THE YARRA VALLEY PROCESS OPTIMISATION PROGRAM – WORKING AT AN OPERATIONAL LEVEL SAVES MONEY AND IMPROVES EFFLUENT QUALITY ACROSS WASTEWATER TREATMENT PLANTS

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ABSTRACT

Yarra Valley Water provides water and wastewater services for approximately 1.5 million customers on the north eastern fringes of the greater Melbourne metropolitan area.

Over the past two years AWT Water and Yarra Valley Water have been working through an efficiency program to both improve the performance of existing treatment plants as well as set and maintain a benchmark for their future operations.

Efficiency studies have consisted of specialist online characterisation work and the development of BioWin process simulation models for the initial evaluation, and then optimisation of several high rate treatment plants owned and operated by YVW. Plants include; Healesville, Brushy Creek, Lilydale, Whittlesea and Upper Yarra (by others).

Recommended alterations have largely been completed at Healesville with particular success. Yarra Valley Water are now in the process of evaluation works programming for the other plants completed to date.

This paper focuses on Yarra Valley Waters' reasons for the efficiency study program, the methodology used to undertake these investigations, including some of the difficulties the project team came across and the results of the changes from the process model outputs.

KEYWORDS

Optimisation, process simulation, efficiency, Wastewater Treatment, BioWin, Ammonia, Alum, Power.

1 INTRODUCTION

1.1 CONTEXT

Yarra Valley Water (YVW) services 1.5 million people on the north and north eastern fringes of the greater Melbourne metropolitan area. Yarra Valley Water own and operate the water and wastewater network for this area which includes nine wastewater treatment plants (WWTPs). Figure 1 below outlines the Yarra Valley Water service area.

Of note is that Craigieburn, Brushy Creek and Lilydale are effectively within the Melbourne Metropolitan area.

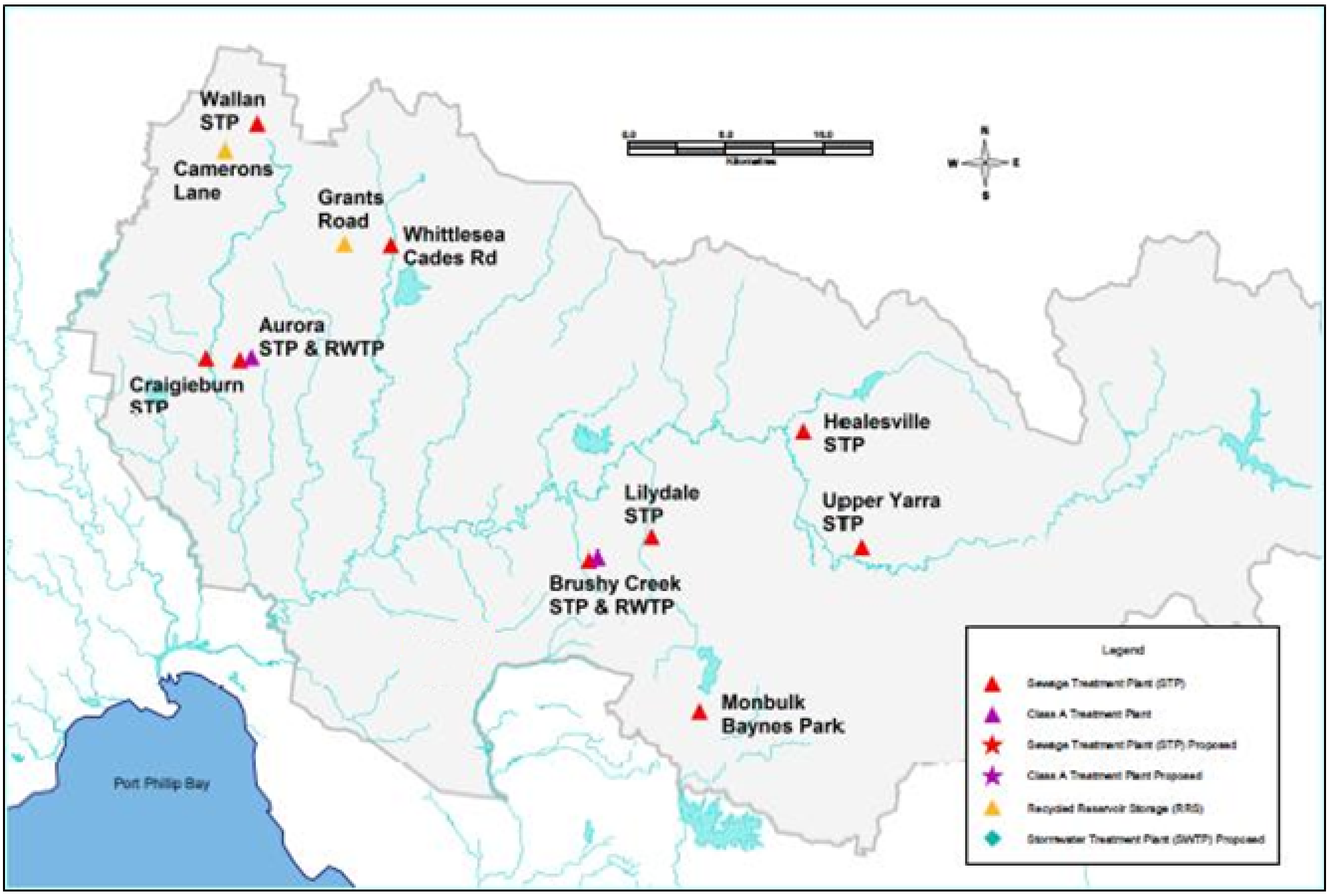

Figure 1: Yarra Valley Water Service Area

The wastewater treatment plants range in size from treating approximately 50 kilolitres per day (kL/d) through to approximately 10 megalitres per day (MLD) and discharge to either waterways or to sewer (Wallan, Whittlesea and Aurora are complete reuse plants). The discharges to sewer pass to the Melbourne Water system and YVW are charged for volume and discharge loads. There are also a series of Class A reuse plants[1].

Further to this YVW have been involved in a catchment wide study of Port Philip Bay where the total nutrient load (and particular nitrogen) have been reviewed in an effort to match the carrying capacity of the Bay with the nutrient inputs from the various sources including the point source discharges from the various WWTPs run by YVW. With this it has been identified that there may be an opportunity to trade nutrient loads with other point source dischargers particularly if the YVW treatment plant nutrient discharge loads can be reduced.

This is particularly relevant when considering the Western Treatment Plant, owned and operated by Melbourne Water, is a lagoon based system. This system is unlikely to be converted into a high rate nutrient removal plant due to the size of the system and the discharge is via a wetland system which is noted as a Ramsar Wetland[2].

YVW have identified the potential to optimise these plants from both a reliability perspective and a general operation perspective, as well as provide the ability in the future to trade nutrient loads. To do this they have adopted a series of efficiency studies on most of their plants. These efficiency studies have been completed by external consultants with input from YVW.

The efficiency studies have been completed on most of YVW WWTPs and these have been undertaken using the BioWin model (EnviroSim Associates)[3].

Having largely completed these studies the next level of investigations has been to implement the recommendations from the efficiency studies. These often include evaluation of alternate methods of control rather than significant capital investment and in particular direct measurement and control of ammonia.

This paper discusses the reasons why YVW have undertaken these studies, the methodology and in particular the benefits of the level of detail selected, and the outcomes of the study.

1.2 AIMS/SCOPE OF STUDY

The primary aims of this study are as follows:

- To gain a greater understanding of how the plants are operating;
- To baseline operation of unit processes between plants;
- To achieve operations savings;

2 BACKGROUND

2.1 YVW TREATMENT PLANTS

Currently 93% of Yarra Valley Waters customers sewage is treated by Melbourne Water at either the Western or Eastern Sewage Treatment Plants. The remaining 7% of flows are treated at localised treatment plants. YVW operates nine treatment plants with varying levels of effluent quality produced at each site. The effluent produced at most plants is discharged to a nearby creek, with the remainder stored in recycled water lagoons for reuse by nearby irrigation customers.

Treatment plants at Yarra Valley Water are presented in Table 1 below with the Recycled Water Treatment Plants which produce dual pipe reticulation supplies from tertiary treated effluent.

Table 1: YVW Treatment Plant Summaries

Treatment Plant Location	Average Daily Flow Treated (ML/d)*	Treatment Quality
Brushy Creek	10.0	Tertiary + Disinfection
Lilydale	5.0	Tertiary + Disinfection
Craigeiburn	2.9	Tertiary + Disinfection
Aurora	1.3	Tertiary + Disinfection
Healesville	1.4	Tertiary + Disinfection
Upper Yarra	2.0	Tertiary + Disinfection
Whittlesea	0.7	Tertiary + Disinfection
Wallan	1.4	Secondary
Monbulk	0.06	Tertiary + Disinfection
Aurora RWTP	4.0	Advanced Filtration
Brushy Creek RWTP	2.0	Advanced Filtration

*Current Average Daily Flow as at 28/09/11

2.2 TREATMENT PROCESS DESCRIPTIONS

Treatment processes at most treatment plants were developed originally to achieve secondary treatment effluent standards. Secondary treatment technologies varied given that plants were constructed at times when different technologies prevailed. The larger treatment plants were retrofitted with tertiary treatment technologies in 2002 to meet stricter EPA final effluent quality requirements. Iron Sulphide was replaced with Aluminium Sulphate in late 1996 due to the requirement to standardise coagulation substances across water and sewage.

The various treatment process steps at each plant include:

- Brushy Creek treatment plant involves screening, extended aeration with secondary clarification, tertiary filtration, ultraviolet disinfection and Aluminium Sulphate dosing for phosphorus reduction and Caustic Soda for pH correction.
- Healesville treatment plant contains screening, an oxidation ditch with surface aeration, secondary clarification, upward flow clarification and ultraviolet disinfection with identical chemical dosing operation as Brushy Creek.
- Whittlesea treatment plant includes screening, sequencing batch reactors, tertiary filtration, ultraviolet disinfection and identical chemical dosing operation as other plants.
- Upper Yarra treatment plant contains, screening, intermittently decanted extended aeration, tertiary filtration, ultraviolet disinfection and wetland retention with identical dosing systems as the other plants.

- Lilydale treatment plant involves a more complex treatment process including screening, pre-fermentation, primary sedimentation, biological nutrient reduction reactor, secondary clarification, tertiary filtration and ultraviolet disinfection with sludge thickening and stockpiling. Chemical dosing is also the same as other plants.

2.3 CORPORATE REQUIREMENTS

Historically treatment plants have operated to ensure reliability in treatment quality standards. Yarra Valley Water operates the treatment plants to achieve regulatory compliance at the lowest community cost. YVW currently has a corporate licence with the Victorian Environmental Protection Agency (EPA) encompassing all sewage treatment plants, effective since 2009. Recycled water plants, are regulated by agreements with the Victorian Department of Health.

The corporate licence specifies quality requirements and general plant operational requirements. “Median Limits” are specified for annual median results, the breach of which is utilised for YVW to provide advanced warning. “Notification Limits” specify parameter limits which cannot be exceeded at any time and the breach of which requires notification to EPA and a subsequent investigation.

Table 2: Notification Limits at YVW Treatment Plants

Treatment Plant	BOD$_5$ (mg/L)	Suspended Solids (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ammonia (mg/L)	E.Coli (orgs/ 100mL)	pH
Brushy Creek	10	10	1	20	5	500	6-9
Lilydale	10	10	1	20	5		
Healesville	20	20	2	20	5		
Upper Yarra	20	20	2	20	5		
Craigieburn	20	20	2	20	5		
Monbulk	20	30	30	40	10		
Whittlesea*	20	30	-	-	-	100	

**Whittlesea STP does not have a licenced discharge point and is instead driven by EPA Class B Recycled Water Quality Requirements specified above (EPA, 2003).*

Quality treatment parameters are driven by waterway monitoring analysis conducted for each plant discharging to water. As treatment flows increase, resulting impacts on creek increase and additional nutrient reduction is required. The fate of discharge requirements are unknown, however YVW is currently tasked with maintaining current discharge requirements while catering for growth in catchments.

3 RISK EVALUATION

3.1 PROCESS UNCERTAINTIES TO ADDRESS

Process modelling was sought to address various risks to the treatment plant operation which could not be resolved though analytical investigations. At this stage five plants have been investigated and are discussed further in the following.

3.1.1 HEALESVILLE PROCESS RISKS

Healesville treatment plant historically experienced poor effluent quality, particularly ammonia and nitrogen. Difficulties with achieving licence compliance were exacerbated by large commercial customers in the sewage catchment which varied the level of treatment required. Additionally, inconsistent inflows to the plant occur due to seasonal fluctuations in the township population. An upgrade to the treatment process was earmarked due to the complications experienced at the plant; however there was uncertainty as to how to proceed with the upgrade given the numerous upgrade options available.

3.1.2 UPPER YARRA PROCESS RISKS

Upper Yarra Treatment Plant was simulated under a process model to determine the ability of the secondary treatment system to treat Average Dry Weather Flow (2.0 ML/day) with one of the two biological Intermittent Decant Extended Aeration (IDEA) reactors offline. This was requested due to various faults which had occurred with the IDEA process decanters causing the shutdown of a reactor until resolved. Additionally, optimisation was sought by analysing the operating sludge age and dissolved oxygen set point levels. Discharge licence breaches were the greatest concern to the treatment process, as was the potential to breach given limits under various proposed augmentation options.

3.1.3 BRUSHY CREEK PROCESS RISKS

Brushy Creek Treatment Plant has experienced significant growth in its sewage catchment over the last 10 years and prompted investigations to confirm its treatment capacity (hydraulic and organic). Various attempts at estimating the treatment capacity of the plant had been attempted but the actual capacity of the plant had not been confirmed. Additional concerns included difficulties in achieving effluent ammonia requirements at the plant and chemical usage patterns. Chemical dosing locations and quantities were also poorly understood in terms of volumes required for licence compliance.

3.1.4 WHITTLESEA PROCESS RISKS

Whittlesea treatment plant operates at 47% of hydraulic capacity and has no EPA effluent discharge licence. The lack of pressure on the operating inflows left only optimisation improvements to be investigated as part of a process model for the plant. Known efficiency issues at the plant included suspected over-dosing of chemicals in comparison to other YVW plants, particularly Caustic Soda. Additionally there was poor understanding of the sludge management systems and their relative efficiency in solids thickening and polyelectrolyte consumption.

3.1.5 LILYDALE PROCESS RISKS

Numerous treatment processes at Lilydale were suspected of operating inefficiently. Poor solids separation from the pre-fermenter suggested incomplete separation of volatile fatty acids from source sludge[4]. High chemical dosing consumption suggested a poorly operating anoxic areas within the Biological Nutrient Removal (BNR) reactor on site[5]. Additionally, multimedia filtration performance was poorly understood and there a requirement to find a suitable filter backwash discharge location to minimise impact to the plant.

3.2 FISCAL RISKS TO ADDRESS

Upgrade projects were investigated as part of the simulation modelling for Upper Yarra, Brushy Creek and Healesville. Process models were utilised to simulate plant performance from numerous upgrade scenarios. Subsequently, process parameters were also modified for various plants to identify where process optimisations could be made.

3.2.1 HEALESVILLE FISCAL RISKS

Capacity requirements were the main driver for upgrading the treatment plant, however there was no consensus as to an option which would deliver the highest plant operating efficiency. Significant factors of concern were reducing dependence on aeration and additional pumping.

3.2.2 UPPER YARRA FISCAL RISKS

Upper Yarra was being investigated for an upgrade to the capacity of the plant, including converting the current system to a Sequencing Batch Reactor (SBR), installing a third IDEA reactor or construction of a secondary clarifier. Process modelling was required to determine the option providing the most optimal treatment performance, highest level of redundancy and lowest community cost.

3.2.3 BRUSHY CREEK FISCAL RISKS

Similarly Brushy Creek treatment plant required investigations to determine the feasibility of reducing the peak loading to the plant, including options to install preliminary sedimentation, improved aeration control and constant return activated sludge (RAS). The aeration system individually constituted the largest potential upgrade to a treatment plant conducted at YVW and greater degree of certainty was required to identify the ideal upgrade strategy. Installation of preliminary sedimentation was also suggested to reduce current aeration requirements via organic loading reductions.

3.2.4 WHITTLESEA FISCAL RISKS

Whittlesea was deemed to not require a capacity upgrade and as such was solely investigated for process optimisations. Operational expenses associated with chemical usage and sludge aeration constituted these points to be investigated as part of the process model.

3.2.5 LILYDALE FISCAL RISKS

Secondary clarification is the largest risk to achieving licence compliance at the plant due to solids carryover. Investigations were sought to identify the cause of the hampered clarification and whether upgrade of the secondary clarification was required.

4 METHODOLOGY

The need for treatment plant simulation modelling was identified during the development of the Efficiency and Development (E&D) Plans at YVW. There was a demand to transition from achieving licence compliance towards increasing plant efficiency without compromising the former. The E&D plans sought to achieve this by holistically examining the current efficiency of the plants and developed benchmarking tools to determine the relative areas for plant improvement. Focus areas for the plants related to planning for future capital upgrades, asset management practices, risk management for achieving licence requirements and general plant efficiency.

Process optimisation however was not included in the original assessment and there was a requirement to determine the root cause of high operation expenses at various plants. Additionally, the E&D Plans identified numerous capital projects which will be required for each plant, and their inherent impacts on plant performance were unknown. Process modelling was selected to ensure:

- Proposed plant augmentations could be simulated;
- Optimal plant performance parameters could be determined;
- Greater understanding could be developed for the current plant performance;
- Customisable process models were developed for all treatment plants.

It was recommended to externalise the development of the process models and work collaboratively with external consultants to develop and utilise process models for future capital works. Process models were developed on an individual plant scale and individual scopes of work were developed for upgrades proposed for each site. BioWin was selected as the preferred process software for YVW as employees within the company had previous exposure to the application and it was deemed to be commonly used for biological treatment system analysis. The development of process models was competitively tendered and the proposed delivery method consisted of:

- Preliminary site visits to confirm treatment plant processes
- Workshops to discuss plant performance
- Sampling programs to collect process build data
- Process model build
- Augmentation and optimisation simulations
- Report development with recommendations and findings

Determining the ideal development process for process simulation creation was an adjusting process and the aforementioned delivery method was selected after having already developed several models.

4.1 HIERACHY

The first step for this investigation was to discuss with YVW the key outcomes based on the scope of works developed and decide upon the level of investigation required to meet these targets. There are several levels of study that can be used for an efficiency evaluation that can be relevant. These are:

1. Site based evaluation of operation and data;
2. Base capacity assessment of unit processes (based on standard text book values);
3. Process Simulation Modelling;
4. Detailed process based calculations.

4.1.1 SITE VISIT

Site based evaluations provide a lot of useful information. This would normally be completed for any “level” of investigation. The primary reason for this is to meet plant operations staff and include input from operations staff in particular with relation to any trade waste or unknown discharges (this can be periods where wastewater of a different colour or smell enters the plant or where there are periods of unknown suppression of DO or poor effluent quality and mixed liquor settlability) and also to investigate the method of operation and control.

Further to this, it is important to evaluate the existing plant data in order toconsider the sampling undertaken and the key target areas of the investigations. For example, there may be periods of high ammonia or nitrate within the effluent that can define the target areas for the efficiency study. This level of investigation on its own can provide relevant information that allows us to identify specific issues, however this does not maximise the efficiency potential of the system. It can be where large gains can be made with little alteration to plant operation and at low cost.

Often there is little sampling that is undertaken on site in order to evaluate the process performance. If sampling is undertaken it is often based on compliance requirements which can mean as few as a single sample a month being captured on the effluent and no influent samples being captured. It is important that an evaluation of the sampling undertaken and sampling procedures is completed. For example sampling for ortho phosphorus in the effluent stream should include a filtration step if biological phosphorus removal is being assessed on site as any solids captured with the sample will release Phosphorus. This is in fact a standard method[5] for collection of water samples which may not be adhered to.

4.1.2 DESKTOP STUDY

A base capacity assessment is often completed using empirically based text book values. For example primary tanks and clarifiers are evaluated based on overflow rate and potentially retention time or solids loading rate with assumed capture efficiencies. In terms of an efficiency investigation the level of accuracy is insufficient to provide anything but a general idea of the plant capacity and pinch points within the plant.

4.1.3 PROCESS SIMULATION MODEL

A process simulation model provides the ability to assess the plant on a dynamic basis. There are several "levels" of modelling (Henze et al[6]) that can be utilised depending on the purpose of the model and the level of information available and the level of accuracy required. Depending on the cost benefit of doing the exercise an amount of sampling[7] is often required, particularly in order to evaluate the COD based inputs to the system. Many water companies or councils simply undertake samples from a compliance perspective only and this often results in minimal influent sampling and if any sampling is undertaken this is often on a BOD basis only.

4.1.4 DETAILED STEADY STATE CALCULATIONS

Whilst detailed process calculations should provide a high level of accuracy in terms of the overall plant capacity there is still a requirement for sampling to provide information to input into calculations. Further to this the dynamic evaluation of the performance of the plant at various conditions is time consuming. The process simulation models use the same calculation basis (Activated Sludge Models[8]) as the detailed process calculations, however a wide range of conditions and actual plant conditions can be evaluated rapidly.

4.2 ADOPTED METHOD

As such it was decided to review plant data and then undertake a process simulation model for the efficiency study. The decision then leads to the level of detail required for each model. This is based on the level of detail available and the cost/benefit of undertaking extra sampling and inserting the data into the model. The BioWin model was selected as the model of choice for these studies.

Generally monthly influent, MLSS and effluent samples are taken at the various sites and sent to an external laboratory (ALS Group) for analysis and reporting. Site based sampling is also completed for ammonia and nitrate using Merck test kits (photolab series).

The Healesville WWTP was the first model undertaken in the efficiency studies. The initial model used only daily flow values and monthly sampling data (influent/MLSS/effluent). After the initial model was completed an s::can UV vis spectrophotometer and on line ammonia analyser (ammolyser) provided by DCM Process Control was installed to collect dynamic influent data (in particular for COD, CODfiltered, COD flocculated and filtered, TSS and ammonia). To calibrate the s::can and Ammolyser we undertook a series of samples at high and load concentration periods and evaluated them using the HACH DR2400 spectrophotometer. Samples for TSS, VSS, TKN were sent to an external laboratory (ALS Group).

5 RESULTS AND DISCUSSION

The following outlines the plants investigated to date, the level of detail and the outcomes of the efficiency study including where the recommendations have been implemented. It should be noted that the flows described in this presentation are the flows at the time of the process models and for the likes of Healesville these flows have altered since the process model was completed.

5.1 Healesville WWTP

The Healesville WWTP is an Oxidation Ditch system. The Healesville WWTP was traditionally struggling to meet license requirements.

The plant treats in the order of 0.7 – 1MLD with alum added to provide phosphorus removal. There are two main trade dischargers into the system, a winery and a brewery, however there are also race events and several wineries nearby that stage special events drawing large numbers of people to the township particularly during weekends.

The plant was having particular difficulty in meeting ammonia limits at times and total nitrogen limits at other times and was taking up considerable operators time for problem solving. As such Yarra Valley Water installed two spare (two of at 150KL) reactors alongside the existing oxidation ditch.

Two 18.5kW surface aerators provide aeration input to the oxidation ditch and two 7.5kW blowers to the side stream reactors. Flows are pumped to the side stream reactors from the oxidation ditch. Solids/liquids separation is via a clarifier and effluent passes through a pebble bed filter and Ultraviolet (UV) disinfection prior to discharge to water. Solids are stored (aerated) prior to being removed off site.

Prior to the efficiency study the side stream tanks were fully aerated and the oxidation ditch surface aerators were controlled via DO level in two places within the reactor basins. 300L/d of alum was added to the influent to reduce Phosphorus.

The following options were broadly investigated:

1. Altering the position of the inlet and outlet from the oxidation ditch;
2. Running the side stream tanks in air off mode;
3. Ammonia based control;

Due to the liquid velocity in the reactors, altering the position of the inlet and outlet from various points around the oxidation ditch had virtually no effect on the predicted effluent quality.

Despite high effluent ammonia concentrations being the main problem on site it was felt that the system was not efficiently using carbon. As such turning the side stream tank aeration off was expected to result in more efficient use of carbon and as such reduce the aeration demand and the demand for alum.

Lastly the system was simulated with the side stream tanks being operated in air off mode and utilizing an ammonia probe (WTW ammonia and nitrate probe – VARION series) that was installed within the reactor (splitter to the clarifier).

From the efficiency study recommendations the plant operation was altered to initially control the side stream tank aeration based on a timer control (to aerate during the peak load periods from 9am – 12am daily) and then recently based on ammonia concentration within the oxidation ditch. This has resulted in a significant improvement in operation complexity and time requirements on site from operators to keep the plant compliant with license requirements, it has clearly reduced the power consumption and lastly it has resulted in reduced Alum addition.

Figure 2 below presents the aeration profile before and after the implementation of the side stream aeration being altered from a time based control to an ammonia based control. As can be seen there were times of very low ammonia where there aeration is on and times where elevated ammonia concentrations are seen and the aeration is not “called up”. The side stream aeration is turned on when the ammonia concentrations reaches 4mg/L and off when the concentration reaches 2mg/L in the reactor (noting that there is significant balancing of concentrations within the clarifier).

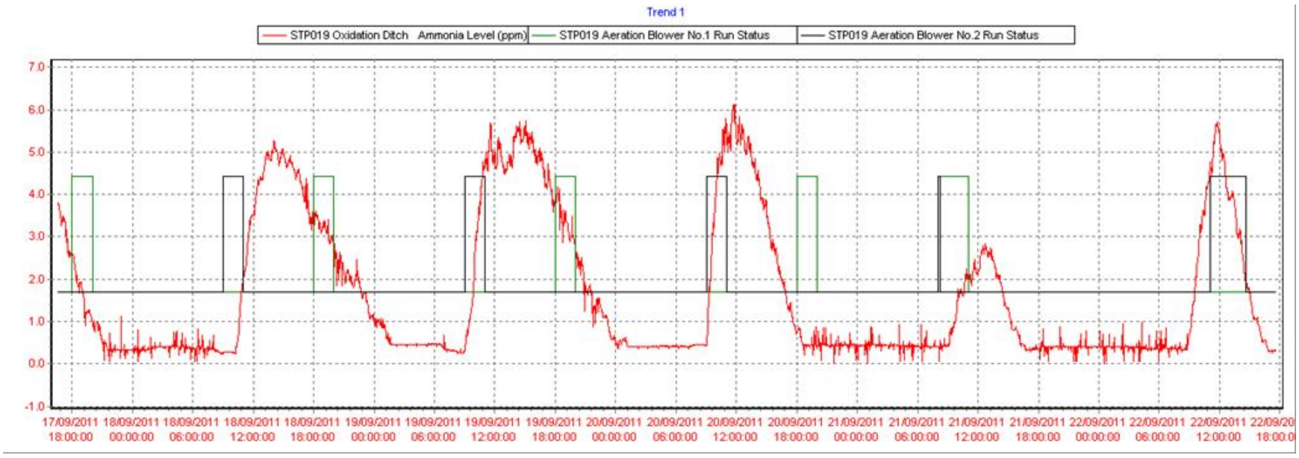

Figure 2 – Aeration Profile after Ammonia Control Implementation

As presented in Figure 2 above the ammonia controller has resulted in significant reduction in aeration input and more so aeration input when it is actually required based on a defined measurable parameter.

Since the modelling study flows (and loads) have increased from approximately 1MLD to 1.4MLD and there has been an improvement in the effluent quality due to increased knowledge and control over this period despite the increase in load.

Figure 3 presents the initial design capacity against the current input on a flow and load basis. As discussed the plant has historically been having problems meeting license requirements (particularly for ammonia). This was potentially due to the high organic capacity, however since the model was completed in 2009 the flows and loads have steadily increased and are now consistently well above the initial design capacity of the plant.

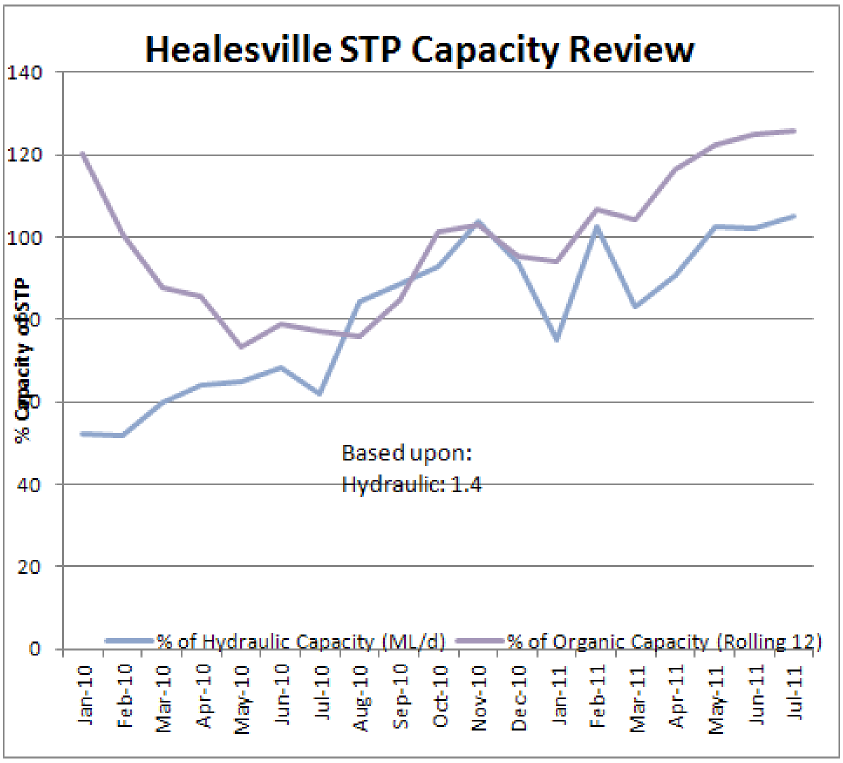

Figure 3: Flows and Loads v Initial Design Capacity

Table 3 below presents the actual results from the plant against the predicted results from the model based on improved control. Of particular note is the reduction of Alum from a dose of 300L/d down to 75L/d. What is presented is the associated reduction in power consumption and caustic dose.

Table 3: Actual v Predicted Optimised Plant Results

Parameter	Actual Median	Optimisation based Median	Units
BOD_5	2	1	mg/L
TSS	3	1	mg/L
Ammonia	1.3	0.7	mg/L
TN	7	6	mg/L
TP	0.2	0.7	mg/L
Alum	300	75	L/d

5.2 Brushy Creek

Brushy Creek is made up of a series of six extended aeration tanks (or donuts). The plant treats approximately 10MLD and also uses Alum for Phosphorus removal. A "Class A" reuse plant has been installed to treat a portion of the effluent stream. The residual effluent passes through mixed media filters and UV disinfection.

Flow enters the plant via a flow splitter arrangement which splits the flow between the six aeration tanks. The splitter arrangement at the time of the efficiency study was in poor condition making the process simulation model difficult to evaluate precisely.

The system is currently controlled on an Anaerobic, Anoxic, Aerobic (AAA) cycle. This cycle is set up to maximise nutrient removal based on DO concentration and time.

The efficiency study made two main observations:

1. There are several different types of diffusers in each of the reactors;
2. The diffusers are aging and appear to have very poor oxygen transfer efficiency (with an alpha factor in the order of <0.5.

Further to this the plant uses 2300L/d of Alum (pre and post dosed). Microscopic analysis witness a large number of Zoogloeal and Nocardia fingers/filaments presenting a likely nutrient difficiency. No Polyphosphate Accumulating Organisms (PAOs) were witnessed.

The efficiency study investigated various forms of control as well as the cost benefit of replacing the diffusers. The study evaluated alternatives to the AAA based control including splitting the reactors into zones to convert the system into a more traditional MLE process.

The RAS system is controlled by an airlift arrangement. The efficiency study included a review of the clarifier capacity (WRc Method) and found that the arrangement whereby the airlift only operates when the air is on reduces the clarifier capacity and thus the entire plant capacity. This was also identified as a pinch point for the plant which has been important due to proposed network alterations being investigated to get more flow to the plant.

In this case the recommendations have led to a requirement for significant capital expenditure rather than the simple operational alterations at Healesville. It is expected that these alterations will result in greater process reliability and significantly greater efficiency of power consumption due to the aeration input requirement.

Table 4: Actual v Predicted Optimised Plant Results

Parameter	Actual median	Optimisation based median	Units
BOD_5	2	1	mg/L
TSS	2	1.5	mg/L
Ammonia	1.2	1.3	mg/L
TN	8	9	mg/L
TP	0.2	0.1	mg/L
Alum	2,300	1,500	L/d

5.3 Lilydale

The Lilydale plant is a more traditional Johannesburg type process and treats approximately 4.5MLD. The system includes primary tanks with pre - fermentation of primary solids. The effluent from this plant is passed through a mixed media filter and UV disinfection prior to discharge to the Olinda Creek.

The key drivers for the efficiency study were to investigate the capacity of the plant and in particular the reasons for the limitations on the clarifier. Further to this YVW wanted feedback on ideas for increasing the efficiency of the system as a whole.

As part of the initial site visits undertaken at this site it became clear that there is no solids liquids separation on the pre – fermenter return stream, and as such all solids removed from the primary tank are effectively returned to the reactor. Also it was identified that solids carry over from the clarifiers was resulting in excessive backwashes of the filters, and the return to the filters was direct to the end of the reactor, exacerbating the problem and resulting in media settling on the diffusers (and it was expected reduced oxygen transfer efficiency).

It was immediately identified (without the use of the model) that the return from the filters could be shifted to a lagoon, to allow balancing and controlled settlement of solids in an area where these could be easily removed (and isolated) and flows could be returned at a low rate to the front of the plant.

During the modelling process we also undertook a microscopy training session on site, this revealed that the plant was in fact nutrient limited (although both Glucose Accumulated Organisms (GAOs) and Polyphosphate Accumulating Organisms (PAOs) some filaments of Nocardia in particular were observed). As part of our overall study of the plant performance it was seen that there was significant Alum added for Phosphorus removal (despite the system being operated for Enhanced Biological Phosphorus Removal (EBPR). Given the influent nitrogen concentrations were as expected it was derived that the Alum addition was resulting in the nutrient limitation and hence contributing to poor settlability.

The process model highlighted the expectation of poor oxygen transfer efficiency with an expected alpha factor of in the order of 0.35 (which is significantly lower than the default for BioWin of 0.5 with this being representative of worn diffusers).

The model highlighted issues with the operation of the dewatering system and highlighted that the expected solids removal efficiency was as low as approximately 50%. This was due to a failed pump which was fixed rapidly upon this being highlighted from the model.

The model also showed that solids liquids separation of the pre – fermenter waste stream could significantly reduce the MLSS concentration (by approximately 20%) with minimal reduction in effluent quality, thus providing significant improvements to plant capacity and reducing the issues with the clarifier.

Other optimisation runs included investigating splitting the reactor into four zones with the expectation that nutrients in the discharge would improved. We did not spend time reviewing internal recycles to optimize this run and it showed no marked improvement in effluent quality despite expectations that it would.

We also investigated using ammonia control at this site and as expected there was an improvement in overall effluent quality and reduction in power input.

Further optimisation should clearly be focused around the Phosphorus removal and reducing the Alum input.

At this stage none of the recommendations from the efficiency study have been implemented other than a reduction of input Alum dose.

5.4 Upper Yarra

Results indicated that plant operation with one IDEA reactor online could result in compliance with peak dry weather flows while complying with EPA licence conditions. It was determined that modifications to the cycle times for the IDEA process could be achieved to increase treatment capacity but an increase in resulting nitrogen effluent levels would result. The minimum sludge age for the plant which retained EPA licence requirements on effluent quality was determined. This was lower than originally expected and improved confidence in plant operation in peak loading.

5.5 Whittlesea

Whittlesea is a two tank Intermittent Decant Extended Aeration (IDEA) and treats approximately 0.7MLD. Phosphorus removal is via Alum addition. Flows pass from the balance tank up to the filter and are chlorinated prior to being pumped to a storage lagoon. A local golf course uses the water for irrigation on the golf course.

During the site visit of particular note was the amount of screenings removed by the screenings system. Approximately three screenings bins per week was being collected and these did not seem to have a high moisture content.

Also conversations with operations staff highlighted that the golf course adds nutrients. A base review of this system in terms of the nutrient carrying capacity of the system highlighted that the golf course would still likely need to add nutrients even if the system was not removing nutrients at all.

The key problem identified by the operations staff in terms of day to day operation was the filter operation (and the sludge holding tank being positioned beside the lunchroom). The filters blocked resulting in significant down time due to backwashing.

The process model was completed using the existing plant data. An s::can was not installed on this site as the model was more a functional review of the overall plant operation than fine tuning the system for nutrient removal. It was felt that there were significant gains if the system could be set up in a fashion to stop full nitrification and if the system could be reviewed to reduce the solids carry over.

The process model identified that the plant is operating at a high sludge age and that given the MLSS concentration the sludge had to settle well in order to stop solids carry over. This was clearly not always the case and it is expected that this results in solids carry over to the filters (up to 100mg/L). As such it is recommended to reduce the sludge age and review the solids processing capacity/efficiency. Also it is unclear as to how the functionality of the filters operates and it is felt that this may be limiting the filter run time.

It was attempted to operate the plant in a fashion that resulted in stopping the system from nitrifying. An investigation focussed on operating the plant with only one tank in operation, however a review of the balancing potential within the second reactor and the practicalities of this from an operation perspective is required.

Further to this the plant influent concentrations were extremely high when compared to the other plants. Given the screenings volume removed it was derived that there was likely to be significant inputs from septic wastes despite there being no license septic receival facility in Whittlesea. This is likely to also have an effect on the solids inventory within the plant and it is expected that the particulate and inorganic fraction would be high should this be measured.

5.6 Financial Summary

From a basic mass balance perspective we have attempted to evaluate the savings that can be achieved by controlling the plant based on ammonia concentration. Generally the discharge based on a DO control system will achieve basically zero ammonia. The study attempts to achieve a discharge ammonia concentration that is elevated, but still safely within license conditions.

Given a 1MLD plant; controlling the discharge concentration to allow an extra 1mg/L in the discharge, results in 1kg of ammonia not being aerated. 1kg ammonia has a base aeration requirement of 4.57kg of Oxygen (Henze et al). Assuming an AOR/SOR conversion of approximately 0.5, this results in an aeration input equivalent to 9.14kg of oxygen. A diffuser based system that has been in operation for a period will likely have an oxygen transfer rate of approximately 4kg or oxygen per kWh (verbal discussions with ITT industries) resulting in a required aeration input of 2.3kW per hour. A surface aeration system will have an equivalent of approximately 1.5kg of oxygen per kWh resulting in a required aeration input of 6.1kW per hour. At 17c per kWh this provides a potential saving of $3,500 for diffused aeration and $9,100 for surface aeration.

The above does not allow for money saved in Alum dose should further biological Phosphorus removal be achieved, is does not allow for the caustic dose required (potentially) for the extra nitrification and does not allow for the potentially reduce sludge volumes. Further to this less aeration is likely to result in a lower effluent nitrate/nitrite concentration.

Further to this given the efficiency studies, the following savings have been achieved in total across the plants (this assumes a total treated flow of approximately 26MLD across the plants operated by YVW):

- Alum – $126,000 per annum or $5,000 per ML treated per annum;
- Caustic - $103,000 per annum or $4,000 per ML treated per annum.

It is expected that further significant savings can be achieved at each of the plants including the potential to use an s::can to produce a forward feed control algorithm (for both aeration/recycle control and alum dosing) at the likes of Brushy Creek and Lilydale.

6 PRACTICAL OUTCOMES

Findings from the plant process simulation models were numerous. Although each process model was developed to address specific questions and requirements for plant operation, the majority of the key findings related to features of the plant which were not under examination. This reaffirmed the need for conducting process modelling due to the quantity of simple improvements identified to improve plant operation. As a result of the findings, YVW increased their resourcing to conduct online monitoring of our plants, as well as discussing process performance against process simulation findings.

The original intent of the majority of the process modelling works were to provide additional information for justifying capital upgrades to the plants. Process modelling and the resulting reports became the main option assessment tool utilised to determine the most suitable upgrade options for each project. Augmentations which were not suitable for the site (e.g. Brushy Creek primary sedimentation) could be removed from consideration and simplified the scope of projects undergoing conceptual assessment. The ability to quantify changes to aeration, chemical dosing and electricity requirements ensure there was a method of quantifying potential savings from upgrade and optimisation projects. Process improvements were also identified which could achieve the same purpose as larger upgrade projects.

Findings provided from the Upper Yarra process modelling suggested that secondary treatment upgrades were not required due to the ability to cater for plant inflows with one reactor. This lead to savings of up to $1M in upgrading the capacity of the plant. Similarly, the installation of the side stream reactors as anoxic tanks has led to savings in aeration estimated at $5k per month. Aside from the fiscal savings in deferring capital works and savings in consumables, the upgrades conducted as per the recommendations of the process models have significantly increased plant performance.

Healesville was the first plant where improvements were conducted as per recommendations from the process modelling results. Since the augmentation of the plant, ammonia and nitrate levels are significantly reduced at the site and the plant has had no breaches of said levels within our EPA licence in the 2010/11 period. Additionally, the plant is now more highly automated and requires less process intervention by the site operator.

Another major finding from the modelling results related to chemical consumption. Process simulations suggested where chemical consumption could safely be reduced, or where usage was significantly above acceptable levels. As part of the workshops in building the process models, these items were raised and operators were encouraged to reduce chemical consumption. The utilisation of process models allowed for target levels for chemical usage to be available for the site operators, something which was not well understood prior to process development.

Since the development of the process models, Aluminium Sulphate usage has decreased substantially at the largest YVW plants (Lilydale and Brushy Creek) while many sites are now not utilising Caustic Soda as part of daily operation. YVW assessed the risks in reducing chemical consumptions at the plants, it was determined that the risks of decreased chemical consumption could easily be addressed through the engineering solutions and safeguards. Caustic Soda is currently being dosed at many of these sites only when triggered by pH concentrations outside of normal operation.

Ammonia control for aeration systems was recommended in the secondary treatment process. Historically aeration systems at YVW's sites have been operated on oxygen levels. The quantification of potential benefits in altering the control methodology in aeration control allowed YVW to feasible determine whether there was sufficient merit in conducting such improvements. This additional parameter was one of many parameters which were recommended throughout the process modelling tasks to improve monitoring of process performance. YVW is currently improving the influent monitoring of most of our plants and increasing the level of ammonia monitoring at plants where significant savings can be justified.

7 CONCLUSIONS

The study assisted YVW to gain further knowledge as to the operation of the plant and in particular highlighted potential for and provided actual savings (from both an operations perspective and off setting construction of new assets). Base lining of plant performance highlighted where there were disparities between plant consumables usage for example which lead to further cost savings.

All of the systems provide opportunities for increasing efficiency whether it be from minor functionality alterations as at Healesville or via plant upgrades such as at Brushy Creek. The benefit of the process model is that once the plant model was operating to match the actual plant operation it was simple to get buy in from operations staff to evaluate optimisation runs.

The level of detail must match the requirements of the operations staff and also the issues on site (and in particular identifying where maximum value can be achieved from the modelling exercise). It is critical to get input from operations staff and use the time with the operations staff to identify where problems may be occurring.

Dissolved Oxygen (DO) probes are an inferred measurement for addition of air; they do not provide direct measurement of a license based criteria. DO probes are a traditional measure for oxygen input, and much of this comes from the reliability or otherwise of the initial ammonia probes. As presented for Healesville significant savings can be made with the addition of an ammonia based control algorithm.

YVW has achieved an increased level of understanding of their system operation and also identified areas where efficiency gains can be made. There are significant inefficiencies in the operation of many of the plants which often relates to the age and set up of the aeration systems. The efficiency studies have allowed targeted alterations to be made to the plants and the aeration systems to investigated holistically. For example at Brushy Creek there are several different types and arrangements of diffusers and rather than simply upgrade the diffusers in a single tank there are significant efficiency gains to be made by updating and standardizing all of the reactors.

YVW have started to evaluate and baseline the plant operation from an energy and consumables perspective in order to identify further potential efficiency gains. YVW have realized distinct and measureable savings across the plants with reduction in alum and caustic dose and further reduction in consumables and power are achievable.

The stage of the optimisation runs would be to install a forward feed control system utilising an s::can and ammonia analyser on the inlet.

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