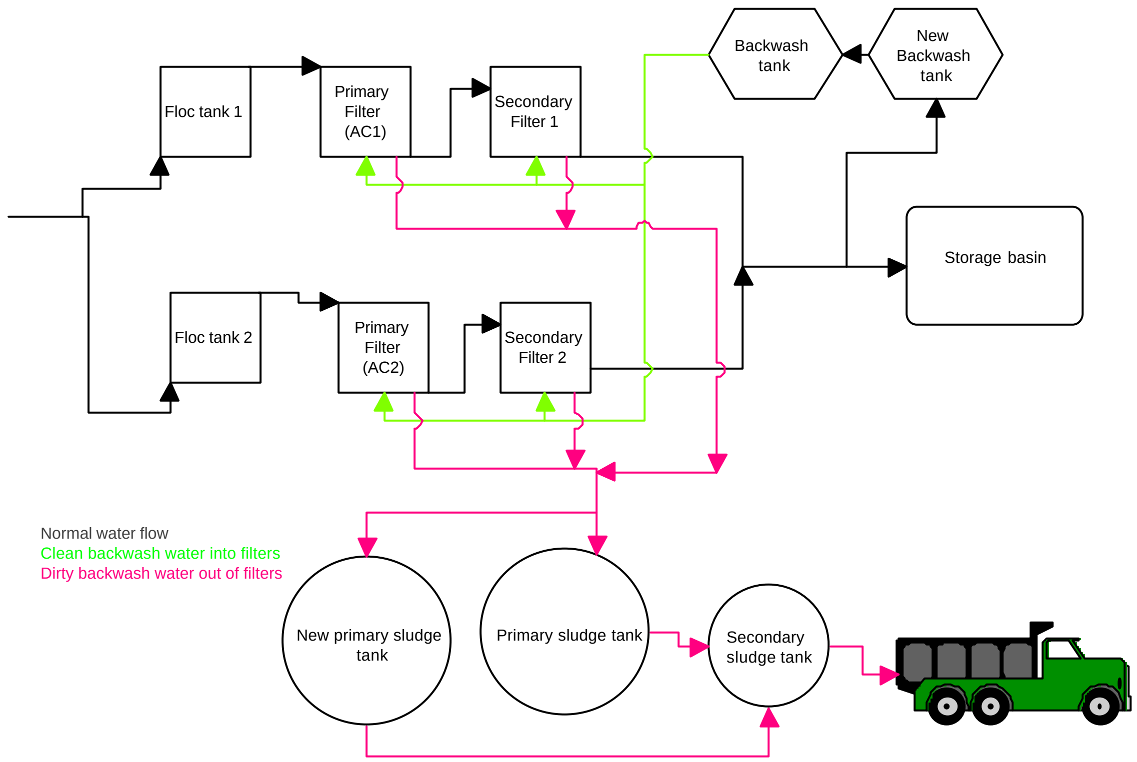
The logic sequence in the PLC was programmed at commissioning to backwash the primary and secondary filters together if the primary filter called for backwash at a point in time that was greater than or equal to 60% of the secondary filter run time. This logic sequence was designed to minimise production down time when a unit was off line due to backwashing and ensured that the primary sludge tank had sufficient capacity to accept the dirty backwash water.

Unfortunately, changes to the backwashing intervals conflicted with the logic sequence, and caused the filters to queue for backwash. This queuing was caused by the inability to return supernatant quickly enough to allow the next washwater volume to enter the primary sludge tank. This resulted in decreased production, and detrimentally affected the condition of the filters, as they were consistently running for longer than their allotted time, but were not being backwashed for longer to compensate for the increased load.

7.0 MAJOR PLANT MODIFICATIONS MADE

The existing plant was modified by adding another backwash tank and primary sludge tank. This increased the backwashing capacity, and the downstream washwater handling capacity. These changes are shown below.

Figure 6 - ***Heyfield WTP schematic after major modifications***



The modifications allow the plant to be backwashed for almost twice as long as was previously possible. The dirty backwash water can be diverted into the primary sludge tank that has the lowest level, and the supernatant return pumps have been upgraded to provide a faster return rate.

Modifications to the PLC have also been made, so that the primary filter backwashes are not linked to the secondary filter backwashes. This increases the flexibility of operation.

8.0 OTHER OPERATIONAL CHANGES

Turbidity meters have been installed on the outlet of each of the primary filters and primary filter backwashes are now triggered when their outlet turbidity exceeds predetermined limits. This operating philosophy allows the primary filters to do the majority of the work at the treatment plant. The secondary filters can then run for longer, as they have a reduced and far more consistent load applied to them. For all intents and purposes, the secondary filter will not be aware of any changes to the raw water quality. This operating philosophy has been successfully implemented at other Gippsland Water WTP's.

9.0 FUTURE DIRECTIONS

To ensure water quality is optimal at all times, particle counters will be progressively introduced at all GW WTP's in order to control backwash frequency. In future, backwashes will be triggered on particle count instead of outlet turbidity. This approach will ensure the best finished water quality for consumers at all times, as particle breakthrough occurs before turbidity breakthrough. It is envisaged that water treatment plants of the future will contain process controlling particle counters as standard items of equipment, rather than as optional extras, as is presently the case.

10.0 CONCLUSION

Particle counters are powerful tools to use when optimising water treatment plant filtration performance. The use of a particle counter at the Heyfield WTP has enabled Gippsland Water to significantly improve the quality of the treated water delivered to Heyfield consumers. The aim to achieve counts in the 2-15µm size range of less than 200 particles/ml 95% of the time was easily met.

11.0 ACKNOWLEDGEMENT

The author wishes to acknowledge the drive and determination of Dr. Peter Mosse of Gippsland Water, without whose insistence this project would not have commenced. The author is also grateful for the assistance of Ron Radford of Transfield for manufacturing the custom built portable particle counting unit.

12.0 REFERENCES

Anon(1996) Australian Drinking Water Guidelines. NHMRC and ARMCANZ. Commonwealth of Australia.

Murray, B. A. (1995). Particle Counting in Water Treatment. *Water*, 22:37-40