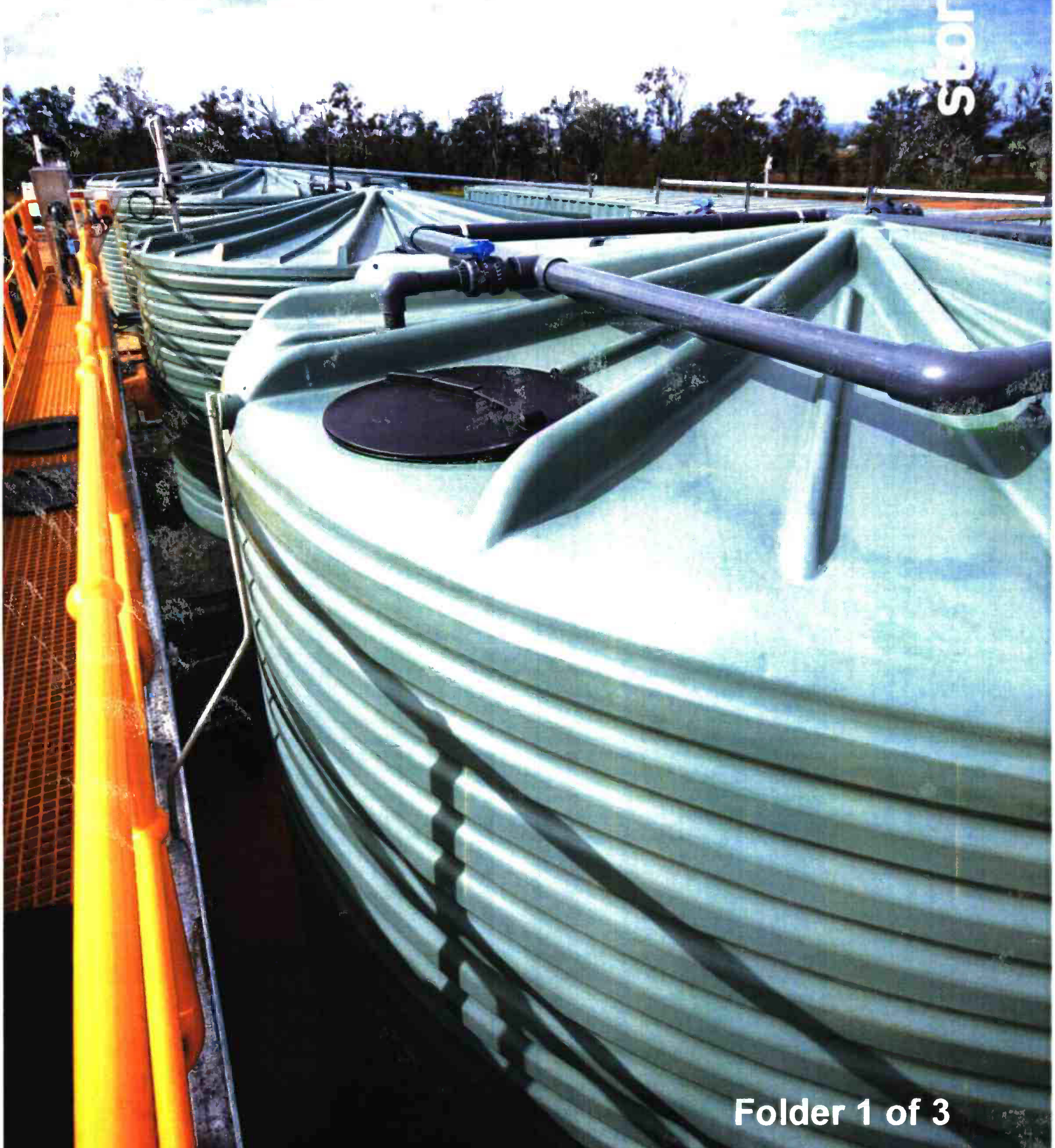
Grantham Waste Water Treatment Plant

Operations and Maintenance Manual

Contract: Grantham Waste Water Treatment Plant

Contractor: Stornoway
Unit 10/71 Jijaws St
Sumner
07 3



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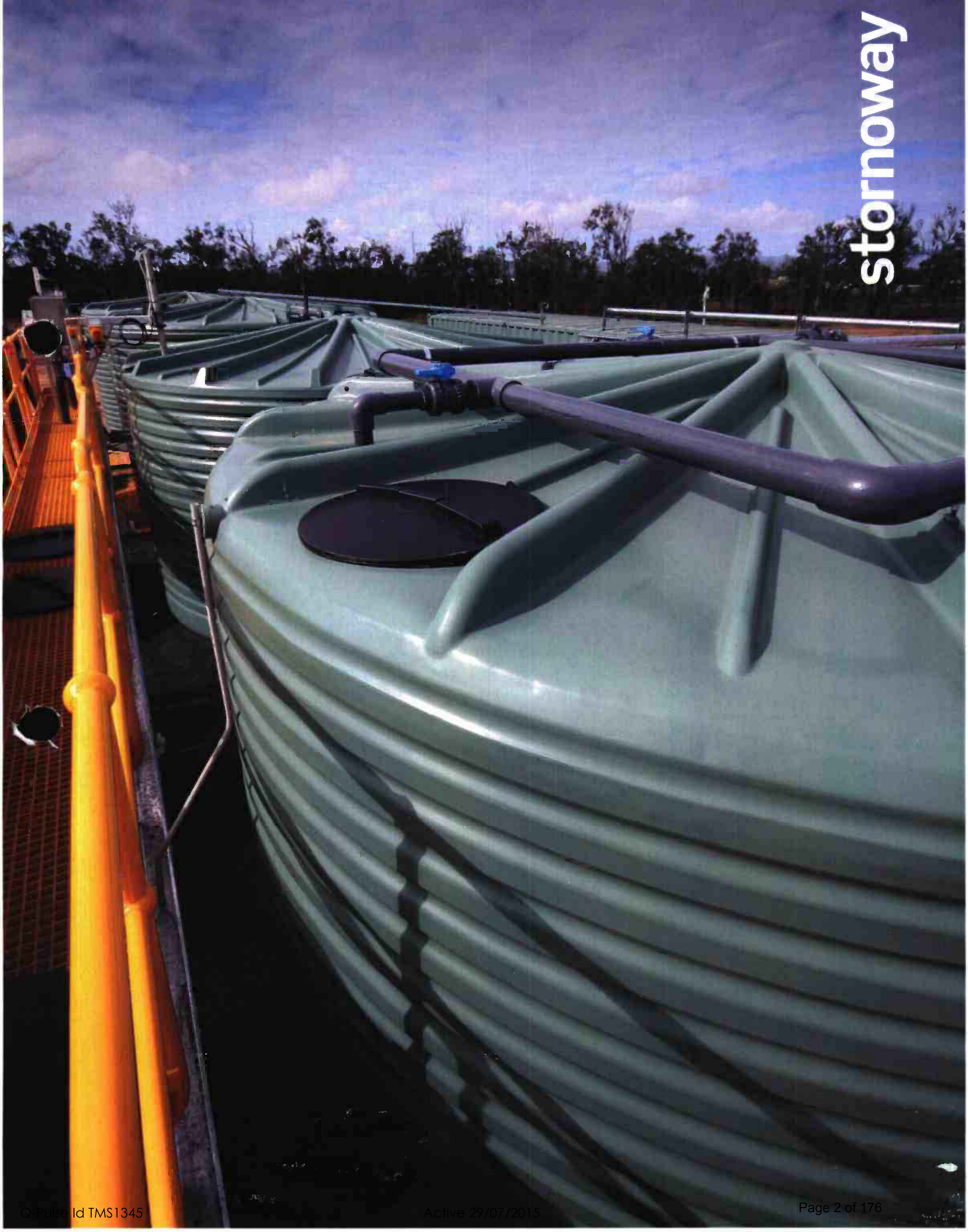
Operations and Maintenance Manual

stornoway



A

Glossary of Terms

Term	Definition
Anoxic	A system devoid of oxygen.
Aerobic	A system that requires oxygen.
Anaerobic	A system that does not require oxygen.
Backwash	A reverse flow of liquid to remove solids from the filter.
Chlorination	The adding of chlorine to water for the purpose of disinfection.
Denitrification	The process where nitrogen is removed from the liquor in the anoxic tank and converted to nitrogen gas.
Disinfection	The process used to kill micro-organisms in the water stream, including all pathogenic (disease causing) bacteria.
Filtration	The process by which solid particles are separated from a liquid by passing the liquid through a permeable material.
Filtration Rate	The volume of liquid that passes through a given area in a specified time.
Membrane	Media through which a liquid is passed associated with filtration.
Nitrification	The process where ammonia (NH_3) is converted (oxidised) into nitrites (NO_2) and nitrates (NO_3) by bacteria within the aeration tank.
Pathogen	Disease causing bacteria particles.
pH	pH the expression intensity of the basic of acidic condition of a liquid.
Sludge	Solid constituents of sewage that precipitate during treatment and are removed.
Supernatant	Liquid floating on the surface over sludge.
Turbidity	The amount of suspended matter in wastewater, obtained by measuring its light scattering ability.

B

List of Abbreviations

AS	— Activated Sludge
BOD	— Biological Oxygen Demand
DO	— Dissolved Oxygen
EPA	— Environmental Protection Agency
HMI	— Human Machine Interface
MCB	— Miniature Circuit Breaker
MLSS	— Mixed Liquor Suspended Solids
MSDS	— Material Safety Data Sheet
NTU	— Nephelometric Turbidity Unit
P&ID	— Process and Instrumentation Diagram
PLC	— Programmable Logic Computer
RAS	— Return Activated Sludge
SSV	— Settled Sludge Volume
SVI	— Sludge Volume Index
TSS	— Total Suspended Solids
UV	— Ultraviolet
VSD	— Variable Speed Drive
WAS	— Waste Activated Sludge
WWTP	— Waste Water Treatment Plant

C

ERRATA

Page 5 - Table 1 – Replace Feed to Mass Ration to Feed to Mass Ratio

Page 9 – Table 2 –Insert Floating Sludge - Denitrification in clarifier- Increase a recycle rate

Page 12 – Table 3 – Delete reference to sludge collectors

Section 1 — Process and General Maintenance

Hazard and Safety Warnings

Prompts have been used throughout the manual to highlight safety, environmental and process concerns. The following information describes the prompts used in the manual and their meanings:

DANGER!

Indicates a hazard or situation where failure to use the correct procedures WILL cause either severe personal injury or death.

WARNING!

Indicates a hazard or situation where failure to use the correct procedures COULD result in severe personal injury or death.

CAUTION!

Indicates a hazard or situation where failure to use the correct procedures COULD result in severe personal injury or equipment damage.

IMPORTANT!

Indicates information within the text which is of particular importance to the procedure or operation being described.

REMEMBER!

Indicates information within the text which is of sufficient importance to warrant highlighting.

NOTE!

Indicates information which has been covered in an earlier section of the text but which warrants reinforcement.

Contents

1.1 Background

The Grantham Township was devastated by floods in 2011. The Lockyer Valley Regional Council has undertaken to rebuild Grantham in a flood free zone adjacent to the original township.

Grantham residents will be able to relocate their homes or construct new homes on sites within the new development.

This is a three stage project appropriately named as the “Strengthening Grantham” project with stage one now complete.

Housing lots in stage one have been connected to a sewage reticulation system that supplies effluent to the Grantham wastewater treatment plant.

The Grantham wastewater treatment plant has been designed to treat a maximum of 50,000L of effluent per day with treated effluent being discharged to a fenced irrigation field adjacent to the treatment plant.

Figure 1 View of Grantham AS Wastewater Treatment Plant under construction

1.2 Introduction

This section provides reference information for the operation and maintenance of the Grantham Activated Sludge (AS) Waste Water Treatment Plant (WWTP).

The AS wastewater treatment system produces a high standard of recycled water, suitable for controlled reuse including above surface irrigation in fenced off areas.

In a technical sense, it is a suspended growth activated sludge system that utilises a clarifier for solid/liquid separation, followed by tertiary treatment through filtration and disinfection.

The system incorporates a proprietary biological treatment process using extended aeration. The treatment process provides flexibility in flow demands, in addition to a high standard of effluent quality with virtually no odours. The clarifier further removes suspended solids from the liquid and the clarifier sludge forms an integral part of the biological process.

Flow balancing is incorporated into the design of the plant to enable the daily peaks to be absorbed, while the normal treatment processes are undertaken. This enables the plant to spread the load over the day resulting in a higher quality final effluent being produced.

Aeration is undertaken in the aeration tank using fine bubble membrane diffusers. Dissolved oxygen monitoring and variable speed control of the aeration equipment is used to maximise plant power efficiency while providing the ideal conditions for optimum wastewater treatment.

Media filtration (Sand Filter) and Ultra Violet (UV) lamps provides the disinfection stage in the plant to destroy liquid bound virus and bacteria.

The UV disinfection removes the E Coli present in the fluid to achieve the required standard of effluent continuously.

The entire treatment plant is automatically controlled by a control system that also allows for manual process intervention.

1.3 AS Waste Water Treatment Plant Process Flow

The composition and volume of wastewater entering the plant varies depending on the number of people using the system. This variability alters the strength and volume of the raw sewage that enters the treatment plant, therefore, impacting the effluent quality leaving the sewage treatment plant after effluent treatment processes have been complete.

The principal producers of wastewater that forms the sewage that is fed into the treatment plant, typically includes that of laundry and shower facilities, kitchen wastewater, and toilet amenities.

Table 1 details the expected Grantham influent characteristics

Parameter	Value	Range
pH		6.5-8.5
Suspended Solids	mg/L	200-450
BOD_5	mg/L	220-450
COD	mg/L	400-800
Ammonia Nitrogen	mg/L	30-75
Total Phosphorous	mg/L	Oct-16
Sulphate	mg/L	20-75
Alkalinity	mg/L	150-250
Total Dissolved Solids	mg/L	250-750

Table 1 Influent Characteristics

The Grantham wastewater treatment plant has been designed to treat the influent to meet the following effluent characteristics and meet the DERM discharge license requirements.

Parameter	Required	Release limit
pH	6.5-8.5	range
Turbidity	<5NTU	80th percentile
Suspended Solids	<15mg/L	80th percentile
BOD_5	<10mg/L	80th percentile
Total Nitrogen	<5mg/L	50th percentile
Total Phosphorous	<2mg/L	50th percentile
Residual Chlorine	0.7mg/L free chlorine	Minimum
Faecal Coliform	<10cfu/100ml	95th percentile

Table 2 Effluent Requirements

ERRATA

Page 7 - Section 1- Table 1 – Replace Oct-16 with 10-16

Page 11 – Section 1.3.2 – Insert following photographs and table

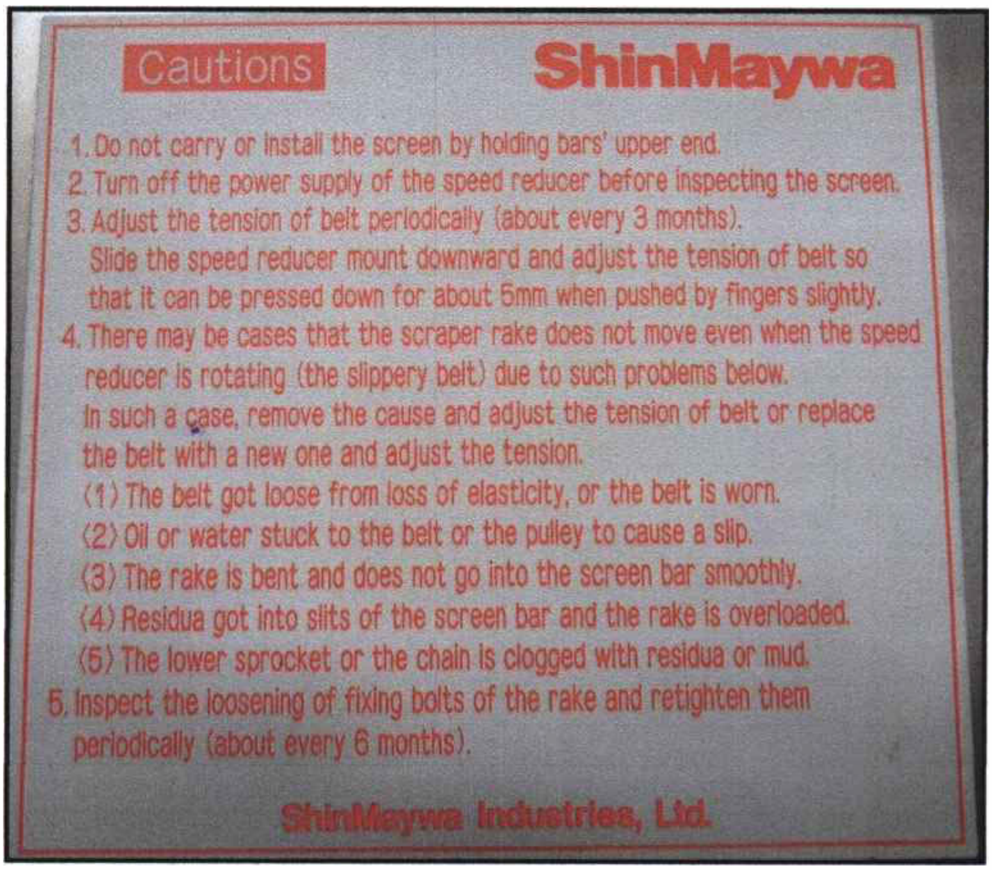


Figure 1 Inlet Screen - Belt Maintenance

	Activity	Frequency
1	Lubricate chain drive using approved silicone based lubricant or grease	Monthly
2	Remove chain by loosen the 12mm bolt head on the bottom right hand side of the screen to remove the bottom support shaft. Once the bottom shaft is removed the top shaft can be loosened. The chains can be removed once both shafts have been removed.	Annually
3	Degrease the chains if necessary. If large amount of grit and other build up is present on the surface of the chain, it is recommended that the chains are degreased. A kerosene or citric acid based degreaser can be used, or approved equivalent.	Annually
4	Using Vernier callipers, measure the distance between 5 links, record this value and calculate the current link length by dividing the total length by 5 to produce the length between each link. Refer Figure 2 for more details.	Annually
5	If the link length has increase by 10% of the original value the chain is to be replaced.	Annually

Figure 2 Inlet Screen – Chain pitch

Figure 3 Inlet Screen – Chain drive

The treatment plant can be broadly separated into key equipment items and processes that include:

- the influent screen
- the screened influent sump
- the balance tank
- the aeration system
- the anoxic and aeration tanks
- the clarifier
- the Clarified tank
- Media filtration
- U.V. disinfection
- the solids digester tank
- the final effluent tank
- The irrigation scheme.

Each of the key equipment items and processes require auxiliary equipment to transfer process liquids and control operation of the treatment plant. These auxiliary equipment items include:

- pumps
- gauges
- meters
- sensors
- valves

NOTE!

The treatment plant is controlled by a PLC control unit that operates the key and auxiliary equipment items. The interface for controlling and operating the treatment plant is located in the control room.

1.3.1 Inlet Screen

Raw sewage is pumped to the wastewater treatment plant via the Grantham effluent reticulation scheme.

The raw sewage enters the plant though a bar screen which separates the sewage solids and liquid.

The bar screen uses a one millimetre screen to separate the solids and the liquid, whereby the solids are scraped from the surface and discarded in a bin and the screened sewage liquid gravity feeds via a sump into the balance tank.

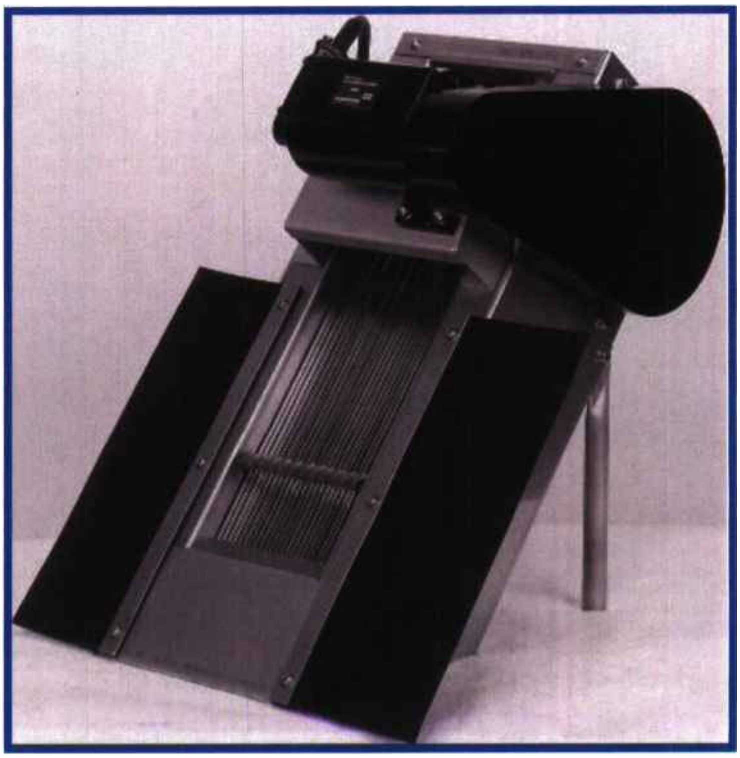


Figure 2 ShinMaywa Inlet Screen

1.3.2 Inlet Screen - General Maintenance

WARNING!

INLET SCREEN CAN START AUTOMATICALLY
ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE

	Activity	Frequency
1	• Visually inspect Screen and record observations on log-sheets	Daily
2	• Check screen bars are clear of debris and that there are no large gaps	Daily
3	• Clean screen and sump (Washdown)	Daily
4	• Service screen chain drive	Annually

Table 3 Inlet Screen-General Maintenance

	Activity	Frequency
1	• Check and record sump level	Daily
2	• Check and clean sump sensor.	Monthly

Table 4 Inlet Screen-Sensor Maintenance

	Activity	Frequency
1	• Visually inspect pipe-work	Daily
2	• Check all valves for signs of corrosion. • Clean valve bodies and apply corrosion protection as required	Weekly
3	• Check operation of all valves by opening and closing through range of motion.	Weekly

Table 5 Inlet Screen - Valve Maintenance

1.3.3 Balance Tank

The screened sewage is transferred to the balance tank where it is stored, before being pumped to the anoxic and aeration tanks.

The balance tank has an operating volume of 45,000L (45m³)

The balance tank allows the treatment plant to capture and control inflow when it is greater than the production capacity of the plant.

Screened raw sewage is fed from the bar screen sump into the aerated flow balance tank.

Aeration is supplied via the air blower's reticulation system.

This tank is critical to protect the plant from hydraulic surges, and provides smoothing of peak loads onto downstream processes

The raw sewage is pumped to the Anoxic tank at a controlled rate by way of the balance pumps.

Entrained suspended solids from the media filters are fed to the Balance tank during media filtration backwash cycle.

Figure 3 Balance Tank

The excess flows during peak periods is stored in the balance tank and gradually introduced to the treatment plant via the balance pumps during off peak periods.

1.3.4 Balance Tank & Balance Pumps - General Maintenance

WARNING!

BALANCE TANK PUMPS START AUTOMATICALLY.
ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE

WARNING!
BALANCE TANK IS A CONFINED SPACE.
DO NOT ENTER WITHOUT APPROPRIATE PERMITS, EQUIPMENT, TRAINING AND PERSONNEL

	Activity	Frequency
1	○ Visually inspect tank and record observations on log-sheets	Daily
2	○ Check and confirm operation of balance tank pumps P-102A and P-102B	Daily
3	○ Clean pump P-101 and P-102 casing and check for signs of corrosion	Daily
4	○ Service Balance Pumps P-101 and P-102	Annually

Table 6 Balance Tank - General Maintenance

	Activity	Frequency
1	○ Check and record tank level	Daily
2	○ Check and clean level sensor.	Monthly

Table 7 Balance Tank - Sensor Maintenance

	Activity	Frequency
1	○ Visually inspect pipe-work	Daily
2	○ Check all valves for signs of corrosion. Clean valve bodies and apply corrosion protection as required	Weekly
3	○ Check operation of all valves by opening and closing through range of motion.	Weekly

Table 8 Balance Tank - Valve Maintenance

1.3.5 Biological (Aeration-Anoxic) System

The biological treatment system is based upon the Modified Ludzak-Ettinger (MLE) treatment process. The process is a compartmentalised process consisting of separate reaction volumes for the Anoxic and Aerobic processes.

A basic process flow is presented in the following Figure.

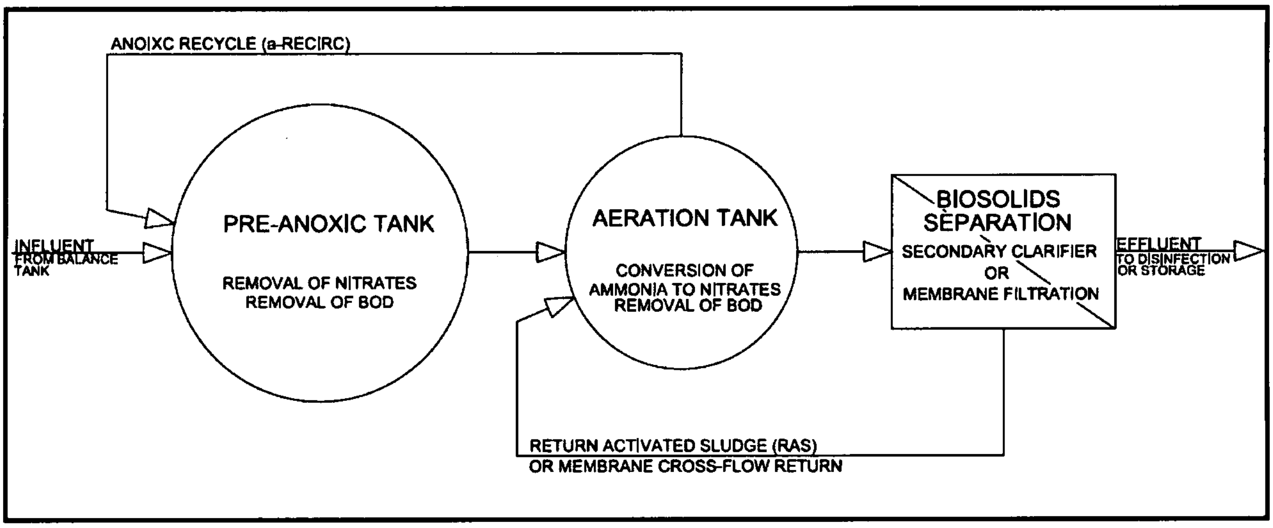


Figure 4 Biological Process Train

The system utilises 'a' recycle in order to provide nitrates to the pre-anoxic zone, where contact with fresh influent BOD and the lack of an active aeration system results in the formation of anoxic conditions, resulting in the conversion of Nitrates into nitrogen gas (with the subsequent release to atmosphere).

Nitrates are created in the aeration zone once the available BOD has been utilised by the bacteria present by bacteria able to metabolise Ammonia (this process requires the presence of oxygen).

The balance of the anoxic recycle rate, the aeration rate, the volume of air entrained in the recycle, and the availability of BOD/COD are all critical in achieving satisfactory results with this process.

1.3.6 Aeration System

The aeration system is comprised of two air blowers and the associated valves and piping that deliver process air to the:

- aeration tank;
- balance tank; and
- Digester tank.

The aeration levels are closely controlled in the aeration tank as they determine the amount of dissolved oxygen in that tank, which in turn affects how the sewage is broken down by the oxygen dependent micro-organisms.

Figure 5 Aeration System Blowers

NOTE!

Aeration minimises the amount of odour the treatment plant emits.

1.3.7 Anoxic Tank

Screened raw sewage is pumped from the balance tank to the anoxic tank by the duty balance pump with standby operation managed by the standby balance pump (P101 and P102). Balance flow rate is at a pre-set rate from the balance tank to the anoxic tank.

The screened influent enters the anoxic tank through a de-aeration chamber which is essentially a vertical pipe of circa 300mm diameter that by way of the vertical column of liquid formed applies pressure on entrained air to allow continuous de-gassifying of this air out of the chamber.

The anoxic tank has an operating volume of 36,000L (36m^3) which is continuously mixed by the anoxic mixer (MX101).

The anoxic mixer turns over the anoxic tank continuously to promote a healthy anoxic zone and prevent settling. The mixer operates continuously when there is sufficient fluid in the anoxic tank.

Returned mixed liquor from the aeration tank is also fed into the anoxic tank, this is known as the ‘a’ Recycle.

The 'a' Recycle system returns biomass rich in nitrates from the aeration tank to the anoxic tank for denitrification.

The 'a' recycle pump (P103) operates on a time run and time stop sequence. The run time and rest time can be set in the SCADA. The 'a' Recycle pump is controlled by a PID loop to achieve the desired flow rate.

Within the anoxic tank the liquor is maintained in an anoxic state where the dissolved oxygen level is below 0.5mg/l. This level is needed to maintain a consistent level of denitrification which breaks down the sewage.

Denitrification

Denitrification is the process where nitrate is removed from the liquor in the anoxic tank and converted to nitrogen gas.

For denitrification to occur four key elements are required;

- Bacteria;
- Food for the bacteria to consume (BOD);
- Nitrates; and
- Anoxic conditions i.e. Free of dissolved oxygen (DO)

In technical terms the biological reduction of nitrate (NO3) to nitrogen gas (N2) by *facultative heterotrophic* bacteria is called Denitrification.

"*Heterotrophic*" bacteria need a carbon source as food to live. (In the form of raw sewage (BOD) and/or supplemental carbon dosing; molasses, dog food etc)

"*Facultative*" bacteria can get their oxygen by taking dissolved oxygen out of the water or by taking it off of nitrate molecules. In this case, nitrates supplied by the returned biomass, rich in nitrates, from the aeration tank via the 'a' recycle system.

Denitrification occurs when oxygen levels are depleted and nitrate becomes the primary oxygen source for microorganisms.

The process is performed under anoxic conditions, when the dissolved oxygen concentration is less than 0.5 mg/L, ideally less than 0.2mg/L.

When bacteria break apart nitrate (NO3-) to gain the oxygen (O2), the nitrate is reduced to nitrous oxide (N2O), and, in turn, nitrogen gas (N2). Since nitrogen gas has low water solubility, it escapes into the atmosphere as gas bubbles.

Free nitrogen is the major component of air, thus its release does not cause any environmental concern.

Therefore for denitrification to occur the anoxic tank must be free of dissolved oxygen and there must be a source of nitrate, (supplied by the 'a' recycle from the aeration tank.)

IMPORTANT!

Effluent rich in nitrogen is very harmful to the environment and can cause algal blooms in waterways which causes fish kills and can damage the entire ecosystem.

1.3.8 Anoxic Tank & 'a' Recycle pump - General Maintenance

WARNING!

ANOXIC MIXER STARTS AUTOMATICALLY
ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE

WARNING!

ANOXIC RECYCLE PUMPS START AUTOMATICALLY
ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE

WARNING!

ANOXIC TANK IS A CONFINED SPACE
DO NOT ENTER WITHOUT APPROPRIATE PERMITS, EQUIPMENT, TRAINING AND PERSONNEL

	Activity	Frequency
1	• Visually observe mixing pattern within anoxic tank. • Record any deviations on the log-sheet	Daily
2	• Check tank Dissolved Oxygen and pH levels using a handheld probe. • Ensure that measurement is being taken outside the inlet baffle. • Record observations on the log-sheet	Daily
3	• Hose down any accumulated scum or foam	Daily
4	• Check operation of Anoxic Recycle Pump (P103)	Daily
5	• Check and record total flow and instant flow of Anoxic Recycle Pump (P103). • Compare to set-point.	Daily

6	○ Conduct a 30min Settled Sludge Volume (SSV) Test. Record results on results sheet	Daily
7	○ Once per week, take a sample and test for Nitrate + Nitrite, Ammonia and Alkalinity using the field test kit. Sample may require settling or filtration. ○ Record results on results sheet.	Weekly
8	○ Lift and check mixer for signs of wear or damage	Quarterly
9	○ Lift and Service Anoxic Mixer	Annually

Table 9 Anoxic Tank General Equipment Maintenance Summary

	Activity	Frequency
1	○ Check operation of 'a' Recycle Pump flowmeter. ○ Record total flow and instant flow and compare with SCADA set-point	Daily
2	○ Check calibration of 'a' recycle flowmeter using draw-down test or calibrated hand-held flowmeter	Annually or as Required
3	○ Check operation of MLSS Meter. Record readings	Daily
	○ Perform basic cross-check using SSV or SVI test (conversion factor from MLSS Testing)	Weekly (MLSS Test Monthly)
4	○ Take MLSS Samples. Perform calibration and store as per instruction Manual. ○ Send samples to lab for suspended solids analysis. ○ Enter calibration points upon receipt of results.	Annually or as Required

Table 10 Anoxic Tank Sensor Summary

	Activity	Frequency
1	○ Check each valve for signs of corrosion or damage. ○ Dust valves and apply corrosion protection as necessary	Weekly
2	○ Open and close valves through full range of movement. ○ Ensure pumps are Off during this. ○ Note any problems on the log-sheets	Weekly

Table 11 Anoxic Tank-Valve Maintenance Summary

1.3.9 Aeration Tank

Mixed liquor from the anoxic tank flows into the aeration tank via a mid level gravity feed system. This hydraulically links the two tanks, such that the levels in both tanks increase and decrease at the same time.

The aeration tank has an operating volume of 46,000L ($46m^3$)

The aeration tank uses fine bubble aeration from the aeration system to maintain the dissolved oxygen levels in the tank. (The air is forced through Rehau diffusers)

Air for the diffuser system is supplied by a set of 2 blowers, running in a duty/duty assist/standby arrangement, with the air injection rate being controlled by a Dissolved Oxygen Probe and variable speed drives on the blowers.

The dissolved oxygen content is critical to the nitrification process which is used to breakdown ammonia (NH3) present in the sewage.

The aeration tank provides oxidation of the BOD and Ammonia present.

BOD is oxidised to Carbon Dioxide with the creation of new cellular biomass (or the maintenance of existing cellular biomass), whereas Ammonia is oxidised to Nitrates via the Nitrification process (producing Nitrates and new cellular biomass).

Nitrification occurs once all the available BOD is removed from the sewage.

Nitrification

The biological conversion of ammonium to nitrate nitrogen is called Nitrification.

Nitrification is a two-step process.

1. Bacteria known as *Nitrosomonas* convert ammonia and ammonium to nitrite.
2. Bacteria called *Nitrobacter* finish the conversion of nitrite to nitrate.

The reactions are generally coupled and proceed rapidly to the nitrate form; therefore, nitrite levels at any given time are usually low.

These bacteria known as “nitrifiers” are strict “aerobes,” meaning they must have free dissolved Oxygen (DO) to perform their work.

Nitrification occurs only under aerobic conditions at dissolved oxygen levels of 1.0 mg/L or more (typically around 1.6mg/L).

At dissolved oxygen (DO) concentrations less than 0.5 mg/L, the growth rate is minimal.

Nitrification requires:

- a long retention time,
- a low food to microorganism ratio (F:M),

- a high mean residence time (Sludge Age), and
- pH control

The nitrates and nitrites are then pumped into the anoxic tank via the 'a' recycle system.

IMPORTANT!

The growth of Nitrosomonas and Nitrobacteria is also dependent on ambient temperature and sludge age, (the average lifespan of bacteria in the system). A 6°C drop temperature can halve the growth rate of the organisms. For this reason, longer sludge ages are required during winter to ensure nitrification occurs, however, 20-30 days sludge age is sufficient for winter temperatures in Australian conditions. The design sludge age of the STP is 20-30 days, which is sufficient to ensure consistent nitrification all year round.

IMPORTANT!

Nitrification is very dependent on pH and is inhibited if the pH is outside the 7 to 8.5 range. The pH can fall during the nitrifying stage, however, this can be rectified by running the treatment plant in a denitrifying mode. .

NOTE!

The dissolved oxygen meter (DO101) in the aeration tank regulates the rate of air that is being transferred to the tank from the aeration system.

Page 20 –Section 1.3.8 Insert table

	Activity
1	Isolate the anoxic mixer via the SCADA screen, MCB lock out in the MCC and finally at the field isolator on the mixer stand.
2	Loosen the nuts on the pipe clamp supporting the mixer pole in the tank. A second person is necessary to support the weight of the mixer pole.
3	Remove the nuts and the front face of the pipe clamp. Together take the weight of the mixer pole and slowly raise the pole out of the tank.
4	Rotate the mixer up onto the side of the manhole and hose off any residual activated sludge back into the tank.
5	Once the mixer is clean, lift the mixer pole up onto the access way.
6	Inspect the propeller on the mixer for ragging or other contaminants. Remove as necessary.
7	If there are signs to indicate water has entered the mixer, do not attempt to repair. Remove the mixer and send back to the supplier for a replacement.
8	Reinstall the mixer by placing the mixer pole back into the man hole and reinstalling the pipe clamps.
9	Un-isolate the mixer by reversing Step 1.
10	Ensure sufficient mixing pattern and no surging is present in the anoxic tank. If surging occurs, loosen the pipe clamp and slightly rotate the direction of the mixer to provide a clockwise rotation around the tank.

Table 1 Anoxic Mixer maintenance procedure

Figure 6 Aeration Tank

The net result of the nitrification denitrification process is a very low total nitrogen concentration in the final effluent.

NOTE!

Total Nitrogen (TN) consists of Ammonia (NH_3), organic nitrogen (Org-N), Nitrate (NO_3) and Nitrite (NO_2); therefore $TN=NH_3+NO_3+NO_2+Org\text{-}N$

1.3.10 Aeration Tank - General Maintenance

WARNING!

AERATION BLOWERS START AUTOMATICALLY

ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE

WARNING!

AERATION TANK IS A CONFINED SPACE

DO NOT ENTER WITHOUT APPROPRIATE PERMITS, EQUIPMENT, TRAINING AND PERSONNEL

	Activity	Frequency
1	• From the access platform, visually inspect tank for colour, foaming and the shape and formation of the bubble plume. • Record observations on log-sheet	Daily

	Activity	Frequency
	• From the access platform, hose down any excessive foam or scum	Daily
2	• From the access platform hose down walls and equipment to remove any built up sludge scum or gunge	Daily
3	• From the access platform, lift DO sensor and clean end using damp cloth or lens wipe	Daily
4	• Check and confirm operation of aeration blowers. • Start and stop manually via SCADA	Daily
5	• Check DO trend on SCADA. Record observations on log-sheet	Daily
6	• Take DO and pH readings using hand-held meter. Record on log-sheet	Daily
7	• Conduct 30min SSV Test. • Record on log-sheet	Daily
8	• Once per week collect a sample and test for Ammonia, Nitrate + Nitrite, Alkalinity and Phosphorous. • Record on log-sheet	Weekly
9	• Isolate blowers.(P203 & P204) . • Open side panel and check drive belt tension (±10mm), tighten as necessary. • Check Filter, replace or service as necessary or after 6 months (whichever is sooner).	Weekly
10	• Isolate blowers. • Open side panel and grease bearings using grease gun. • Check oil level	Monthly
11	• Isolate blowers. • Open side panel and grease and replace blower Oil. • Replace filter.	6-Monthly
12	• Service Blowers	Annually

Table 12 Aeration Tank - General Maintenance

	Activity	Frequency
1	• From the access platform, lift DO sensor and clean end using damp cloth or lens wipe	Daily
2	• Check accuracy of DO sensor against handheld DO Probe. Ensure Probe is calibrated	Daily
3	• Check and record level in Aeration Tank	Daily
4	• Lift DO Sensor from tank and perform air-saturation calibration	Monthly
5	• Service DO sensor and replace sensor head	Quarterly

Table 13 Aeration Tank - Sensors Maintenance

	Activity	Frequency
1	• Check all valves for signs of damage or corrosion. • Dust valves and apply corrosion protection as required	Daily
2	• Operate valves through range of motion. • Ensure any pumps or equipment are not operating while doing so. • Note any difficulty in operation	Weekly

Table 14 Aeration Tank - Valves Maintenance

1.3.11 Phosphorous Removal

Phosphorous is removed using chemical coagulation by dosing the sewage with sodium Aluminate solution. Sodium Aluminate precipitates dissolved phosphorous, which is removed though sludge wasting.

The Sodium Aluminate is pumped from the 500L bunded tank by P104 into the aeration tank

The dose of chemical can be increased or decreased to adjust the concentration of phosphorus in the effluent, and some operator intervention will be required to keep the system running optimally.

The sodium Aluminate store is located in the chemical storage area in the control room container.

The precipitated phosphorous settles out in the aeration tank and is wasted from the system with the Waste Activated Sludge (WAS).

In addition to precipitation of phosphorous, Sodium Aluminate aids in alkalinity maintenance, both through the production of Hydroxide ions in the reaction itself, and the fact that the solution is provided on a caustic basis (i.e. contains a part caustic soda).

It should be noted, however, that Sodium Aluminate alone may not provide sufficient alkalinity to maintain the Nitrification process, and as such, alkalinity testing and balancing is an important part of overall process monitoring.

Figure 7 Sodium Aluminate Dosing pump

1.3.12 Phosphorous System General Maintenance

WARNING!

DOSING PUMP STARTS AUTOMATICALLY.
ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE
(OTHER THAN PUMP BLEEDING)

WARNING!

SODIUM ALUMINATE IS A CAUSTIC CHEMICAL

CONSULT MATERIAL SAFETY DATA SHEETS. ALWAYS WEAR CHEMICAL RESISTANT SAFETY GLOVES AND SAFETY GLASSES WHEN HANDLING

	Activity	Frequency
1	○ Check pump (P104) for gas-locking, bleed pump as necessary	Daily
2	○ Check and confirm operation of dosing pump	Daily
3	○ Check dosing head for signs of chemical or precipitate build up	Weekly
4	○ Clean dosing pump casing and dosing head using warm water and detergent	Monthly
5	○ Dismantle and clean dosing head, check diaphragm and seals for signs of wear or damage	Quarterly
6	○ Service dosing pump	Annually

Table 15 Sodium Aluminate Dosing - General Maintenance

	Activity	Frequency
1	○ There are no sensors associated with this process	N/A

Table 16 Sodium Aluminate Dosing - Sensors Maintenance

	Activity	Frequency
1	○ Check all valves for signs of damage or corrosion. ○ Dust valves and apply corrosion protection as required	Daily
2	○ Operate valves through range of motion. ○ Ensure any pumps or equipment are not operating while doing so. ○ Note any difficulty in operation	Weekly
3	○ From the Aeration Tank access way, check loading valve for signs of precipitation or clogging. ○ Clean as required	Daily

Table 17 Sodium Aluminate Dosing - Valve Maintenance

The sodium Aluminate pumps should be inspected daily to ensure that they are operational.

Care should be taken to check for gassed liquid gas-locking the pump lines, which will cause the metering pump to lose its prime.

The chemical dosing pumps should also be cleaned on a weekly basis.

The sodium Aluminate supply will need to be inspected on a daily basis to ensure levels are adequate for dosing requirements. If the level is below half full a new drum will need to be ordered.

1.3.13 Clarifier

Liquor is gravity fed from the aeration tank to the inlet of the clarifier.

The Grantham clarifier is a 4 hopper clarifier (constructed from grade 316 stainless steel) with an operating volume of 7,800L (7.8m^3)

The clarifier forms a key part in the treatment process to reduce the suspended solids in the final effluent.

The clarifier is designed to provide sufficient retention time in the clarifier to allow larger solids to settle out into the hoppers located at the base of the clarifier.

Typically, conventional activated sludge, settles at 1.35 m/hr.

An energy dissipating inlet (EDI) is used to reduce the velocity and control the direction of the liquid entering the clarifier. The EDI avoids fluid short circuiting across the clarifier by directing the flow downwards to ensure the desired retention time is achieved.

The outlet launder uses a V notch weir design to control the velocity surrounding the launder. The upflow velocity in the clarifier is kept below 3.5m/hr under normal operating conditions.

A return activated sludge (RAS) system is used to return sludge from the base of the clarifier to the bioreactor, to maintain the desired mixed liquor suspended solids (MLSS) concentration.

A surface skimmer is used to remove floating sludge and containments from the surface of the clarifier. Without a surface skimmer the lighter sludge and other containments would pass through the outlet weir to the final effluent tank.

1.3.14 Clarifier - General Maintenance

WARNING!

RAS PUMPS START AUTOMATICALLY

ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE

Page 25 Section 1.3.9 Insert table

	Activity
1	Turn the air OFF to the diffuser to be serviced by closing the ball valve on top of the aeration tank off the main header where the pipe enters the tank.
2	Once the air is off, remove the manhole cover to access the diffuser pipe work.
3	Unscrew the barrel union located on the inside of the tank which is accessed via the man hole.
4	Once the barrel union is undone, the pipe work can be rotated toward the man hole and the base will lift out of the support ring.
5	As the aeration dropper is removed attempt to wash as much activated sludge back into the tank as possible.
6	Once the diffusers become visible above the water line, loosen the backing nut of the back of each diffusers. Care must be taken during this step to avoid dropping any of the diffuser parts into the aeration tank
7	Remove the diffuser, backing nut and the two pipe connectors.
8	The diffuser can now be cleaned using a mild detergent and water. Avoid pressure cleaning the diffusers as the silicone membrane can be damaged.
9	Reinstall the diffusers by reversing Steps 1 – 7. Tip: Diffusers must be installed inside the tank as they will not fit through the man hole if they are fitted to the dropper outside of the tank.

Table 2 Aeration Tank –Diffuser maintenance

Page 29 – Section 1.3.13 Replace containments with contaminants

Figure 8 Clarifier – External View

Figure 9 Clarifier – Internal View

1.3.15 Clarifier Tank

The Clarified tank stores liquor laundered from the clarifier for supply to the tertiary treatment requirements of the wastewater treatment process. The clarifier tank has an operating volume of 10,000L (10m^3).

	Activity	Frequency
1	• From access way visually observe performance of clarifier (colour, presence or loss of solids, foaming or scumming, etc). • Note any changes on log-sheet	Daily
2	• From access way, visually observe condition	Daily
3	• From access way, gently skim any floating sludge towards the scum Skimmer (Check air skimmer operational)	Daily
4	• Drain and clean clarifier.	Annually
5	• Check RAS pump operation. • Record timer settings on log-sheet. Note any changes to timers	Daily
6	• Observe operation of RAS pumps. • Note any peculiarities or changes on log-sheet	Daily
7	• Service RAS pump	Annually

Table 18 Clarifier General Maintenance

	Activity	Frequency
1	• There are no sensors associated with this process	N/A

Table 19 Clarifier -Sensor Maintenance

	Activity	Frequency
1	• Open RAS pump trim valve fully to flush any accumulated detritus. • Return valve to operating position	Daily
2	• Check all valves for signs of damage or corrosion. • Dust valves and apply corrosion protection as required	Daily
3	• Operate valves through range of motion. • Ensure any pumps or equipment are not operating while doing so. Note any difficulty in operation	Weekly

Table 20 Clarifier Valve Maintenance

NOTE!

The clarifier removes suspended solids from the liquid to produce the required effluent standard.

Figure 10 Clarified tank

1.3.16 Clarified Tank - General Maintenance

WARNING!

CLARIFIED TANK IS A CONFINED SPACE.

DO NOT ENTER WITHOUT APPROPRIATE PERMITS, EQUIPMENT, TRAINING AND PERSONNEL

	Activity	Frequency
1	• Visually inspect tank and record observations on log-sheets	Daily

Table 21 Clarified Tank - General Maintenance

	Activity	Frequency
1	• Check and record tank level	Daily
2	• Check and clean level sensor.	Monthly

Table 22 Clarified Tank – Sensor Maintenance

	Activity	Frequency
1	• Visually inspect pipe-work	Daily
2	• Check all valves for signs of corrosion. Clean valve bodies and apply corrosion protection as required	Weekly
3	• Check operation of all valves by opening and closing through range of motion.	Weekly

Table 23 Clarified Tank - Valve Maintenance

1.3.17 Media Filtration

There are two media filters installed in parallel to assist in the removal of suspended solids from liquor (crossflow) supplied from the clarified tank.

The media used is sand and consists of the following graded material:

- Sand – sized nominally 0.8mm – 1.8mm
- Sand – sized nominally 1.5mm – 3.0m
- Gravel – sized nominally 6.0mm to 12.0mm

The crossflow is pumped down through the media via the Crossflow pumps P301 and P302.

Laterals installed within the filter allow water to be discharged but retain the media within the filter.

A filter backwash cycle is installed where treated effluent is supplied from the final effluent tank via the backwash pump P303.

The backwash from the filters is returned to the balance tank for re-treatment.

The backwash cycle is triggered by a pre-determined differential pressure between filter inlet and outlet.

Figure 11 Media filters

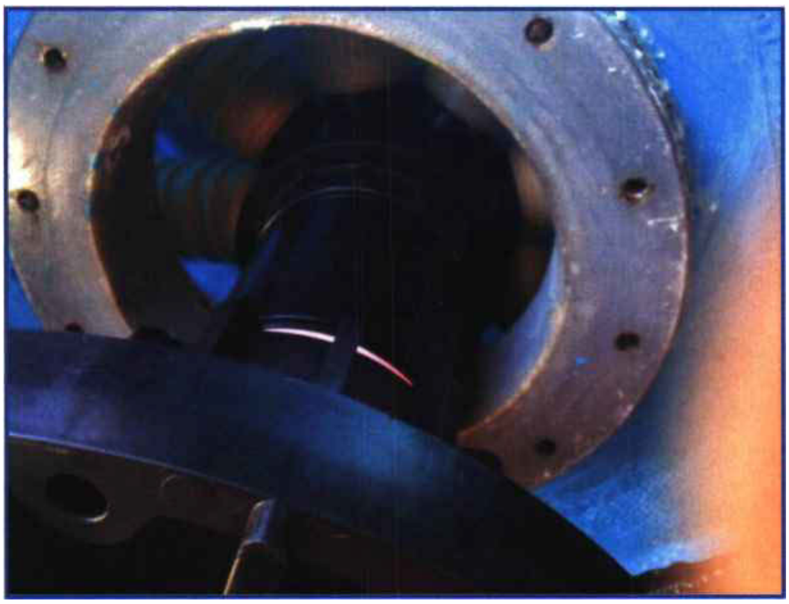


Figure 12 Media filter laterals

1.3.18 Media Filters - General Maintenance

WARNING!

MEDIA FILTER IS A CONFINED SPACE.

DO NOT ENTER WITHOUT APPROPRIATE PERMITS, EQUIPMENT, TRAINING AND PERSONNEL

ENSURE CROSSFLOW AND BACKWASH PUMPS ARE ISOLATED BEFORE UNDERTAKING ANY MAINTENANCE

	Activity	Frequency
1	• Ensure media filters are clean, washdown if required	Daily
2	• Drain and clean filters.	Annually
3	• Check Crossflow pump (P301, P302) operation.	Daily
4	• Check Crossflow pumps for damage & corrosion	Daily
5	• Check Backwash pump (P303) operation.	Daily
6	• Check Backwash pump for damage & corrosion	Daily
7	• Service Crossflow and Backwash Pumps	Annually
8	• Observe operation of Crossflow and Backwash pumps. Note any peculiarities or changes on log-sheet	Daily

Table 24 Media Filters General Maintenance

	Activity	Frequency
1	• Check all valves for signs of damage or corrosion. • Dust valves and apply corrosion protection as required	• Daily
2	• Operate valves through range of motion. • Ensure any pumps or equipment are not operating while doing so. Note any difficulty in operation	• Weekly

Table 25 Media filter Valve Maintenance

1.3.19 UV Disinfection

Ultraviolet (UV) disinfection is a physical process that instantaneously neutralises microorganisms as they pass by ultraviolet lamps submerged in the effluent.

The process adds nothing to the water but UV light, and therefore, has no impact on the chemical composition or the dissolved oxygen content of the water. In that respect, it ensures compliance with ever-tightening wastewater effluent discharge regulations.

UV is the only cost-effective disinfection alternative that does not have the potential to create or release carcinogenic by-products into the environment and effectively removed Ecoli from the filtered effluent. In addition, UV is an effective disinfectant for chlorine-resistant protozoa like Cryptosporidium and Giardia.

The Grantham WWTP UV system uses two lamps in parallel.

Filtered effluent is passed through the UV system and into the final effluent tank an insertion meter post UV measures the filtered and disinfected effluent turbidity.

Figure 13 UV System

1.3.20 UV System-General Maintenance

WARNING!
ENSURE EQUIPMENT IS ISOLATED BEFORE UNDERTAKING ANY MAINTENANCE

FOLLOW MANUFACTURER'S INSTRUCTIONS!

1.3.21 Final Effluent Tank

The treated effluent is stored in the final effluent tank where it can be transferred via the treated effluent pumps (P404 and P405) to irrigation as required by compliance discharge conditions.

A final effluent tank recirculation pump (P401) circulates treated effluent and allows monitoring and control of disinfection by way of a CONEX unit and Sodium Hypochlorite (NaOCl) dosing system (P402)

The Sodium Hypochlorite (NaOCl) is stored in a bunded 200l tank

The CONEX unit is a chlorine analyser that measures Chlorine residue in the treated effluent as well as measuring temperature and pH.

A Reticulation pump (P403) provides treated effluent for general washdown purposes.

Figure 14 CONEX Unit

Figure 15 Sodium Hypochlorite dosing pump

1.3.22 Final Effluent - General Maintenance

WARNING!

SODIUM HYPOCHLORITE DOSING PUMP STARTS AUTOMATICALLY.
ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE

WARNING!

RECIRCULATION LOOP PUMP STARTS AUTOMATICALLY.
ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE

WARNING!

SODIUM HYPOCHLORITE IS A CAUSTIC CHEMICAL
CONSULT MSDS. ALWAYS WEAR CHEMICAL RESISTANT SAFETY GLOVES (LATEX OR SIMILAR) AND SAFETY GLASSES WHEN HANDLING

WARNING!

FINAL EFFLUENT TANK IS A CONFINED SPACE

DO NOT ENTER WITHOUT APPROPRIATE PERMITS, EQUIPMENT, TRAINING AND PERSONNEL

	Activity	Frequency
1	• Check and observe operation of Chlorine Recirculation pump	Daily
2	• Check and observe operation of Sodium Hypochlorite dosing pump	Daily
3	• Check dosing fittings for leaks. Tighten as necessary	Daily
4	• Check hypochlorite pump for gas locking. Bleed as necessary	Daily
5	• Check and record level of chlorine storage. Replace as necessary	Daily
6	• Check pH and DO of effluent	Daily
7	• Collect sample of Effluent and perform field test for Ammonia, Nitrate + Nitrite, Phosphorous and Alkalinity	Weekly
8	• Clean pump casings	Weekly
9	• Clean dosing head and dosing pump casing	Weekly
10	• Dismantle dosing head and check condition of Diaphragm and Seals	6-Monthly or as required
11	• Service Dosing pump	Annually
12	• Service Recirculation Pump	Annually
13	• Visually inspect tank and record observations on log-sheets	Daily

Table 26 Final Effluent - General Maintenance

Page 36-Section 1.3.18 Insert Table

	Activity
1	Isolate Crossflow and Backwash pumps on the SCADA screen and at the field isolators
2	Isolate the manual valves upstream and downstream of the filters.
3	Undo the barrel union located at the top of the filter. Remove the pipe work to provide access to the 4" flange on top of the filters.
4	Undo the bolts on the flange and remove the flange with the inlet diffuser still installed.
5	Using either a vacuum truck or a wet/dry vacuum, remove the media from the filter. Once the majority of the media has been removed the pipe work on the bottom of the filter can be disconnected and the filter can be rotated onto its side to assist in removing the remaining media.
6	The inside of the filter can be cleaned using a diluted chlorine solution and a pressure cleaner.
7	Install media as per the following schedule: • **First** - Product Number 4 (6-12mm) Gravel = Total 26 bags • **Second** - Product Number 6 (1.5-3.0mm) Sand = Total 8 bags • **Third** - Product Number 6.5 (0.8-1.8mm) Sand = Total 44 bags Care must be taken when installing the first load of bags not to damage the laterals at the base of the filter. Once the laterals are covered the bags can be installed faster.
8	Once the media is installed, fill the filter will water and allow to soak for 4 hrs.
9	Reinstall the pipe work, un-isolate the valves and pumps.
10	Manually run a backwash cycle on the SCADA screen to remove any contaminates from the filters before filtrating.

Table 3 Filter media replacement procedure

	Activity	Frequency
1	• Check and record free chlorine residual reading from HMI.	Daily
2	• Conduct Free Chlorine analysis using field kit.	Daily
3	• Cross-Check result with chlorine meter. Recalibrate as necessary.	Daily
4	• Check Chlorine Analyser pH Probe reading using Buffer. Recalibrate as necessary	Monthly or as required
5	• Check and record level of Final Effluent Tank.	Daily
6	• Service Chlorine Analyser.	Annually

Table 27 Final Effluent - Sensor maintenance

	Activity	Frequency
1	• Check all valves for operation. Record observations on log-sheet	Daily
2	• Dust valve casings and apply corrosion protection as required	Weekly

Table 28 Final Effluent - Valve Maintenance

The level of Sodium Hypochlorite in the dosing tank should be checked daily, and the difference in level from the day before calculated, and used to calculate the volume used.

The dosing pumps should be visually observed daily, and cleaned on a monthly basis. Cleaning should consist of warm water and a phosphorous free detergent.

Every 6 months or when performance degrades, the pump head should be dismantled and the diaphragm checked.

A sample of the final effluent should be taken and checked for Chlorine, Ammonia, Nitrate + Nitrite, Phosphorous and Turbidity once per week, with results being recorded.

The chlorine result from the test should be checked to the reading of the on-line chlorine analyser.

The level of the final effluent tank should be checked and recorded. The Recirculation Pump should be inspected and cleaned on a daily basis, and serviced annually.

The composition of the effluent stored in the final effluent tank should include:

Parameter	Unit	50%ile	80%ile	95%ile	Range
Biochemical Oxygen Demand (BOD)	mg/L		<10		
Total Nitrogen (TN)	mg/L	<5			
Total Phosphorous (TP)	mg/L	<2			
Total Suspended Solids (TSS)	mg/L		<15		
pH Value					6.5 — 8.5
E Coli	cfu/100ml			<10	
Turbidity	NTU		<5		
Residual Chlorine	mg/L				0.7)min)

Table 29 Discharge License Requirements

Discharge license requirements for the Grantham wastewater Treatment Plant

These required effluent quality characteristics from the treatment plant are the emission limits to meet Class A requirements for re-use.

1.3.23 Solids Digester Tank

The organic solids that accumulate in the sewage treatment plant are pumped to the solids digester tank during the digestion operation that occurs once daily or as required.

During this process organic solids or sludge is pumped by the WAS pump

The Digester tank has an operating volume of 46,000L (46m^3)

The Grantham WWTP operates at a lower sludge age of approximately 25 days or less, in order to keep the solids loading at a level compatible with the secondary clarifier. This requires frequent sludge wasting.

Sludge is pumped from the aeration tank as fully mixed liquor, either based upon mixed liquor concentration or based upon an on/off time clock setting.

Sequenced aeration within the digester allows for the settling out of the sludge component, allowing displacement of clear supernatant from the digester during sludge wasting.

The clear supernatant gravity feeds back into the Balance tank.

This increases the sludge residence time in the digester, producing a thicker, more stable sludge and increasing the time between pump-out of the digester.

Over time the solids concentrate in the digester tank and break down through aerobic digestion. Aerobic digestion is a bacterial process occurring in the presence of oxygen, whereby bacteria rapidly breakdown the organic matter and convert it to carbon dioxide (CO2).

Air is supplied via the aeration system and forced through a set of Rehau diffusers.

The solids digester tank is fitted with an isolation valve and camlock fitting to allow removal of sludge via tanker removal.

NOTE!

The treatment plant's aeration system supplies the digester tank with air which aids in the aerobic digestion process, along with suppressing unpleasant odours.

Figure 16 Digester Tank

1.3.24 Sludge Management - General Maintenance

WARNING!

WASTE ACTIVATED SLUDGE PUMP STARTS AUTOMATICALLY.
ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE

WARNING!

DIGESTER AIR SUPPLY VALVE OPERATES AUTOMATICALLY.
ALWAYS ISOLATE BEFORE CONDUCTING MAINTENANCE

WARNING!

THE SOLIDS DIGESTER TANK IS A CONFINED SPACE
DO NOT ENTER WITHOUT APPROPRIATE PERMITS, EQUIPMENT, TRAINING AND PERSONNEL

WARNING!

ANAEROBIC CONDITIONS MAY RESULT IN HYDROGEN SULPHIDE GENERATION OR AN OXYGEN DEFICIENT ATMOSPHERE

The WAS sludge digester should be checked on a daily basis.

Operators should check the level of sludge within the digester, and the aeration plume pattern.

The digester air supply should be shut down and the sludge be allowed to settle, with operators observing the colouring the supernatant after settling.

The run time for the WAS pump should be checked and recorded.

The operation of the WAS air supply control valve should be checked by opening and closing the valve manually from the HMI.

	Activity	Frequency
1	• Check and Observe operation of WAS pump	Daily
2	• Check and Observe operation of WAS aeration control solenoid	Daily
3	• Check and Observe Sludge management aeration operation	Daily

4	• Check and Observe contents of digester tank. Record observations	Daily
5	• Service WAS Pump	Daily
6	• Check supernatant flow for entrained sludge. Record observations	Daily
7	• Arrange for Vacuum Tanker for removal of Sludge	As Required by wasting schedule

Table 30 Sludge Management - General Maintenance

	Activity	Frequency
1	• Operate all valves through range.	Weekly
2	• Clean valve casing and apply corrosion protection as necessary	Weekly
3	• Check and observe operation of air control solenoid valve	Daily

Table 31 Sludge Management-Valve Maintenance

1.3.25 Chemical Storage Room

The chemicals used in the process are stored in liquid form in a bunded area in the chemical store. All chemicals are pumped via metering pumps from the chemical store to the dosing point. An eyewash and chemical shower is situated outside the chemical storage area.

WARNING!

SODIUM HYPOCHLORITE IS A CAUSTIC CHEMICAL

CONSULT MSDS. ALWAYS WEAR CHEMICAL RESISTANT SAFETY GLOVES (LATEX OR SIMILAR) AND SAFETY GLASSES WHEN HANDLING

WARNING!

SODIUM ALUMINATE IS A CAUSTIC CHEMICAL

CONSULT MSDS. ALWAYS WEAR CHEMICAL RESISTANT SAFETY GLOVES (LATEX OR SIMILAR) AND SAFETY GLASSES WHEN HANDLING

	Activity	Frequency
1	• Check bunds for signs of spillage. • Arrange removal if spillage has occurred	Daily
2	• Check, prime and clean dosing pumps as per specific sections	Daily
3	• Check level of chemical in all chemical storage drums. • Refill or replace as necessary	Daily
4	• Organise replacement chemicals if storage levels are low. • Allow for lead and delivery time when ordering	As Required
5	• Sweep room floor	Daily
6	• Check and observe operation of safety shower. • Ensure wash-water is cool	Daily
7	• Check and observe operation of eyewash. • Ensure wash-water is cool	Daily

Table 32 Chemical Storage - Maintenance

The storage bunds within the chemical store need to be visually inspected daily for signs of leaks. Cleaning and removal of spilt chemicals needs to be conducted using spill absorbent kits. Once used the absorbent needs to be disposed of to a registered land fill and a new spill kit ordered.

Daily chemical usage should be noted on the log sheets, and the chemical stores should be inspected weekly to ensure that adequate chemical is available for dosing. If the stores are low they will need to be refilled or replaced.

The chemical dosing pumps should be inspected daily for loss of prime, and re-primed if the prime has been lost. The dosing pumps should also be cleaned on a weekly basis.

1.3.26 Automatic Control Systems

The treatment plant is equipped with an automated control system, allowing for automatic control of electrical equipment (pumps, motors, etc). In order to optimise the operation of the treatment plant operators will need to be familiar with the use of the control system.

The MCC controls both VSD and DOL pumps with VSDs externally mounted adjacent to the MCC

Pumps, blowers, and other process equipment are controlled by PLC's (Programmable Logic Controllers), which are fed information by various sensors installed into the process, and timers, which can be set by the operator.

This is used to control the overall process. In this manual a 'control element' is any mechanical device which is controlled by the switchboard, generally the motor for a pump or a blower.

The information collected by the plant PLC's is organised and presented using a Supervisory Control and Data Acquisition (SCADA) system.

This information is presented via an interface (HMI or Human Machine Interface, a PC computer), and is centrally organised for ease of reference.

The HMI also contains controls allowing for adjustment of process set-points, manual operation of equipment, trend logging and alarm logging. It's possible to control the plant completely from the HMI, however manual checking and cleaning of equipment is still required.

The following section gives an overview of the electrical control system, the switchboard, HMI, control loops and an overview of the HMI system and how to control system elements remotely.

1.3.27 Switchboard

DANGER!

ONLY LICENSED ELECTRICIANS TO ENTER SWITCHBOARD ENCLOSURE

The switchboard is located in the plant control room, next to the pump room.

The control panel contains a number of elements, including indicator lights, mode selector switches, and various information readouts.

While it is possible to perform basic element control from the switchboard, the majority of process control is conducted using the SCADA system.

The following sections explain the various switchboard elements in more detail.

Mode Selector switches

All control elements installed are capable of running in 2 modes: manual and automatic.

When in automatic mode the PLC controls the equipment.

In manual mode the operator is able to select whether the element is on, or off. When manually controlled from the switchboard PLC control of the piece of equipment is completely bypassed.

Changing modes is achieved by using a selector switch. The switches installed at this plant generally have 3 positions.

Manual or 'Man'

When in manual the motor connected runs constantly, unless it is isolated (turned off at its local power point) or an interlock device, or sensor (emergency low level stop, interlocked pump, etc), locks the piece of equipment out (prevents it from starting, generally to avoid damage to pumps or pipe-work).

Off

When in the 'off' position the element (motor, drive, light, etc) is 'off', and will not be allowed to start.

Auto

When in the 'auto' position the element is placed under the control of the PLC, which will start, stop, open or close the control element depending on its programming and process sensor input.

Figure 17 Form 1 MCC

Figure 18 Externally Mounted VSDs

1.3.28 Supervisory Control and Data Acquisition (SCADA)

The treatment plant is equipped with a Supervisory Control and Data Acquisition (SCADA) system that collects data from the process for control over various elements via Programmable Logic Controllers (PLC's).

Data is presented to the operators via a Human Machine Interface (HMI).

The HMI consists of a Personal Computer, running the SCADA program.

The SCADA program interfaces with the plants PLC (Programmable Logic Controller), and displays a large range of process data in an easy-to-follow graphical format.

From the HMI it is possible for operators to monitor various process parameters (tank level, pump speed, Dissolved Oxygen concentration, the run status of various pieces of equipment, etc), to make adjustments to the treatment plant controls set points (pump start levels, dissolved oxygen concentration set-points, timer setpoints, etc), and to initiate various process activities.

1.3.29 Human Machine Interface (HMI)

General Use of the HMI

Various aspects of the HMI are available through 'clicking' with the mouse.

Equipment is represented by various icons on the screen, which are connected via arrows showing basic process arrangements. This is roughly analogous to the P&ID, but is not as complicated.

The HMI consists of 4 primary screens:

- Pre-Treatment, which covers the inlet screens, Aerated Balance Tank and the Balance pumps.
- Biological Process, which covers the Anoxic and Aeration tanks, Aeration blowers and WAS digester
- Secondary Treatment, which covers clarifier, RAS pumps & clarified tank
- Post-Treatment, which covers Media filtration, UV and final effluent tank Pumps

Equipment (Actuated Valves, Blowers, Pumps and Mixers) may be directly controlled by clicking the equipment tag below the icon. This will bring up a small control screen allowing the equipment in question to be operated manually or placed in automatic. Automatic and Manual control will be further detailed below.

System variables and set-points may be accessed by clicking on the 'Settings' option at the bottom of the screen. This will request a password that will need to be entered to access the menu (this ensures that the general populace is unable to change settings). From the settings menu various set-points may be adjusted, including start times, pump start and stop levels for tanks, VSD or Flow set-points and ETC. A functional description explaining these set-points is provided in the 'Grantham WWTP Control Philosophy Document'.

Alarms may be accessed by clicking the 'Alarm' button at the bottom of the page. Alarms remain on the alarm page until acknowledged and re-set.

A summary of the information on the page can be accessed by clicking the 'Summary' button at the bottom of the page. This shows information such as flowmeter totalised values, and process steps and timers.

Finally, Plant Start-up and Effluent class may be selected using the buttons at the bottom left of the HMI. 'Biological' will start the biological process, It should also be noted that if the plant is stopped and started again all equipment will be re-set to automatic and will run to the set-points set in the 'settings' menus.

Automatic Control

The automated control system is governed by a number of 'set-points'. These set-points generally define target sensor readings (such as DO concentration in the aeration tank), and the plant PLC alters equipment settings to achieve these set-points. Set-points themselves may be a variety of sensor inputs, such as tank level, Dissolved Oxygen, flow-rate, pH, Turbidity, or may be timer settings, such as time on or time off, filtration time, number-of-cycles or other similar information.

Operators may input process set-points simply by clicking on the set-point indicator and typing in a new set-point. Limits are hard-coded into the system to prevent operators from making detrimental changes to the system

Manual Control

Automated equipment may be set from manual to automatic operation via the HMI by clicking on the equipment icon and selecting the operation. Manual control both allows equipment to be turned on and off (or open and closed in the case of actuated valves) or allow for manual control over other parameters, such as the VSD speed of pumps or blowers. Care must be taken when using manual control, as safety lockouts within the control system may be bypassed, allowing operators to overflow tanks or damage pumps, or blowers.

HMI Overview

As stated previously, the HMI is organised into a number of 'screens' which logically gather process units for ease of browsing. Information about these units (such as tank level) may be read from the HMI. The operational status of equipment (i.e. is it stopped, operating, is it running in automatic or manual, is there a fault, etc) is also displayed graphically.

The following section gives an overview of some the HMI screens available.

Figure 19 – General status screen

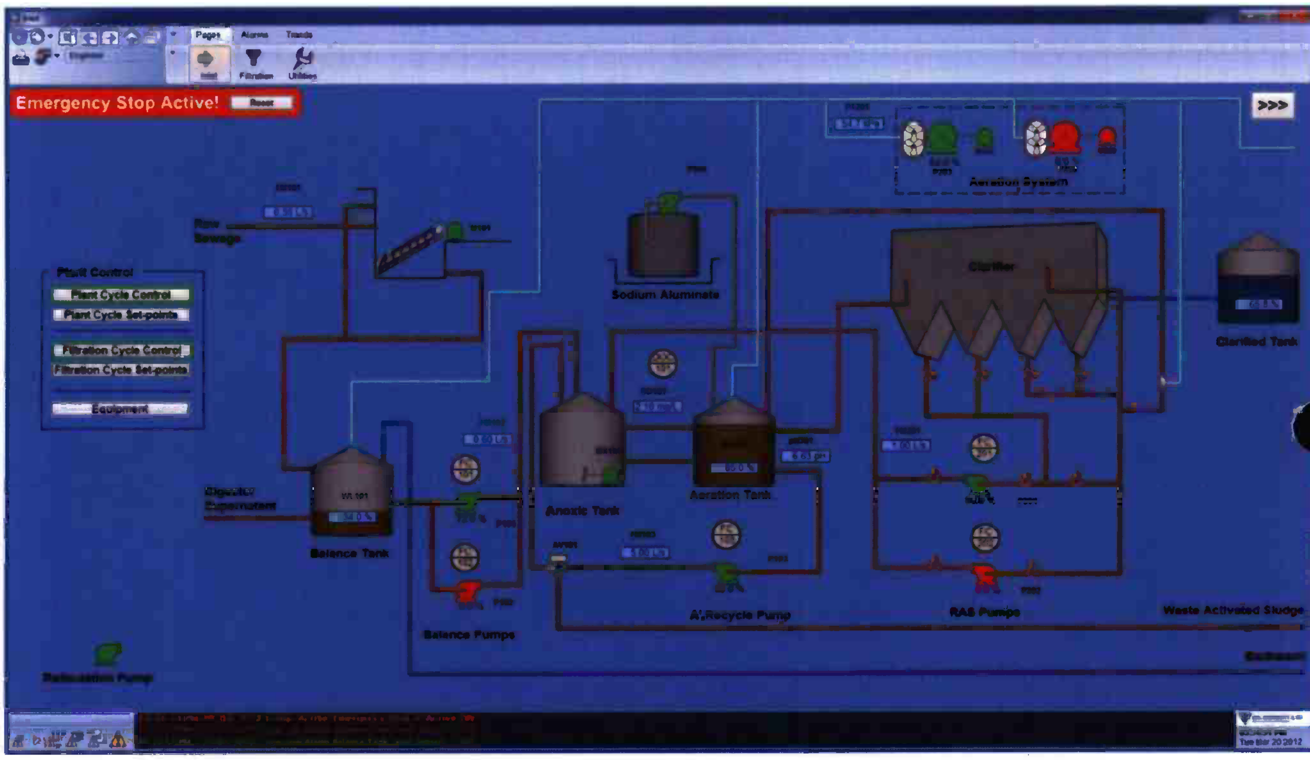


Figure 20 - Inlet Works Screen

Figure 21 – Alarms Page

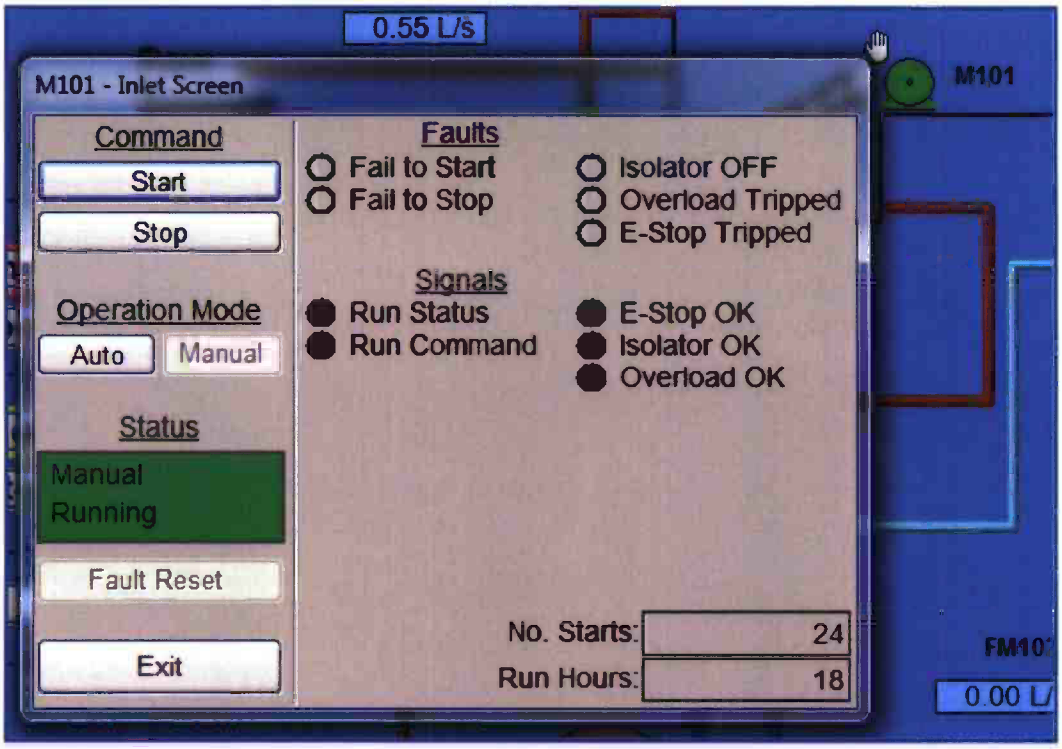


Figure 22 – DOL Running

Figure 23 – DOL Fault

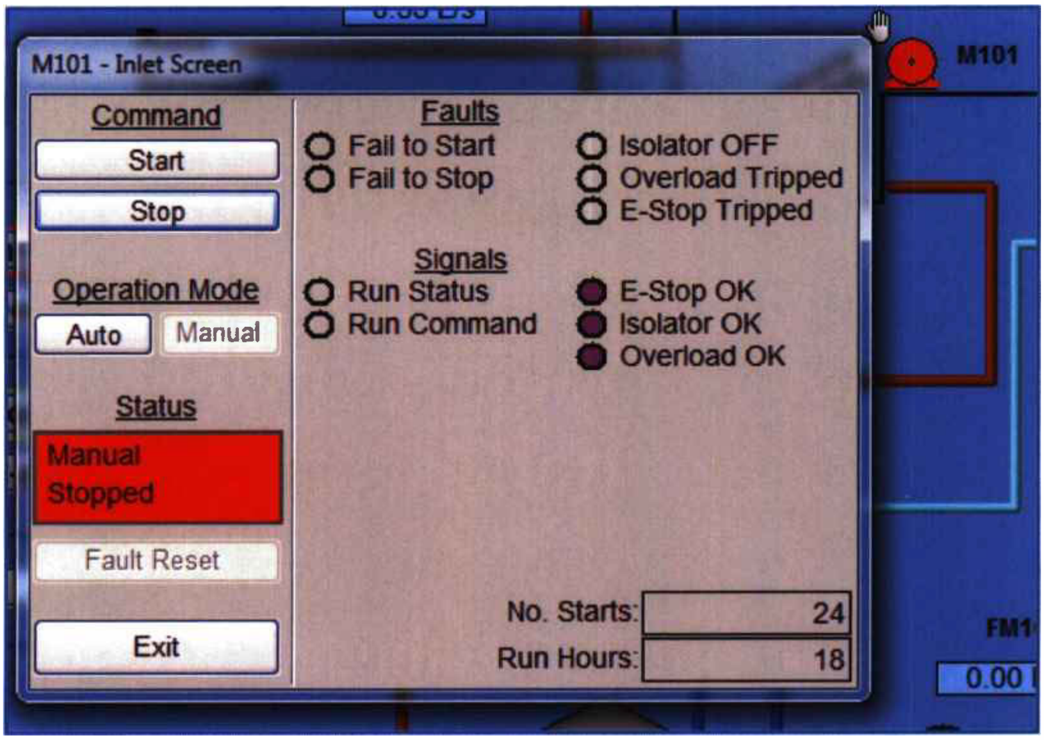


Figure 24 – DOL Stopped

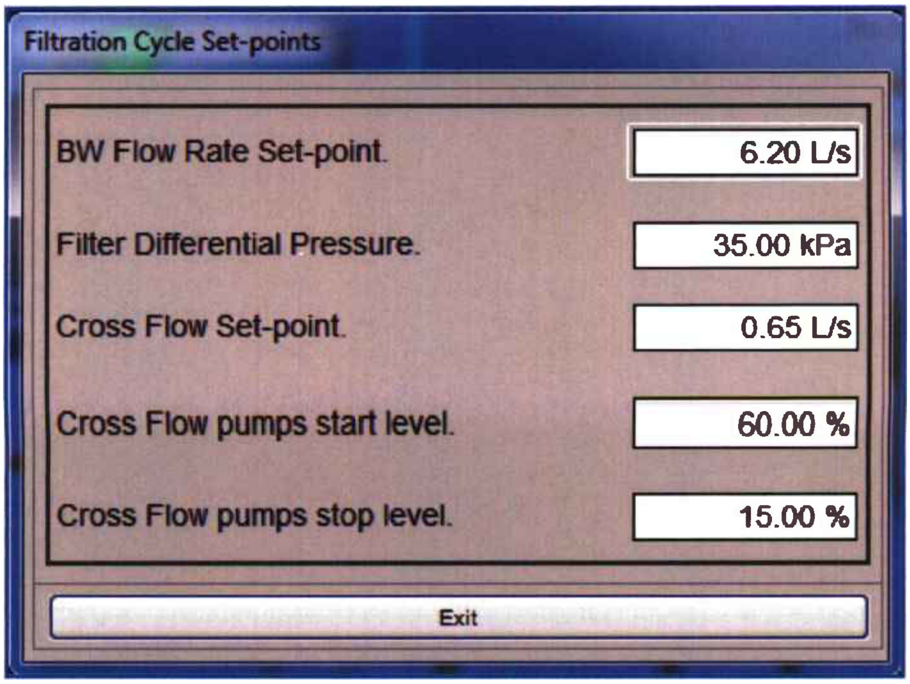


Figure 25 – Filtration Cycle Set Points

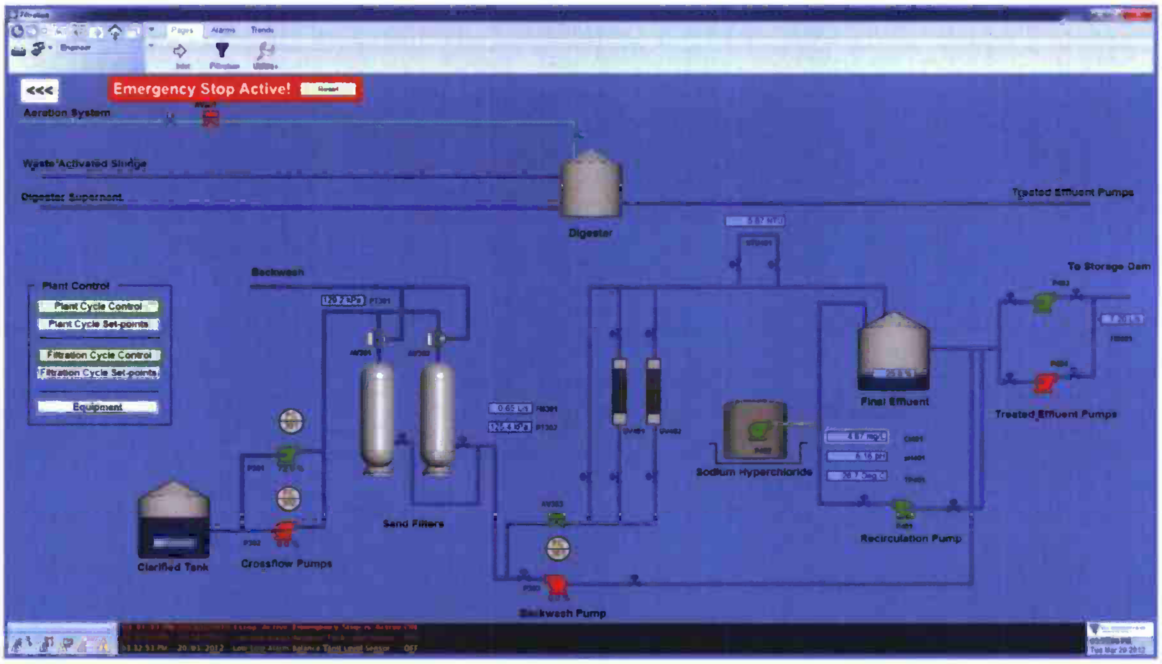


Figure 26 – Filtration Page

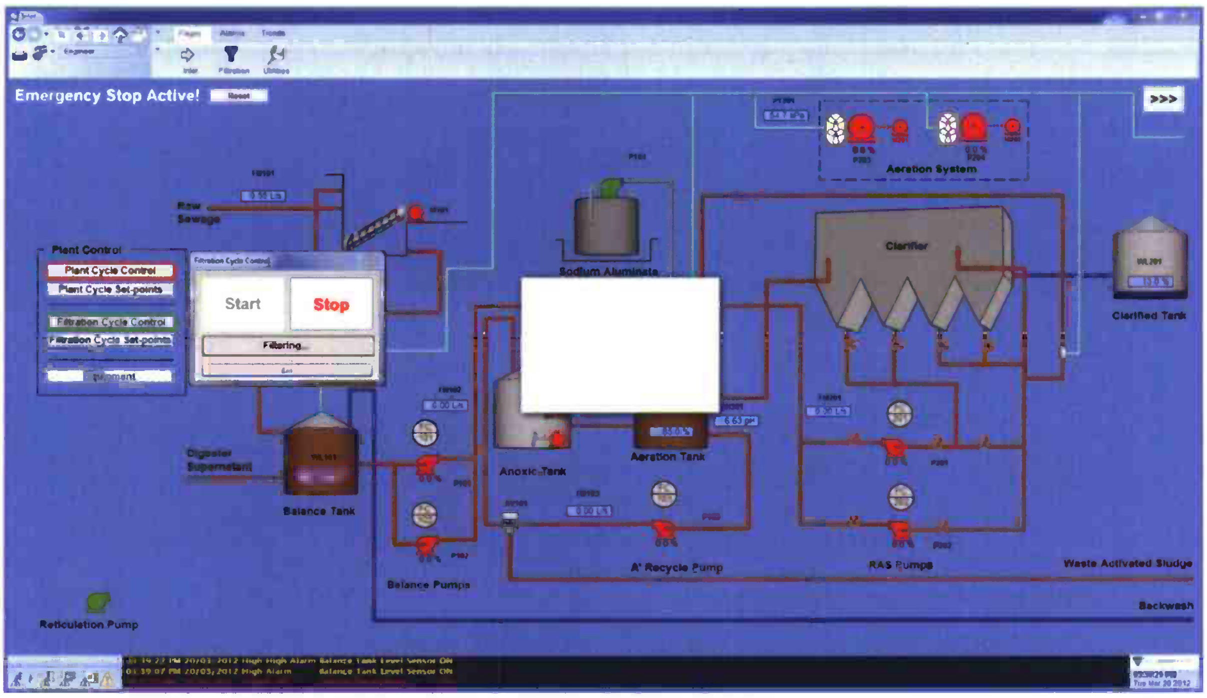


Figure 27 – Filtration Page Pop up running

SECTION 2 – SAFETY INFORMATION

Hazard and Safety Warnings

Prompts have been used throughout the manual to highlight safety, environmental and process concerns. The following information describes the prompts used in the manual and their meanings:

DANGER!

Indicates a hazard or situation where failure to use the correct procedures WILL cause either severe personal injury or death.

WARNING!

Indicates a hazard or situation where failure to use the correct procedures COULD result in severe personal injury or death.

CAUTION!

Indicates a hazard or situation where failure to use the correct procedures COULD result in severe personal injury or equipment damage.

IMPORTANT!

Indicates information within the text which is of particular importance to the procedure or operation being described.

REMEMBER!

Indicates information within the text which is of sufficient importance to warrant highlighting.

NOTE!

Indicates information which has been covered in an earlier section of the text but which warrants reinforcement.

Contents

1.1 Introduction

The treatment plant has been designed with safety in mind. It is a fully enclosed structure which eliminates the risk of operators coming into contact with hazardous substances.

However, there are other hazards associated with working on or around the waste water treatment facility.

This section describes the safety regulations, procedures and considerations that must be taken into account and followed during the operation and maintenance of the treatment plant.

WARNING!

Prior to conducting certain operational or maintenance tasks around the Wastewater treatment plant, conduct a risk assessment in accordance with work site procedures to assess the risk posed by any identified hazards that may be present when conducting the task.

1.2 Hazard Identification

Hazard identification is the ability to identify an item, action or process that has the potential to cause harm, damage or injury to personnel or equipment. In the treatment plant, hazard identification means being able to identify any hazards that may affect the water quality for example, pollutions sources, as well as any hazards that may causes incidents and injury, for example, slips and trips.

Hazards associated with the operation, maintenance and equipment items in the treatment plant include:

- water quality
- hazardous substances
- pressurised systems
- electrical energy
- slips and trips
- confined spaces.

IMPORTANT!

Operators are responsible to identify all hazards and hazardous events that may affect final effluent quality and safety (what can happen and how) should be identified.

1.2.1 Treated Final Effluent Quality

The table below lists some examples of hazardous events/areas and the potential sources of hazards that may impact treated final effluent quality.

Hazardous Event	Potential Source of Hazard
Storage Tanks and Intakes	• Uncovered storages • Human access • Depletion of reservoir storage • Unsuitable intake location • Bushfires and natural disasters
Treatment Systems	• Significant flow variations through treatment system • Incapable equipment or unit processes • Process control incapability • Use of unapproved or contaminated water treatment, chemicals and materials • Chemical dosing failures • Inadequate mixing • Failure of dosing equipment • Inadequate clarification • Equipment malfunctions • Poor reliability of processes • Power failures • Failure of alarms and monitoring equipment • Sabotage and natural disaster
Storage Tanks and Distribution Systems	• Open reservoirs, uncovered storage areas • Animal access including birds and vermin • Build-up of sediments and slime • Pipe burst or leaks • Flow variability and inadequate pressures • Failure of alarms and monitoring equipment • Sabotage and natural disasters • Treatment dosing failure

Table 1 Possible Hazards

1.2.2 Hazardous Substances

Hazardous substances are substances that have an adverse effect on a person's health after exposure through inhalation, ingestion or direct skin contact.

Hazardous substances within the treatment plant include:

- biological waste,
- chlorine, and
- acids.

Follow the correct storage, handling and disposal procedures when working around chemicals and biological waste in the treatment plant to minimise the risk posed operators.

The correct storage, handling and disposal procedures for chemicals and biological waste are found on Material Safety Data Sheets (MSDS) located within the wastewater treatment control room. Read and follow the instructions on each Material Safety Data Sheet before handling any chemical or biological waste.

IMPORTANT!

Store chemicals in the correct storage place and in accordance to the instructions on the MSDS when not in use.

1.2.3 Pressurised Systems

Pressurised systems include pipes, pumps and hoses containing pressurised fluids. Loss of control over pressurised fluids can cause equipment damage, severe personal injuries or even death.

The treatment plant contains a number of high pressure pumps and pipes used to transport liquids. Always endeavour to know what type of fluid is being pumped or transported and work in accordance with the correct procedures for the specific type of fluid.

Figure 1 Pressurised System

When conducting operational or maintenance work around pressurised systems relieve any pressures before proceeding.

WARNING!

Never open a pipeline or valve unless the proper isolation and/or bleed down procedure has been implemented.

1.2.4 Electrical

All electrical equipment within the wastewater treatment facility has been designed and installed in accordance with the specified workplace standards.

When working around electrical equipment, it is always to be considered 'live' and therefore considered dangerous.

DANGER!

Uncontrolled electrical energy can cause electrocution, explosion and fires.

Persons carrying out work on electrical equipment within the treatment plant must hold a recognised competency.

Before work is carried out any exposed electrical conductor, it must be positively isolated from the source of electricity, tested for dead and if it is a high voltage conductor earthed.

1.2.5 Slips and Trips

Spilled fluids around the treatment plant increase the risk of slips and trips occurring. Use caution when walking around sewage treatment tanks and pumps to avoid slipping and tripping on any spilled fluids.

1.2.6 Confined Spaces

The process and storage tanks in the treatment plant and some of the piping instrumentation are designated confined spaces. A confined space is an enclosed or partially enclosed space which is:

- at atmospheric pressure during occupancy
- not intended or designed primarily as a place of work
- restricted in means of entry and exit
- a space which may have at atmosphere containing harmful levels of contaminant, an unsafe oxygen level and could potentially cause engulfment.

Figure 2 Confined space signage

Hazards associated with working within confined spaces include:

- oxygen deficiency
- oxygen excess
- presence of contaminants on surfaces or in the atmosphere
- uncontrolled introduction of liquid into the space

All confined spaces in the treatment plant are signposted and secured and should only be entered if:

1. Personnel are trained and deemed competent.
2. Signed onto a confined space permit. Refer to Section 4. 6. 1 Confined Space Entry Permit.

1.3 Safety Equipment

Using safety equipment is essential to the safe operation and maintenance of the sewage treatment plant. All safety equipment is to be in a good condition and approved for usage by the site workplace. The safety equipment required to operate and maintain the treatment plant includes:

- personal protective equipment
- safety harness and rope
- emergency spill kit
- safety showers / eyewash stations
- fire extinguishers
- first aid kits.

1.3.1 Personal Protective Equipment

The following items of personal protective equipment (PPE) are to be worn when working on or around the WWTP:

- steel capped boots
- high visibility clothing
- safety glasses
- safety gloves
- hearing protection
- breathing protection when working inside tanks.

Figure 3 Typical Safety Equipment

Additional PPE may be required when performing specific operational and/or maintenance tasks, for example, wear rubber knee high boots when working in pump wells and half empty tanks. Refer to site work instructions for specific PPE requirements.

1.3.2 Safety Harness and Rope

Personnel working in confined space tanks must be provided with and wear safety harnesses and rope.

When working inside the tanks, there is a risk of personnel collapsing due to lingering odours.

Attaching a safety harness and rope to the operator inside the tank and connecting it to a tripod mounted outside the tank or anchor point ensures the operator can be easily lifted out in the event of a collapse.

All safety harnesses and safety lifting equipment must be certified compliant and hold current date.

1.3.3 Emergency Response Spill Kit

An emergency response spill kit should be located in the treatment plant to enable personnel to immediately respond to and deal with hazardous substance spills.

Each spill kit contains absorbent material, waste recovery containers, shovel, PPE and approved containers for the use of repackaging any contents of leaking packages.

Figure 4 Typical Emergency Spill Kit

1.3.4 Safety Shower / Eyewash Stations

A Safety showers and eyewash station is located next to the control room/MCC for immediate first-aid treatment of chemical splashes and extinguishing clothing fires.

Any person who comes into contact with hazardous substances is to wash the affected part of his/her body under running water.

Figure 5 Safety Shower and eye wash station

To activate the safety shower, pull down on the triangular grab handle. To activate the eyewash station, step on the foot activation bar located under the hand basin at ground level or push down on the lever located on the right hand side of the basin.

WARNING!

Personnel who come into contact with hazardous substances must immediately seek medical attention.

1.4 Isolation

Isolation is the disconnection from all possible sources of energy that have the potential for harm. Disconnection includes making mechanical disconnections by opening switches, closing valves and/or switching the main isolation switches to the off position.

Isolation is required whenever:

- a risk assessment identifies potential exposure to hazardous energy or substances
- required as set out in work procedures and/or instructions for repairs and maintenance.

The distribution box in the control room houses the main isolator switch used to isolate the entire wastewater treatment plant.

Figure 6 Isolation switch above pump

Individual field isolators are located in the control room above each pump. Refer to relevant workplace isolation procedures for the location of nominated isolation points where appointed persons place isolation locks as directed by the procedure.

WARNING!

Failure to isolate equipment in accordance with workplace isolation procedures may result in severe injury and/or death.

Perform isolation tasks in accordance with workplace standards. On occasion, electrical isolation of equipment or conductors is required. Electrical isolations are to be carried out by an authorised electrician. In some cases, a permit is required to perform electrical isolations.

Figure 7 Typical field isolations

1.5 Emergency Stop

An emergency stop button is located on the control board in the control room. Press the button to stop the operation of the sewage treatment plant in the event of an emergency.

Figure 8 Emergency Stop

1.6 Safety Permits

In addition to isolation procedures, permits are required when performing hazardous actions or processes on site. Recommended safety permits to obtain for performing certain operational and maintenance tasks on or around the wastewater treatment plant include confined space entry and hot work permits.

1.6.1 Confined Space Entry Permit

Before any work can be undertaken in a confined space, site management must provide written approval in the form of a Confined Space Entry Permit.

The confined space entry permit includes:

- precautions and instructions for safe entry and work into confined spaces such as applicable isolations
- hot work requirements
- hazards specific to the task
- atmospheric testing requirements
- stand-by personnel
- PPE requirements.

IMPORTANT!

Only persons trained and certified holding current certification may undertake confined space activities

1.6.2 Hot Work Permit

A Hot Work Permit is required when performing welding, oxy/acetylene cutting or other hot work on or around the WWTP where there is a risk of personal injury or damage to the WWTP facilities from a fire. The Hot Work Permit controls hot work tasks such as:

- time and place of work
- availability of fire fighting equipment
- post work inspections
- fire watch requirements
- other requirements specific to the hot work task.

A Hot Work Permit must be completed and signed by a competent and authorised person before commencing any hot work at the WWTP.

1.7 Housekeeping

All operators are responsible for maintaining high standards of housekeeping within the wastewater treatment facility. Poor housekeeping increases the risk of slips and trips and can result in incidents.

General housekeeping tasks involve:

- cleaning-up your work area as you go by removing any spillages other materials off floors, walls and machine walkways to eliminate slip and trip hazards
- returning equipment and materials you may be using to their correct storage place when you finish using them
- ensure all containers are labelled in accordance with the contents they contain
- keeping entrances, aisles and stairways clear of obstructions at all times
- discarding rubbish and packaging correctly.

1.8 Contamination

Contamination of treated final effluent water in the treatment plant is a major safety issue as the treated water will be used on site and could enter local waterways. To prevent contamination:

- perform adequate checks to ensure the treated final effluent is a class B standard
- check final effluent storage tanks are securely roofed at all times
- follow workplace maintenance procedures/instructions when repairing faults exactly as directed to ensure work is carried out in such a way contamination is prevented
- ensure appropriate security and regulations are in place to prevent unauthorised access to, or interference with, final effluent storages
- confirm adequate training of operational and maintenance personnel responsible for the system takes place.

E

SECTION 3 – TROUBLESHOOTING

Hazard and Safety Warnings

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1.1 Operational Challenges

1.1.1 Scum Growth

Scum growth can accumulate on the surface of the anoxic mixing and aeration tanks. The scum is not harmful to the wastewater treatment process, however, it does create dangerous and unpleasant operating conditions including pungent odours and slippery surfaces.

Scum growth in most instances is attributed to over aeration for prolonged periods of time. Maintaining 1.6 mg/L of dissolved oxygen within the aeration tank greatly reduces the chances of scum growth.

In the event that scum growth does occur the issue is best resolved by reducing the oxygen level throughout the treatment plant.

This is done by reducing the flow of the aeration system by reducing the flow rate of the blowers. The result will be an increase in odour from the treatment plant; however, the problem will be rapidly solved.

In addition to a reduction in oxygen levels rapid de-sludging of the treatment plant by an authorised contractor is also required so that the mixed liquor suspended solids (MLSS) drops to approximately 4000 mg/L.

CAUTION!

Do not use chemicals such as chlorine to remove scum growth as this will kill the good bacteria used to breakdown and treat the effluent.

CAUTION!

Do not allow any scum that has been removed from the reactor tanks to be recycled back into the system. This will result in the scum 'reseeding' and the problem returning.

Low oxygen and MLSS levels must be maintained until the problem is resolved, followed by a gradual increase of both oxygen and sludge volume until normal operating conditions are achieved.

1.1.2 Filamentous Bacteria Growth

Filamentous bacteria, as the name suggests, are filament shaped bacteria that are often branched.

Large quantities of filamentous bacteria can cause poor settling and promote denitrification in the aerobic tank. This problem can be avoided by maintaining the dissolved oxygen concentration in the aeration tank between 1.5 and 2.5 mg/l.

If the dissolved oxygen concentration in the aerobic tank falls below 0.5 mg/l filamentous bacteria growth will be encouraged.

1.1.3 Aeration System Failure

Anaerobic conditions within the treatment plant, especially the aeration tank, will result if the aeration system fails for approximately four to six hours in a 24 hour period, resulting in rapid deterioration of the effluent quality.

Sludge wasting will decrease the mixed liquor suspended solids (MLSS) and help minimise the problems resulting from the aeration system failure, however, other problems may need to be rectified once the aeration system is working again.

CAUTION!

If the treatment plant's aeration system fails for over six hour in any 24 hour period a portable air compressor must be commissioned to provide aeration

1.1.4 Maintaining Treated Water Specification – Suspended Solids and Turbidity

The critical aspect of control for an Activated Sludge Process utilising Media Filtration as the means of sustaining treated water quality is the operation of the Clarifier.

The Clarifier is the unit operation that dictates the load on the Media (Sand) Filter and its associated performance. As the Activated Sludge Process is integrally linked with the Clarifier operation, then it follows on that to control the Clarifier means controlling the whole process adequately.

The key impacts on Clarifier control are the hydraulic rate and settling characteristics of the sludge.

One important control is to not allow the Clarifier to go anoxic where it produces sludge blankets, which will immediately cause failure to meet treated water specifications and over-loading of the Media Filter.

Another key aspect in regards to settling and clarity of overflow from the Clarifier is to maintain the feed to biomass ratio (FM Ratio) within the acceptable range.

Maintaining the correct balance is important as it impacts sludge settling rates and density, and the formation of a higher quality supernatant (clear liquid above settled sludge).

It should be noted that the system being controlled is biological and has the associated sensitivities in control. While the following operational controls will minimise turbidity and suspended solids loading of the treated water, the list of controls is by no means exhaustive. The specific ranges specified will vary marginally depending on the design of the site specific treatment system and specific operating characteristics.

The following table lists the key control parameters required to maintain plant operation, optimise Clarifier operation and minimise Suspended Solids and Turbidity of treated water.

Parameter	Objective Range / Control	Corrective Action	Analysis / Task Frequency (While within specification)	Analysis / Task Frequency (While outside specification)
Feed Flow	Feed Flow must be maintained constant over day with flow maintained below design peak rate	Manage flow from Balance Tank	Weekly	Daily
Return Activated Sludge Rate (RAS) rate	0.8 to 1.5 times the feed rate	Determine why sludge rate exceeds 1.5 feed rate, refer to settling characteristics	Weekly	Daily
Settled Solids Volume test	400 to 800 ml/L	Check sludge wasting regime	Weekly	Three times per week
Suspended Solids Test and Settled Solids Volume Index	SVI of 50 to 100	Check F/M ratios and corrective actions, obtain advice	Monthly	Twice per week
Clarifier DO at depth	>0.5 mg/l	Adjust sludge return rates and concentration of biomass	Monthly	Daily
Feed to Biomass Ration	0.2 to 0.7 gBOD/gVSS.d	Adjust Biomass concentration and review feed aspects against design	Monthly	Weekly
Feed Nitrogen Loading	< 75 mg/l, high nitrogen of influent can result in high nitrate in clarifier and denitrification within clarifier	Identify cause of high nitrogen in sewage and mitigate	Monthly	Twice per Month
Feed Temperature	< 30C	Determine cause of high temperature	Monthly	Daily
Feed Fat Oil and Grease	< 50 mg/l. Oil and grease will accumulate on clarifier surface and add to turbidity issues.	Determine source and control	Monthly	Weekly

Parameter	Objective Range / Control	Corrective Action	Analysis / Task Frequency (While within specification)	Analysis / Task Frequency (While outside specification)
Contamination of Feed	No Contamination	Ensure no biocide, paints, oils, insecticides, formaldehyde, and non-sewage based materials in influent.	Quarterly	Weekly
Detergents and Surfactants in Sewage	No foaming on aeration. Detergents cause suspension of solids in Clarifier	Determine source and control	Quarterly	Daily
Feed pH	6.5 to 8.5	Adjust feed pH	Monthly	Daily
Clarifier Overflow Turbidity	< 30 NTU	Check above parameters	Weekly	Daily
Clarifier Suspended Solids	< 30 mg/l	Check above parameters	Weekly	Daily
Filtered Water Turbidity	< specification	Ensure Clarifier Turbidity on specification	Weekly	Daily
Filtered Water Suspended Solids	< specification	Ensure Suspended Solids on specification	Weekly	Daily
Filter Back Flush Control	Not too excessive and performed at a sufficient frequency	Too frequent reduces filter performance, not frequent enough causes process problems	Weekly	Daily

Table 1 Key control parameters - SS & NTU

1.2 Troubleshooting

The Grantham Waste Water Treatment Plant runs automatically and trouble free, however situations may arise that are beyond the operator's control.

The table displayed in the following pages describes various operational issues that may be encountered with the treatment plant and the best method for quickly resolving the issues.

Item	Problem	Possible Causes	Solution
Inlet Screen	Water running down spiral screen	Rundown mesh clogged	Dispose of garbage bag.
	Wheelie bin full of water solids	High solid content in influent	Clean mesh with supplied hose daily, check operation of automatic screen washing.
	Sump full of water	Blockage	Shut down power to screen and inspect blockage in discharge pipe work.
Balance System	Balance Tank overflowing	Balance Pumps Not Running	Isolator Switch off – Turn on isolator switches for Balance Pumps (P101 and P102) Check the water level in the Balance Tank (WL201) is reading on the Overview page of operator interface screen. If not replace probe. Overload – Check Balance Pump (P101, P102) for blockages, clean out pump as necessary and reset the isolator in the control board.

Item	Problem	Possible Causes	Solution
Balance System	Balance Tank overflowing	Water Level Sensor Failure (WL101)	Check overview screen on the operator interface to confirm probe failure (0%). Visually inspect the probe located on the side of the Balance Tank to see if the probe is connected to the wiring. Check Aeration Tank level on the Overview screen (WL102) of the operator interface. If the reading is less than 90% the balance pumps can be activated manually via "Pump Control" on operator interface. Activate P101 and P102 to transfer from the balance tank to the anoxic tank. Monitor the level with the main process tank and manually turn P101 and P102 OFF when the level in the tanks reaches 100%. The liquid in the Balance tank will have to be manually transferred until a replacement probe is installed
Aeration Tank	Water Level High	Water Level Probe Failure (WL102)	Check level on Overview page of operator interface. If WL101 reads 0% then there has been a failure of WL102. Visually inspect WL102 and check that cabling is connected and has not been damaged. If it does not appear damaged, remove the connector cap and inspect terminals for corrosion. To stop water being transferred from the Balance Tanks the Balance pumps need to be manually stopped. Stop P101 and P102 by switching off their isolators located above the pumps. To enable the plant to operate while a replacement probe is sourced, it is recommended to remove the water

Item	Problem	Possible Causes	Solution
			level probe from the Balance Tank (WL101) and place it in the location of WL102. If the probe is not installed the plant will not run in filtration mode and will trigger relaxation mode.
		Balance Pumps P101 and P102 left in "Manual ON" on operator interface.	Go to "Pump Control" on operator interface. Select OFF button for P101 and P102.
Clarifier	Carry over floc	Air skimmer blocked or not operating at correct depth	Check the operation of the air skimmer and ensure valve for the air supply to the skimmer is fully opened. Back flush the air skimmer return line if a blockage is found in the line. Adjust air skimmer stilling tube height by either tighten or loosening the thread to lower and extend the tube respectively.
	Build up on	Excessive sludge in bioreactor	Remove and clean with hose and broom. Reinstall cleaned plates. Check SSV reading and refer to correct levels for digestion.

Table 2 Troubleshooting guide

Indicators/Observations	Probable Cause	Check or Monitor	Solutions
Very stable Dark tan foam on aeration basin which hosing cannot break up	1. Sludge age is too old 2. Plant loading <25% of Plant capacity		Increase sludge wasting in order to reduce sludge age
Thick billows of white sudsy foam on the aeration tank	1. MLSS, too low 2. Hydraulic washout of biomass (solids) 3. Sludge wasting too high 4. Plant Start-up	1. Confirm MLSS with Lab	1. Reduce hydraulic inflow if possible. 2. Shorten pump station loading times to 1% of aeration volume 3. Decrease sludge wasting rate. 4. Start up supplementary feeding if required, otherwise do nothing.
Aeration basin contents turn grey to black	1. Inadequate aeration	1. Aeration basin dissolved oxygen	1. Increase aeration by increasing run times 2. Decrease mixed liquor suspended solids if SSV is above 400ml/l 3. Clean any plugged diffusers. 4. Check aeration system for efficient operation.
Pipe blockages	1. High solids loading 2. Inadequate pumping	1. Screens solids or rats in the treatment plant	1. Rake screens more frequently. 2. Lessen rubbish in-take to the plant.

Indicators/Observations	Probable Cause	Check or Monitor	Solutions
Aeration tank smells	1. Low aeration 2. Low pH	1. Dissolved oxygen 2. SSV 3. pH	1. Increase aeration until D.O. is between 1.5 - 2.5mg/L 2. Increase sludge wasting if SSV is above 600mL/L 3. If pH is below 7.2 add lime.
pH of mixed liquor decreases to 6.7 or lower. Sludge becomes less dense	Nitrification occurring without denitrification and wastewater alkalinity is too low.	Effluent NH_3. Influent and effluent alkalinity. Nitrification/denitrification cycles Influent pH	Alter aeration times to give minimum 30 minutes off to allow denitrification. Add source of alkalinity - lime or sodium bicarbonate. Determine source of acid wastewater and stop flow into the system.
Sludge concentration in return sludge is too low	Sludge return rate too low. WAS too high. Actinomycetes (floating sludge) predominates.	Return sludge rate Check rate of concentration Microscopic examination (if available) dissolved from content	Increase sludge return rate Lower WAS rate Reduce aeration and increase WAS to lower concentration.
Dead spots in aeration tank	Diffusers malfunctioning Under-aeration resulting in low D.O.	Visual inspection Check D.O.	Clean or repair diffusers - check blower belts Increase rate of aeration to bring D.O. concentration up to 2 to 3mg/L

Indicators/Observations	Probable Cause	Check or Monitor	Solutions
Sludge blanket over-flowing aeration tank weir	MLSS (SSV) too high due to inadequate wasting Inadequate sludge return.	Check SSV to see if it is above 600ml/l	Increase wasting if SSV > 600ml/l
Sludge floating to surface of aeration tank	Filamentous organisms pre-dominating in mixed liquor (bulking sludge). Actinomycetes organisms pre-dominating in mixed liquor. Denitrification occurring in tank; nitrogen gas bubbles attaching to sludge particles; sludge rises in clumps. Sludge collectors operating too slowly (septic sludge producing H_2S gas) Over-aerated sludge.	SSV - if less than 800mL/L is not likely the cause. If surface sludge is oily, actinomycetes bacteria likely. Nitrate concentration in aeration tank influx too high Frequency and speed of sludge collection (sludge black with septic odour) Mixed liquor dissolved oxygen should be 2-4mg/L Effluent nitrogen concentration	Increase D.O. if < 1mg/L Increase pH above 7.2 If SSV is > 600mL/L increase sludge waste by 10% per day until SSV 400ml/l or less, but no less than 250ml/l. Keep sludge age at 20 to 25 days Increase the sludge return rate. Decrease sludge return rate. Increase D.O. - if < 1.0mg/l during aeration make sure denitrification off time > 30 minutes. Reduce sludge age. Increase frequency of sludge waste. Reduce aeration if D.O. > 4 mg/l. Increase denitrification time but do not exceed 1.0 hr/cycle.

Indicators/Observations	Probable Cause	Check or Monitor	Solutions
Pin floc in effluent overflow - SSV (400 to 600) is good but effluent is turbid (cloudy)	Excessive aeration in aeration tanks. Sludge age > 40 days. Anaerobic conditions in aeration tanks. Toxic shock load. Short - circuiting of flow allowing solids to pass into effluent.	D.O. in aeration chamber. Sludge appearance very dark and dense. Microscopically examine sludge for inactive protozoa. Inlet baffles for leaks.	Reduce air input to Plant. Increase sludge wasting to decrease sludge age. Increase D.O. in aeration tanks. Enforce toxics exclusion rules. If toxic loads still likely, neutralise as fast as possible. Repair leaks/fractures to inlet baffles. Identify and correct sources of anaerobic conditions.
Plugging of sludge suction	High content of rubbish and debris. Low velocity in withdrawal lines.	Visual inspection Sludge withdrawal rate and resulting velocity	Clean rubbish and debris from sludge pipe-work. Back-flush clogged line. Check and keep inlet screens clear to reduce input of rubbish into the plant. Increase sludge return rate.
Short-circuiting of flow through aeration tank	Excessive hydraulic loading. Equipment malfunction. Reduced detention time due to large solids and grit accumulation. Damaged inlet baffles.	Visual inspection Visual inspection Visual inspection	Reduce raw sewage pump loading to plant to 1% of aeration volume if loading exceeds 120% of plant capacity, augmentation required.

Indicators/Observations	Probable Cause	Check or Monitor	Solutions
De-flocculation in aeration tank	Toxic or acid wastes. Anaerobic condition in aeration tanks. Aeration basin overloaded. Inadequate nitrogen or phosphorus supply. Excessive shear caused by turbulence.	Supernatant above settled sludge is uniform in turbidity	Remove source of toxic discharge or ensure adequate dilution when toxic spillages occur. Increase D.O. in aeration tanks. Ensure loading of pump stations 1% of aeration volume. If plant loaded 120% above design, plant augmentation needed. Supplement deficiency in nutrients by chemical addition. Reduce agitation, i.e. aeration if D.O allows, otherwise step down aeration headers inlet to outlet.
Billowing sludge	Hydraulic surges. Density currents, e.g. hot sun on one side of Plant.	Visual inspection of sludge conditions	Ensure loading of pump stations 1% of aeration volume. If plant loaded 120% above design, plant augmentation needed. Keep sludge depth as low as possible.
Dissolved oxygen low in aeration tanks	Under-aeration	Aeration times Shorten anoxic period	Maintain D.O. between 1.5 and 2.5mg/L during aeration period by increasing aeration rate. Shorten anoxic period to maximum of 30 minutes. Intersperse anoxic and anaerobic periods.

Indicators/Observations	Probable Cause	Check or Monitor	Solutions
Dissolved oxygen concentration low in final effluent	Anoxic conditions in aeration tank	Sludge return rate D.O. in aeration tanks - increase if <1.0mg/L	Ensure sludge return ratio 0.5 to 1.0. Aeration decreased to 2 to 4 mg/l.
Dissolved oxygen concentration high in aeration tanks	Over-aeration	Aeration times	Decrease aeration to achieve between 1.0 and 2.5mg/l per minute.
Final effluent chlorine concentration low	Under-chlorination Effluent quality poor Sludge in base of chlorine detention tank	Free and total chlorine residuals Visual inspection	Adjust chlorine dose so as to provide free chlorine residual of between 0.3 and 0.7mg/L after 30 minutes detention If final effluent is of poor quality, particularly with respect to suspended solids, chlorine concentration will be low due to high Cl_2 demand. Recheck Cl_2 concentrations once effluent quality improves. Empty and clean out chlorine detention tank. This should be done monthly as preventative maintenance
Final effluent chlorine concentration high	Over-chlorination	Free and total chlorine residual	Adjust chlorine dose so as to provide free chlorine residual of between 0.3 and 0.7mg/l after 30 minutes detention.

Indicators/Observations	Probable Cause	Check or Monitor	Solutions
Mixed liquor pH < 7	Low pH influent (< 7)	Influent pH. Nitrification occurring without denitrification.	Neutralise all inflows to sewer with soda ash or lime Dose soda ash or lime to balance tanks to increase pH to between 7 and 8. Set aeration 1 hr off, and adjust for D.O. levels of 30 minutes to allow denitrification.
Mixed liquor pH > 8.5	High pH influent > 8.5	Influent pH	Neutralise all inflow to sewer with diluted hydrochloric acid. Allow longer nitrification periods of up to 2 hrs with only 30 minutes denitrification.
Sludge dark in colour (grey or black)	Septic sludge - inadequate aeration	Oxygen input	Increase aeration while maintaining D.O. between 1.5 and 2.5 mg/L during aeration period Increase by 10% WAS. Clean any plugged diffusers. Check aeration system piping for leaks.
Large free-floc percentage (> 15%) - turbid effluent	Over agitation of mixed liquor. Over-aeration.	Visual inspection Oxygen input Effluent nitrogen concentration	Reduce turbulence in aeration tanks (if possible). Maintain D.O. between 1.5 and 2.5mg/L during aeration. Create anoxic periods to reduce air input and turbulence; set plant 1hour on and 1 hour off, with minimum off time = 30 minutes (then readjust for D.O.).

Indicators/Observations	Probable Cause	Check or Monitor	Solutions
Dominance of filamentous bacteria (poor settleability)	Plant operating outside optimal performance criteria	D.O. concentration in mixed liquor. 30 minute SSV.	Reduce length of anoxic periods (no < 30 minutes). Maintain high recycle ratio (up to 1.5 ADWF). Maintain D.O. in aeration tanks between 1.5 & 2.5. Increase pH to at least 7.2. Increase WAS gradually until SSV 250mL/L (maintain for at least 14 days).
Large quantities of actinomycetes bacteria (scum forming)	Infection from area	Microscopic identification	Reduce D.O. in Plant to 1.0mg/L and hold for up to 21 days. There will be some odour on start of each cycle. Alter sludge age drastically by WAS.
Floc weak and poorly formed	Numerous	Microscopic identification. Check pH to see if low.	Maintain sludge age at 25 days. Reduce turbulence in aeration tanks. Maintain D.O. between 1.5 and 2.5 mg/L in aeration tanks. Add lime if pH < 7.

Indicators/Observations	Probable Cause	Check or Monitor	Solutions
Dominance of amoeba and flagellates	Plant in recovery stage	Microscopic identification. Plant performance parameters.	Maintain sludge age between 20 and 25 days. Maintain D.O. in aeration tanks between 1.0 and 2.5. Stabilise Plant operation with respect to influent and aeration. Prevent entry to sewer system of toxic compounds. Limit anoxic periods to 30 minutes. Maintain high recycle ratio.
SSV test above 700ml/l. Effluent dirty, full of sludge	Too much sludge Sludge bulking	Check WAS rate Check SSV again Check D.O. Check WAS	Waste sludge at twice daily requirement for 2 days, then leave for 3 days. Repeat until SSV below 400ml/l. Maintain D.O. in range 1.5-2.5mg/l.
SSV test below 300ml/l	Too high waste rate. Too little sludge	Check WAS Check SSV Check D.O.	Reduce WAS until SSV above 300ml/l. Maintain D.O. between 1.5 and 2.5.

Table 3 Process Indicators (1)

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
Secondary clarifier effluent looks muddy brown, and effluent suspended solids have been increasing	1. Dentrification in clarifier	1. Floating sludge and Nitrate in the effluent. If Nitrate >5mg/L this is most likely the cause	1. Increase clarifier sludge recycle rate (RAS); increase anoxic recycle rate. 2. Skim floating sludge from entire surface of clarifier or use water sprays to release nitrogen gas from sludge so sludge will resettle.
	2. Sludge off take lines fouled or running too slow	2. Sludge collection equipment	3. Repair or adjust valves in sludge off take manifold if failed or running slow
	3. RAS recycle pump failure	3. RAS recycle pumps	4. Rectify fault as per Manufacturer's specifications 5. Maintain routine maintenance schedule
	4. Short circuiting of flow through secondary clarifier	4. Inlet and outlet baffles	6. Ensure inlet and outlet baffles working correctly, in place and operating without blockage. Reposition or repair baffle as necessary
Increase in secondary clarifier effluent Ammonia	1. Poor Oxidation of the Sewage.		1.
	1a. Blower Mechanical Fault	1a. Check blowers for operation, as per maintenance guide (Filters, belts, pullies, etc	1a. Rectify any mechanical faults as per manufactures recommendations
	1b. Aeration Diffusers Ruptured will generally require multiple	1b. Check aeration plume for signs of ruptured or	1b. If significant numbers of diffuser are ruptured the diffusers will need to be replaced

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
		damaged diffusers ('Mushrooming')	
	1c. Air Supply pipework ruptured or leaking	1c. Check aeration pipework for signs of leaks or other damage	1c. Repair pipework breakages, tighten bolts or change flange seals where required
	1d. Closed valve or sticking reflux	1d. Check all valves are open, all reflux valves are operational (i.e. not sticking closed)	1d. Open isolation valves on blowers, diffuser headers and droppers. Replace faulty reflux valves
	1e. WAS digester harvesting too much air	1e. Check WAS digester valve settings to ensure that the WAS digester isn't taking too much air	1e. Reduce volume of air directed to WAS digester using WAS digester trim valve
	1f. DO Probe Calibration drift	1f. Check DO probe calibration against calibrated hand-held meter	1f. Recalibrate probe.
	1g. DO Probe giving faulty reading or probe itself is	1g. Ensure DO probe is giving a true	1g. Recalibrate if possible, otherwise remove for repair and run blowers in

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
	faulty	reading of the DO concentration.	manual to achieve a DO of 1.5 – 2.0 mg/L in the aeration tank
	2. Insufficient alkalinity available to support Nitrification reaction	2.	2.
	2a. Insufficient Alkalinity In Raw Sewage	2a. Alkalinity in Raw Sewage, Final Effluent and Aeration Tank	2a. Increase (or commence) alkalinity dosing in the form of Soda Ash or Quicklime into BOD Fortification solution
	2b. Poor De-Nitrification resulting in sufficient alkalinity to maintain pH	2b. Check anoxic tank performance as per next section of troubleshooting guide	2b. Rectify anoxic performance as per the next section of the troubleshooting guide
	2c. Insufficient alkalinity addition	2c. Check alkalinity dosing	2c. Increase alkalinity dosing
Increase in secondary clarifier effluent nitrate >5mg/L	1. Inadequate Anoxic recycle rate		3.
	1a. Anoxic Recycle Pumps Mechanical Fault	1a. Check operation of a-recycle pumps as per maintenance guide.	1a. Rectify any faults as per manufacturer's documentation
	1b. Anoxic Recycle Pumps Stopped	1b. Check for root cause of stoppage	1b. Restart pumps if safe to do so. If not, identify fault and rectify
	1c. Inadequate Anoxic Recycle Rate	1c. Check anoxic recycle flowmeter and calculate daily	1c. Increase recycle ratio of below 18x the influent flow

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
		anoxic recycle flow and daily influent flow	
	1d. Flowmeter reading faulty/VSD Reading faulty	1d. Check flowmeter reading against VSD setting	1d. Calibrate flowmeter as per manufacturer's documentation. May require qualified technician
	2. Oxygen Inhibition of the Anoxic Tank	2.	2.
	2a. Excessive Recycle of Oxygen from Aeration Tank	2a. Check recycle rate	2a. If recycle ratio is above 20x influent flow rate, reduce recycle to 18-20x inflow
	2b. Excessive DO concentration in aeration tank	2b. Check DO in Anoxic Tank, ensure DO is below 0.5mg/L	2b. Reduce DO setpoint for Aeration Tank or reduce blower VSD to achieve a DO of 1.3 – 2.0 mg/L
	2c. Anoxic conditions not achieved even though DO concentration reads as 0mg/L (i.e. dissolved oxygen not present, but sufficient oxygen is recycled to inhibit process)	2c. Check ORP (Oxidation Reduction Potential) in Anoxic tank is below 0mV	2c. Restart mixer if safe to do so
	2d. Anoxic Mixer Stopped	2d. Check mixer for mechanical faults as per maintenance guide	2d. Restart mixer if safe to do so

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
	3. Insufficient BOD dosing to balance raw sewage requirements	3.	3.
	3a. Dosing Pumps Stopped	3a. Check for root cause of stoppage and rectify as per maintenance guide	3a. Restart pumps if safe to do so
	3b. Insufficient BOD Dose rate	3b. Check dosage rate, check raw sewage BOD (preferable by lab test, or through turbidity)	3b. Increase dose rate if required
	3c. Insufficient BOD fortificant added to mixing tank	3c. Check mass of BOD fortification vector added. Calculate approximate BOD mass required	3c. Increase mass of fortificant added
	3d. Mixer failure resulting ineffective solution dissolution	3d. Check operation of Anoxic Mixer	3d. Rectify any faults and restart mixer if safe to do so
	3e. Clogged dosing lines, injection quill, non-return valves or loading valve	3e. Check dosing lines, valves, injection quills and non-return valves for signs of blockage	3e. Dose through warm water solution. Remove and clean valves or injection quills. Replace damaged dosing lines.

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
	3f. Airlocking or clogging of dosing pump	3f. Listen to dosing pump. If actuation noise is abnormally loud it is likely to be airlocked or clogged	3f. Bleed any air from dosing pumps. Remove pump head and clean diaphragm
	3g. Crystalisation of sugar in valves or dosing head	3g. Check dosing head if safe to do so	3g. Dose warm water and detergent solution or similar to dissolve crystal deposits. Alternatively, remove and dismantle dosing and check valves and clean manually using warm water and detergent
Objectionable odours from Plant	1. Excessive organic load causing anaerobic decomposition in anoxic tank and/or aeration tank	1. Colour and condition mixed liquor. Dissolved oxygen trend in Balance Tank. Low (negative) ORP in Anoxic Tank.	1a. If running on timer control, increase aeration time 1b. Increase DO setpoint 1c. Increase anoxic recycle rate 1d. Reduce BOD fortification dose if dose is in excess of requirements
	2. Insufficient dissolved oxygen in balance tank	2.	2.
	2a. Insufficient Aeration Time	2a. Check dissolved oxygen concentration	2a. Increase aeration time if dissolved oxygen is below 1.0mg/L during aeration
	2b. Aerator Fault	2b. If aerator fails to start, check aerator as per	2b. Rectify any faults according to manufacturer's documentation. Restart aerator if safe to do so

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
		maintenance guide	
	2c. Aerator ejector pipe clogged or damaged	2c. If aerator starts but fails to deliver water, check aerator as per maintenance guide	2c. Life aerator and remove blockage. Replace discharge piping. Replace and restart aerator if safe to do so.
	2d. Dissolved Oxygen Meter Calibration Drift High	2d. Cross-check DO meter reading with calibrated handheld meter	2d. Repair or service DO probe as per manufacturer's instructions
	3. Sludge acidic	3.	3.
	3a. Insufficient alkalinity to maintain pH	3a. pH of sludge Aeration tank and final effluent alkalinity	3a. If sludge pH,6.0, increase (or commence) alkalinity dosing to increase pH to 7.0, or until residual alkalinity in the effluent is at least 50mg/L as CaC03
Short Circuiting through Anoxic Tank	1. Anoxic Mixer failure	1.	
	1a. Anoxic tank miser mechanical fault	1a. Check mixer as per maintenance guide.	1a. Rectify any mechanical faults as per manufacturer's documentation. Restart if safe
	1b. Anoxic tank mixer stopped	1b. Check for root cause of mixer stoppage. Check level sensors against PLC outputs	1b. Rectify any faulty level sensor readings as per manufacturer's documentation. Restart mixer if safe to do so.

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
	1c. Baffle leak or break	1c. Visually inspect baffle integrity	1c. Repair any breaks or damage to the anoxic baffle as required if safe to do so
	2. Sludge viscosity too great for anoxic mixer	2. Check Mixed Liquor Suspended Solids	2. Initiate sludge waste if suspended solids are greater than 11,000mg/L, to a target range of 8,000-10,000mg/L
Balance Tank overflows	1. Excessive inflow from pumping network	1. Investigate cause of excessive inflows (infiltration, leak into pumping station, illegal dumping into pumping station, etc)	1. Rectify problem at source if able to do so. Otherwise organize temporary pump-out of ABT
	2. Balance tank transfer pumps operating at insufficient rate	2. Trim valve settings	2. Increase opening of forward trim valve, close backflow valve if open
	3. Standby pump fails to start	3. Pump indicator lights/HMI Alarm Page	3. 3a. Heck pump as per routing maintenance schedule. Identify fault according to manufacturer's recommendations and rectify if safe to do so.
			3b. If pump fails to start, check screen, as screenings may be clogging pump if screen has blinded/failed
			3c. If no fault can be found, check level sensor output.

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
Pipe blockages	1. Ineffective Screening	1a. Bar screen rake drive failures	1a. Check bar screen rake drive and identify root cause of fault as per manufacturer's documentation. Rectify fault if safe to do so
		1b. Drum screen cleaning jet failure	1b. Check solenoids, RPZDs and isolation valves for failure or inappropriate settings (closed isolation valves, etc). Rectify faults if safe to do so.
		1c. Drum screen drive failure	1c. Check drum screen drive. Identify faults as per manufacturer's documentation and rectify if safe to do so.
		1d. Drum screen blinded	1d. Check bar screen and grit settler and clean as necessary. Clean drum screen.
		1e. Insufficient water pressure from booster pump to operate cleaning jets effectively	1e. Check output pressure from pressure pump. Check valves and fittings for signs of clogging. Identify faults according to manufacturer's documentation. Rectify faults if safe to do so.
		1f. If very large solids being passed in from raw sewage catchment	1f. Check condition of macerator pumps and impellers in raw sewage pumping stations for signs of damage. Rectify or replace damaged macerator blades or pump impellers if safe to do so
		1g. Ingres of foreign	1g. Remove any detritus found floating

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
		matter from environment (i.e. falling or blowing into open topped tanks)	in tanks during routine operations. Isolate affected equipment and remove blockages. Recommission equipment.
Foaming in Aeration or Balance Tank	1. Surfactant (Detergent) Foaming	1. Colour of Foam. Frothy white foam is generally associated with surfactant foaming	1. Check with cleaners about cleaning solutions used in toilets and crib rooms around site. Cleaners should use biodegradable phosphorous free detergents. High foaming detergents or cleaners should be avoided
	2. Bacterial Stress Reaction	2. Check colour of Foam. Brown coloured foam indicates bacterial reactions	2. Temporary control may be attained by hosing down foam. If long-term problems persist a sprinkler system may need to be considered.
	2a. Very low F:M ratio (i.e. not enough BOD) causing stress	2a. Influent BOD and BOD fortification rates	2a. Increase BOD fortification rate
	2b. Inhibitor or Toxin entering system	2b. Take samples for Laboratory testing. Check local catchment for any obvious signs of toxins or toxic substances (Oils, hydrocarbons, heavy metals such	2b. If able, remove source of toxin or inhibitor. Process may need to be re-started with fresh biological seed.

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	CHECK OR MONITOR	SOLUTIONS
		as Copper, Nickel, biocides such as chlorine, etc)	
	2c. Excessively low temperatures	2c. Unlikely to occur in Western Australia. Check Mixed Liquor temperature	2c. Unlikely to occur in Western Australia. Hose down foam temporarily.
Formation of surface Scum	1. Generally associated with Anoxic processes. Scum is generally thicker than foaming. Anaerobic conditions in Anoxic tank	1. Anoxic system performance. pH of sludge, general odour around plant	1. If foam is light brown, hose down scum. If septic odours are present, increase oxygen input into aeration tank, increase dissolved oxygen concentration in aeration tank to between 1.0 and 2.0mg/L

Table 4 Process Indicators (2)

SECTION 4 – PLANT OPERATION

Hazard and Safety Warnings

Prompts have been used throughout the manual to highlight safety, environmental and process concerns. The following information describes the prompts used in the manual and their meanings:

DANGER!

Indicates a hazard or situation where failure to use the correct procedures WILL cause either severe personal injury or death.

WARNING!

Indicates a hazard or situation where failure to use the correct procedures COULD result in severe personal injury or death.

CAUTION!

Indicates a hazard or situation where failure to use the correct procedures COULD result in severe personal injury or equipment damage.

IMPORTANT!

Indicates information within the text which is of particular importance to the procedure or operation being described.

REMEMBER!

Indicates information within the text which is of sufficient importance to warrant highlighting.

NOTE!

Indicates information which has been covered in an earlier section of the text but which warrants reinforcement.

Contents

1.1 Introduction

The Grantham Waste Water Treatment Plant (WWTP) is an automated plant that requires minimal operator intervention.

The following processes are explained in this section:

- Plant Operation
- Filtration Operation
- Digester Operation
- Sludge Management
- Plant Checks
- Process Sampling

NOTE!

Each of the automated processes can be manually initiated through the operator interface screen (HMI)

IMPORTANT!

The following chemicals are not permitted to enter the treatment plant during operation or any other time:

- ***Pesticides/ herbicides/ insecticides***
- ***Petrol/ oil/any hydrocarbons***
- ***Organic Solvents***
- ***Large quantities of chlorine***
- ***Large quantities of acids or caustic material***
- ***Heavy metals***
- ***Detergents with high concentrators of nitrogen phosphorus.***

1.2 Plant Operation

The plant operation can be controlled on the main screen of the operator interface (HMI). Once the plant cycle has been initiated, the vital equipment required to maintain a healthy bioreactor is operated in auto mode. This equipment includes;

- Balance pumps (P101 & P102)
- Inlet Screen (SC101)
- Aeration blowers (P203 or P204)
- a' Recycle pump (P103)
- RAS pumps (P201 & P202)
- Sodium Aluminate Dosing pump (P104)

Testing and operator observations will provide the indicators on whether adjustments are required to optimise performance.

Key pumps have variable speed drives (VSDs) where adjustments can be made to flow rates

Key pumps are:

- Balance pumps (P101 & P102)
- Aeration blowers (P203 or P204)
- a' Recycle pump (P103)
- RAS pumps (P201 & P202)

For full explanation, please refer to W536 Grantham WWTP Control Methodology in the Appendix

1.3 Filtration Operation

The filtration cycle can be controlled on the main screen of the operator interface.

Once the filtration cycle has been initiated, the equipment required to filtrate and produce final effluent at the desired flow rate is operated in auto mode.

Filtration mode cannot be initiated without the plant cycle also running.

The crossflow pumps (P301 & P302) transfer clarified influent from the clarified tank through the sand filter and the UV disinfection system to the final effluent tank. The crossflow pumps are VSD driven. A PID loop is used to adjust the speed of the pumps to achieve a desired flow rate.

The backwash pump (P303) transfers final effluent from the final effluent tank through the sand filter in the reversed direction.

The flow of the backwash removes contaminants that have built up in the sand during filtration. The backwash pump is VSD driven.

A PID loop is used to adjust the speed of the pump to achieve a desired flow rate.

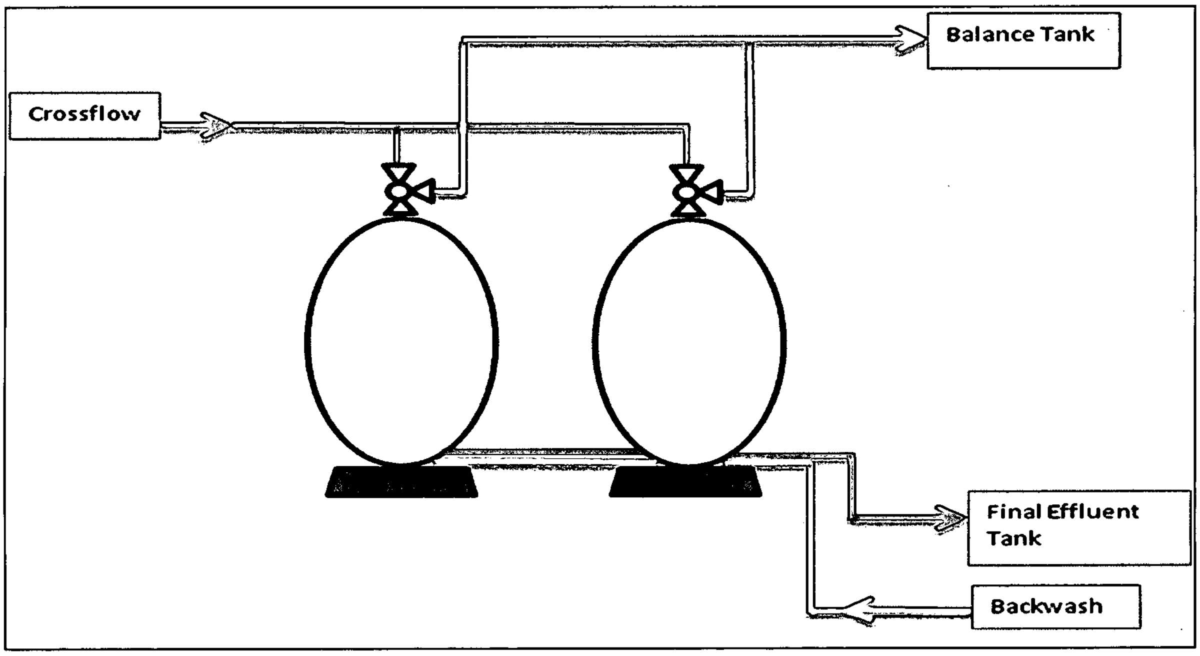


Figure 1 Basic Media Filter Operation

Step	Next Step	Description	Delay (secs)	Crossflow (P301 or P302)	Backwash Pump (P303)	Filter 1 Divert Valve (AV301)	Filter 2 Divert Valve (AV302)	Backwash Valve (AV303)	P301/P302 VSD Speed Setpoint	P303 VSD Speed Setpoint	Filtration Cycle	BW Cycle
1	2	Filtration Cycle	-	R	S	O	O	O	Filtration Flow	-	ON	OFF
2	3	Backwash Triggered (Filter 1)	4	S	S	O	O	O	-	-	OFF	ON
3	4	Set Valves (Filter 1)	Valve Time	S	S	C	O	C	-	-	OFF	ON
4	5	Start Backwash Pump (Filter 1)	BW Run Time	S	R	C	O	C	-	BW Flow	OFF	ON
5	6	Stop Backwash Pump (Filter 1)	4	S	S	C	O	C	-	-	OFF	ON
6	7	Set Valves (Filter 2)	Valve Time	S	S	O	C	C	-	-	OFF	ON
7	8	Start Backwash Pump (Filter 2)	BW Run Time	S	R	O	C	C	-	BW Flow	OFF	ON
8	9	Stop Backwash Pump (Filter 2)	4	S	S	O	C	C	-	-	OFF	ON
9	10	Reset Valves	Valve Time	S	S	O	O	O	-	-	OFF	ON
10	1	Return to Filtration	-	R	S	O	O	O	Filtration Flow	-	ON	OFF

Figure 2 Filtration Cycle

O = Valve Open (Divert valves = Filtration)
C = Valve Closed (Divert valves = Waste)
R = Pump Running
S = Pump Stopped

1.4 Digester Operation

During the sewage treatment process, solids build up and must be purged from the system and stored.

The digester tank acts as a storage and concentrating location for solids within the treatment plant. The micro-organisms in the solid organic matter in the digester tank break down over time reducing the amount of solid waste the treatment plant produces. The supernatant or digester liquid is returned to the balance tanks via gravity discharge.

In order to remove solids from treatment process the automatic digester operation must occur once or twice daily. The process is automatic and the frequency is selected through the operator interface. The digester process sequence is displayed below.

The waste activated sludge cycle transfers aged sludge from the aeration tank to the digester tank for further aerobic digestion. The digester tank, with the addition of air, breaks down the remaining sludge and releases carbon dioxide gas.

The digestion cycle first turns the air off to the tank to allow the sludge to settle and supernatant to form. The WAS is then introduced to the tank and the supernatant overflows back to the balance tank. The air remains off for an additional settling period. (See Figure 4 WAS cycle).

Figure 3 Grantham Digester Tank

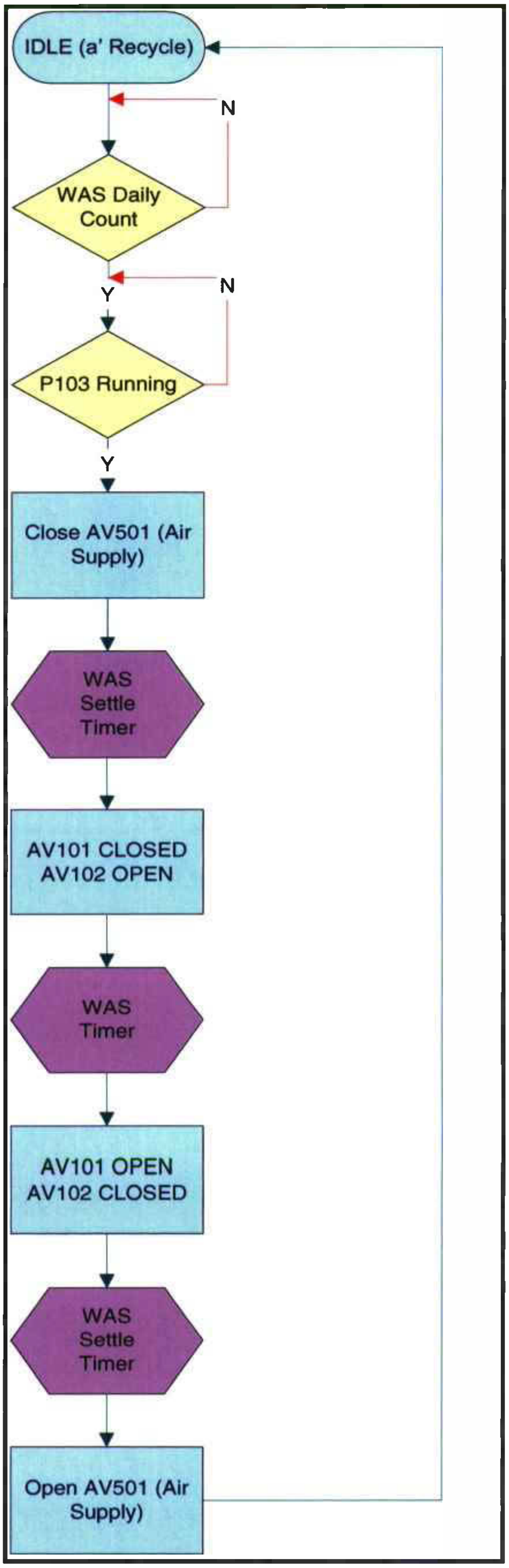


Figure 4 WAS Cycle

1.5 Sludge Management

In order to maintain the correct sludge or suspended solids concentrations, mixed liquor samples must be taken monthly and the settled sludge volume determined. This is required to ensure the mixed liquor suspended solids concentration is in the correct range (3500 to 4500 mg/l) and that the sludge is settling at the required rate.

NOTE!

Mixed liquor sampling is explained in section 1.6.5

1.5.1 Sludge Volume Index (SVI)

The sludge volume index provides a further measure of the settling characteristics of the sludge. It is defined as the volume in millilitres occupied by one gram of sludge, dry weight, after settling for 30 minutes in a 1000 millilitre graduated flask. It may be calculated from the following expression:

$$SVI = \frac{30\,\text{min}\; SSV\;(ml) \times 1000}{Suspended\ Solids\ Concentration\ \left({}^{mg}/_{l}\right)}$$

Values of the SVI less than 100 are generally regarded as good, while values greater than 200 often indicate a bulking sludge.

IMPORTANT!

The SVI can only be calculated when the mixed liquor suspended solids concentration has been performed by a laboratory.

1.5.2 Sludge Removal

When the mixed liquor suspended solids within the solids digester tank reaches a point where settling has little or no effect, the digester requires a pump out and sludge disposal by a licensed contractor.

Typically this point occurs when the MLSS within the solids digester tank reaches in excess of 20,000 mg/l.

NOTE!

Observation of digester supernatant return to the balance tank gives a good indication of settling performance.

1.6 Treatment Plant Monitoring

Key elements of the treatment plant must be monitored daily, weekly and monthly to ensure efficient operation.

The information must be recorded on a form and retained to ensure the treatment is always operating within specification. The operator interface allows easy access to the majority of the required information.

NOTE!

A sample of a weekly checklist form is displayed in the appendix.

1.6.1 Daily Monitoring Checks and Tasks

Required daily monitoring checks include:

- checking the treatment plant for operational alarms
- checking the Inlet flow meter (FM101) and recording the value
- visually inspecting the inlet screen (SC01) and hosing the screenings off the top of the screen as required
- visually inspecting tanks to ensure they are in good working order
- checking the pump station control board for alarms
- checking the balance pumps (P101 and P102), that feed the bioreactor, for priming
- checking and recording the values of the treatment plant's flow meters.

1.6.2 Weekly Monitoring Checks

Required weekly monitoring checks include:

- recording the result of the settled sludge volume testing of the aeration tank
- checking the chlorine in the chlorine dosing tank and replacing when the levels are low
- observing the operation of the digestion cycle
- recording chemical levels.

1.6.3 Monthly Monitoring Checks

Monthly checks require samples to be taken from the final effluent tank, the solids digester tank and the aerobic tank, with the samples to be analysed by a laboratory. The method for correctly sampling is discussed in section 1.6.5 — 'Sampling'.

The final effluent must comply with DERM requirements which include:

Parameter	Required	Release limit
pH	6.5-8.5	range
Turbidity	<5NTU	80th percentile
Suspended Solids	<15mg/L	80th percentile
BOD_5	<10mg/L	80th percentile
Total Nitrogen	<5mg/L	50th percentile
Total Phosphorous	<2mg/L	50th percentile
Residual Chlorine	0.7mg/L free chlorine	Minimum
Faecal Coliform	<10cfu/100ml	95th percentile

Table 1 Discharge requirements

The check of the final effluent ensures the treatment plant is operating efficiently and within specification. Additional samples from the aeration and solids digester tanks are also required to ensure the mixed liquor suspended solids (MLSS) is within specification.

1.6.4 Three Monthly Checks

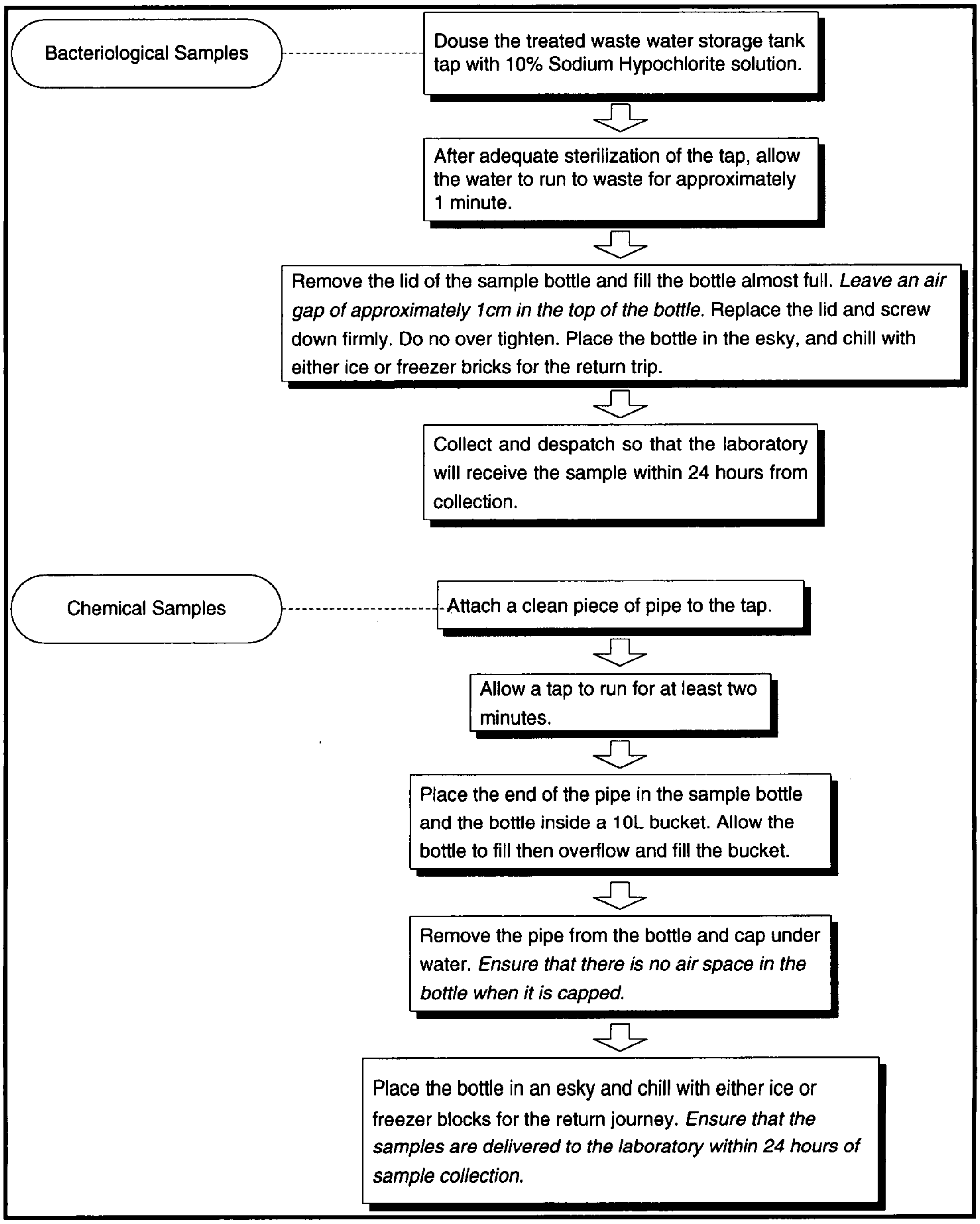
Required three monthly monitoring checks include:

- checking the air blowers (P203 & P204) for undue noise and checking for pressure loss, if any, by observing bubbling in the aeration tank
- cleaning the air blowers air filter.
- checking the correct operation of all pumps
- checking all air lines for leaks
- checking for adequate chlorine levels in the storage vessel
- checking the clarifier unit for correct operation
- checking air skimmer in clarifier and clean any build up
- checking for correct operation of the chemical dosing pumps (P304, P305)
- checking for aeration in the solids digester tank, screened influent
- checking the sludge level in the solids digester tank is below one metre, (sludge needs to be removed from the tank if it is above this level).

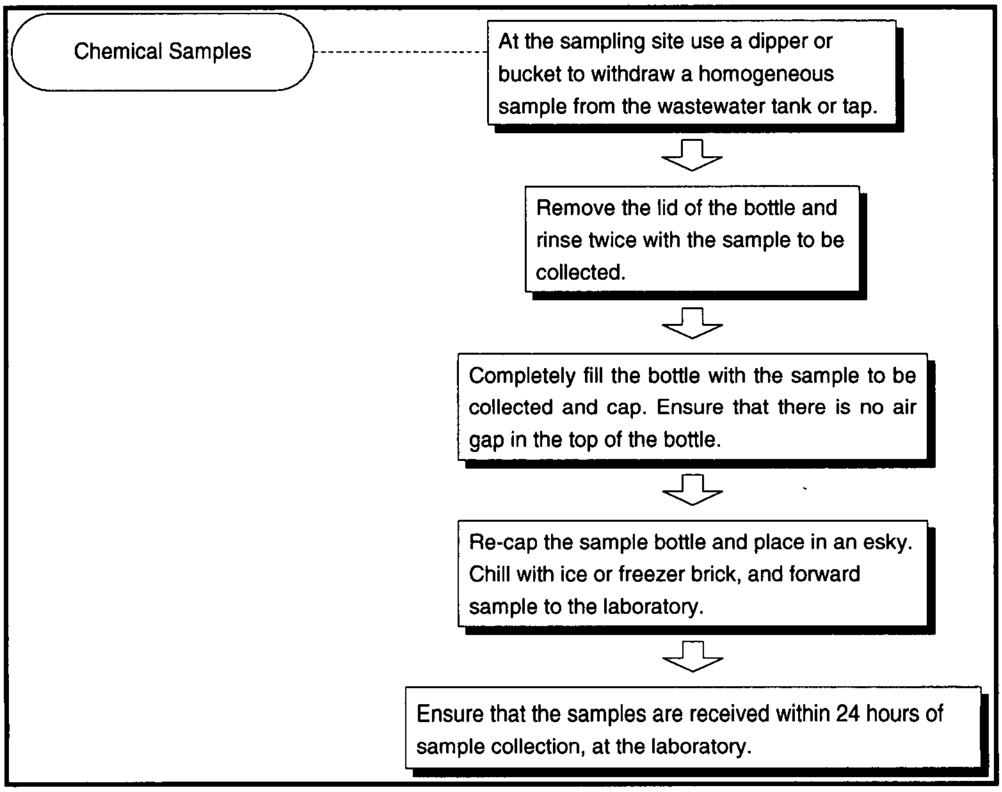
1.6.5 Sampling Procedure

Collection of samples for on site and laboratory testing is extremely important to ensure the treatment plant is operating normally. Samples must be collected in the correct manner to ensure that the results are accurate and not misleading. The instructions for taking the required samples are displayed in the following sections.

1.6.6 Sampling from the Final Effluent Tank



1.6.7 Sampling from Process Tanks

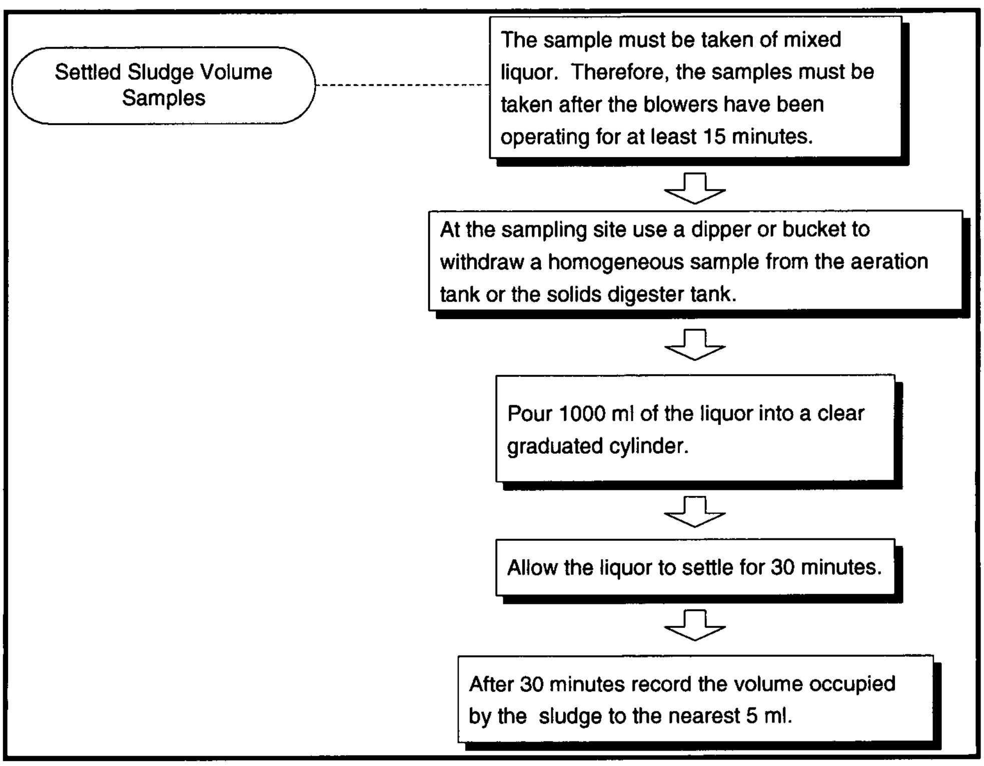


1.6.8 SSV Sampling

SSV Sampling from the Solids Digester Tank and the Aeration Tank

Settled Sludge Volume (SSV) samples are taken to determine the suspended solids concentration and sludge settleability.

SSV = ml of sludge in 1000 ml cylinder after 30 minutes of settling.



Settled Sludge Volume (SSV) Sampling Procedure

stornoway

Project Ref W536

GRANTHAM SEWAGE TREATMENT PLANT

Control Methodology

June 2012

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Document Status

Rev	Status	Author	Reviewer		Approved for Issue		
			Name	Signature	Name	Signature	Date
A	First Issue	D Cokley	A Mythen				
B	Additional Specs	J Styles					

TABLE OF CONTENTS

1. INTRODUCTION

This document summarises the control methodology for the Grantham Development Wastewater Treatment Plant to be commissioned in April, 2012 at Grantham, Queensland.

2. CONTROL REQUIREMENTS

Treatment plant control requirements are summarised in Appendix A. General system control requirements are outlined in the sections below.

2.1. Pumps

2.1.1. General

All pump and all control valves to have manual start, manual stop and auto modes.

The minimum run speed for all VSD driven motors shall be 60% of the maximum run speed.

2.1.2. Duty Standby Pumps

Duty/Standby configuration ensures the critical process pumps will continue to operate if one pump fails. The duty pump is to alternate between pumps on each activation (ie. P105 runs, then system stops, next time the duty pump is called P106 runs). If an MCB or contactor failure is registered for the duty pump, the standby pump is automatically started. If the duty pump registers a VSD fault, the standby pump is activated.

2.2. Alarms

Treatment plant alarm list is summarised in Appendix B. The alarm list includes low, medium and high priority alarms.

High Level Alarm – Critical to the operation of the plant. This fault must be attended to within 4 hours.

Medium Level Alarm – Standby equipment has been activated or is non-critical to the plants operation. This fault must be attended to within 12 hours.

Low Level Alarm – Non-critical alarm. This fault must be attended to at the next scheduled daily visit.

Low Flow Alarms are activated if the pump is running but the flow meter is reading no flow. (Possible causes are fault with pump or fault with flow meter)

2.3. Treatment System

The STP has two main modes of operation, the plant cycle and the filtration mode.

The plant cycle runs the vital equipment to maintain the biological system in the STP. When only the plant cycle is operating the STP will not treat and discharge effluent.

The filtration mode runs the filtration system including the final discharge system. The STP is to be running in filtration mode when required to treat and release effluent.

The purpose of the two modes is to allow operators to stop the filtration cycle for maintenance whilst the vital plant equipment is still able to operate.

Manual backwash of sand filters is to be available from SCADA.

2.4. SCADA Security

Three levels of security will be provided with users able to be assigned the following roles:

- Operator
  - Change device modes (auto/manual)
  - Start and stop equipment
- Supervisor
  - Change set-points
- Engineer
  - Change PI controller tuning parameters
  - Change administrative settings

Automatic logon of the operator user will be provided and, in addition, higher level users will be logged off and replaced automatically by the operator user after a predetermined amount of time.

2.5. Response to power failure

In the event of a power failure when power is restored the plant will restart in automatic operation as if it has been started from scratch. In addition, the SCADA computer will automatically power up and logon as an operator user. Historical Trending

All recorded data will be retained on the SCADA computer for a period of 12 months and can be accessed through the SCADA computer using Process Analyst.

2.6. SCADA device colour standards

The following specifies colours that will indicate device states on the SCADA screen:

- Any Fault – Flashing Yellow
- Any Interlock – Blue
- Analogue
  - High-High alarm – Red bar above displayed value
  - High alarm – Orange above displayed value
  - Low alarm – Orange below displayed value
  - Low-Low alarm – Red below displayed value
- On/Off Valve
  - Closed – Red
  - Open – Green
- 3-way Valve – Green highlight indicates current path
- Drive
  - Stopped – Red
  - Running – Green
  - Starting/Ramping – Flashing Green

2.7.Alarm Paging

TBA

2.8.Materials and Equipment

2.8.1. SCADA

The Citect SCADA system provides operators with control over, and feedback from the WWTP. The Citect system will also provide alarming and diagnostic reporting functionality.

2.8.2. PLC

A Schneider Modicon system will be used. The PLC processor is located in the WWTP MCC.

2.8.3. *Equipment – Instruments*

Instrument ID	Description	Range
FM101	Inlet Flow meter	0 – 50L/s
FM102	Balance Delivery Flow meter	0 – 5L/s
WL101	Balance Tank Level Sensor	0 – 0.4bar
DO101	Aeration Tank Dissolved Oxygen	0 – 10mg/L
WL102	Aeration Tank Level Sensor	0 – 0.4bar
FM103	a' Recycle Flow meter	0 – 5L/s
FM201	RAS Flow meter	0 – 5L/s
WL201	Clarified Tank Level Sensor	0 – 0.25bar
PT201	Aeration Pressure Sensor	0 – 1bar
FM301	Filtration Flow meter	0 – 5L/s
pH301	Aeration pH	0-14
PT301	Pre-filter Pressure	0 – 4bar
PT302	Post-filter Pressure	0 – 4bar
WL401	Final Effluent Tank Level Sensor	0 – 0.4bar
NTU401	Turbidity Meter	0 – 1000 NTU
UV401	UV disinfection system	On..Off
UV402	UV disinfection system	On..Off
CL401	Chlorine Residual Analyser	0 – 10mg/L
pH401	pH probe	0 - 14
TP401	Temperature sensor	0 - 50°C

2.8.4. *Equipment – Drives*

Equipment ID	Description	Type
MX101	Anoxic Mixer	DOL
M101	Screen Motor	DOL
M201	Blower Fan 1	DOL
M202	Blower Fan 2	DOL
P101	Balance Pump 1	VSD
P102	Balance Pump 2	VSD
P103	a' Recycle Pump	VSD
P104	Sodium Aluminate Dosing Pump	DOL
P201	RAS Pump 1	VSD
P202	RAS Pump 2	VSD
P203	Aeration Blower 1	VSD
P204	Aeration Blower 2	VSD
P301	Cross flow Pump 1	VSD
P302	Cross flow Pump 2	VSD
P303	Backwash Pump	VSD
P401	Recirculation Pump	DOL
P402	Chlorine Dosing Pump	DOL

2.8.5. *Equipment – Solenoid Valves*

Equipment ID	Description

AV101	Three way Electronic Actuated Ball Valve
AV301	Three way Electronic Actuated Ball Valve
AV302	Three way Electronic Actuated Ball Valve
AV303	Electronic Actuated Ball Valve
AV501	Brass Solenoid Valve

2.8.6. Equipment – PID Loops

Equipment ID	Description
FC101	Balance flow controller 1
FC102	Balance flow controller 2
DOC101	Dissolved oxygen controller
FC103	Recycle flow controller
FC201	RAS pump 1 flow controller
FC202	RAS pump 2 flow controller
FC301	Cross flow pump 1 flow controller
FC302	Cross flow pump 2 flow controller
FC303	Back wash pump flow controller
FC403	Treated effluent pump 1 flow controller
FC404	Treated effluent pump 2 flow controller

2.9. Device Code Blocks

Equipment will be divided into specific types to allow common blocks of code to be reused for the same types of equipment both inside the PLC program and within the Citect SCADA environment. All devices will have an associated symbol on the SCADA screen, for example, a drive will have a motor symbol colour coded to indicate the status of the drive. When the symbol is clicked a popup will appear giving the operator details and controls for the device. The following device types will be created…

2.9.1. Analogue input

The analogue input device allows the raw 4-20mA signal from the field to be scaled to engineering units and displayed on the Citect SCADA screen. Other features include:

- Raw signal 1st order filter
- Trending of the engineering value displayed on the SCADA pop-up
- Low, Low-Low, High, High-High alarms dead-band all configurable from the SCADA pop-up

2.9.2. Digital input

This device provides an interface for contact based feedback signals, for example, a high level switch or fault signal. It includes:

- Signal inversion
- On and Off delays configurable from the SCADA pop-up
- Trending of the inverted and delayed value displayed on the SCADA pop-up
- Associated alarm

2.9.3. DOL drive

This device provides code for a standard contactor based DOL drive and the associated feedback and alarms. It includes:

- Safety interlocks, displayed on the SCADA pop-up
- Fail to start and stop faults with delays
- Run feedback indication on the SCADA pop-up
- Overload fault displayed on the SCADA pop-up
- Auto and Manual start/stop modes selectable via the SCADA pop-up
- Number of starts recorded and displayed via the SCADA pop-up
- Run hours recorded and displayed via the SCADA pop-up

2.9.4. VSD drive

The VSD drive device is essentially the same as the DOL but with the following additions:

- Speed reference and current displayed and trended on the SCADA pop-up
- VSD Fault displayed on the SCADA pop-up
- Manual speed reference is possible in manual mode

2.9.5. Actuated valve

The Actuated valve device is capable of driving both a normal single action on/off valve and a dual destination 3-way valve. Both valves are controlled by a single digital output and can have up to two digital feedbacks for position. It also includes:

- Safety interlocks, displayed on the SCADA pop-up
- Fail to move faults with delays
- Position feedback indication on the SCADA pop-up
- Number of actuations recorded and displayed via the SCADA pop-up
- Auto and Manual modes selectable via the SCADA pop-up

2.9.6. PI loop controller

This device implements a standard proportional-integral loop controller. Derivative action is deemed unnecessary because all plant control loops are not unstable enough to warrant derivative action. The PI loop controller includes:

- Auto and manual modes selectable via the SCADA pop-up
- Bump-less transfer between auto and manual modes
- Trending of set-point, measurement and output variables displayed on the SCADA pop-up
- Proportional and integral gain configurable on the SCADA pop-up
- High and low output limits and alarms
- High and low set-point limits
- Deviation alarm with dead-band configurable on the SCADA pop-up

Appendix A. Control Requirements

A.1 Details

Treatment plant control requirements are summarised in Table 1. Table 1 details the control requirements for the STP.

Table 1 STP Control Summary

Process	Control Methodology	Related Instruments	Control Logic
Balance Pumps P101 & P102	The balance pumps transfer screened influent from the balance tank to the anoxic tank. The balance pumps control the flow across the clarifier as the system gravity feeds from anoxic to aeration to clarifier. The balance pumps are VSD driven. A PID loop is used to adjust the speed of the pumps to achieve a desired flow rate.	• WL101 • FM102 • WL102 • WL201	DUTY/STANDBY SYSTEM MANUAL START/ STOP/ AUTO/ RUNNING STATUS Duty pump starts IF: • Plant cycle = ON AND; • WL101 ≥ balance duty start AND; • WL102 < aeration high level AND; • WL201 < clarified high level Duty pump stops IF: • Plant cycle = OFF OR; • WL101 < balance duty stop OR; • WL102 > aeration high level, with 30s delay OR; • WL201 > clarified high level with 30s delay Balance Flow rate: • Balance flow rate set point on SCADA screen (Range 0 – 1 L/s) • Feedback for PID loop = FM102
Inlet Screen M101	The inlet screen removes solids greater than 1mm from the sewage entering the system. The inlet screen motor operates when there is flow entering the screen. The screen motor operates the chain driven teeth that remove the trapped solids from the bar screen.	• FM101	MANUAL START/ STOP/ AUTO/ RUNNING STATUS Motor starts IF: • FM101 > screen run flow rate AND; • Plant cycle = ON

Process	Control Methodology	Related Instruments	Control Logic
			Motor stops IF: • FM101 < screen run flow with 1 min delay OR; • Plant cycle = OFF
Anoxic Mixer (MX101)	The anoxic mixer turns over the anoxic tank continuously to promote a healthy anoxic zone and prevent settling. The mixer operates continuously when there is sufficient fluid in the anoxic tank.	• WL102	MANUAL START/ STOP/ AUTO/ RUNNING STATUS Mixer starts IF: • WL102 > aeration low level AND; • Plant cycle = ON Mixer stops IF: • WL102 < aeration low level with 30 sec delay OR; • Plant cycle = OFF
a' Recycle Pump (P103)	The a' Recycle pump returns biomass rich in nitrates from the aeration tank to the anoxic tank for denitrification. The a' recycle pump operates on a time run and time stop sequence. The run time and rest time can be set in the SCADA. The a' Recycle pump is also controlled by a PID loop to achieve the desired flow rate.	• WL102 • FM103	MANUAL START/ STOP/ AUTO/ RUNNING STATUS Pump starts IF: • WL102 > aeration low level AND; • a' Recycle run timer = ON AND; • Plant cycle = ON Pump stops IF: • WL102 < aeration low level after 30 sec delay OR; • a' Recycle run timer = OFF OR; • Plant cycle = OFF a' Recycle flow rate: • A' Recycle flow rate set point on SCADA screen (0 – 5L/s) • Feedback for PID loop = FM103

Process	Control Methodology	Related Instruments	Control Logic
			Rest timer starts when run timer is complete. The run timer restarts when the rest timer is complete.
Alum Dosing Pump (P104)	The alum dosing pump doses Sodium Aluminate into the aeration tank to assist with phosphorus removal from the influent. The dosage rate can be manually adjusted on the screen of the pump.		MANUAL START/ STOP/ AUTO/ RUNNING STATUS Pump starts IF: • Filtration mode = ON Pump stops IF: • Filtration mode = OFF
RAS pumps (P201 & P202)	The RAS pumps transfers activated sludge from the hoppers of the clarifier back to the anoxic zone. This process helps maintain the desired MLSS level in the bioreactor. The RAS pumps operates on a time run and time stop sequence. The run time and rest time can be set in the SCADA. P201 draws sludge from the first two hoppers of the clarifier to form RAS A. P202 draws sludge from the last two hoppers of the clarifier to form RAS B. The run and rest times for RAS A & B are independent as A is typically 4 x greater than B. The RAS pumps are VSD driven and a PID loop controlled the flow rate according to FM201.		MANUAL START/ STOP/ AUTO/ RUNNING STATUS **RAS A (Hoppers 1 & 2)** Pump starts IF: • Plant cycle = ON AND; • RAS A run timer = ON Pump stop IF: • RAS A run timer = OFF OR; • Plant cycle = OFF **RAS B (Hoppers 3 & 4)** Pump starts IF: • Plant cycle = ON AND; • RAS B run timer = ON Pump stop IF: • RAS B run timer = OFF OR;

Process	Control Methodology	Related Instruments	Control Logic
			• Plant cycle = OFF RAS A flow rate: • IF P201 = ON THEN; • PID set point for P201 = RAS A flow rate • FM201 = Feedback for PID loop RAS B flow rate: • IF P202 = ON THEN; • PID set point for P202 = RAS B flow rate • FM201 = Feedback for PID loop Combined flow rate: • IF P201 = ON AND; • P202 = ON THEN; • PID set point for P201 = (RAS A flow rate + RAS B flow rate) • PID set point for P202 = (RAS A flow rate + RAS B flow rate) • FM201 = Feedback for PID loop • RAS A flow rate set point on SCADA (Range 0 – 5 L/s) • RAS B flow rate set point on SCADA (Range 0 – 5L/s) *Rest timer starts when run timer is complete. The run timer restarts when the rest timer is complete.*
Aeration blowers (P203 & P204)	The aeration blowers supply air to the aeration, balance and digester tank. A dissolved oxygen sensor located in the aeration tank continuously monitors the DO level. The aeration blowers are VSD	• DO101	DUTY/STANDBY SYSTEM MANUAL START/ STOP/ AUTO/ RUNNING STATUS Duty blower starts IF:

Process	Control Methodology	Related Instruments	Control Logic
	driven. A PID loop is used to adjust the speed of the blowers to achieve a desired dissolved oxygen level in the aeration tank.		• Plant cycle = ON AND; • DO101 < DO low level Duty blower stop IF: • Plant cycle = OFF OR; • DO101 ≥ DO high level Blower run speed: • DO level set point on SCADA (0-3mg/L) • Reset PID loop when blower starts
Aeration blower fans (M201 & M202)	The aeration blower fans provide circulation of fresh air into the acoustic housing to cool the motor and the roots pump. The associated fan is to run continuously when the duty blower is in operation.		M201 starts IF: • P203 = ON M202 starts IF: • P204 = ON M201 stop IF: • P203 = OFF M202 stop IF: • P204 = OFF
Filtration cycle	The filtration cycle transfers clarified influent from the clarified tank through the sand filters and UV disinfection unit to the final effluent tank.		Refer to Table 2 Filtration Sequence for detailed control logic. Filtration Start IF: • Filtration mode = ON AND;

Process	Control Methodology	Related Instruments	Control Logic
			• Filtration timer = ON AND; • Turbidity filtration stop = OFF Filtration Stop IF: • Filtration mode = OFF OR; • BW cycle = ON OR; • Turbidity filtration stop = ON
Filter backwash cycle	The sand filter backwash is initiated by either the filtration timer elapsed or a high pressure differential across the filters	PT301; PT302;	Refer to Table 2 Filtration Sequence for further details. Backwash Start IF: • BW cycle = ON OR; • Sand Filter Differential (PT301 – PT302) > filter diff pressure Backwash Stop IF: • BW cycle = OFF IF BW cycle = ON THEN Filtration cycle = OFF IF BW CYCLE COUNT > 2, within < 1 day THEN FILTER BW ALARM = ON
Crossflow pumps (P301 & P302)	The crossflow pumps transfer clarified influent from the clarified tank through the sand filter and the UV disinfection system to the final effluent tank. The crossflow pumps are VSD driven. A PID loop is used to adjust the speed of the pumps to achieve	• WL201 • PT301 • PT302 • FM301 • WL401	DUTY/STANDBY SYSTEM MANUAL START/ STOP/ AUTO/ RUNNING STATUS Duty Pump Starts IF: • Filtration mode = ON AND;

Process	Control Methodology	Related Instruments	Control Logic
	a desired flow rate.		• WL201 ≥ crossflow duty start AND; • WL401 < final effluent high level AND; • Turbidity filtration stop = OFF Duty Pump Stop IF: • Filtration mode = OFF OR; • WL202 < crossflow duty stop OR; • WL401 ≥ final effluent high level after 30 sec delay OR; • Turbidity filtration stop = ON Crossflow Flow rate: • Crossflow flow rate set point on SCADA (0 – 3L/s) • Feedback for PID loop = FM301
Backwash pump (P303)	The backwash pump transfers final effluent from the final effluent tank through the sand filter in the reversed direction. The flow of the backwash removes contaminants that have built up in the sand during filtration. The backwash pump is VSD driven. A PID loop is used to adjust the speed of the pump to achieve a desired flow rate.	• FM301 • WL401	MANUAL START/ STOP/ AUTO/ RUNNING STATUS Duty Pump Starts IF: • BW cycle = ON AND; • WL401 > final effluent low level Duty Pump Stop IF: • BW cycle = OFF OR; • WL401 < final effluent low level after 30 sec delay

Process	Control Methodology	Related Instruments	Control Logic
UV disinfection system UV401, UV402	The UV disinfection system is self-controlling with UV intensity and lamp hour life control logic. The UV units are self alarming.		
WAS Digestion Cycle	The waste activated sludge cycle transfers aged sludge from the aeration tank to the digester tank for further aerobic digestion. The digester tank with the addition of air, breaks down the remaining sludge to a carbon and releases carbon dioxide gas. The digestion cycle first turns the air off to the tank to allow the sludge to settle and supernatant to form. The WAS is then introduced to the tank and the supernatant overflows back to the balance tank. The air remains off for an additional settling period.		WAS cycle start IF: • Plant cycle = ON AND; • WAS rest timer = OFF WAS cycle stop IF: • Plant cycle = OFF OR; • WAS rest timer = ON Refer to Table 3 Waste activated sludge cycle, for further details
Recirculation Pump (P401)	The recirculation pump turns over the final effluent tank to reduce the likelihood of bacteria regrowth. The recirculation system operates continuously when the running in plant auto mode. The recirculation pump provides a sample for the chlorine analyser. Chlorine is then dosed into the recirculation line down stream of the	• WL401	MANUAL START/ STOP/ AUTO/ RUNNING STATUS Pump Start IF: • Plant cycle = ON AND; • WL401 > final effluent low level Pump Stop IF: • Plant cycle = OFF OR;

Process	Control Methodology	Related Instruments	Control Logic
	analyser to maintain constant free chlorine residual in the final effluent tank.		• WL401 < final effluent low level after 30 sec delay
Chlorine dosing pump (P402)	The chlorine dosing pump doses sodium hypochlorite into the recirculation line to maintain constant free chlorine residual in the final effluent tank. The chlorine dosing pump is independently controlled by the chlorine analyser. The chlorine analyser has three analogue outputs to the PLC for chlorine, pH and Temperature.		
Reticulation pressure pump (P403)	The reticulation pressure pump supplies final effluent to a hose reel and tap for screen wash, anoxic/aeration wash down and general wash down for the STP. The pressure pump is self controlling to maintain a set pressure in the discharge line.		MANUAL START/ STOP/ AUTO/ RUNNING STATUS • ALWAYS ON regardless of plant/filtration mode
Turbidity Off Specification	The turbidity meter (NTU401) measures the turbidity of the final effluent post sand filtration. If the turbidity is greater than the given set point the plant is not able to release to the irrigation field. A warning alarm is to signal when the turbidity is greater than the set point. If the warning alarm remains true for a given period of time the filtration cycle will stop, to avoid	• NTU401	Turbidity warning alarm ON, IF: • NTU401 > Turbidity set point Turbidity warning alarm OFF, IF: • NTU401 < Turbidity set point Turbidity filtration stop IF: • Turbidity warning = ON for filtration stop time

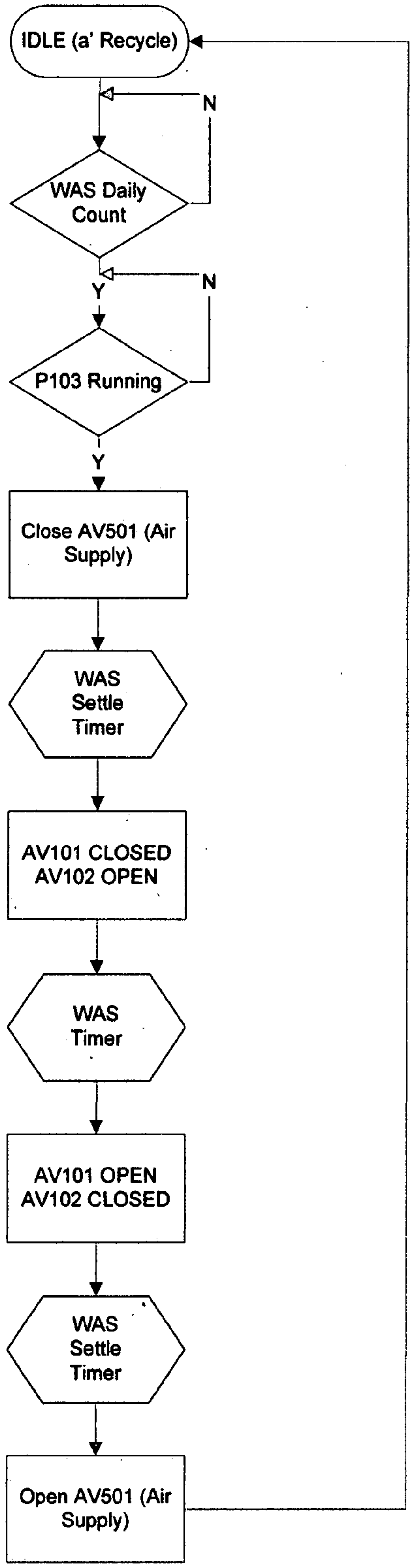
Process	Control Methodology	Related Instruments	Control Logic
	contaminating the final effluent tank.		

Table 2 Filtration Sequence

Step	Next Step	Description	Delay (secs)	Crossflow (P301 or P302)	Backwash Pump (P303)	Filter 1 Divert Valve (AV301)	Filter 2 Divert Valve (AV302)	Backwash Valve (AV303)	P301/P302 VSD Speed Setpoint	P303 VSD Speed Setpoint	Filtration Cycle	BW Cycle
1	2	Filtration Cycle	-	R	S	O	O	O	Filtration Flow	-	ON	OFF
2	3	Backwash Triggered (Filter 1)	4	S	S	O	O	O	-	-	OFF	ON
3	4	Set Valves (Filter 1)	Valve Time	S	S	C	O	C	-	-	OFF	ON
4	5	Start Backwash Pump (Filter 1)	BW Run Time	S	R	C	O	C	-	BW Flow	OFF	ON
5	6	Stop Backwash Pump (Filter 1)	4	S	S	C	O	C	-	-	OFF	ON
6	7	Set Valves (Filter 2)	Valve Time	S	S	O	C	C	-	-	OFF	ON
7	8	Start Backwash Pump (Filter 2)	BW Run Time	S	R	O	C	C	-	BW Flow	OFF	ON
8	9	Stop Backwash Pump (Filter 2)	4	S	S	O	C	C	-	-	OFF	ON
9	10	Reset Valves	Valve Time	S	S	O	O	O	-	-	OFF	ON
10	1	Return to Filtration	-	R	S	O	O	O	Filtration Flow	-	ON	OFF

O = Valve Open (Divert valves = Filtration)
C = Valve Closed (Divert valves = Waste)
R = Pump Running
S = Pump Stopped

Table 3 Waste activated sludge cycle



Appendix B. Alarm Listing

B.1 General

The table below summarises the treatment system alarm requirements.

Alarm Description	ALARM	PRIORITY		
		HIGH	MED	LOW
Emergency Stop	Emergency stop	X		
Phase Failure	Phase failure	X		
Crossflow pump 1 VSD	P301 VSD FAULT		X	
Crossflow pump 2 VSD	P302 VSD FAULT		X	
Crossflow pump 1 & 2 VSD	P301 & P302 VSD FAULT	X		
Balance Pump 1 VSD	P101 VSD FAULT		X	
Balance Pump 2 VSD	P102 VSD FAULT		X	
Balance Pump 1 & 2 VSD	P101 & P102 VSD FAULT	X		
RAS Pump 1 VSD	P201 VSD FAULT		X	
RAS Pump 2 VSD	P202 VSD FAULT		X	
RAS Pump 1 & 2 VSD	P201 & P202 VSD FAULT	X		
a' Recycle VSD	P103 VSD FAULT		X	
Aeration Blower 1 VSD	P203 VSD FAULT		X	
Aeration Blower 2 VSD	P204 VSD FAULT		X	
Aeration Blower 1 & 2 VSD	P203 & 204 VSD FAULT	X		
Backwash Pump VSD	P303 VSD FAULT		X	
Screen Motor	M101 MCB & CONTACTOR	X		
Anoxic Mixer	MX101 MCB & CONTACTOR		X	
Balance Pump 1 D/S	P105 MCB		X	
Balance Pump 2 D/S	P106 MCB		X	
Balance Pump 1 & 2	P105 & P106 MCB	X		
a' Recycle Pump	P103 MCB		X	
RAS Pump 1	P201 MCB		X	

Alarm Description	ALARM	PRIORITY		
		HIGH	MED	LOW
RAS Pump 2	P202 MCB		X	
Aeration Blower 1 D/S	P203 MCB		X	
Aeration Blower 2 D/S	P204 MCB		X	
Aeration Blower 1 & 2	P203 & P204 MCB	X		
Crossflow pump 1 D/S	P301 MCB		X	
Crossflow pump 2 D/S	P302 MCB		X	
Crossflow pump 1 & 2 D/S	P301 & P302 MCB	X		
Backwash Pump	P303 MCB		X	
Recirculation Pump	P401 MCB & CONTACTOR		X	
Reticulation Pressure Pump	P403 MCB			X
Balance Tank Low Level	WL101 LOW LEVEL			X
Balance Tank High Level	WL101 HIGH LEVEL		X	
Balance Tank High High Level	WL101 HIGH HIGH LEVEL	X		
Aeration Tank Low Level	WL201 LOW LEVEL	X		
Aeration Tank High Level	WL201 HIGH LEVEL	X		
Clarified Tank Low Level	WL202 LOW LEVEL		X	
Clarified Tank High Level	WL202 HIGH LEVEL	X		
Final Effluent Tank Low Level	WL401 LOW LEVEL		X	
Final Effluent Tank High Level	WL401 HIGH LEVEL	X		
Sand Filter Pressure Differential	High sand filter pressure			X
BW alarm	Sand Filter BW alarm		X	
Dissolved Oxygen Low Level	DO LOW LEVEL			X
Turbidity Off spec warning	NTU401 OFF SPEC		X	
Turbidity Off spec filtration stop	NTU401 FILTRATION STOP	X		
Balance Low Flow	P101/102 LOW FLOW	X		
a' Recycle Low Flow	P103 LOW FLOW		X	
RAS A Low Flow	P201 LOW FLOW		X	
RAS B Low Flow	P202 LOW FLOW		X	
Crossflow Low Flow	P301/302 LOW FLOW		X	

Alarm Description	ALARM	PRIORITY		
		HIGH	MED	LOW
Low Chlorine Residual	CL401 LOW LEVEL		X	
Aeration Pressure High	PT201 HIGH PRESSURE		X	

Appendix C. Process Set points

C.1 General

The table below summarises the process set points values for the treatment plant.

PLC Address	Set point Name	Units	Preliminary Setpoint	Commissioning Setpoint
	SCREEN RUN FLOW	L/s	0.5	
	BALANCE DUTY START	%	30	
	BALANCE DUTY STOP	%	20	
	BALANCE STANDBY START	%	80	
	BALANCE FLOW RATE	L/s	0.6	
	BALANCE HIGH LEVEL	%	90	
	BALANCE HIGH HIGH LEVEL	%	100	
	AERATION LOW LEVEL	%	30	
	AERATION HIGH LEVEL	%	98	
	CLARIFIED LOW LEVEL	%	30	
	CLARIFIED HIGH LEVEL	%	95	
	CROSSFLOW DUTY START	%	60	
	CROSSFLOW DUTY STOP	%	15	
	FINAL EFFLUENT LOW LEVEL	%	10	
	FINAL EFFLUENT HIGH LEVEL	%	95	
	FINAL EFFLUENT DUTY START	%	30	
	FINAL EFFLUENT DUTY STOP	%	15	
	WAS RUN TIMER	MINS	5	
	WAS REST TIMER	HRS	23	
	WAS SETTLE TIMER	MINS	30	

PLC Address	Set point Name	Units	Preliminary Setpoint	Commissioning Setpoint
	RAS A RUN TIMER	MINS	3	
	RAS A REST TIMER	MINS	2	
	RAS B RUN TIMER	MINS	1	
	RAS B REST TIMER	MINS	10	
	RAS A FLOW RATE	L/S	1	
	RAS B FLOW RATE	L/S	1	
	a' REC FLOW RATE	L/S	6	
	A' REC RUN TIMER	MINS	50	
	A' REC REST TIMER	MINS	10	
	FILTER DIFF PRESSURE	kPa	35	
	BW CYCLE TIME	0:00	11:00 AM	
	BW RUN TIMER (PER FILTER)	MINS	12	
	CROSSFLOW FLOW RATE	L/s	0.6	
	BW FLOW RATE	L/s	6.2	
	VALVE ACTUATION TIME	SECS	20	
	BALANCE LOW FLOW	L/s	0.1	
	RAS A LOW FLOW	L/s	0.2	
	RAS B LOW FLOW	L/s	0.2	
	a' REC LOW FLOW	L/s	0.2	
	CROSSFLOW LOW FLOW	L/s	0.2	
	LOW DISSOLVED OXYGEN	mg/L	1	
	TURBIDITY WARNING	NTU	10	
	TURBIDITY FILTRATION STOP	HRS	1	
	LOW CHLORINE RESIDUAL	mg/L	0.3	
	HIGH AERATION PRESSURE	kPa	100	

PLC Address	Set point Name	Units	Preliminary Setpoint	Commissioning Setpoint
	BW CYCLE ALARM	COUNT	2	

G

SECTION 5 – PLANT START UP AND SHUT DOWN

Hazard and Safety Warnings

Prompts have been used throughout the manual to highlight safety, environmental and process concerns. The following information describes the prompts used in the manual and their meanings:

DANGER!

Indicates a hazard or situation where failure to use the correct procedures WILL cause either severe personal injury or death.

WARNING!

Indicates a hazard or situation where failure to use the correct procedures COULD result in severe personal injury or death.

CAUTION!

Indicates a hazard or situation where failure to use the correct procedures COULD result in severe personal injury or equipment damage.

IMPORTANT!

Indicates information within the text which is of particular importance to the procedure or operation being described.

REMEMBER!

Indicates information within the text which is of sufficient importance to warrant highlighting.

NOTE!

Indicates information which has been covered in an earlier section of the text but which warrants reinforcement.

Contents

1.1 Plant Start-Up

The Grantham wastewater treatment system is able to treat raw sewage and deliver a class A final effluent.

In order to achieve this result the start-up of the treatment plant must take into account the type of sewage, (also called the plant load) that the plant is treating.

The treatment plant has process variables that can be altered to accommodate sewage with different properties. These process variables include:

- flow rate of the a' recycle pump
- flow rate of the aeration system
- flow rate of the RAS pumps
- running times
- the amount of chemical dosing
- the amount of sludge wasted per day
- the amount of effluent being pumped through recycle streams.

Plant loads are unique, therefore it is impossible to pre-install the treatment plant with the optimum settings.

The optimum process settings are generated after making adjustments based on daily observations of key process parameters. The following pre-start and start-up process must be conducted before the sewage treatment plant will achieve peak operating efficiency.

1.1.1 Pre-Start Checks

Task Step	Explanation	Critical Comment
Section One: Electrical Control Board		
1. Confirm correct power supply to the electrical control board.	This will have been verified during Site Acceptance Testing (SAT)	**WARNING!** **Do not touch any electrical connections or wires.** **WARNING!** **A qualified electrician must perform this task step.**
2. Check that all components are wired and plugged in to the correct field isolators	This will have been verified during Site Acceptance Testing (SAT)	**WARNING!** **Do not touch any electrical connections or wires.** **WARNING!** **A qualified electrician must perform this task step.**
Section Two: Anoxic and Aeration Tanks		
3. Check the tanks are clear of any rags or debris.	Perform a visual check.	**CAUTION!** **Tanks are confined spaces. Ensure precautions are taken to prevent personnel from falling into the tanks.**
4. Inspect the condition of the diffusers.	Ensure the diffusers are clear of any blockages and they are level.	
5. Check the tanks for any external or internal leaks.		**IMPORTANT!** **All tank leaks must be repaired before start-up.**
6. Confirm valves are in their 'normal' position	Perform a visual check	

Task Step	Explanation	Critical Comment
Section Three: Chemical Dosing and General Checks		
7. Ensure there are sufficient chemicals in the chemical storage tank.		**CAUTION!** **Chemicals in the dosing unit are corrosive. Ensure correct PPE is used at all times.**
8. Remove all inspection covers throughout the treatment plant and check fluid levels in all chambers are correct.		
9. Tested emergency stop switches throughout the plant	This function will be tested during SAT.	

1.1.2 Initial Start-Up

Task Step	Explanation	Critical Comment
Section One: General Checks		
1. Confirm that all valves, level switches and operation levels are correct.		
2. Fill the balance chamber to not less than one metre in depth.		
3. Fill the anoxic tank to one metre in depth.		
4. Fill the aeration tank and clarifier to remain at same level as anoxic tank due to equalisation.		

Task Step	Explanation	Critical Comment
Section Two: Electrical Start-Up		
5. Ensure that all main switches, Miniature Circuit Breakers (MCB), field isolation switches and equipment switches are in the off position.		
6. Switch on the main control breaker and the MCB for the PLC and interface screen.		
7. Turn on the PC and place all equipment in the 'manual off' position.		
8. Turn on all field isolation, equipment and MCBs.		
9. Turn on each piece of equipment and test.	Using the PC turn on the treatment plant equipment, test each piece of equipment before selecting the AUTO function.	
Section Three: Influent Screen		
10. Ensure the influent is received into the screen by the influent rising main.	The influent wash down is manual in operation	
Section Four: Balance System		
11. Adjust the level sensor in the balance tank to preset levels.	Use the operator interface to adjust the level sensor and turn the isolation switches for balance pump one and two to ON.	

Task Step	Explanation	Critical Comment
12. Adjust the aeration system.	Adjust the aeration system to the balance tank to 25% open. Open as a start-up position and adjust as needed to maintain <1.0 mg/l Dissolved Oxygen (DO) content.	
Section Five: Aeration System		
13. Turn the field isolation switches to the aeration unit to ON	Adjust the DO sensor and Variable Speed Drive (VSD) blowers using the operator interface.	
Section Six: Recycle and Return Pumps		
14. Turn all field isolation switches to on and adjust run times for suit ADWF.	The recycle pumps are VSD driven and maintain a set flow rate based on the operator input parameters.	
Section Seven: Inflow		
15. Allow the raw sewage to flow into the inlet screen.		
16. Adjust the a' recycle flow rate.	Adjust the a' recycle flow rate once the liquid levels have equalised and normal flow through the plant has been established.	**NOTE!** **When the plant operates under normal conditions activated sludge will gradually build up in the aeration tank which is returned to the anoxic tank. The activated sludge should be brownish in colour.**
17. Check the sludge digester operation for adequate aeration.		

Task Step	Explanation	Critical Comment
18. Determine the rate at which sludge is wasted into the sludge digester during the operational sequence.	Ensure the supernatant return time is long enough to remove all supernatant that the plumbing allows.	**IMPORTANT!** **It is critical that the sludge wasted into the digester is not greater than the transfer capacity of the supernatant return in its allotted time period.**
Section Eight: Air, Mixing and Cycle Adjustments		
19. Adjust the aeration rate of the air flow rate through the aeration diffusers to achieve even mixing.	Minor adjustments — Regulate the individual valves for each diffuser bar assembly within the operator interface screen. Large adjustments — Regulate the dissolved oxygen probe that controls the blower, using the operator interface screen.	**IMPORTANT!** **The level of dissolved oxygen and the degree of mixing within the aeration tank is determined by the flow rate of air inputted by the diffusers.** **IMPORTANT!** **The valves should never be 'throttled down'.** **NOTE!** **Even mixing means the air from the diffusers should move the tank contents so it is rolling evenly along the tank wall.** **NOTE!** **It is possible to maintain high mixing velocities in the aeration tank and still control and maintain the desired level of dissolved oxygen.**

1.1.3 Inflow Troubleshooting at Start -Up

INFLUENT COLOUR	AERATION COLOUR	RETURN SLUDGE COLOUR	ODOUR	CONDITION	ADJUSTMENT
Grey	Chocolate Brown	Chocolate Brown	Earthy	Good Operation	None
Grey	Chocolate Brown	Chocolate Brown	Earthy	Excessive Foaming	Foaming is Normal During Start-Up
Grey	Chocolate Brown	Light	Musty	Solids in Effluent	Reduce Sludge Return Rate
Grey	Light Brown	Light	Slightly Septic	No Sludge return	Back Wash Sludge Return
Grey	Red	Light Brown	None	Over Mixing	Reduce Aeration
Grey	Brown	Black	Septic	Insufficient Aeration	Increase Aeration

1.2 Shutdown Procedures

IMPORTANT!

The Grantham wastewater treatment system is designed to run automatically and continuously, therefore, a complete shutdown is generally not required.

1.3 Failure and Emergency Procedures

Always leave the power to the treatment plant turned on. In the event of a complete power outage, upon the return of power the treatment plant will reset and start up automatically.

IMPORTANT!

In the event of an emergency situation, the emergency stop button located in the control room must be pressed to stop all treatment plant equipment.

H

SECTION 6 – PLANT EQUIPMENT FUNCTION

Hazard and Safety Warnings

Prompts have been used throughout the manual to highlight safety, environmental and process concerns. The following information describes the prompts used in the manual and their meanings:

DANGER!

Indicates a hazard or situation where failure to use the correct procedures WILL cause either severe personal injury or death.

WARNING!

Indicates a hazard or situation where failure to use the correct procedures COULD result in severe personal injury or death.

CAUTION!

Indicates a hazard or situation where failure to use the correct procedures COULD result in severe personal injury or equipment damage.

IMPORTANT!

Indicates information within the text which is of particular importance to the procedure or operation being described.

REMEMBER!

Indicates information within the text which is of sufficient importance to warrant highlighting.

NOTE!

Indicates information which has been covered in an earlier section of the text but which warrants reinforcement.

Contents

Equipment Function

Equipment

The specific equipment items and their function are described in this section.

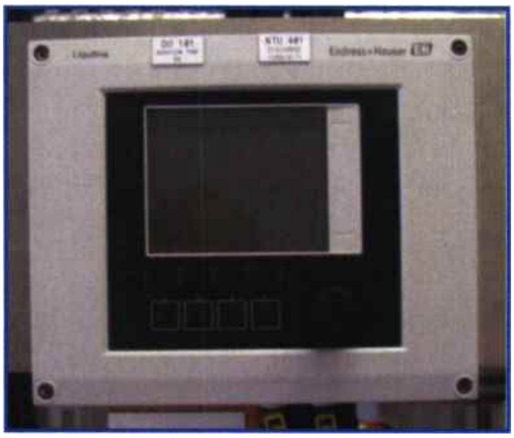
IMPORTANT!

All equipment functions are automatically controlled by the treatment plant's control system. Manual intervention is possible through the operator interface that is described in *Error! Reference source not found.* ***'Software'.***

Equipment Name	Equipment Number	Equipment Function
Balance Tank	N/A	The holding tank where screened influent is transferred and held for further treatment. The holding tank ensures the treatment plant can manage high inflows during peak periods by storing the influent and treating it during off peak periods.
Anoxic Tank	N/A	The denitrification process occurs in the anoxic tank under anaerobic conditions, removing and releasing nitrogen (N) from the effluent.
Aeration Tank	N/A	The nitrification process occurs in the aeration tank under aerobic conditions, where ammonia (NH_3) is converted (oxidised) into nitrites (NO_2^-) and nitrates (NO_3) by bacteria within the aeration tank.
Clarified Tank	N/A	The clarified tank is a holding tank for effluent that has been clarified prior to being pumped to tertiary treatment via the crossflow pumps (P301 & 302)
Solids Digester Tank	N/A	The organic solids that accumulate in the sewage treatment plant are pumped to the solids digester tank during the digestion operation that occurs once or twice daily. Over time the solids concentrate in the digester tank and break down through aerobic digestion. Aerobic digestion is a bacterial process occurring in the presence of oxygen, whereby bacteria rapidly breakdown the organic matter and convert in to carbon dioxide (CO_2).

Final Effluent Tank	N/A	The treated effluent is stored in the final effluent tank where it is transferred to the irrigation storage tanks.
Pump Room	N/A	All pumps except blowers & dosing pumps are installed in the pump room. 
Balance Pump 1	P101	Pump screened influent from the balance tank to the anoxic tank in tandem with balance pump 2.
Balance Pump 2	P102	Pump screened influent from the balance tank to the anoxic tank in tandem with balance pump 1.
Air Blowers	P203 & P204	Delivers process air to the aeration tank, balance tank and solids digester tank.
a' Recycle Pump	P103	Recirculates liquor from the aeration tank to the anoxic tank to ensure sufficient denitrification.
RAS Pumps	P201 & P202	Returns activated sludge to the anoxic tank to maintain sufficient MLSS level in the bioreactor.
Backwash pump	P303	Pumps treated effluent to backwash media filters.
Crossflow Pumps	P301 & P302	Pumps clarified effluent through media filters and UV lamps to final effluent tank
Recirculation Pump	P401	Pump recirculates final treated effluent to maintain a chlorine residue via CL401 and P402
Sodium Hypochlorite Dosing Pump	P402	Chlorine addition 

Sodium Aluminate Dosing Pump	P205	Phosphorous removal 
Digital Flow Meter – Full Bore	FM101	Measures the flow rate of raw sewage entering the treatment plant and feeds the information into the treatment plant control system.
Insertion Flow Meter	FM102	Balance tank delivery flow meter
Insertion Flow Meter	FM103	'a' recycle flow meter 
Diaphragm Pressure Sensor 0-0.4 Bar	WL101	Measures the liquid level by sensing pressure in the balance tank and feeds the information into the treatment plant control system.
Dissolved Oxygen Sensor & Transmitter	DO101	Measures dissolved Oxygen level in aeration tank

		
Diaphragm Pressure Sensor 0-0.4 Bar	WL102	Aeration tank level sensor
Diaphragm Pressure Sensor 0-0.25 Bar	WL201	Clarified tank level sensor
Diaphragm Pressure Sensor 0-1 Bar	PT201	Aeration pressure sensor.
Insertion Flow Meter	FM301	Filtration flow meter 
pH transmitter	pH301	Aeration pH
Diaphragm Pressure Sensor 0-4Bar	PT301	Pre-filter pressure sensor 

Diaphragm Pressure Sensor 0-4 Bar	PT302	Post filter pressure sensor
Diaphragm Pressure Sensor 0-0.4 Bar	WL401	Final effluent tank level sensor
Insertion Flow Meter	FM401	Discharge flow meter
CONEX 314	CL401	Chlorine residual monitor & controller 
CONEX 314	pH401	pH probe
CONEX 314	TP401	Temperature probe
	NTU401	Turbidity sensor and transmitter

Manual Valves		Many types of manual shut off valves have been installed within the treatment plant and are used to isolate equipment items or perform other manual tasks like draining a process tank. 
UV System	UV401 & UV402	Disinfects filtered effluent 
Digester Air Supply Solenoid Valve	AV101	Controls the air supply to the digester. Turns off during the WAS cycle to allow the digester to settle and the supernatant overflow back to the anoxic tank.

Equipment Description and Specifications

The following tables display a complete parts list of the equipment used in the Grantham Waste Water Treatment Plant, including:

- the part number as displayed in Stornoway's Process and Instrumentation Diagrams (P&IDs)
- the power requirements and size of the equipment
- the electric power phase
- a description of the equipment
- where the equipment is located on Stornoway P&IDs
- the manufacturer of the equipment
- the model of the equipment
- the type of treatment process flow the equipment works with, for example, raw sewage.

Parts List

NOTE!

Refer to the Process & Instrumentation Drawings.

Tank	Description	Drawing #	Volume	Material	Liquid
Balance Tank	Screened sewage holding tank	P&ID-01	46 m^3	Polyethylene	Screened Influent
Anoxic Tank	Denitrification — very low dissolved oxygen	P&ID-01	36m^3	Polyethylene	Process Liquor
Aeration Tank	Nitrification — aerated liquor and high dissolved oxygen	P&ID-01	46m^3	Polyethylene	Process Liquor
Clarified Tank	Storage of clarified liquor, holding tank for tertiary treatment (filtration/UV)	P&ID-02	10m^3	Polyethylene	Process Liquor
Solids Digester Tank	Aerobic digestion — breaks down organic solids	P&ID-05	46m^3	Polyethylene	Activated Sludge
Final Effluent Tank	Stores final effluent	P&ID-04	46m^3	Polyethylene	Treated Effluent

Table 1 Tank Register

Motor Number	kW	Phase	Drive	Description	Drawing #	Manufacturer	Model	Liquid	Plant Location	Control Location
MX101	0.75	3	DOL	Anoxic Mixer	W536 - P001	GRUNDFOS	AMD.07.18.1410	Screened Influer	Anoxic Tank	STP MCC
M101	0.5	3	DOL	Screen Motor	W536 - P001			Raw Sewage	Screen	STP MCC
M201	0.14	3	DOL	Blower Fan 1	W536 - P002	ROBUSCHI		Air	Blower	STP MCC
M202	0.14	3	DOL	Blower Fan 2	W536 - P002	ROBUSCHI		Air	Blower	STP MCC
Pump Number	**kW**	**Phase**		**Description**	**Drawing #**	**Manufacturer**	**Model**	**Liquid**	**Plant Location**	**Control Location**
P101	0.75	3	VSD	Balance Pump 1	W536 - P001	GRUNDFOS	NBG 50-32-160/177	Screened Influer	Control Room	STP MCC
P102	0.75	3	VSD	Balance Pump 2	W536 - P001	GRUNDFOS	NBG 50-32-160/177	Screened Influer	Control Room	STP MCC
P103	0.55	3	VSD	a' Recycle Pump	W536 - P001	GRUNDFOS	NBG 50-32-160/172	Screened Influer	Control Room	STP MCC
P104	0.02	1	DOL	Sodium Aluminate Dosing Pump	W536 - P001	GRUNDFOS		NaAlO2	Chemical Room	STP MCC
P201	0.75	3	VSD	RAS Pump 1	W536 - P002	GRUNDFOS	NBG 50-32-160/177	Screened Influer	Control Room	STP MCC
P202	0.75	3	VSD	RAS Pump 2	W536 - P002	GRUNDFOS	NBG 50-32-160/177	Screened Influer	Control Room	STP MCC
P203	4	3	VSD	Aeration Blower 1	W536 - P002	ROBUSCHI	ES15/1P	Air	Outside control roo	STP MCC
P204	4	3	VSD	Aeration Blower 2	W536 - P002	ROBUSCHI	ES15/1P	Air	Outside control roo	STP MCC
P301	0.75	3	VSD	Crossflow Pump 1	W536 - P003	GRUNDFOS	NBG 50-32-160/177	Screened Influer	Control Room	STP MCC
P302	0.75	3	VSD	Crossflow Pump 2	W536 - P003	GRUNDFOS	NBG 50-32-160/177	Screened Influer	Control Room	STP MCC
P303	2.2	3	VSD	Backwash Pump	W536 - P003	GRUNDFOS	NBG 65-40-200/217	Final Effluent	Control Room	STP MCC
P401	1.5	3	DOL	Recirc Pump	W535 - P004	GRUNDFOS	NBG 50-32-160/172	Final Effluent	Control Room	STP MCC
P402	0.02	1	DOL	Chlorine Dosing Pump	W536 - P004	GRUNDFOS		NAOCl	Chemical Room	Via Conex Unit
P403	0.55	3	VSD	Reticultation Pump	W536 - P004	GRUNDFOS		Final Effluent		
P404	<4 kW	3	DOL	Discharge Pump 1	W536 - P004	GRUNDFOS		Final Effluent	Control Room	STP MCC
P405	<4 kW	3	DOL	Discharge Pump 2	W536 - P004	GRUNDFOS		Final Effluent	Control Room	STP MCC

Table 2 Motors and pumps register

Equipment Number	Size	Power Supply	Phase	Output	Application	Description	Drawing #	Manufacturer	Model	Liquid
FM101	3"	24v	DC	4-20mA	Inlet Flowmeter	Digital flow meter - Mag Flow	W536 - P001	Burkert	Series SO55 & SE56	Raw Sewage
FM102	1 1/2"	24v	DC	4-20mA	Balance Delivery Flowmeter	Digital flow meter - Insertion	W536 - P001	Burkert	Series 8045 & SO20	Screened Influent
WL101	1" BSP	24v	DC	4-20mA	Balance Tank Level Sensor	Diaphragm Pressure Sensor; 0-0.4 Bar	W536 - P001	Burkert	Series 8323	Screened Influent
DO101	24v	240v	1 ph	4-20mA	Aeration Tank Dissolved Oxygen	Dissolved Oxygen Sensor and Transmitter	W536 - P001	Endress & Hauser	Liquisys M COM253 & Oxymax W COS61	Screened Influent
WL102	1" BSP	24v	DC	4-20mA	Aeration Tank Level Sensor	Diaphragm Pressure Sensor; 0-0.4Bar	W536 - P001	Burkert	Series 8323	Screened Influent
FM103	3"	24v	DC	4-20mA	a' Recycle Flowmeter	Digital flow meter - Insertion	W536 - P001	Burkert	Series 8045 & SO20	Screened Influent
WL201	1" BSP	24v	DC	4-20mA	Clarified Tank Level Sensor	Diaphragm Pressure Sensor; 0-0.25Bar	W536 - P002	Burkert	Series 8323	Screened Influent
PT201	1/2"	24v	DC	4-20mA	Aeration Pressure Sensor	Diaphragm Pressure Sensor; 0-1 Bar	W536 - P002	Burkert	Series 8323	Air
FM301	2"	24v	DC	4-20mA	Filtration Flowmeter	Digital flow meter - Insertion	W536 - P003	Burkert	Series 8045 & SO20	Clarified Sewage
pH301	2"	24v	DC	4-20mA	Aeration pH	pH Transmitter	W536 - P003	Burkert	Series 8202	Clarified Sewage
PT301	1/2"	24v	DC	4-20mA	Pre-filter Pressure	Diaphragm Pressure Sensor; 0-4Bar	W536 - P003	Burkert	Series 8323	Clarified Sewage
PT302	1/2"	24v	DC	4-20mA	Post-filter Pressure	Diaphragm Pressure Sensor; 0-4Bar	W536 - P003	Burkert	Series 8323	Filtered Sewage
WL401	1"BSP	24v	DC	4-20mA	Final Effluent Tank Level Sensor	Diaphragm Pressure Sensor; 0-0.4Bar	W536 - P004	Burkert	Series 8323	Final Effluent
FM401	2"	24v	DC	4-20mA	Discharge Flowmeter	Digital flow meter - Insertion	W536 - P004	Burkert	Series 8045 & SO20	Final Effluent
UV401	N/A	240v	1 ph	Contact	UV disinfection system	UV Disinfection Unit	W536 - P004	UV Safewater	Upstream 10-50	Filtered Sewage
UV402	N/A	240v	1 ph	Contact	UV disinfection system	UV Disinfection Unit	W536 - P004	UV Safewater	Upstream 10-50	Filtered Sewage
CL401	N/A	240v	1 ph	4-20mA	Chlorine Residual Analyser	Chlorine Residual Monitor and Controller	W536 - P004	Grundfos	Conex 314	Final Effluent
pH401	N/A	240v	1 ph	4-20mA	pH probe	pH Transmitter	W536 - P004	Grundfos	Conex 314	Final Effluent
TP401	N/A	240v	1 ph	4-20mA	Temperature sensor	Temperature Transmitter	W536 - P004	Grundfos	Conex 314	Final Effluent
NTU401	N/A	240v	1 ph	4-20mA	Turbidity meter	NTU Sensor and Transmitter	W536 - P004	Endress & Hauser	Turnimax WCUS31	Final Effluent

Table 3 Instrumentation Register

Auomatic Valve List	SIZE	Voltage	Status	Description	Drawing #	Manufacturer	Model	Liquid
AV101	3"	24V AC/DC	N/O	Electronic Actuated Ball Valve	W536 - P001	AVFI		Mixed Liqour
AV102	2"	24V AC/DC	N/O	Electronic Actuated Ball Valve	W536 - P001	AVFI		Mixed Liqour
AV301	2"	24V AC/DC	N/O	Three way Electronic Actuated Ball Valve	W536 - P003	AVFI	OM-1	Clarified Sewage
AV302	2"	24V AC/DC	N/O	Three way Electronic Actuated Ball Valve	W536 - P003	AVFI	OM-1	Clarified Sewage
AV303	2"	24V AC/DC	N/O	Electronic Actuated Ball Valve	W536 - P003	AVFI	OM-1	Filtered Sewage
AV501	2"	24V DC	N/O	Brass Solenoid Valve	W536 - P005	AVFI	Series 5281	Air

Table 4 Automatic Valve Register

Valve List	SIZE		Status	Description	Drawing #	Manufacturer	Model	Liquid
V101	2"		N/O	Cast Iron Butterfly Valve	W536 - P001	Tony Powell		Screened Influent
V102	2"		N/O	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Air
V103	2"		N/O	Cast Iron Butterfly Valve	W536 - P001	Tony Powell		Screened Influent
V104	2"		N/O	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Screened Influent
V105	2"		N/O	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Screened Influent
V106	1¼"		N/O	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Screened Influent
V107	1¼"		N/O	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Screened Influent
V108	1¼"		N/O	Brass Swing Check Valve	W536 - P001	Tony Powell		Screened Influent
V109	1¼"		N/O	Brass Swing Check Valve	W536 - P001	Tony Powell		Screened Influent
V110	6"		N/O	Cast Iron Butterfly Valve	W536 - P001	Tony Powell		Mixed Liquor
V111	6"		N/O	Cast Iron Butterfly Valve	W536 - P001	Tony Powell		Mixed Liquor
V112	6"		N/O	Cast Iron Butterfly Valve	W536 - P001	Tony Powell		Mixed Liquor
V113	2"		N/O	Cast Iron Butterfly Valve	W536 - P001	Tony Powell		Mixed Liquor
V114	2"		N/O	Cast Iron Butterfly Valve	W536 - P001	Tony Powell		Mixed Liquor
V115	2"		N/O	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Mixed Liquor
V116	1¼"		N/O	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Mixed Liquor
V117	1¼"		N/O	Brass Swing Check Valve	W536 - P001	Tony Powell		Mixed Liquor
V118	2"		N/O	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Air
V119	2"		%	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Air
V120	2"		%	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Air
V121	2"		%	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Air
V122	2"		%	uPVC True Union Ball Valve	W536 - P001	Georg Fischer		Air
V123	4mm		%	Pressure Regulating Valve	W536 - P001	Grundfos		NaAlO2
V124	4mm		%	Pressure Relief Valve	W536 - P001	Grundfos		NaAlO2
V125	4mm		N/O	Internal PE Ball Check Valve	W536 - P001	Grundfos		NaAlO2
V126	1"		N/C	uPVC Glued Socket Ball Valve	W536 - P001	Georg Fischer		Screened Influent
V127	1"		N/C	uPVC Glued Socket Ball Valve	W536 - P001	Georg Fischer		Mixed Liquor
V128	1"		N/C	uPVC Glued Socket Ball Valve	W536 - P001	Georg Fischer		Mixed Liquor
V128	1"		N/C	uPVC Glued Socket Ball Valve	W536 - P001	Georg Fischer		
V201	3"		N/O	Cast Iron Butterfly Valve	W536 - P002	Tony Powell		Mixed Liquor
V202	3"		N/O	Cast Iron Butterfly Valve	W536 - P002	Tony Powell		Mixed Liquor
V203	3"		N/O	Cast Iron Butterfly Valve	W536 - P002	Tony Powell		Mixed Liquor
V204	3"		N/O	Cast Iron Butterfly Valve	W536 - P002	Tony Powell		Mixed Liquor
Valve List	SIZE		Status	Description	Drawing #	Manufacturer	Model	Liquid

V205	3"		N/O	Cast Iron Butterfly Valve	W536 - P002	Tony Powell		Mixed Liquor
V206	2"		N/O	uPVC True Union Ball Valve	W536 - P002	Georg Fischer		Mixed Liquor
V207	2"		N/O	uPVC True Union Ball Valve	W536 - P002	Georg Fischer		Mixed Liquor
V208	1¼"		N/O	uPVC True Union Ball Valve	W536 - P002	Georg Fischer		Mixed Liquor
V208	1¼"		N/O	uPVC True Union Ball Valve	W536 - P002	Georg Fischer		Mixed Liquor
V210	1¼"		N/O	Brass Swing Check Valve	W536 - P002	Tony Powell		Mixed Liquor
V211	1¼"		N/O	Brass Swing Check Valve	W536 - P002	Tony Powell		Mixed Liquor
V212	1/4"		%	SS Quarter Turn Ball Valve	W536 - P002	Tony Powell		Air
V213	2"		N/O	Cast Iron Butterfly Valve	W536 - P002	Tony Powell		Clarified Influent
V214	2"		N/O	Cast Iron Butterfly Valve	W536 - P002	Tony Powell		
V215	3"		N/O	Brass Swing Check Valve	W536 - P002	Tony Powell		Air
V216	3"		N/O	Brass Swing Check Valve	W536 - P002	Tony Powell		Air
V217	3"		N/O	Brass Gate Valve	W536 - P002	Tony Powell		Air
V218	3"		N/O	Brass Gate Valve	W536 - P002	Tony Powell		Air
V219	1"		N/C	uPVC Glued Socket Ball Valve	W536 - P002	Georg Fischer		Mixed Liquor
V220	1"		N/C	uPVC Glued Socket Ball Valve	W536 - P002	Georg Fischer		Mixed Liquor
V301	2"		N/O	uPVC True Union Ball Valve	W536 - P003	Georg Fischer		Clarified Influent
V302	2"		N/O	uPVC True Union Ball Valve	W536 - P003	Georg Fischer		Clarified Influent
V303	2"		N/O	uPVC True Union Ball Valve	W536 - P003	Georg Fischer		Clarified Influent
V304	2"		N/O	uPVC True Union Ball Valve	W536 - P003	Georg Fischer		Clarified Influent
V305	2"		N/O	Brass Swing Check Valve	W536 - P003	Tony Powell		Clarified Influent
V306	2"		N/O	Brass Swing Check Valve	W536 - P003	Tony Powell		Clarified Influent
V307	2"		N/C	PVC Air Release Valve	W536 - P003	Georg Fischer		Clarified Influent
V308	2"		N/O	uPVC True Union Ball Valve	W536 - P003	Georg Fischer		Filtered Influent
V309	2"		N/O	uPVC True Union Ball Valve	W536 - P003	Georg Fischer		Filtered Influent
V310	2"		N/O	uPVC True Union Ball Valve	W536 - P003	Georg Fischer		Final Effluent
V311	2"		N/O	uPVC True Union Ball Valve	W536 - P003	Georg Fischer		Final Effluent
V312	2"		N/O	Brass Swing Check Valve	W536 - P003	Tony Powell		Final Effluent
V313	1"		N/C	uPVC Glued Socket Ball Valve	W536 - P003	Georg Fischer		Mixed Liquor
V401	2"		N/C	uPVC Glued Socket Ball Valve	W536 - P004	Georg Fischer		Filtered Influent
V402	1"		N/O	uPVC Glued Socket Ball Valve	W536 - P004	Georg Fischer		Filtered Influent
V403	1"		N/O	uPVC Glued Socket Ball Valve	W536 - P004	Georg Fischer		Filtered Influent
V404	1"		N/O	uPVC Glued Socket Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V405	1"		N/O	uPVC Glued Socket Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V406	1"		N/C	uPVC Glued Socket Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V407	1"		N/C	uPVC Glued Socket Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V408	2"		N/C	PVC Air Release Valve	W536 - P004	Georg Fischer		Filtered Influent
V409	4mm		N/O	Internal PE Ball Check Valve	W536 - P004	Grundfos		NaOCl
V410	2"		N/O	Cast Iron Butterfly Valve	W536 - P004	Tony Powell		Final Effluent
V411	2"		N/O	uPVC True Union Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V412	2"		N/O	uPVC True Union Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V413	2"		N/O	Brass Swing Check Valve	W536 - P004	Tony Powell		Final Effluent
V414	6"		N/O	Cast Iron Butterfly Valve	W536 - P004	Tony Powell		Final Effluent
V415	2"		N/O	uPVC True Union Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V416	1¼"		N/O	uPVC True Union Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V417	1"		N/O	uPVC True Union Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V418	1"		N/O	Brass Swing Check Valve	W536 - P004	Tony Powell		Final Effluent
V419	63mm		N/O	uPVC True Union Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V420	63mm		N/O	uPVC True Union Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V421	63mm		N/O	uPVC True Union Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V422	63mm		N/O	uPVC True Union Ball Valve	W536 - P004	Georg Fischer		Final Effluent
V423	63mm		N/O	Brass Swing Check Valve	W536 - P004	Tony Powell		Final Effluent
V424	63mm		N/O	Brass Swing Check Valve	W536 - P004	Tony Powell		Final Effluent
V501	2"		%	Brass Gate Valve	W536 - P005	Tony Powell		Air
V502	2"		%	uPVC Glued Socket Ball Valve	W536 - P005	Georg Fischer		Air
V503	3"		N/O	Cast Iron Butterfly Valve	W536 - P005	Tony Powell		Mixed Liquor
V504	1"		N/C	uPVC Glued Socket Ball Valve	W536 – P005	Georg Fischer		Mixed Liquor

Table 5 Valve Register