DAFF AIR DISPERSION REVAMP

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ABSTRACT

The Shepparton Water Treatment Plant (WTP) can treat up to 114 ML/day. The site consists of four separate treatment plants that have developed with demand augmentation requirements; two of the plants are hopper bottom clarifiers, one mechanical clarifier, direct filtration common plants and a DAF(F) (Dissolved Air Flotation (Filtration) plant.

DAF(F) is a well-established and a popular water treatment process. One of the emerging challenges for DAF(F) treatment plant operators is optimising the DAF process to improve the quality of subnatant water entering the filter and the performance of the DAF(F) when experiencing relatively high turbidity raw water (>60 NTU).

Operators have undertaken a number of process improvements relating to the location and operational control of a streaming current meter; the dosing of coagulants; extensive trial work associated with recycle rates, supernatant return, dispersion control valve configurations and filter control.

There has been a wide variability in the performance of the DAF system. This paper seeks to explain key aspects of work undertaken at the Shepparton WTP to improve the DAF process, in particular improvements relating to producing high quality subnatant water. The paper also details what can be expected from DAF performance and some known problems with DAF systems. The aim here is also to provide some background on levers that may be available to operators of DAF plants to optimise the performance of existing assets using our experience at Shepparton WTP as a guide.

KEYWORDS

DAF(F) Dissolved Air Floatation Filtration
GVW Goulburn Valley Water
WTP Water Treatment Plant
DWQL Drinking Water Quality Limits
NTU Nephelometric Turbidity Units

1.0 INTRODUCTION

Goulburn Valley Water (GVW) manages 39 water treatment plants and 26 wastewater management facilities in Northern Victoria. GVW is broken up into four districts (Northern, Central, South West and South East).

The Shepparton WTP is the largest plant within the GVW district. It consists of four different WTP's capable of producing 114 ML/D. Shepparton WTP's raw water is sourced directly from the Goulburn River and thus is a run of stream system. It can experience frequent fluctuations in raw water quality. Shepparton WTP provides water to four towns; Shepparton, Mooroopna, Tallygaroopna and Toolamba. It also provides water to two major food processing factories, SPC and Campbell Soups.

This paper focuses on the modifications made to Plant 1 to maintain production during poor raw water quality conditions. Plant 1 is a 14 year old (1998) 40 ML/D Dissolved Air Floatation Filtration (DAFF) plant.

With Shepparton's population growing every year, Shepparton WTP needs to be able to supply safe drinking water all year round. In the past few years we have had significant rain and the water quality in the Goulburn River fluctuates anywhere from 20 NTU to 200 NTU and from 50 True Colour to 300 True Colour. These fluctuations have been increasingly more varied following a sustained period of drought. Plant 1 has historically only been capable of treating water up to 50 NTU and 100 True Colour before the filtered water NTU increases to unacceptable levels.

2.0 DISCUSSION

2.1 Plant 1 Design and Operation

The basic design/operation of plant 1 is dosing points for lime, alum and polyelectrolyte are provided on the inlet main. Alum is injected into the raw water inlet pipework and is used as the coagulant, creating floc. Lime is added when required to counteract the excessive acidity in the raw water, to raise the pH for optimum coagulation. Polyelectrolyte is added into the inlet main at the head of the plant prior to the flocculation tanks as coagulation aid.

A splitter box evenly divides the flow to each of the three DAFF trains where it passes through two flocculation tanks. Each flocculation tank compartment is fitted with two vertical shaft "picket fence" style flocculation paddles. These paddles encourage mixing to form larger coagulated particles.

Flow enters the floatation/filtration tank via an underflow baffle where pressurised air saturated recycle water is injected. Depressurisation of the recycle water releases micro-bubbles which attach themselves to the floc and "float" them to the surface, forming a floating layer of sludge. This is drawn off the top by hydraulic decantation by raising the water level of the floatation tank and overflow of the sludge layer into a collection tank for offsite disposal.

Figure 1: ***Plant 1 cell***

The filters are located at the base in the same tank as the floatation process, beneath the floated sludge layer. Settled (floated) water passes through a dual-media (sand and anthracite) filter removing any carryover floc. Filtered water is collected by an array of nozzles in the floor of the filters connected to the plenum under drain system and plenum chamber. Filtered water flows to the filtered water tank for supply to the Air Saturation System or overflows into the Dosing Duct for post treatment (addition of chlorine, fluoride and lime). Treated water then flows into the clear water storages for supply to the town's reticulation systems

2.2 The Issue

The Shepparton Water Treatment operations staff found that during poor raw water quality conditions, plant 1 was unable to treat water to meet the Drinking Water Quality Standards.

GVW appointed a consultant to investigate the issues associated with Plant 1. After going through the report and several meetings and group discussions with GVW operators we all agreed on the main issues that needed to be addressed.

1. Pea size air bubbles were observed rising from the DAF entrance chimney. They were particularly noted to be in a wide scatter around each bullhorn outlet.

2. The distribution of the milky flotation cloud was not ideal in that there were patches of low air bubble concentration (darker patches) across the DAF tank which can lead to uneven floatation.

3. The dispersion bullhorns were noted to be at 500 centres compared to the current standard maximum separation of 250 mm. Note that the outlet velocity at maximum flow and full recycle is likely to be higher than the standard maximum of 0.5 m/s. Redesign of the bullhorns to reduce spacing is recommended.

4. The bullhorns were noted to be discharging hard against the chimney wall which may aid distribution or lead to coalescence on the wall's surface.

5. The saturator operation pressure was reported to be around 600 to 700 kPa. Improved dissolved air dispersion can be expected with increasing air pressure to 700 kPa if achievable, due to increased air solution in the recycle stream.

6. The recycle stream was operating at about 16% recycle rate which is high and should lead to improved operation. However it was noted that the pumps are at the limit of their capacity and may need to be replaced and/ or have their mount improved.

From this we knew we needed to improve the bullhorns

Figure 2: ***Old Bullhorns***

2.3 Trials of Different Outlets, Success & Failures

After working out what needed to be done, now was the time for the managers to find some money. The first course of action was to modify the existing alum dosing point and instrumentation (Streaming Current Detector and pH analyser). Some trial work was carried out and the alum injection point was altered closer to the head of the plant to facilitate better floc formation. The analysers were constructed on a new board, plumbed and electrically altered to facilitate better operation of the instruments and coagulation control in the future.

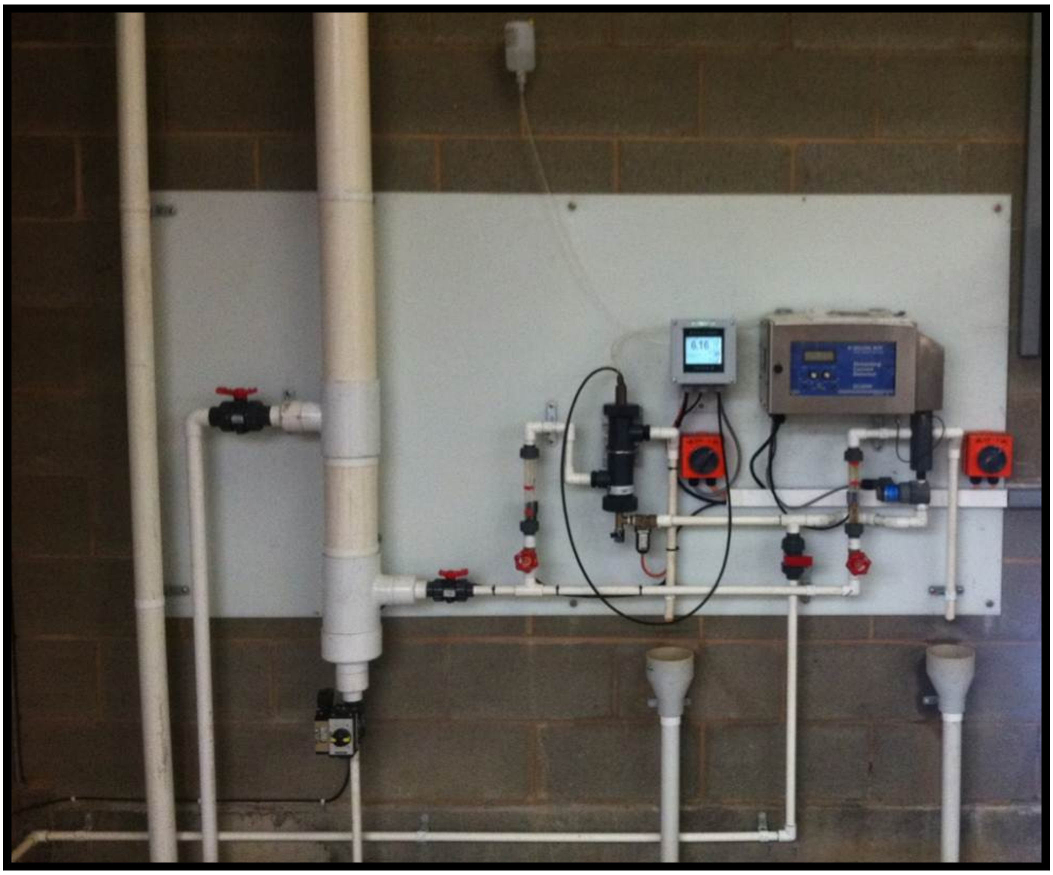

Figure 3: ***The dosed water analysers***

The second phase included improving the DAF dispersion. After talking to a local engineer (JMAR Engineering) we started to trial a few different bullhorns to see which ones would give us the best air dispersion blanket.

Trial 1:

Did not work. Majority of the air saturated water was released through the middle cut and left blank spots at the end of each bullhorn.

Figure 4: ***Trial 1***

Trial 2:

Did not work either. Majority of the air saturated water flowed out in a V shape leaving dead spots in the middle of each bullhorn.

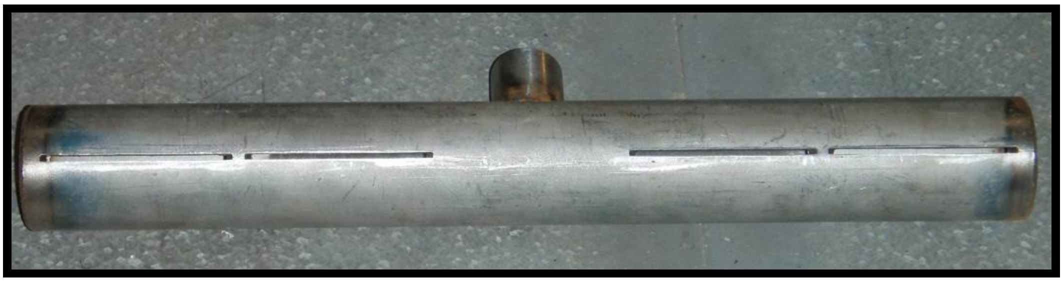

Figure 5: ***Trial 2***

Trial 3:

After the first two trials not meeting our expectations, it was back to the drawing board to look at how we could change the existing bullhorns. With the existing bullhorns, there was 6 across the whole filter where now there is 24 single outlets every 250mm across the width of the air dispersion chamber. With this design we are able to get an even curtain of milky air dispersion.

Figure 6: **New Air Dispersions**

The globe valves were down sized from 1 inch to ¾ inch to allow the operators to have more control with air dispersion and minimise the pea size bubbles. The train was extended to cover the full width of the chamber.

3.0 CONCLUSION

As the plant 1 air dispersion project is still ongoing, we are yet to draw any solid conclusions on the success of the project as we haven't experienced any major dirty raw water events. However, we have discovered that in changing the bullhorns and downsizing the globe valves we were able to improve the distribution of the milky flotation cloud.

By adding an extra 18 bullhorn outlets, we are now getting a nice curtain of milky air dispersion across the whole filter. In the past streaks of water without saturated air were visible. Downsizing the globe valves has allowed the operator to be able to fine turn the amount of air saturated water and bubble size released out off each bullhorns. The modifications on reasonable raw water turbidity (20 – 40 NTU) has seen floated NTU drop to below 1.5 and filtered water to less than 0.1 on a more consistent basis.

Figure 7: ***Milky Float***

Future modifications and improvements that are under consideration for Plant 1 include individual air saturators for each filter train, upsize pump sets to increase recycle rate capability, trial coagulation aids including dosing locations and improve the cutting sprays.

4.0 ACKNOWLEDGEMENTS

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