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OPERATION OF AN STP FOR RECYCLED WATER PRODUCTION PLANT

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ABSTRACT

Rouse Hill Recycled Water Plant (RWP) has been producing recycled water for the largest residential re-use scheme in Australia since September 2001. During the evolution of the recycled water process train, the plant production team has learnt a lot about how to reliably operate a sewage treatment plant in order to achieve quality feed water to the recycled water disinfection process units. Chemical use, trade waste inflow, aeration patterns, storm flow, oxidants, drought and power failures all have significant impacts of the reliable production of recycled water. This paper details how Rouse Hill RWP has evolved over the past 5 years and the special requirements of an STP that is specifically designed for large scale recycled water production.

KEYWORDS
Rouse Hill, Recycled Water, Dual Reticulation, Public Health, Continuous Micro-filtration, UV Irradiation and Super-chlorination

1.0 INTRODUCTION

Rouse Hill RWP is located in Sydney's North West Sector, one of the fastest developing areas in Australia. Wastewater generated from the development area could not be effectively treated and discharged due to the sensitive local waterways. The load on these waterways had to be kept to a minimum. The preferred option was to send part of the treated effluent back to the residents for outdoor use (irrigation, car washing etc) and toilet flushing, removing the nutrient load from the environment. During the current drought, as potable water supplies diminish, the scheme has also taken on a second role, directly reducing the amount of potable water used in the catchment.

2.0 DISCUSSION

2.1 The Development of Rouse Hill RWP

Rouse Hill RWP was commissioned in 1994 with around 500 **kL/d** of flow received, mainly from the Kellyville area where an existing STP was decommissioned and flows pumped to the new Rouse Hill plant. The recycled water supply was initially commissioned using potable water as there was not enough wastewater entering the STP to warrant building the additional recycled water process units. During the late 1990's, urban development began to rapidly increase within the development area and correspondingly, the inflow to Rouse Hill RWP increased from 1 **ML/d** to 8 **ML/d**.

In 2001, the recycled water process units were commissioned and houses were supplied recycled water for the first time. The recycled water process at that stage consisted of advanced tertiary treatment plus Ozonation, Continuous Micro-filtration and Super-chlorination. From 2001 until 2003, supply of recycled water from Rouse Hill was intermittent. Most of the downtime was associated with the ozonation facility. Since the plant relied on ozonation for inactivation of Cryptosporidium, the system was designed such that any failures of the ozonation facility would automatically shutdown the production of recycled water.

When Rouse Hill RWP was designed, it was the first large scale residential reuse scheme in Australia. To ensure community acceptance and to protect public health, Sydney Water has established a multi-barrier approach to recycled water treatment. The inclusion of ozonation and continuous micro-filtration were above the minimum requirements set by the Department of Health. With the continued problems with the ozone generator, it was decided to seek approval from the Department of Health to decommission the ozone disinfection process at Rouse Hill. A 30 day proving period was conducted in September 2003 to test the quality of the Recycled Water without the ozone process unit. The recycled water quality from Rouse Hill RWP continued to meet the NSW Guidelines for Urban and Residential Use of Reclaimed Water (Anderson 1993).

With growth continuing in the development area and the demand for recycled water exceeding supply on some days during the summer months, the recycled water treatment processes required amplification. Rather than installing more CMF modules, Sydney Water decided to install a medium pressure UV Reactor to run in parallel with the CMF. Another proving period was required by the Department of Health and Sydney Water also commissioned further 'challenge testing' through the UNSW Centre for Water and Waste Technology. The results of the proving period and the challenge tests showed that the reactor achieved greater than 3 log reduction for Cryptosporidium and E. coli (Davies and Ashbolt, 2006)

2.2 Sewage Treatment Processes

The sewage treatment process has been designed to produce low nutrient effluent while reducing the amount of chemicals added during treatment. Biological nutrient removal takes place in two reactors that have anaerobic, anoxic and aerobic zones as well as raw sludge fermenters and RAS de-nitrification tanks. The effluent quality leaving the secondary process is very high with virtually no ammonia, a nitrate concentration of 5 **mg/L** and an ortho-phosphate concentration of 0.5 **mg/L** using a combination of biological and chemical (alum) removal techniques.

After secondary clarification, more alum is added prior to tertiary flocculation, clarification and filtration to remove the remaining phosphate and suspended solids. Polymer is used to condition the feed water to the deep bed filters. Effluent leaving the deep bed filters is pumped to the recycled water plant for further treatment. During peak flow and at times of low recycled water demand (wet weather, winter) some effluent is disinfected and discharged to the local waterway via a series of constructed wetlands.

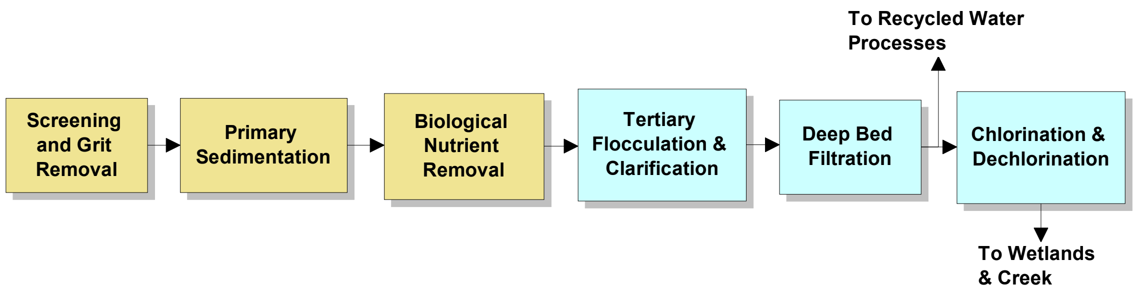

__Figure 1:__ ***Sewage Treatment Process – Liquid Treatment Train***

2.3 Recycled Water Treatment

Recycled Water can be produced using a 5 **ML/d** continuous micro-filtration (CMF) facility and/or a 10 **ML/d** medium pressure UV Reactor. The CMF uses 0.2 **μm** membranes to physically remove microbial contaminants whereas the UV Reactor used UV light to inactivate organisms such as Cryptosporidium, preventing them from causing infection. The CMF/UV treated water is disinfected further through super-chlorination at 6 – 7 **mg/L** for between 80 and 140 minutes prior to storage and transfer to the three elevated recycled water storages throughout the catchment.

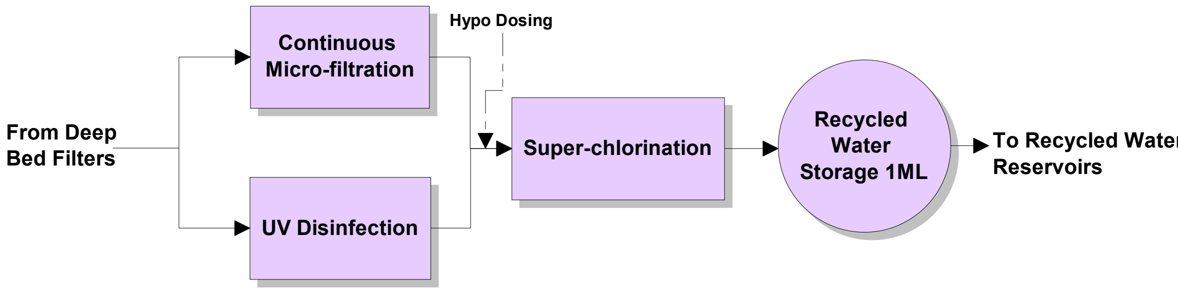

Figure 2: ***Recycled Water Treatment Process Train***

Recycled water production at Rouse Hill is more than just adding on additional treatment units. There are many special considerations that need to be addressed and incorporated into the operation of the sewage treatment system.

2.4 Plumbing Controls and Inspections

Ensuring that the recycled water supply does not contaminate the drinking water supply is a fundamental challenge in a dual reticulation system. Every effort has been made to clearly identify the recycled water pipelines and fittings. Houses in the area must be inspected and tested several times to ensure that recycled water is only used in toilets and special outdoor taps.

Even with rigorous testing, inspections and training of tradesmen and homeowners there have been several occasions where cross-connections of the two water supplies have occurred. It is very difficult to totally mitigate this risk with over 30,000 properties in the development are and hundreds of houses under construction at any time. Sydney Water uses a multiple barrier approach to recycled water production to ensure that its recycled water product also meets drinking water quality guidelines.

2.5 Quality Sewage Feed

Sewage treatment plants can accept a wide variety of waste products from household sewage to industrial trade waste. Most sewage treatment plants are not able to treat industrial waste affectively and this could lead to contamination of the recycled water supply. Fortunately, the Rouse Hill catchment is predominately residential, which greatly reduces the risk of industrial waste entering the treatment plant.

Although the risk is low, the production team at Rouse Hill have developed an automatic response to this kind of trade waste entry by monitoring its effects on the biological process.

If a large quantity of industrial waste entered the treatment plant it would normally cause some or all of the biomass to die. Without the biomass consuming dissolved oxygen (DO), the residual DO will increase sharply during the start of an aeration cycle.

Some trade waste entries may contain an unusually high BOD load that will overwhelm the biological process. Under this condition, the residual DO concentration will remain very low even during extended aeration of the biomass.

Under these scenarios, feed to the recycled water plant is automatically isolated and a member of the production team is notified immediately to investigate the incident. Recycled Water production will not commence until it is confirmed that the sewage treatment processes have returned to normal operation.

Normal variation in plant load can sometimes cause fluctuations in dissolved oxygen concentrations in the biological reactors. At low flow, over-aeration can lead to rapid increases in DO concentration and during high flow/load conditions, the DO concentration can be suppressed for extended periods. Careful management and optimisation of the intermittent aeration system has ensured that false alarms do not occur that would reduce the production of recycled water unnecessarily.

2.6 Management of Incoming Flows

Most sewage treatment plants receive a diurnal pattern of inflow where a distinct morning and evening peak are noticed. During the early morning (1am until 7am) there is often very little sewage entering the treatment plant. At Rouse Hill RWP we have managed to reduce the diurnal aspect of the inflow to reduce the size of the morning peak flow and maintain higher flows to the plant in the early morning.

Through careful control of the inlet pumping stations that supply sewage to the plant, the capacity of the pumping stations has been used to store sewage during the day and pump it into the plant in the early morning. This method has been useful in increasing recycled water production, but as development increases, storage volumes at the pumping stations diminish along with their effectiveness to balance flows. The risks of overflows from the pumping stations also increase during power failures, as the wet well may be already full.

The ideal solution for recycled water plants is onsite storage of secondary or tertiary treated effluent that can be filled during peak flows and then used to maintain feed to the recycled water processes overnight.

2.7 Chemical Overdose Incidents

While Rouse Hill has been designed to operate with only minor chemical addition, it is possible that a chemical overdose incident could occur that would impact on recycled water quality. Alum and Sodium Hydroxide (Caustic) are added during treatment and an overdose of either chemical would cause a decrease or increase in the pH of the tertiary effluent.

The pH is monitored in four locations throughout the treatment process including the chamber where the feed to the recycled water processes is withdrawn. If the pH is outside the acceptable range (6.5 – 8.0) then the supply to the recycled water plant is isolated and the production team is immediately notified. Recycled water production will not resume until the pH of the feed water is returned to the acceptable range.

This protection is in addition to the standard Sydney Water chemical dosing design that uses pressure sustaining valves, motorised ball valves and High / Low flow alarms to detect and prevent overdose or underdose of chemicals.

2.8 Out of Specification Recycled Water

Due to process upsets or equipment failures, there are times when recycled water should not be produced. Rouse Hill has a number of process interlocks that isolate the feed water to the recycled water processes and call out a member of the production team to investigate.

The performance of the biological reactors is continually monitored using Dissolved Oxygen (DO) probes that can indicate if there is a problem within the reactor. Very high DO measurements suggest that the biomass may have been killed due to toxic inflows and very low DO measurements can indicate that the biological reactors are not able to fully treat the incoming flow. During these instances, the production of recycled water is suspended. If deep bed filtered effluent has a high turbidity (>0.5 **NTU**) or high/low pH will not be pumped to the recycled water processes and will be directed to the effluent discharge.

2.9 Ammonia Breakthrough from the Biological Reactors

Most sewage treatment plants have some breakthrough of Ammonia during the peak loading of the biological process. This is especially true of treatment plants that maintain low residual DO and are optimised for Total Nitrogen reduction. This ammonia breakthrough can significantly impact the chlorination of recycled water and cause the product to be diverted to the plant discharge due to low free chlorine residual.

When the feed water to the super-chlorination process contains high ammonia (> 0.5mg/L), the addition of chlorine reacts with the ammonia to form chloramines. The free chlorine residual cannot be maintained even with increased chlorine dosing. This water must be diverted from the RW storage tank as the NSW Recycled Water Guidelines state that a free chlorine residual of at least 5 mg/L must be maintained for 30 minutes.

The Rouse Hill Production Team has established a creative aeration control system that automatically adjusts the intermittent aeration cycles and mixed liquor recycle (MLR) ratios based on timers and DO concentration. During low flow periods, aeration cycles automatically shorten to allow more anoxic time and more de-nitrification. When the load on the biological reactors is high, the aeration time is lengthened and aerator speeds are increased to provide full nitrification. The MLR ratio is automatically adjusted based on the DO in the aeration zone. The ratio increases when the DO is low to maximise nitrate return to the anoxic zone and when the DO is higher the MLR ratio is reduced to prevent the return of oxygen to the anoxic zones. This allows complete conversion of ammonia and also manages the biological treatment to achieve optimal reduction of Total Nitrogen.

3.0 CONCLUSION

While there is an increasing trend to recycle or reuse treated wastewater, there are many special considerations that must be addressed to ensure that risks to public health are minimised. This is especially true for dual reticulation schemes like the Rouse Hill development.

Improper use of recycled water can still occur even with comprehensive plumbing inspections and education campaigns within the plumbing industry and for the general public.

The Rouse Hill Production Team has tailored the treatment of wastewater to ensure that its recycled water product meets both the NSW recycled water guidelines and the national drinking water quality guidelines.

The team has also developed several automatic responses to conditions that threaten recycled water quality and protects the recycled water supply through isolation, diversion and 24hr notification to the production team. Recycled water production is much more that adding some additional disinfection processes onto an existing sewage treatment plant.

The adoption of a multiple barrier approach has ensured that many layers of protection exist both within the catchment and at the treatment plant to protect public health and ensure that acceptance of recycled water remains high throughout the community.

4.0 ACKNOWLEDGEMENTS

I would like to acknowledge the ongoing support and commitment of the Rouse Hill Production Team who professionally manage the production of recycled water during times of great change at the treatment plant.

5.0 REFERENCES

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