World Health Organisation. *A Guide to the Development of on-site Sanitation* (1992)

CHALLENGES IN BIOLOGICAL NUTRIENT REMOVAL AT THE BALLARAT SOUTH WWTP

Paper Presented by:

Andrew Harris

Authors:

Fawzi Saldin, *Process Engineer,*
Andrew Harris, *Coordinator Wastewater & Reuse,*
Greg Plier, *Supervisor Wastewater Treatment*

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CHALLENGES IN BIOLOGICAL NUTRIENT REMOVAL AT THE BALLARAT SOUTH WWTP

Fawzi Saldin, *Process Engineer,* Central Highlands Water
Andrew Harris, *Cordinator Wastewater & Reuse,* Central Highlands Water
Greg Plier, *Supervisor Wastewatere Treatment,* Central Highlands Water

ABSTRACT

Constructed in 1926 as the first step towards modernising the sewage disposal system, the Ballarat South Waste Water Treatment Plant (BSWWTP) has been periodically augmented to cope with urban growth and development. Demand management and continued search for process improvement has triggered the need for major upgrades. These pose challenges to operational practice as new works are undertaken while effluent standards are not compromised.

The plant effluent is discharged to the Yarrowee River and is licensed to meet strict Environmental Protection Agency (EPA) regulations. Regular monitoring and reporting through National Association Testing Authorities (NATA) accredited laboratory's confirms performance against operations. Lagoon based disinfection ensures pathogen reduction is achieved. More recent improvements across the primary secondary processes and sludge handling components combine the new and the old generating an exciting chapter in the history of waste water treatment at Central Highlands Water (CHW).

1.0 INTRODUCTION

The Ballarat South system contains 37 sewer pump stations and a network of over 700 km sewer pipe lines that deliver to the BSWWTP. Additionally tankered sewage is received at site.

Average flows for 2013-2015 and the pollutant concentrations are presented graphically in Figure 1 and 2. During wet weather, raw influent gets diluted due to groundwater ingress and infiltration. During drier months the concentrations of the raw wastewater pollutants increase but the flow rate decreases.
Wastewater is treated to meet EPA regulatory standards for discharge to the environment, the treated effluent flows through a cascade of lagoons and into the Yarrowee River .

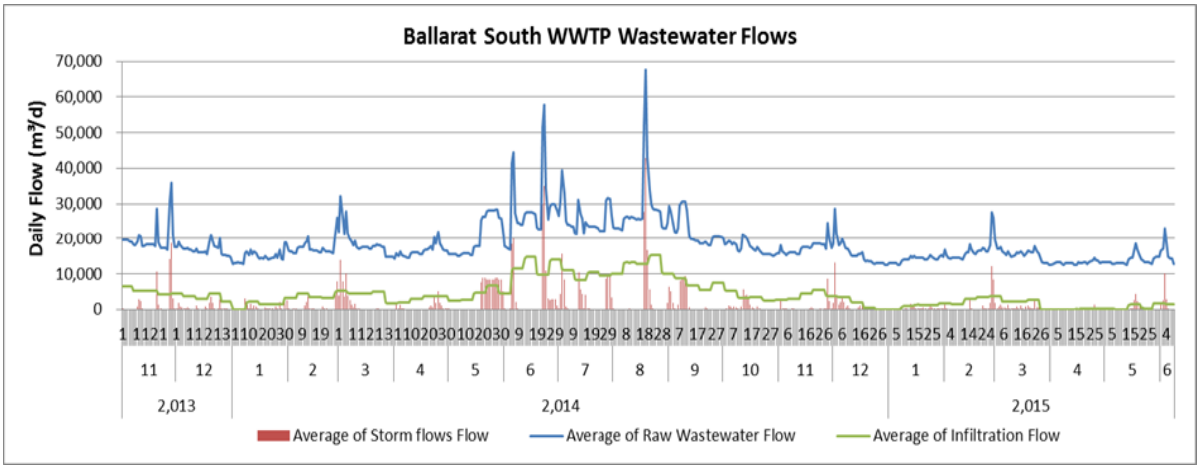
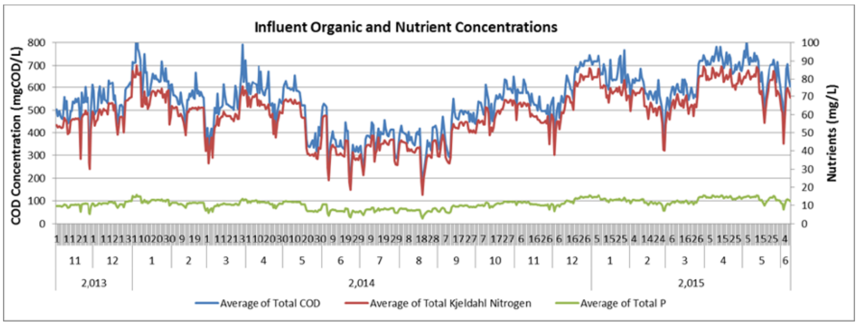


Figure 1: ***Influent Flows***



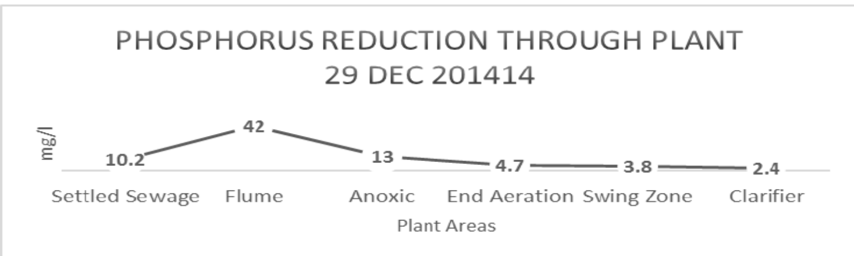
<u>Figure 2:</u> ***Pollutent Concentrations***

2.0 Plant Description

The plant comprises of coarse and fine screens, vortex grit remover, primary sedimentation tanks, pre-denitrification tanks, anaerobic tanks, anoxic tanks, aeration tanks and secondary clarifiers. The bio-reactor that runs in series to provide anoxic, aerobic zones and suitabaly operated to optimise nutrient removal. Return Activitated Sludge (RAS) from the secondary clarifiers is returned to the pre-denitrification tanks.

The primary clarified effluent (PCE) is directed into the anerobic tanks along with the RAS from the pre-denitrification tank. The volatile fatty acids (VFAs) produced in the prefermentor gets pumped to the head of the anaerobic tank. The hetrotrophic phophorous (P) accumulating organisms (PAOs) in the biomass absorb the VFAs as its food source and in the absence of oxygen releases phosphorus. Typical plant data is indicative of P release of 20 to 30 mg/l.

The flow continues through the anoxic tanks and is mixed with the A-Recycle over flowing a weir at the end of the swing zone. Weir control at the swing zone of the bioreactor allows a regulated quantity of activated biomass to flow into the anoxic zone which mixes with the flow from the anaerobic tanks. Denitrification occures and passes from the anoxic tank to the aeration tanks where nitrification occures and the P is abrorbed and synthesised by the PAOs in the presence of oxygen. The aerated mixed liquor is then pumped up into the bioreactor swing zone where it cascades around the semi circular baffles. Four horizontal rotors provide aeration for further nitrification and P synthesis. The mixed liquor over flows to the clarifiers. Figure 3 provides a graphical representation of P contents prior to improvements to plant equipment and process were implemented in 2015. Note the P mg/l at the swing zone and clarifier are much higher than a target level of P< 0.5 mg/l.



<u>Figure 3:</u> ***Progressive Change to Phosphorus***

Primary settled sludge is pumped into the prefermentation tank. The settlement and removal of the sludge from the primary tanks are controlled to provide suitable residence time through the pre-fermenter to optimise the production of short chain VFAs.

The fermented sludge is pumped to a drum thickener. The filtrate that contains most of the solulable VFAs is used in the Biological Nutrient Removal (BNR) process . The thickened sludge is delivered to anaerobic digesters. The digested and waste activated sludge (WAS) is dewatered using belt filter-presses. The dewatered sludge is then transported to CHW's Clunes Biosolids Processing Facility. The filterate from the belt presses is treated with lime to presipitate the P before the supernatant is returned to the inlet works.

3.0 CHALLENGES

Major capital works at BSWWTP are being implemented to meet the requirements of an increasing population. It is anticipated the plant will accomadate another 18,000 connections by 2035. The current capital upgrade projects will enable CHW to accept the increased demand while being 100 per cent compliant with environmental and regulator requirements.

When delivering complex solutions to aging infrustructure it is difficult to fully manage the operational inter-relationship such as the micro aspects of the controls, where the PLC programs integrate the multitude of electro-mechanical equipment. When all plant equipment is functional weather changes could cause elevated flows, totally disrupting compliance targets. Experience shows that it is difficult to apply engineering solutions and calculations in a retrofit environment (often the case) to pre-existing pinch points

4.0 PRE-EXISTING BOTTLE NECKS

As CHW moves to our ultimate design of three times dry weather flow in 2035, there are a number of pinch-points to consider:

- Inadequate production of VFAs to meet demands for enhanced BNR process,
- Upgrade existing aeration system to improve efficiency and increase aeration basins capacity,
- Enhancements to the existing screening and grit removal systems requires consideration of a new inlet works upgrade, and
- Treatment of increasing wet weather bypass flows required to meet the EPA licence.

5.0 RECENT UPGRADES

Several upgrades have been implemented, with the more significant being the improvements to the inlet works. This included additional 3mm step screen, the primary sludge augmentation program that improved the carbon collection and processing system, and the upgrade of the optical cable network for the SCADA improvements.

Upgrades at the final stages of completion and still to be commissioned are the boiler / heat exchanger replacement, new mechanical mixers for the digesters and a new 42m diameter secondary clarifier to abrorb impacts of increased flow.

Other emminent upgrades include installation of new aeration blowers for better dissolved oxygen (DO) control, upgrades to the instrumentation for plant monitoring, and the BioWin program for modeling impacts of operational changes.

5.1 Primary Solids Augmentation and Pre-fermenter Cleanout

A large amount of work was undertaken during the upgrade to the primary solids capture project, that included new pumps, storage tank, drum thickener and a sludge withdrawl system. We underestimated the importance of some features in our supply infrastructue which was highlighted in the commisioning phase as a number of pump chokes, pipe blockages and mixer failure complications occurred due to ragging. This led to an investigation of the contents in the tank which highlighted the presence of a large amount of rag and grit that had by-passed the screening system. This resulted in the prefermenter being issolated, taken off-line and cleaned out. An inductor truck was engaged to undertake the cleaning.

With no prefermenter in operation the BNR process did not have the VFA it needed and within 24 hours the change in the process was noticiable. As a substitute several options were considered, the quickest and easiest solution was Molasses. With the introduction of molasses the process began to recover. After the prefermenter was cleaned and operable it was brought back online ceasing the use of molasses. The process started to deteriated again. This demostrated that the time required for complete fermentation to take place was inadequate, hence a combination of prefermenter VFA and molasses were used and the process soon recovered and compliance was achieved.

Experience demonstrated the need for a regular carbon source to be introduced into the BNR process. It also highlighted the need for increased screening and consideration to the associated processes and inter-reationship within the plant when renewing infrastructure.

6.0 NEW OPERATIONAL ISSUES

As projects were delivered a number of issues arose, some being extremly complex in needing to manage compliance while operating a live plant. For example, we have encounted issues accociated with the operational process control. As we size the new infrastructure to assist us with future demands we may not be optimising the plant to it its full efficency. For instance operating pumps within the most efficient duty point of the power curve. It must be considered whether to increase pump capacity now or set replacement bench marks to trigger the upgrade requirments to meet the future demand.

The dynamic nature of the wastewater treatment process requires responsiveness to aviod environmental impacts thus is a challenge to fully test and commission new plant modifications without impacting on the process. As the enhanced BNR process is live, it is extremly difficult to revert the process to an offline condition to make modifications. To ensure seamless integaration, the commissioning of upgraded processes must be implemented with all engineering disciplines working together.

As communication infrastructure is introduced, process controls are intergrated into existing control logic. A challenge of the implementation includes the training of operational staff to understand the intended process control and the implementation within the control system. As the operators inherit new pieces of plant and control logic it is critical the operational staff are engaged during implementation/commissioning to fully understand its workings.

7.0 RECENT CHALLENGES

7.1 Aeration - Damaged Air Distribution Pipe-Work

As part of the capital upgrade new technologies were being investigated for new blowers.

However we encountered a more urgent need. As the process struggled to meet DO requirments within the aeration zone and a belief that the failing capacity was the mechanical blowers, as the run times and operational power input had increased.

As air bubbles leaking from concrete gaps were noticed, it triggered an investigation. This identified that the underground mainifold was corroded and required urgent replacement. To replace the aeration ducting while continuing to deliver air to the biomass without disrupting aeration was a huge challenge. Working with CHW's prefered engineering suppliers, a way forward was agreed upon.

Duplicating the pipe work to an above ground configeration made sure minimal shutdown was acheived. The new pipework had a number of valves installed which allowed part of the blower pipework to be available while the other duct sections were installed. A control document (method statement) was developed ensuring that a constant air supply was achieved and minimal impact to the aeration process during the air duct change over.

It is important that when looking and aiming for future growth that all associated interconections within the systems are investigated.

7.2 Primary Sedimentation Tank- Failing of the Scraper Rails

Over the years the Primary Sedimentation Tanks (PST) have had the scrapers, chains and railings replaced. However due to the supply difficulty and complexity, the bearings, housings and shafts have been overlooked and not maintained. One major reason for this is due to the PSTs 24/7 operational requirement.

The easier consumables are often replaced on a regular basis as they have little impact on the plant. The main components such as shafts, bearings and sprockets can be taken for granted.

While undertaking replacment of the consumables it was identified that the major issue was that the critical components were contributing to failure. Once again working with CHW's prefered contractor and supplier's a more sustainable outcome was possible. Undertaking a full refurbishent of the running gear would assist CHW in meeting the 2035 vison while reducing repairs and shutdowns going into the future.

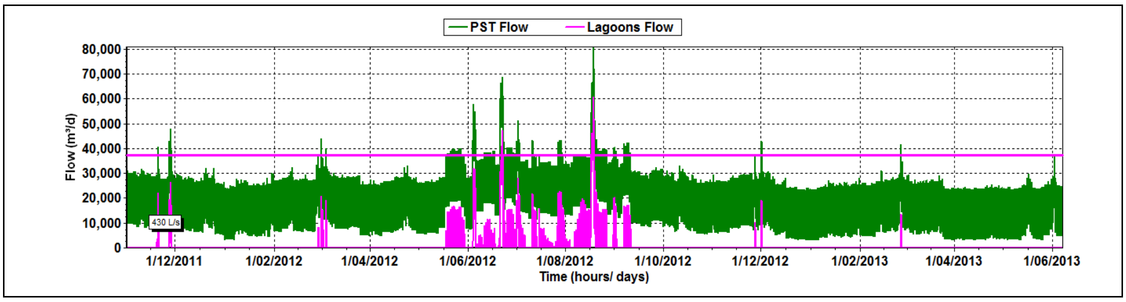
7.3 High Flow Impact

Ballarat South was built when sewers were all gravity or nightsoil deliveries. Today the sewer system is a combined gravity and pumped sewer network from around the district. The impact of wet weather conditions have consequences which require specific actions to mitigate impacts on the plant performance. Depending on the intensity of the weather, stormwater inflows overflow to the lagoons. Actions required and negative impacts at these times include:

- Having to reset plant into storm mode which diverts flows to the balance tank to protect the bio-mass,
- Further flow to the balance tanks causes untreated sewage to overflow to the lagoons with no secondary treatment,
- High flows reduce the soluble COD/BOD to the process which in turn reduces available carbon required for the BNR process, resulting in poor treatment, and
- Screen bypass causes non-biodegradable material to pass into the plant including grit flushed out from sewer chambers.

7.4 High Flow Management / New Clarifier

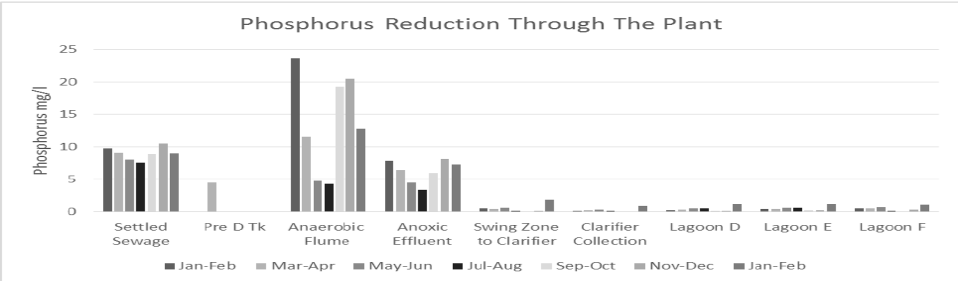
The BSWWTP experiences a wide range of flow conditions influenced by seasonal conditions. Winter flows are affected by inflow and infiltration in the wastewater reticulation system that results in high flows at the treatment plant. Trends shown in Figure 5 and Figure 1 respectively show the components of the influent wastewater and how these events impact plant operation during these events in the past, and flow components discharging to the lagoons. When the new clarifier is built and commissioned the wet weather excess flow can be gravitated to the clarifiers to trap suspended solids in the sludge blanket. The additional clarifier being constructed is to increase the overall clarifier capacity to match population growth, ingress and infiltration to manage treatment of wet weather flow conditions.



<u>Figure 5:</u> ***2011 to 2013 Primary Influent with Wet Weather Bypass to Lagoons***

8.0 IMPROVED BIOLOGICAL PHOSOHORUS REMOVAL

Upgrades to the prefermenter, carbon dosing system and primary sludge screening equipment has improved reliability of enhanced biological phosphorus removal. Figure 6 documents the last 12 months showing phosphorus uptake in the anaerobic uptake and release in the aerobic portion of the plant.



<u>Figure 6:</u> ***Phosphorus Concentrations***

9.0 CONCLUSION

When working on a historic plant which has undergone a number of changes throughout the decades it is important to fully understand the inter-conection and relationships that are at play. This means that although it is extremly difficult to operate a BNR process with frequent equipment failures, it is still critical to consider the right outcomes and management of the situations to obtian the longterm benefit of the preferred works.

In operating a wastewater treatment plant where plant failures and seasonal impacts in an uncontrolled catchment are part of the dynamics of plant operations. The ability to change, adapt and evolve is critical to ensure the environment is protected and regulatory licence conditions are achieved as CHW have done through the years.