FILTER REFURBISHMENT AT PYRAMID HILL WATER TREATMENT PLANT

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ABSTRACT

Filter media and the filter underdrain system at the Pyramid Hill Water Treatment Plant (WTP) were refurbished following a sudden increase in filtered water turbidity, which resulted in deterioration of treated water quality and output.

A new charge of media comprising 400 mm filter coal and 300 mm sand was installed to replace the original mono-media as well as new air scour laterals and pipework with nozzles to replace the original pipe-lateral arrangement. Results indicate that substantial increase of filter throughput and filter run time and decreased filtered water turbidity have been achieved. The marked improvement has demonstrated how conversion of filters from mono- to dual-media configuration can dramatically improve overall WTP performance.

1.0 INTRODUCTION

Pyramid Hill WTP was constructed in 1996 and has a nominal capacity of 20 L/s. Raw water is transferred to the treatment plant from Pyramid Hill Basin which is in turn fed from the nearby Pyramid Hill No.1 Channel (part of the Waranga Western Channel Supply System). Charging of the channel and basin is a manual operation and is carried out at scheduled times of the year.

The raw water is treated via a conventional treatment process, comprising coagulation, clarification and filtration.

Raw water from basin is initially dosed in-line with alum coagulant and soda ash for pre-treatment pH correction and alkalinity adjustment before it is pumped to the inlet of the WTP via a Vacuum Chamber. The chamber provides mixing and contact time for the coagulant to develop floc particles. The flocculated raw water is then directed to the bottom of a Clarifier which operates as a sludge-blanket unit. Particles not trapped by the sludge-blanket agglomerate within inclined tube settlers provided to the surface of the Clarifier and settle out into the sludge-blanket at the bottom. Clarified water overflows to two filters and is then 'polished' by rapid gravity sand filtration for removal of any floc that may be still present. The filtered water is finally dosed with soda ash for post-treatment pH adjustment as well as chlorine for disinfection, and then flows by gravity to a Clearwater Storage Tank.

1.1 Original Filters Arrangement

Each filter is an open, split-bed type comprising sand mono-media supported on a gravel support layer, with a pipe-lateral underdrain and separate air scour arrangement. The original filters arrangement and details are shown in Table 1. The filters were designed to provide filtered throughput of 20 L/s and filtered water turbidity of less than 1 NTU.

1.2 Decrease of Filter Performance

The treatment plant has had a history of low filter run times since construction. Problems of low filter run time owing to high head loss accumulation rate has attributed to excessive backwash volume and decreased treated water production. The filters are designed to be backwashed either automatically or manually, and if automatically, by filter head loss (high water level in the filter compartment) or filter run time (adjustable at the SCADA system operator interface).

Premature turbidity breakthrough also routinely contributed to short filter run times. Sustained poor filtered water quality (excessive turbidity) has also been noted, especially after recharging of the Pyramid Hill Basin from the Waranga Western Channel. The turbidity of filtered water from each filter and the combined filtered water leaving the Upstand is monitored continuously via a common turbidimeter. An alert alarm is raised through the SCADA system if the filtered water turbidity from any of the three sources monitored is greater than 0.5 NTU for 15 minutes. Whereas a critical alarm is raised if the turbidity exceeds 0.8 NTU for more than 4 hours or turbidity exceeds 1 NTU at any time during operation. In these cases, the WTP will be shut down and immediate attention is required from the Operator.

Table 1: ***Original filters arrangement and details***

Parameter	Value or Description
No. of Filters	2
Filter Bed	1.5 m x 3.0 m (each)
Filter Area	9.0 m^2 (total)
Filter Loading Rate	8.0 m/h
Filter Throughput	20 L/s (design value)
Backwash Flow	39 L/s
Backwash Rate	31 m/h
Air Scour Blower Duty	130 m^3/hr
Air Scour Rate	29 m/h
Media	top to bottom: - 900 mm silica sand: ES 0.9 mm and uniformity coefficient (UC) < 1.4 - 80 mm silica coarse sand: ES 1-3 mm
Media Support	300 mm gravel (5-15 mm)
Underdrain System	Pipe-lateral underdrain with separate air scour pipework and laterals

1.3 Filter Refurbishment

In September 2007 after recharge of the Pyramid Hill Basin from the Waranga Western Channel, performance of the WTP quickly deteriorated. Filtered water turbidity exceeded 4 NTU and filter run time decreased to less than 4 hours. The raw water pumped from the channel was noted to contain a significant amount of finely- divided colloidal material, including high numbers of diatoms. This change in raw water quality contributed to the sudden decrease in WTP performance.

Remedial actions were carried out to address the problem including adjustment of the chemical dosing regime. These remedial actions failed to improve plant performance.

Media assessment was carried out and the results showed that the depth of sand in each of the filters has decreased from 900 mm to 300 mm, indicating gross media loss since plant start-up in 1996. Gravel was also discovered in the sand layer, suggesting backwash and air scour procedures had disturbed the underdrain and encouraged migration of gravel to the sand layer.

The current situation could not be tolerated and so a decision was immediately made by Coliban Water to rehabilitate the two filters. Coliban Water, with advice from SMEC, concluded that the filters could be rebuilt by converting from mono- to dual-media configuration including reconstruction of the underdrain system.

Laurie Curran Water was engaged to undertake the refurbishment works, which included the design, supply and installation of dual-media and new underdrain system to the two filters.

A new charge of dual-media comprising filter coal (400 mm x ES 0.9 mm) and sand (300 mm x ES 0.8 mm) was installed to replace the sand media. New air scour laterals and pipework with nozzles were installed to replace the pipe-lateral arrangement and air scour laterals. The height of the backwash troughs as well as the dividing wall between the two filters was also raised by the installation of 'hungry boards' (6 mm uPVC sheet) in order to accommodate bed expansion during backwash and to prevent media washout.

The work proceeded over a two week period in November 2007, refurbishing one filter at a time in order to maintain supply to the township during a period of prolonged hot weather. The work was scheduled according to the following plan:

a. Ensure sufficient storage in the Clearwater Storage Tank
b. Shutdown the WTP and drain the filters
c. Remove media and underdrain system from one filter
d. Commence installation of new underdrain system
e. Lay graded gravel beneath the underdrain arrangement as a support medium
f. Commence installation of air scour laterals and connect air laterals from air scour header pipe to the nozzle pipes
g. Install 'hungry boards' to backwash troughs and centre wall between the two filters to raise height
h. Lay remaining gravel as appropriate in order to give sufficient support
i. Load sand
j. Load filter coal
k. Backwash the filter and return it into operation
l. Repeat above steps to refurbish the second filter

The works were conducted over a two week period as the extent of progress each day was dependent on water consumption. If the level in the Clearwater Tank falls below the required minimum, work was suspended to allow the WTP to return to production and top-up the tank.

Figure 1 shows the installation of the underdrain system with filter nozzles.

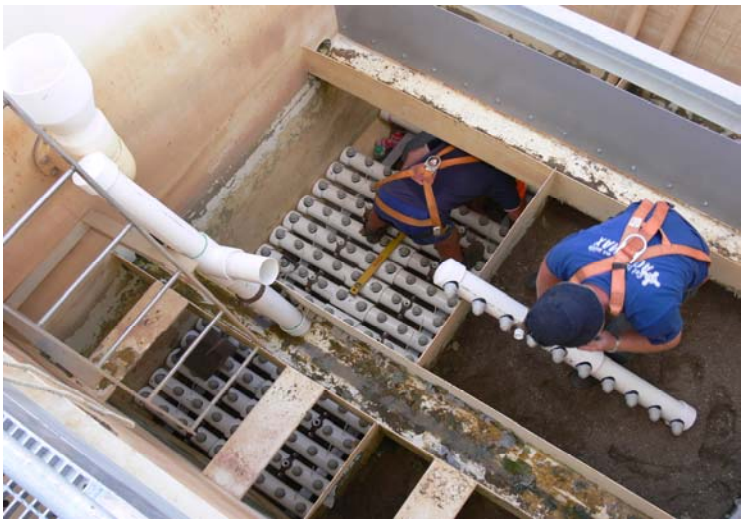

Figure 1: ***Installation of 'hungry boards' to backwash troughs and 100 NB uPVC Class PN 18 nozzle pipes to the underdrain system***

1.4 Results

Excellent results have been achieved following the upgrade works: filter throughput in excess of 15 L/s with filter run times of 15 hours and filtered water turbidity of 0.13 NTU. This is a marked improvement over the pre-upgrade flow of 10 L/s, filter run time of 4-6 hours and turbidity in excess of 4 NTU.

Table 2 summaries the comparison of filters performance before and after the upgrade work.

Table 2: ***Filters performance and details before and after the upgrade work***

Parameter	Value or Description	
	Before	**After**
Filter Throughput	10 L/s	>15 L/s
Filter Run Time	4 – 5 hours	15 hours
Filtered Water Turbidity	4 NTU	0.13 NTU
Media (top to bottom)	- 900 mm silica sand (ES 0.9 mm, UC < 1.4) - 80 mm silica coarse sand (ES 1-3 mm)	- 400 mm filter coal (ES 0.9 mm, UC < 1.4) - 300 mm sand (ES 0.8 mm, UC < 1.4)
Media Support	300 mm gravel (5-15 mm)	600 mm gravel
Underdrain System	Pipe-lateral underdrain and separate air scour arrangement	Combined air scour laterals and pipework with nozzles

The overall cost to refurbish the filters was approximately $60,000.

Figures 2 and 3 are a plan and section view of the upgraded filters, showing the general arrangement of the new underdrain system.

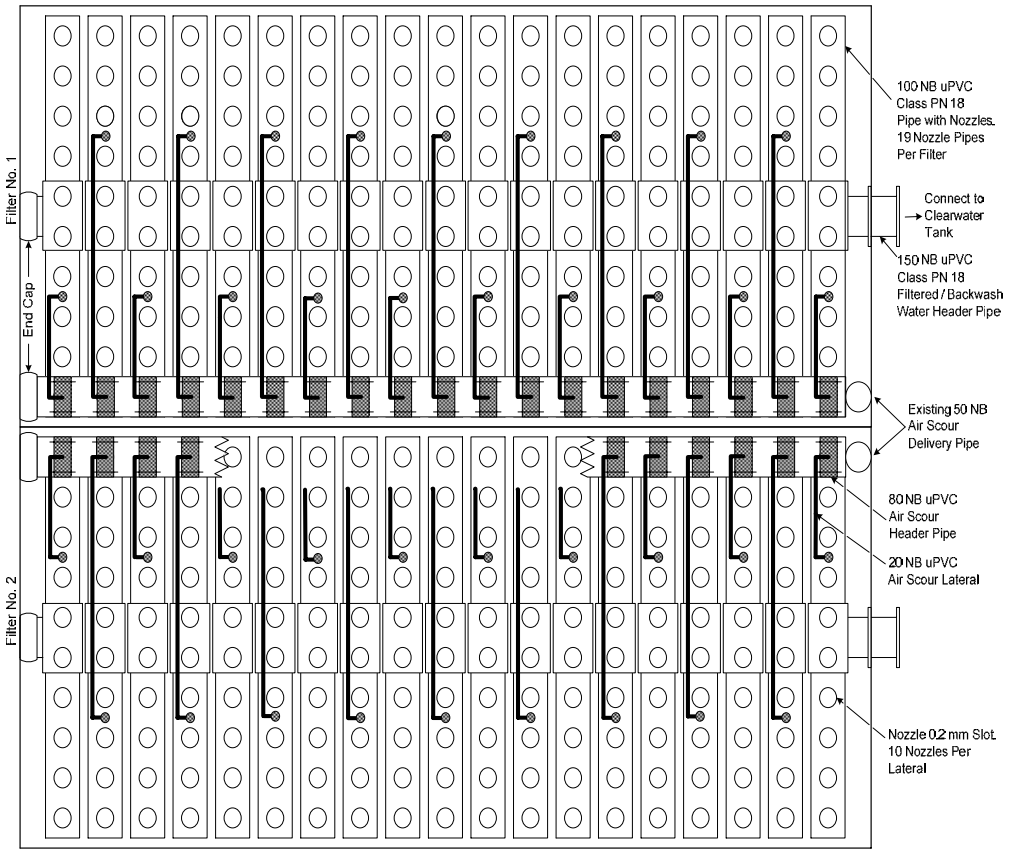

Figure 2: ***Filter plan***

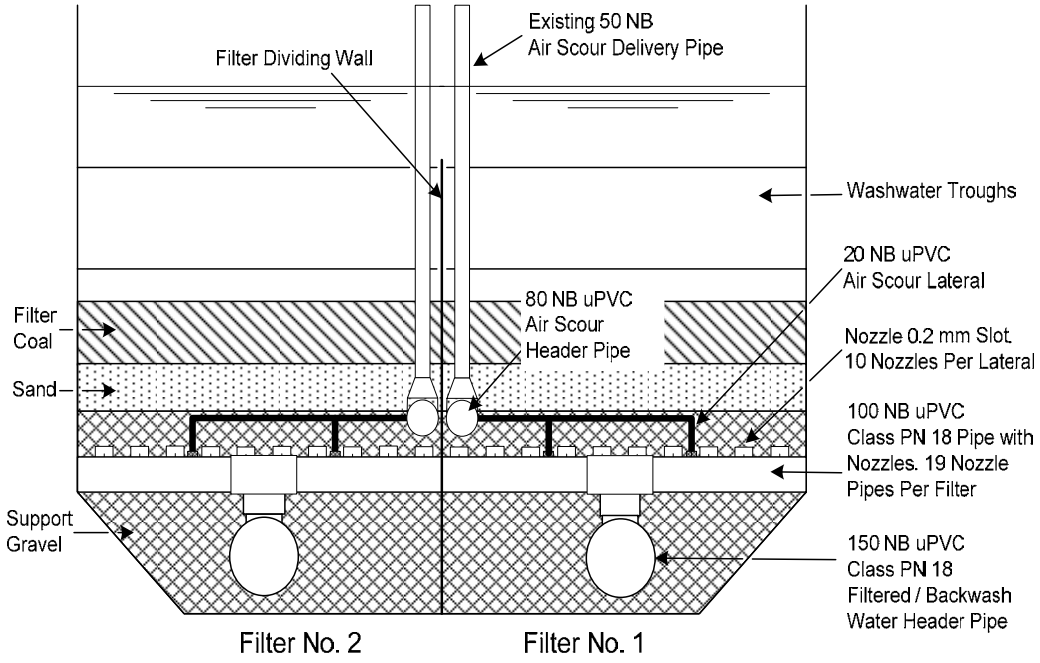

Figure 3: ***Filter section***

2.0 DISCUSSION

The filters are currently backwashed at 39 L/s which correspond to a backwash rate of 31 m/h. This performance was achieved with the backwash pump discharge valve partially closed. With the valve fully open, the backwash pump will deliver ~45 L/s and backwash rate increases to 36 m/h. This is approaching the minimum rate of 40 m/h that is usually recommended for effective backwashing of dual-media filters.

The depth of filter coal that was proposed to be installed initially was 600 mm in lieu of 400 mm. The full depth of filter coal was not placed due to concern of filter coal carry over during backwash. The full depth will be put in place when a new air scour blower and backwash pumps are installed as part of additional proposed upgrade works at the Pyramid Hill WTP.

The new underdrain design with nozzles provides better distribution of air over the entire surface of filters during air scour, therefore, preventing loss of media into the filtered water as well as providing better separation of each layer.

It was recommended to perform media assessment regularly in order to notice any media loss and to monitor media separation. If sand and coal are mixed together, then the filters are not backwashing at a sufficiently high rate to attain fluidisation and separation of the two layers. If required, the backwash pump discharge valve shall be opened to increase the backwash rate. A sample core of the media has been taken after the upgrade works and inspection showed good separation of each media layer after air scour and water backwash at 31 m/h.

3.0 CONCLUSION

Refurbishment of the filters at the Pyramid Hill WTP has delivered successful outcomes, resulting in achievement of acceptable filtered water turbidity, with excellent filter run times. This project demonstrates the benefits of implementing dual-media as opposed to mono-media filtration.

3.1 Further Work

Coliban Water proposes to introduce a 'Filter Media and Conditioning Monitoring Program' in order to monitor media separation and lose more closely. A similar program will also be introduced at three other WTPs after completion of additional planned refurbishment works.

These results have raised the suggestion for future possible conversion from mono- to dual-media across the other plants. The condition and performance of those WTPs which currently have mono-media installed will be first assessed prior to any consideration of conversion.

4.0 ACKNOWLEDGEMENTS

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