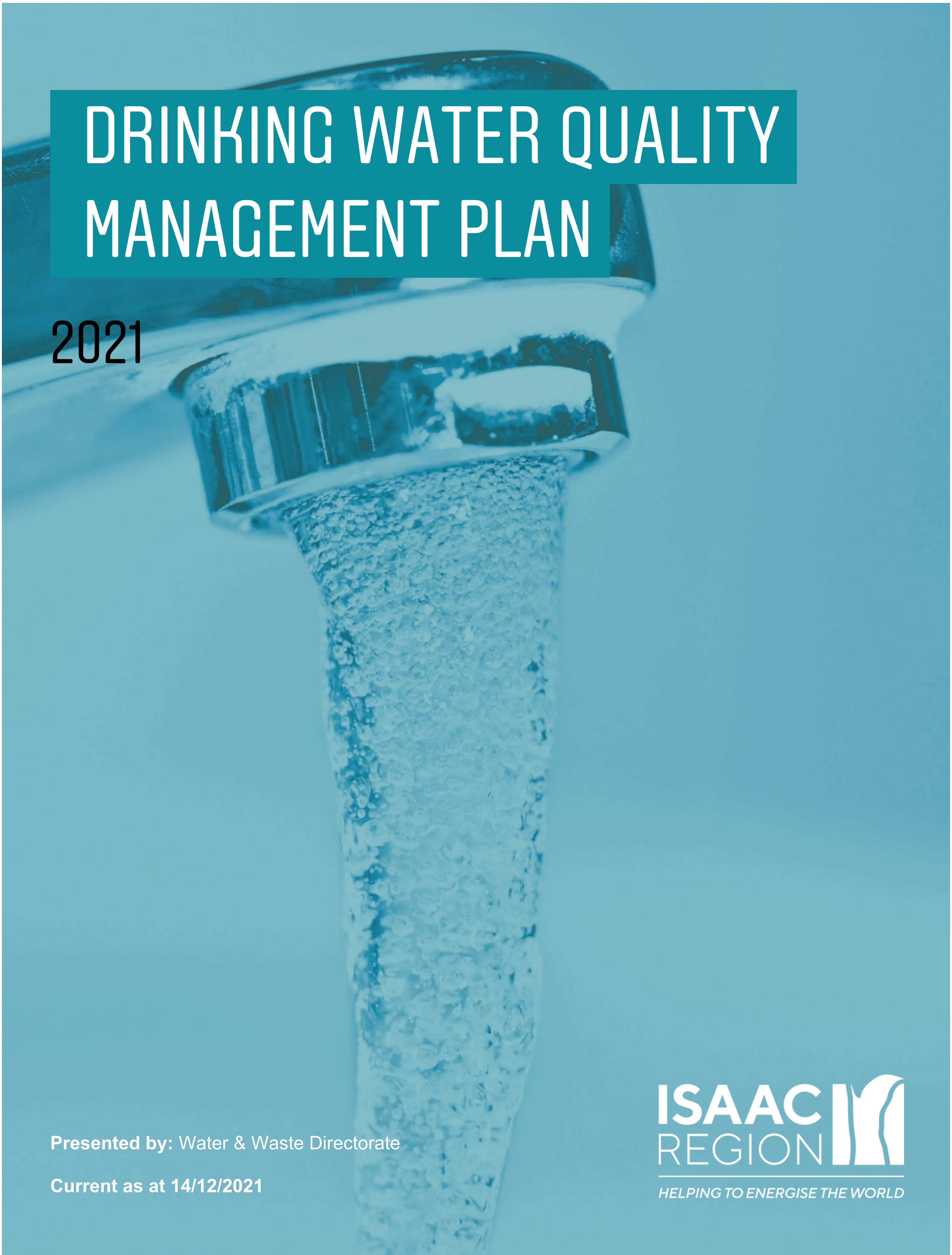

DRINKING WATER QUALITY MANAGEMENT PLAN

2021

Presented by: Water & Waste Directorate

Current as at 14/12/2021

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Information	Details
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8	Final DWQMP submission for Approval	06/11/2013

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PURPOSE

The purpose of the Drinking Water Quality Management Plan (DWQMP) is to provide a structure for sustainably managing water quality of water supply schemes in Isaac Regions; Clermont, Moranbah, Nebo, Glenden, St Lawrence, Carmila, Dysart and Middlemount.

REGISTERED SERVICE DETAILS

TABLE 0-1: SERVICE PROVIDER DETAILS	
Service Provider	Isaac Regional Council
SPID	486
Contact Details	Isaac Regional Council PO Box 97 Moranbah QLD 4744

SCHEME DETAILS

This DWQMP applies to eight drinking water schemes within the Isaac Regional Council - Clermont, Moranbah, Nebo, Glenden, St Lawrence, Carmila, Dysart and Middlemount. The locations of each of these schemes are shown on the map in Figure 0-1.

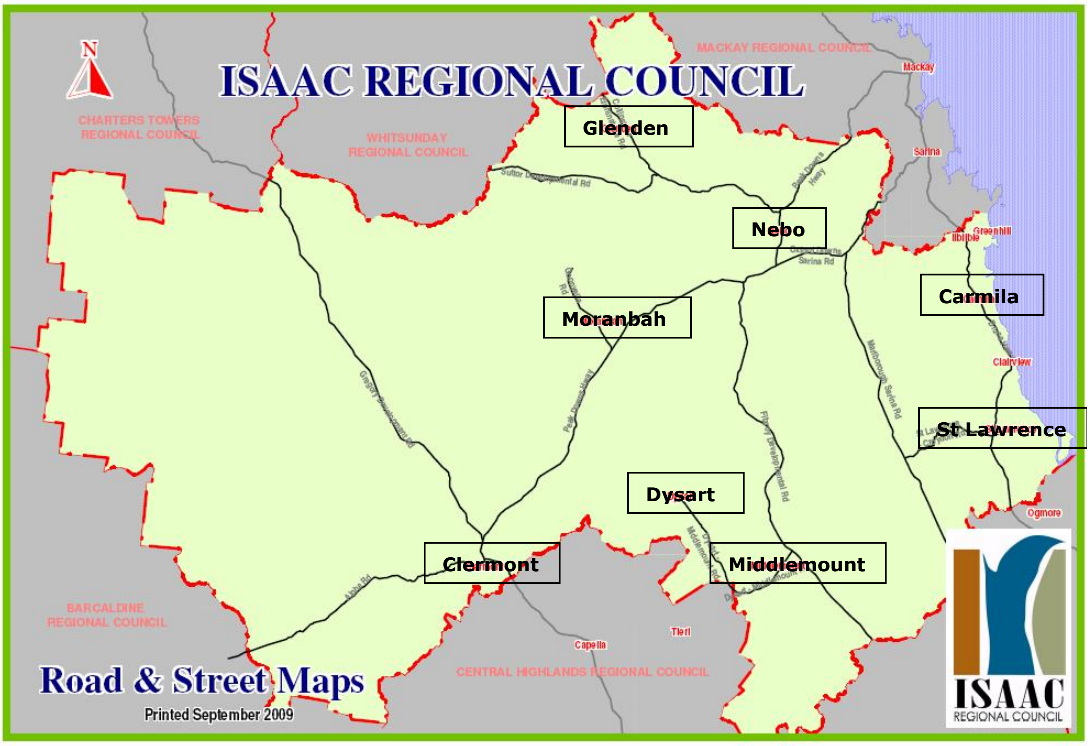


Figure 0-1: Isaac Region Map

POPULATIONS AND DEMAND

In 2011 KPMG conducted a study into population growth and demand projections for the Isaac region. Since this time there has been a significant downturn in mining activities, resulting in a substantial decrease in population, with negative population growth for the Isaac region compared to positive growth for the greater Mackay-Isaac-Whitsunday area (REMPLAN Community Profile, 2020) and serviced connections. In light of this, previous growth projections are no longer applicable and future growth should be reassessed prior to any major infrastructure upgrades to ensure capacity is commensurate with current demand expectations. Current population, connections and demand are summarised Table 0-2 Isaac Region 2020 Population (Remplan, 2020) and Connection Figures (IRC, 2021).

TABLE 0-2: ISAAC REGION 2020 POPULATION (REMPLAN, 2020) AND CONNECTION FIGURES (IRC, 2021)

Community	Population	Connections	ADD (ML/day)
Clermont	3,031	1,429	2.055
Moranbah	8,735	4,194	6.495
Nebo	753	401	0.564
Glenden	620	590	0.936
St Lawrence	235	137	0.059
Carmila	333	71	0.047
Dysart	2,991	1,500	2.239
Middlemount	1,841	969	1.265

Council continues to monitor mining development and housing demand in the area as they are aware of several potential new mine developments which may result in significant increase in population and water demand. High level population and demand forecasts are undertaken every 2 years as part of Council's Strategic Asset Management Plan (SAMP) process to develop and update a 10-year CAPEX plan as required by the Queensland Government Department of State Development.

CLERMONT WATER SCHEME

Raw water for the Clermont Water Scheme is taken from the Theresa Creek Dam located approximately 22 km south west of Clermont WTP. Water from the Clermont WTP is supplied to the residents of Clermont via a gravity reticulation network. The infrastructure for the overall scheme is shown schematically in Figure 0-1. The WTP process is shown schematically in Figure1 0-2.

It should be noted that the bore fields and Douglas Street reservoir have not been used for many years. This infrastructure has been included in the diagram as the pipework has not been demolished. However, the pumps are electrically disconnected, hence it is not possible for water from the Douglas Street bores to enter the Clermont water supply network. The Capricorn St reservoir is being reinstated to increase treated water storage capacity. New pipework will be installed for the new configuration.

An overview of the Clermont Water Scheme is shown in Table 3.1 with further details in the sections following.

TABLE 0-1: CLERMONT SYSTEM OVERVIEW

System Component	Description
Population Supplied	Total of approximately 1,429 connections, comprising of approximately 3,031 persons.
Water Sources	• Surface water from the Theresa Creek Dam
Water Storage (Before Treatment)	• 0.45 ML Raw Water Balance Reservoir • 2.0 ML Raw Water Reservoir
Water Treatment	Raw Water from the Theresa Creek Dam is dosed with pre-treatment chemicals prior to entering the Raw Water Reservoir: • Pre-pH correction with sodium hydroxide (if required); • Pre chlorine gas dosing for metals oxidation (alternate oxidant); • PAC dosing for removal of tastes and odours; • Oxidation with potassium permanganate (preferred). Additional chemicals can be dosed on the outlet of the Raw Water Reservoir if required, to increase process flexibility: • PAC • Potassium permanganate Pre-dosed water is treated at Clermont WTP as follows: • Pre pH correction with sodium hydroxide (when required); • Pre chlorine gas dosing for metals oxidation; • Coagulation with alum; • Polymer dosing for flocculation aid (when required); • Flocculation; • Clarification; • PAC dosing for taste and odour removal; • Chlorine dosing for residual metals oxidation;

TABLE 0-1: CLERMONT SYSTEM OVERVIEW	
System Component	**Description**
	• Sand filtration; • Disinfection with chlorine gas; • pH correction with sodium hydroxide; and • Trim chlorine gas dosing to maintain a residual in the reticulation. The wastewater system comprises of: • Backwash holding Tank; • Sludge and Backwash water sent to Sludge Lagoons (x4); and • Supernatant used for onsite irrigation or returned to the Raw Water Reservoir.
Water Storage (After Treatment)	• 3.0 ML and 5.0 ML Clearwater Tanks located onsite and hydraulically linked0.52 ML Jeffrey Street Reservoir • 0.45 ML Capricorn Street Reservoir • Douglas Street Reservoir (not in use) All treated water storages are roofed, and vermin proofed.
Distribution of Product	Gravity fed from both the Jeffrey Street and Capricorn Street Reservoirs via reticulation mains.
Any Special Controls Required	Quality of chemicals, materials, etc. used in the production and delivery of the product. Manual verification sampling of water from the distribution network. Backflow prevention and trade waste management. Operation and maintenance of all infrastructure to prevent recontamination.

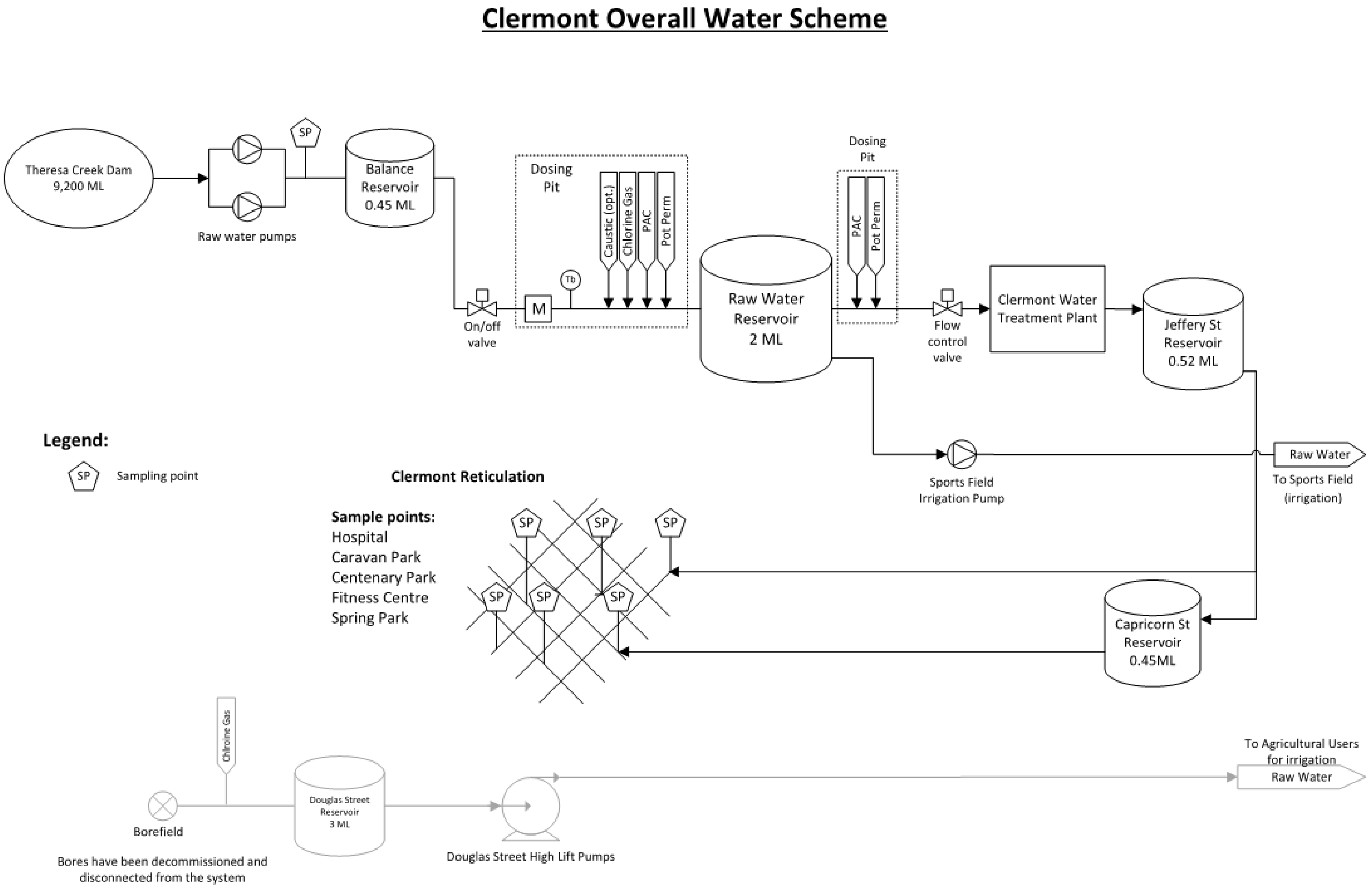


Figure 0-1: Clermont Overall Water Supply System

Clermont Water Treatment Plant

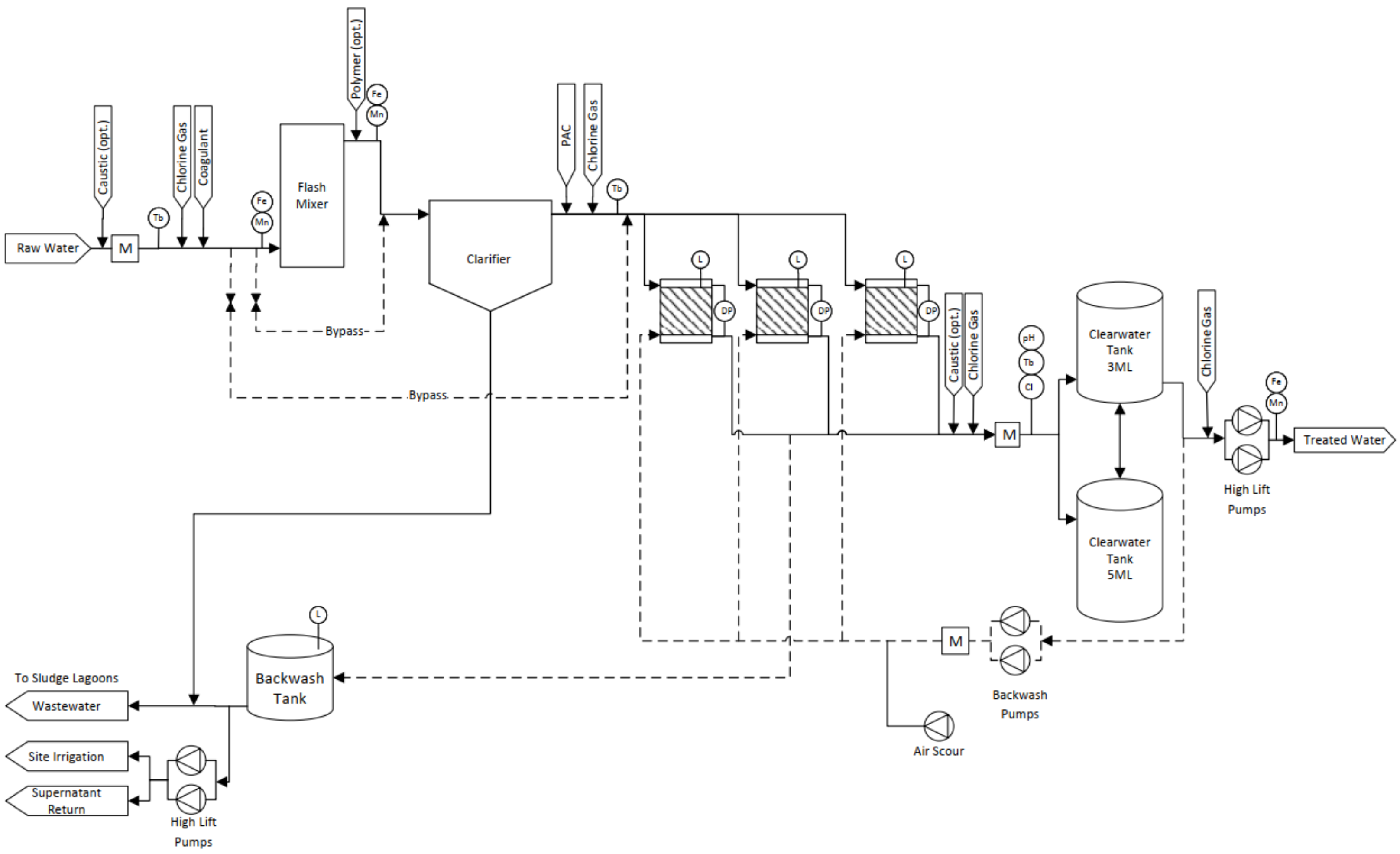


Figure1 0-2: Clermont Water Treatment Plant

CLERMONT CATCHMENT

The Theresa Creek Dam catchment is in the Queensland Central Highlands. The Central Highlands Regional Resources Use Planning Cooperative produced a Central Highlands Natural Resource Management Plan in December 2003 which states that the area experiences a sub-tropical climate characterised by high variability in rainfall, temperature and evaporation. Droughts, floods, heat waves and frosts all feature as part of the local climate. In the Clermont catchment 70-75% of the annual rainfall occurs in the summer months (October to March). Most rain between September and December results from thunderstorms, whose high intensity can produce run-off and soil erosion issues. The Theresa Creek Dam catchment is made up of alluvial plains, brigalow plains, eucalypt uplands and undulating downs.

The Theresa Creek Dam catchment area is approximately 600 km^2. Aside from being the raw water supply to the Clermont WTP, the Theresa Creek Dam catchment has the following uses:

- Stock farming;
- Contact recreation including swimming, sailing, and fishing;
- Non-contact recreation including picnicking, bush walking, and camping;
- There are no known industrial or mining activities planned for the catchment.

CLERMONT RAW WATER

All raw water for the Clermont Water Scheme is taken from the Theresa Creek Dam.

There are six licensed bores in Clermont which will require upgrades for untreated irrigation use to reduce the demand on Theresa Creek Dam raw water supply. These bores are completely isolated from the treated water supply system. Accordingly, this document does not further discuss these bores.

Theresa Creek Dam

Theresa Creek Dam has an area of 250 ha, and has a design capacity of approximately 9,200 ML[1], however the maximum usable storage has been reduced to approximately 7,000 ML due to siltation. This corresponds to 7 years storage capacity at current average annual demand. The dam also has a high rate of evaporation, especially during the summer months, resulting in reduced availability of raw water during dry periods. There are additional requirements for riparian release of water to the downstream farmers. Riparian release is initiated by manually opening a valve at the spillway. The spillway is constructed of reinforced concrete and the riparian release valve is a hydraulic cone dispersion valve which allows a flow rate of up to 1972 L/s. This valve is operated by WTP operators when required.

A raw water intake tower constructed from reinforced concrete is located in the dam. This tower has four intake levels which can be opened and closed manually depending on the level of water in the dam. The intake levels of the tower are at two, four, six and eight metres. There is a screen located on the intake which protects the pumps from debris. This screen is manually lifted and cleaned by the operators when required. Water is pumped from the dam to the Raw Water Balance Reservoir by a set of two identical centrifugal high lift pumps arranged in a duty/standby configuration. The intake is 300 mm in diameter and the pumps can each provide 112 L/s at 78 m head.

1 Parsons Brinckerhoff (2009) Theresa Creek Dam Siltation Study.

Figure 0-3: Theresa Creek Dam Intake Tower

The water then flows via an open surge standpipe to the Raw Water Balance Reservoir.

Raw Water Balance Reservoir

The Raw Water Balance Reservoir is constructed of reinforced concrete. It has a diameter of 10.7 m, a height of 5.35 m and a capacity of 0.45 ML. The level in this reservoir is measured and sent by telemetry to the raw water pumps. The raw water pumps stop when the reservoir reaches a stop fill level setpoint and start again when the level reaches a refill level setpoint.

Raw water from the Raw Water Balance Reservoir flows by gravity through the raw water main to the Raw Water Reservoir located adjacent to the Clermont Water Treatment Plant. The raw water main is 19.5 km long and is made from 375 mm diameter pipe sections of asbestos cement and ductile iron.

Raw Water Reservoir

The Raw Water Reservoir is an open reservoir constructed from reinforced concrete. It has a diameter of 25 m, a height of 4.2 m, and a capacity of 2 ML.

A control valve on the inlet to the Raw Water Reservoir closes when the level in this reservoir reaches a stop fill level setpoint and opens when the reservoir reaches a refill level setpoint. The gravity main from the Raw Water Balance Reservoir to the Raw Water Reservoir normally remains full.

Raw Water flows by gravity from the Raw Water Reservoir to the Clermont WTP. The flow is measured at the inlet to the WTP and is controlled to the operator's setpoint by a flow control valve located at the outlet of the Raw Water Reservoir. In addition to controlling flow to the operator setpoint, this valve will also close automatically when the level in the Treated Water Reservoir reaches the WTP stop level setpoint. The valve opens again automatically once the Treated Water Reservoir level reaches the start level setpoint.

There is a chemical dosing pit at the WTP, prior to the Raw Water Reservoir that enables dosing of sodium hydroxide, chlorine gas, PAC and/or potassium permanganate as required for pre-treatment. Potassium permanganate is typically preferred over chlorine for oxidation when there are high levels of organics in the raw water, to reduce the risk of THM formation.

CLERMONT WATER TREATMENT PLANT

The WTP was originally rated for an instantaneous throughput of 65L/s (as detailed in the WTP Operations and Maintenance Manual) but sizing calculations show that the WTP could run at up to 80L/s if necessary. The WTP throughput is typically set at 60L/s. The WTP does not run continuously, but automatically starts and stops as required by the level in the Treated Water Reservoir.

Raw Water Dosing

The first raw water dosing point at Clermont WTP is a pit just prior to the plant flow control valve where PAC and potassium permanganate can be dosed if required. From this pit, the raw water main from the Raw Water Reservoir continues to the flash mixer via a magnetic flowmeter as shown in the photograph in Figure 0-4. Sodium hydroxide is dosed into the raw water main on the outlet of the dosing pit as required to adjust the pH for coagulation. Chlorine and alum are dosed just after the flowmeter at the inlet to the flash mixer. The first dose point is chlorine which is dosed at this point to oxidise any residual iron and manganese. The second dose point is for alum which is added for coagulation.

All chemical dosing setpoints are selected when required by the operators and flow paced to the WTP flow. The chemical dosing stops automatically when no flow is detected in the WTP.

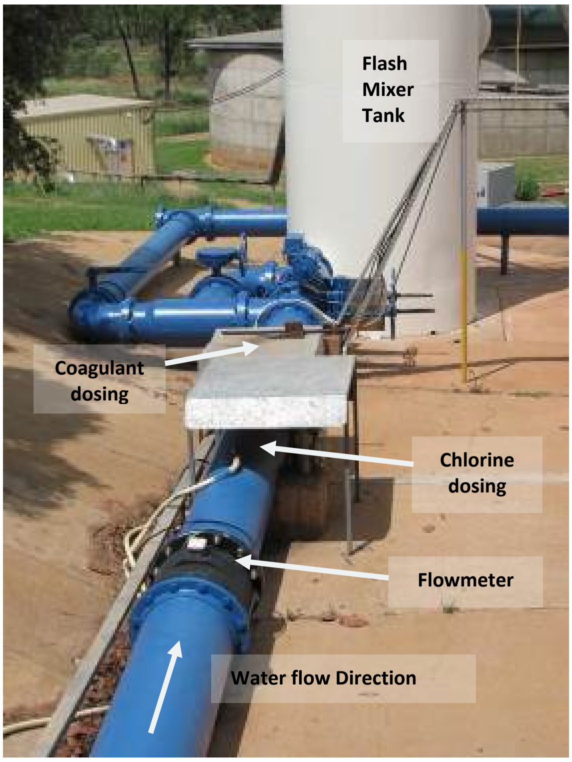


Figure 0-4: WTP Inlet

Flash Mixing and Flocculation

Hydraulic mixing occurs in the raw water line at each dosing point and by passing through the flash mixer. This tank was constructed to provide time for floc formation and for flow distribution to a future second clarifier. The flash mix tank is constructed of steel and is 2 m in diameter and 4.7 m tall, resulting in a volume of 15 m³ which provides 3 minutes of detention time at maximum flow of 80 L/s.

A polymer preparation unit and dosing pumps are installed so that polymer can be dosed into the flash mixer outlets as a flocculation aid. Polymer dosing is only used when poor quality water enters the WTP and is normally turned off.

Water flows by gravity from the flash mixer to the flocculation chamber in the centre of the sludge blanket clarifier. The water is mixed in the flocculation chamber by three mixers. Mixers are only run while the plant is in operation, which can cause sludge blanket disturbance and floc carryover into the filters during start-up. The flocculation chamber is 6 m in diameter and 3 m deep, resulting in a volume of approximately 85 m³.

The estimated total retention time in the flash mixer and the flocculation chamber is 20 minutes at the normal WTP flowrate of 60 L/s. This retention time is sufficiently long to promote good floc formation.

Clarification

The clarifier is a reactor-type clarifier with a central flocculation zone as described in Section 0.

The floc that has formed during flocculation settles to the bottom of the clarifier. Clarified water flows out via the launders and to the filters via the outlet channel. PAC, when required, is dosed into the settled water in the clarifier outlet channel. PAC is dosed to prevent the taste and odour issues caused by cyanotoxins created by algal growth in the Theresa Creek Dam. Figure 0-5 shows the PAC slurry being dosed into the clarifier outlet channel.

Figure 0-5: Clarifier with Central Flocculation Chamber

Chlorine can also be dosed into the clarifier outlet channel to oxidise and residual iron and manganese for removal in the filters.

Sludge is collected on the bottom of the clarifier and there is a motorised rake which moves the sludge to a central sludge collection hopper. The sludge is removed by opening an air-actuated de-sludge valve at the bottom of the clarifier sludge hopper. The de-sludge valve is opened on a timer-control set by the operators and the sludge flows to four sludge lagoons. This timer is adjusted depending on raw water quality.

The clarifier's shell is constructed from steel and appears to be in good condition with no observed deterioration on its external surface. The mechanical mixers also appear to be in good working order.

The flash mixer and/or clarifier can be bypassed when raw water quality is acceptable for direct filtration.

Filtration

The clarified water flows by gravity into three rapid sand filters. The media depth is 1,250 mm and is a mixture of various sizes of gravel and sand layers. The filter shells are constructed of steel and each has a diameter of 3.6 m.

Filter backwash is manually initiated but the sequence is automatically controlled through SCADA. The operator normally watches the backwash and only returns the filter to service once the water is visually clear. The dirty backwash water flows from the filters into a dedicated backwash holding tank.

The filter backwash pumps have a capacity of 148 L/s at a total head of 10 m. The air scour blowers have a capacity of 5.3 m3/min against a pressure of 3.5 m of water. The filter tank surface and associated mechanical equipment appear to be in good condition. The filters are shown in Figure 0-6.

Figure 0-6: Rapid Sand Filters

Treated Water Reservoirs (Clearwater Tanks)

Water flows by gravity from the three filters to the two Treated Water Reservoirs. The Treated Water Reservoirs are also used as chlorine contact tanks. They provide more than the 30 minutes of chlorine contact time required for disinfection. The two reservoirs are hydraulically balanced for simultaneous inlet and outlet.

The filtered water main which leads to the Treated Water Reservoirs is 300 mm in diameter and approximately 50 m long. Chlorine gas is dosed for disinfection into the filtered water main leading to the Treated Water Reservoirs (Clearwater Tanks). Sodium hydroxide can also be dosed into the filtered water main as required for pH correction.

The 3 ML Treated Water Reservoir is 24.8 m in diameter and 6 m high. It is constructed from reinforced concrete and has a steel roof. Since it is completely enclosed, this reservoir is considered vermin proof.

The 5 ML Treated Water Reservoir is 32.5 m in diameter and 6.9 m high. It is constructed from galvanised steel panels, has a reinforced PVC liner and a steel roof. It is completely enclosed, including the use of vent guards, and is considered vermin proof.

The WTP is operated at an operator selected flow setpoint and is stopped and re-started based on the level in the 3 ML Treated Water Reservoir.

Figure 0-7: 3 ML Treated Water Reservoir (Clearwater Tank)

Two high lift pumps transfer water from the 3 ML Treated Water Reservoir to the Jeffrey Street reservoir. These pumps start and stop based on the measured level in the Jeffrey Street Reservoir. The pumps are arranged in a duty/standby configuration and have a capacity of 100 L/s at a head of 48 m. Treated water is dosed with a chlorine trim dose prior to the high lift pumps if required to boost the residual in the reticulated water. The high lift pumps are located within a pump house as shown in Figure 0-8.

Figure 0-8: High-lift pump rising main (left) and filter backwash line (right)

Sludge and Backwash Treatment

The WTP has a backwash holding tank where dirty backwash water is collected prior to flowing by gravity to the sludge lagoons. Wastewater from the backwash tank can be directed to 3 places – supernatant return to the Raw Water Reservoir, supernatant recycled for onsite irrigation, thickened sludge and clarifier blowdown to the sludge lagoons.

There are four sludge lagoons which receive the clarifier sludge and thickened backwash wastewater from the holding tank. The volume of each lagoon is 2,500 m^3. The lagoons are operated in series so solids sedimentation takes place mostly in the first two lagoons. The settled sludge is removed infrequently, and the supernatant is released manually to the nearby creek. This creek is downstream of the Theresa Creek catchment and therefore this release of supernatant has no effect on the raw water supplied to the Clermont WTP.

Chemical Dosing

The WTP process currently uses the following chemicals:

TABLE 0-2: CHEMICAL USE IN THE CLERMONT WATER TREATMENT PROCESS		
Chemicals	**Dosing Location**	**Uses / Comments**
Potassium permanganate	Raw water dosing pit	Oxidation of Iron and Manganese
PAC	Raw water dosing pit Clarifier outlet	Taste and odour removal Taste and odour removal
Sodium hydroxide	Raw water dosing pit outlet Filtered Water	Pre-pH adjustment (as required) Post-pH correction
Chlorine gas	Flash Mixer Inlet Clarifier Outlet Filtered Water Treated Water	Iron and Manganese oxidation Residual Iron and Manganese oxidation Disinfection Residual Trim Dose
Alum	Flash Mixer Inlet	Coagulation and Flocculation
Polymer	Flash mixer outlet	Flocculation Aid (when required)

There is one dosing pump for each of the two sodium hydroxide dose points, PAC dose point, and coagulant dose point. There is one common dosing pump for the sodium hydroxide dosing points into the flash mixer inlet and filtered water stream. There is a duty/standby system for polymer dosing, though they utilise a common dosing line. There is one chlorinator for each chlorine dose point at the WTP.

Dosing of all chemicals is now flow paced according to dose rates which are manually adjusted by the operators as required on the basis of operational sampling results (e.g. jar testing). Flow pacing ensures that a more stable concentration of each chemical is dosed into the system. A SCADA system has now been installed along with chemical system upgrades for improved monitoring and control of the process.

CLERMONT RESERVOIRS

Water from the Treated Water Reservoir (located on the WTP site) is pumped using two high lift pumps to the elevated Jeffrey Street Reservoir. This reservoir is 8.7 m in diameter, 10 m high and has a capacity of 0.52 ML. Water flows to reticulation from this reservoir by gravity. This reservoir is roofed and constructed of reinforced concrete. Since the reservoir is completely enclosed, there is no possible access for vermin.

The Capricorn Street reservoir is at a slightly lower elevation than Jeffery Street reservoir but is still at a higher elevation than much of Clermont. Water will be transferred from Jeffery Street to Capricorn Street reservoir by gravity. This reservoir is 9.15 m in diameter, 24.4 m high and has a useable capacity 0.45 ML.

Water will flow to the reticulation from both these reservoirs by gravity. This reservoir is also roofed and constructed of reinforced concrete. It is completely enclosed, there is no possible access for vermin.

TABLE 0-3: CLERMONT RESERVOIRS		
	Jeffrey Street	**Capricorn Street**
Volume	520 kL	1600 kL
Materials of construction	Concrete	Concrete
Roof	Yes	Yes
Vermin-Proof	Yes	Yes

The Douglas Street Reservoir was the third reservoir in the system and was operated when the bores were in use. However, the Douglas Street system has been un-used for a number of years and the pumps have been disconnected. Contamination of water supply from this reservoir or pumps is not possible as the infrastructure is located at a lower elevation than the Jeffery Street reservoir, and the pumps have been disconnected and isolated.

CLERMONT RETICULATION

The reticulation pipelines are mostly constructed of asbestos cement, and most are over 40 years old. When pipelines are replaced or a new section is installed, these are being constructed from suitable products.

The mains in the reticulation system vary in size. The main pipelines are:

- A 375 mm diameter main from Jeffrey Street reservoir to the Capricorn Street reservoir (not in use).
- A 225 mm rising main from the Capricorn Street reservoir along Tropic Street.
- A 200 mm diameter main along Capricorn Street to Douglas Street reservoir.
- A 225 mm diameter main along Capricorn Street to McDonnell Flat Road.
- A 180 mm HDPE ring main in Lime Street to East Street

The mains that service Douglas Street reservoir (not currently in use) begin at 150 mm and increase to 200 mm and again to 25 0mm.

The majority of the distribution network consists of 150 mm or 100 mm pipework.

In any reticulation system, solids can settle at low points or at dead ends. The Clermont mains are cleaned periodically by the IRC network team as per Council's flushing program. Most of the previous dead ends in the reticulation system have now also been replaced.

CLERMONT WATER SUPPLY SYSTEM CAPACITY

The raw water conveyance infrastructure (pumps and raw water main) is rated for 110 L/s. Clermont WTP has a theoretical capacity of 80 L/s and the operational staff typically operate the treatment process at a fixed throughput setpoint of between 60 and 65 L/s.

The high lift pumps and rising main from the Treated Water Reservoir to the elevated reservoirs are rated for 100 L/s.

AECOM have completed a Water Sustainability Strategy which will assist Council with future planning around the improvement and capacity upgrade works of the scheme.

CLERMONT STAKEHOLDERS

The main stakeholders associated with raw water quality are members of the Theresa Creek Dam action plan group as well as the campers and recreational users of the dam. The approach that has been taken to date by Council is to erect barriers at the raw water intake to prevent campers and other people visiting the dam from swimming or boating around the intake area. An educational approach with the caretaker has also been implemented, providing information about the dam and its use as a potable water source for the Clermont area which he passes on to recreational users.

The caretaker of the campground is in a good position to notice any obvious water quality issues first-hand and notifies water and wastewater staff of changes.

TABLE 0-4: CLERMONT STAKEHOLDERS

Organisation	Contact Name and Details	Relevance to management of drinking water quality	How the stakeholder is engaged in the DWQMP
Campers at Theresa Creek Dam	Steve and Marie-Ann Ph. 49832327	Camper activities can affect raw water quality at the dam.	Not engaged as such. Permits for camping must be obtained from Council offices in Clermont.
Farmers downstream of Theresa Creek dam	Eleven farmers as detailed in the Theresa Creek Dam Emergency Response Plan document	Farmers receive water from the dam.	Not engaged.
Fire Department		Quality not relevant. Reticulation pressure important.	Not engaged.
Residential Users		Supplied with reticulated water from the Clermont scheme.	Not engaged.

CLERMONT WATER QUALITY

Water quality sampling at the Clermont WTP is carried out by experienced operators. Samples that are taken for external testing are labelled with date and times and are placed in an insulated container. These are then couriered to the Mackay Regional Council NATA Accredited laboratory. If these samples are not received by the laboratory within 24 hours of collection, they are not tested, and the laboratory advises operators that new samples must be taken.

Sections 0 and 0 detail the operational and verification monitoring that is currently implemented.

OPERATIONAL MONITORING

The operational monitoring currently undertaken at Clermont is detailed in the following table. Testing parameters are separated by process step.

TABLE 0-1: CLERMONT OPERATIONAL MONITORING

Process Step	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if target limit exceeded	Critical Limit	Action if critical limit exceeded
Operator Sampling							
Raw Water entering WTP	pH	High or Low pH	Daily	6.5 – 7.5	Monitoring only. An indicator to adjust pH with appropriate chemical dosing.	N/A	N/A
Raw Water entering WTP	Turbidity	High Turbidity	Online / Daily	>100	Coagulant dosing adjusted as per operator's charts or as turbidity/colour increases.	N/A	N/A
Raw Water entering WTP	Apparent Colour	High Colour	Daily	>250	Coagulant dosing adjusted as per operator's charts or as turbidity/colour increases.	N/A	N/A
Raw Water entering WTP	True Colour	High Colour	Daily	>250	Coagulant dosing adjusted as per operator's charts or as turbidity/colour increases.	N/A	N/A
Raw Water entering WTP	Temperature	N/A	Daily	N/A	Monitoring only	N/A	N/A
Raw Water entering WTP	Total Iron	High Iron	Daily	<0.3 mg/L (in treated water)	Increase potassium permanganate or pre-chlorine dose to oxidise	N/A	N/A
Raw Water entering WTP	Total Manganese	High Manganese	Daily	<0.05 mg/L (in treated water)	Increase potassium permanganate or pre-chlorine dose to oxidise	N/A	N/A
Raw Water entering WTP	Alkalinity	Coagulation failure	Daily	N/A	Assess pH adjustment dosing requirements	N/A	N/A
Prior to entering flash mixer	Total Iron	High Iron	Daily	<0.3 mg/L (in treated water)	Increase potassium permanganate or pre-chlorine dose to oxidise	N/A	N/A
Prior to entering flash mixer	Total Manganese	High Manganese	Daily	<0.05 mg/L (in treated water)	Increase potassium permanganate or pre-chlorine dose to oxidise	N/A	N/A
After flash mixer	Total Iron	High Iron	Daily	<0.3 mg/L (in treated water)	Increase potassium permanganate or pre-chlorine dose to oxidise	N/A	N/A

TABLE 0-1: CLERMONT OPERATIONAL MONITORING							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if target limit exceeded**	**Critical Limit**	**Action if critical limit exceeded**
After flash mixer	Total Manganese	High Manganese	Daily	<0.05 mg/L (in treated water)	Increase potassium permanganate or pre-chlorine dose to oxidise	N/A	N/A
Settled Water (outlet of clarifier)	pH	High or Low pH	Daily	6.5 – 7.5	Assess pH adjustment dosing requirements of raw water if pH becomes high or low.	N/A	N/A
Settled Water (outlet of clarifier)	Turbidity	High Turbidity	Daily	<2 NTU	Check coagulation pH. Adjust coagulant and/or sodium hydroxide dose rates.	N/A	N/A
Settled Water (outlet of clarifier)	Apparent Colour	High Colour	Daily	< 15 HU	Assess chemical dosing requirements if colour is high	N/A	N/A
Settled Water (outlet of clarifier)	Free Chlorine	Metals (in treated water)	Daily	Maintain residual	Adjust chlorine gas dosing	N/A	N/A
Settled Water (outlet of clarifier)	Total Iron	High Iron (in treated water – aesthetic)	Daily	<0.3 mg/L (in treated water)	Increase potassium permanganate or pre-chlorine dose to oxidise. Adjust coagulant dose to optimise clarification.	N/A	N/A
Settled Water (outlet of clarifier)	Total Manganese	High Manganese (in treated water - health/ aesthetic)	Daily	<0.1 mg/L	Increase potassium permanganate or pre-chlorine dose to oxidise.	N/A	N/A
Filtered Water (outlet of filters)	pH	High or Low pH	Daily	7.0 – 7.5	Monitoring only (target for optimal effective disinfection with chlorine)	N/A	N/A
Filtered Water (outlet of filters)	Free Chlorine	High Manganese (in treated water - health/ aesthetic)	Online / Daily	>0.1 mg/L	Increase pre-chlorine dose to ensure manganese coating is maintained for complete oxidation of soluble manganese.	N/A	N/A
Filtered Water (outlet of filters)	Turbidity	High Turbidity	Daily	<0.2 NTU	See Critical Control Points for Clermont		
Treated Water (treated water tank)	pH	High or Low pH	Daily	7 – 7.5	See Critical Control Points for Clermont		
Treated Water (treated water tank)	Turbidity	High Turbidity	Daily	<0.5 NTU	See Critical Control Points for Clermont		
Treated Water (treated water tank)	Free chlorine	Pathogens	Daily	1.5 - 2.5 mg/L	See Critical Control Points for Clermont		
Treated Water (treated water tank)	Apparent Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Daily	< 15 HU	Adjust WTP chemical dosing.	N/A	NA
Treated Water (treated water tank)	Temperature	N/A	Daily	N/A	N/A	N/A	N/A

TABLE 0-1: CLERMONT OPERATIONAL MONITORING							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if target limit exceeded**	**Critical Limit**	**Action if critical limit exceeded**
Treated Water (treated water tank)	Total Manganese	High Manganese	Daily	<0.05 mg/L	This level causes possible staining. Chlorine dosing should be adjusted (ADWG Health limit 0.5 mg/L)	N/A	N/A
Treated Water (treated water tank)	Total Iron	High Iron (aesthetic)	Daily	<0.3 mg/L	Adjust pre-chlorine dose to oxidise.	N/A	N/A
Treated Water (treated water tank)	Alkalinity	N/A	Daily	N/A	Monitoring only	N/A	N/A
Treated Water (treated water tank)	Total Hardness	Aesthetic problems such as scaling and difficulty lathering.	Daily	60 - 200 mg/L	Monitoring only	N/A	N/A
Treated Water (treated water tank)	Aluminium	High Aluminium	Daily	< 0.2 mg/L	Check coagulant dose (overdosing may be occurring)	N/A	N/A
Potable Water (Town Water)	Free chlorine	Pathogens	Monthly	> 0.2 mg/L	Adjust chlorine gas dose rates.	N/A	N/A
Potable Water (Town Water)	pH	High or Low pH	Monthly	7 – 7.5	Monitoring Only	N/A	N/A
Potable Water (Town Water)	Turbidity	High Turbidity	Monthly	< 0.5 NTU	Monitoring Only	N/A	N/A
Potable Water (Town Water)	Apparent Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Monthly	< 15 HU	Monitoring Only	N/A	N/A
Potable Water (Town Water)	Temperature	N/A	Monthly	N/A	N/A	N/A	N/A
Potable Water (Town Water)	Total Manganese	High Manganese	Monthly	< 0.05 mg/L	This level causes possible staining. Chlorine dosing should be adjusted (ADWG Health limit 0.5 mg/L)	N/A	N/A

CRITICAL CONTROL POINTS

Table 0-2 details the critical control points (CCPs), limits and rectification actions for Clermont WTP. Target limits are in line with ADWG best practice operation guidelines and critical limits are as per ADWG health limits.

TABLE 0-2: CLERMONT CRITICAL CONTROL POINTS							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if target limit exceeded**	**Critical Limit**	**Action if critical limit exceeded**
Filtered Water (outlet of individual filters)	Turbidity	Pathogens	As frequently as practicable, minimum daily. (Target online ASAP)	<0.2 NTU	Optimise coagulation, i.e. adjust coagulant dose rate and coagulation pH. Backwash filter if turbidity continues to approach critical limit.	0.5 NTU	Backwash filter immediately then continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water (treated water tank)	pH	High or Low pH	Daily	7 – 7.5	Adjust with appropriate chemical dose for filtered water	<7.0 or >8.5	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water (treated water tank)	Turbidity	High Turbidity	Daily	< 0.5 NTU	Adjust WTP coagulant dosing. Backwash filter(s) if required.	1.0 NTU	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water (treated water tank)	Free chlorine	Pathogens	As frequently as practicable, minimum daily. (Target online ASAP)	1.5 - 2.5 mg/L	Target limit is set to ensure that there is sufficient residual maintained throughout reticulation. If concentration is high or low, adjust chlorine dose rate.	< 1.0 or >3.0 mg/L	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit ADWG allows residual between 0.2 and 5.0 mg/L. However, chlorine dose rate should be adjusted prior to reaching the low/high limits Action is critical if the concentration is below 1mg/L. If the concentration is too low at the exit of the plant, an adequate residual is unlikely to be maintained in the reticulation Advise W&WW manager of non-compliant water

CLERMONT RAW WATER QUALITY

Presented below are the results of raw water operational monitoring for July 2014 to October 2021.

TABLE 0-3: CLERMONT RAW WATER QUALITY

Clermont Raw Water – Theresa Creek Dam (July 2014 to October 2021)

Parameter	Units	Sampling Location	Summary of Results						Comments
			No. of Samples	Minimum	5th percentile	Average	95th percentile	Maximum	
pH	pH units	Raw Water main into WTP	2548	6.15	6.94	7.40	7.79	9.79	
Turbidity	NTU		2545	3.1	4.9	49.9	218.6	1430.0	
Apparent Colour	HU		1569	0.0	5.4	40.6	140.0	1940.0	Sampled daily until Dec 2020 and have become less regular since then
Iron	mg/L		1975	0.00	0.01	0.06	0.24	1.03	Sampled 1-2 per month July 2014 – February 2016, followed by daily sampling March 2016 - present
Manganese	mg/L		1855	0.00	0.00	0.02	0.05	0.89	Tested after initial chlorine dose point. Sampled 1-2 per month July 2014 – February 2016, followed by daily sampling March 2016 - present
Alkalinity	mg/L $CaCO_3$		1927	0.05	50.00	95.60	140.00	215.00	Sampled 1-2 per month July 2014 – February 2016, followed by daily sampling March 2016 - present
Hardness	mg/L $CaCO_3$		64	45.0	50.8	125.6	194.1	202.0	Measured 1-2 per month July 2014 - January 2016 only

The results in Table 0-3: Clermont Raw Water Quality table indicate that the raw water quality is generally good with the exception of higher levels of turbidity and colour (e.g. organics) and occasionally high levels of iron and manganese.

CLERMONT TREATED WATER QUALITY

Daily samples of treated water are collected for onsite analysis. Operators also send treated water samples to Mackay Regional Council Scientific and Analytical Services Laboratory for analysis. The table below presents the external test results of treated water compared with the Australian Drinking Water Guidelines (ADWG).

The results of these external test results are provided in the table below. The treated water is generally in accordance with the ADWG. The table below indicates the number of times that test results have exceeded the ADWG.

TABLE 0-4: CLERMONT TREATED WATER QUALITY (JULY 2014 – OCTOBER 2021)

Clermont Water Treatment Plant Outlet

Parameters	Units	Sampling Location	Summary of Results						CCP		ADWG		Comments
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	Critical Limits	Exceptions	Guideline Value [2]	Exceptions	
pH	pH units	Inlet to treated water tank	2640	6.18	6.90	7.23	7.54	9.89	7.0-8.5	236,5	6.5-8.5 (A)	8,5	9.13% of samples outside of CCP range. 0.49% outside of ADWG range
Colour (Apparent)	HU		2572	0.0	0.0	1.4	5.0	120.0	N/A	0	N/A	0	
Turbidity	NTU		2610	0.0	0.1	0.3	0.5	19.8	1	48	<=1 (H)[3]	48	1.84% above CCP limit and ADWG recommendation for disinfection with chlorine. 0.19% of samples above ADWG aesthetic guideline
Chlorine (Free)	mg/L		2636	0.21	1.19	1.97	2.90	10.86	1.0-3.0	51, 97	0.2-5.0 (H)	0, 1	51 of exceedances were below limit of 1 mg/L (1.93% of samples).97 samples above limit (3.72% of samples)
Alkalinity	mg/L $CaCO_3$		2025	20.00	45.00	87.16	135.00	180.00	N/A	0	N/A	0	
Hardness	mg/L $CaCO_3$		2056	0.0	0.0	45.8	100.0	201.0	N/A	0	60-200 (A)	1	Often potentially corrosive, rarely scaling
Manganese	mg/L		1945	0.000	0.000	0.004	0.011	0.280	N/A	0	<=0.5 (H) <=0.1 (A)	0,2	0.10% above ADWG aesthetic guideline but not above health limit
Iron	mg/L		2057	0.000	0.000	0.008	0.028	0.390	N/A	0	<=0.3 (A)	1	Isolated instance of ADWG aesthetic guideline exceedance
Aluminium	mg/L		1874	0.000	0.020	0.073	0.210	0.510	N/A	0	<=0.2 (A)	103	5.49% above ADWG aesthetic guideline

[2] A = aesthetic guideline value; H = health-based guideline value

Chlorine needs to be present in the treated water for sufficient time to ensure disinfection takes place. Chlorine residual also needs to be maintained throughout the reticulation to prevent re-contamination. The results in Table 0-4: Clermont Treated Water Quality (July 2014 - October 2021) table and Figure 0-1 show that there is high fluctuation in total and free chlorine concentration in the treated water. A chlorine analyser which provides continuous readings and alarms, or control actions has been installed to assist the operators in keeping the chlorine levels in the treated water more stable. The figure below presents the level of free chlorine in treated water between July 2014-October 2021 with relevant limits. Chlorine levels are seen to fluctuate the most in late 2015, the first 6 months of 2016, and, again more prominently, from July 2020 onwards.

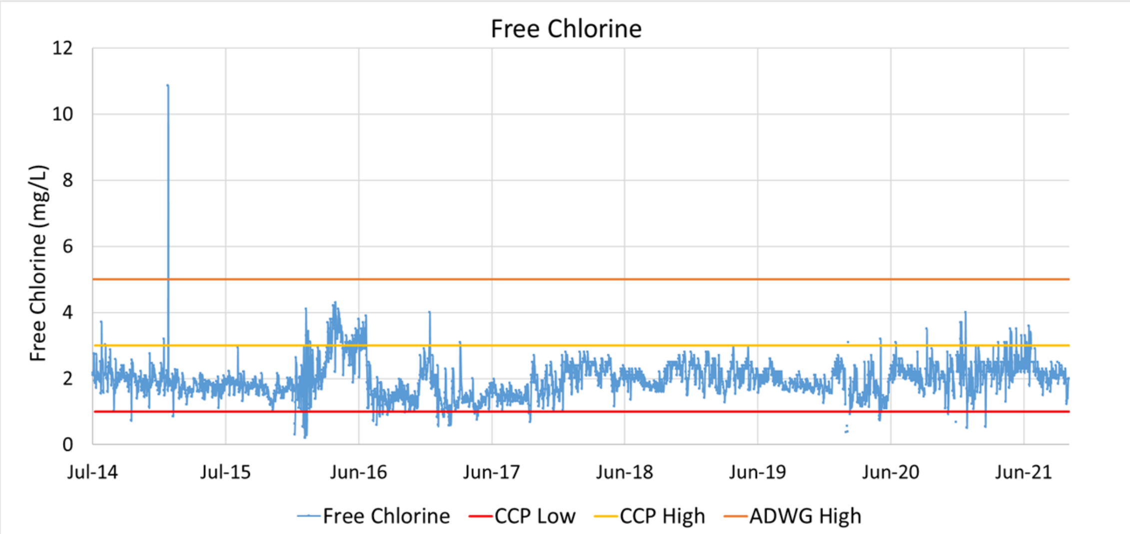


Figure 0-1: Treated Water Free Chlorine

Figure 0-2 and Figure 0-3 present the variation in colour and turbidity in the treated water as compared with the colour and turbidity of the raw water. The turbidity levels are shown on a logarithmic scale and colour is shown on a separate axis. The charts confirm that high levels of colour and turbidity occur in the treated water when the raw water has high levels of colour and turbidity. A filtered water turbidity meter with alarms has been installed to assist operators in ensuring compliant turbidity levels and timely response to any exceedances.

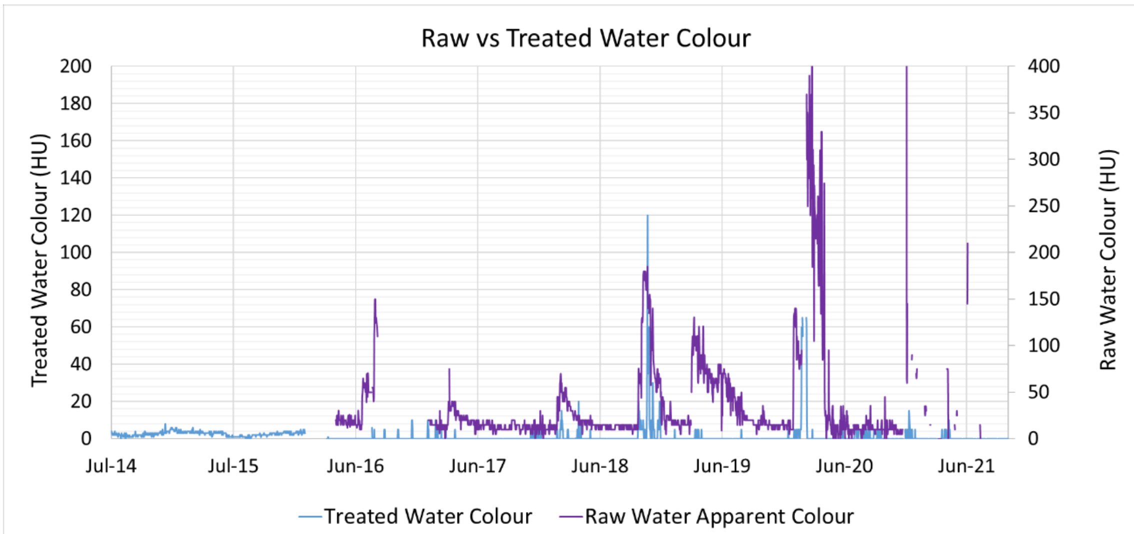


Figure 0-2: Colour in the Raw and Treated Water

There was also a dramatic spike in raw water colour (>2,000 HU) beginning in March 2020, though this had minimal impact on treated water colour.

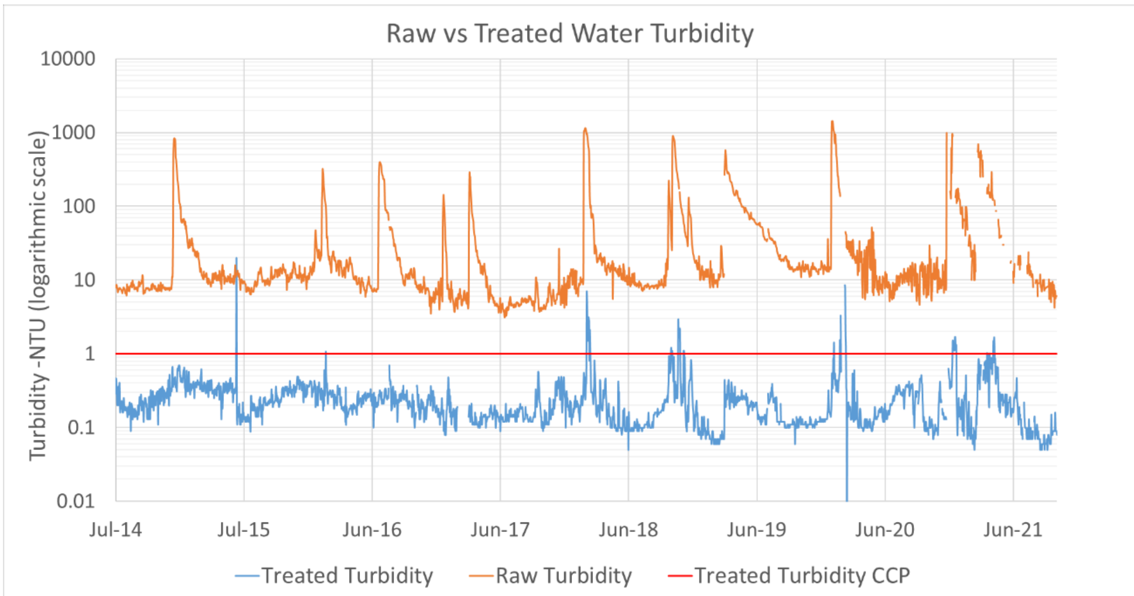


Figure 0-3: Turbidity in the Raw and Treated Water

Figure 0-4 and Figure 0-5 below show the variation in iron and manganese in the treated water for the period July 2014 – October 2021. CCP limits are not shown on the graphs as all treated water results are well below the limits. The graphs show sufficient removal of iron and manganese, even with increased levels. There are 2 instances of treated manganese exceeding the ADWG aesthetic threshold, but concentrations were never detected above the health threshold.

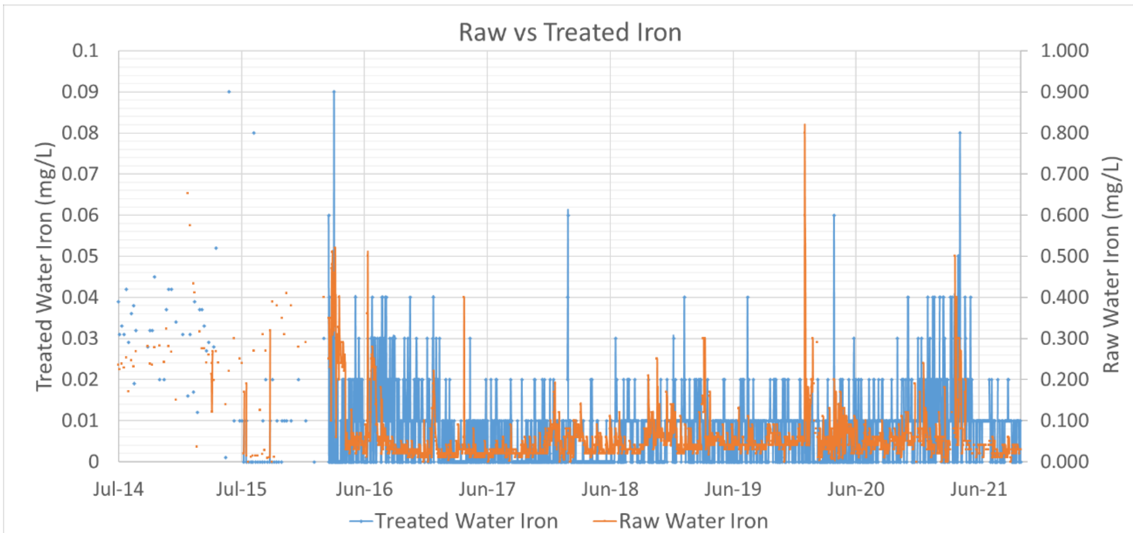


Figure 0-4: Iron Concentration in Raw and Treated Water

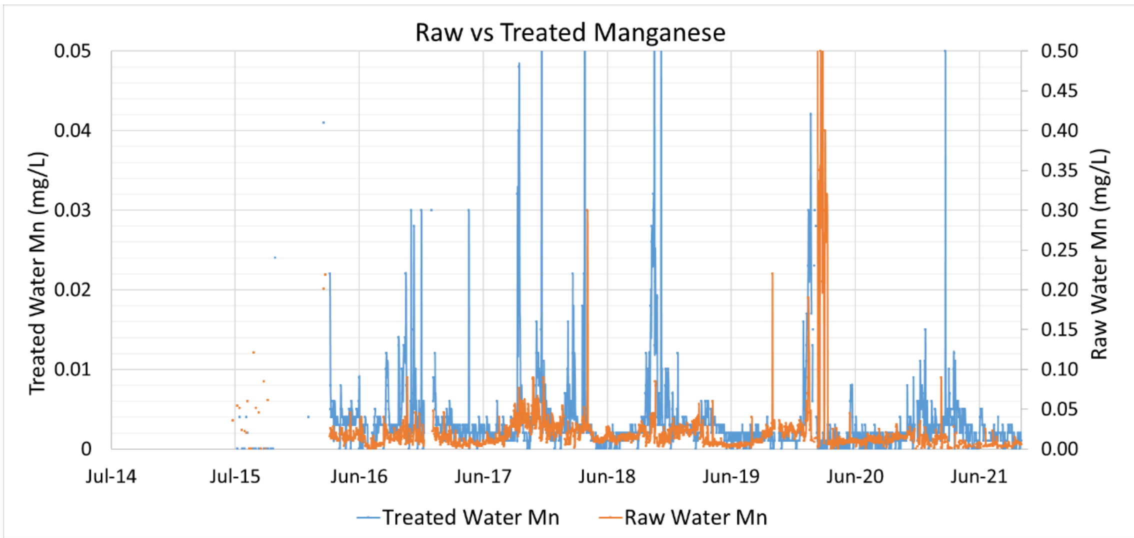


Figure 0-5: Manganese Concentration in the Raw and Treated Water

CLERMONT RETICULATED WATER QUALITY

TABLE 0-5: CLERMONT RETICULATED WATER QUALITY (FEBRUARY 2014 TO OCTOBER 2021)								
Samples taken at: Spring Park, Hospital, Library, Fitness Centre, Centenary Park, Jeffery Street								
Parameter	No. of Samples	Summary of Results					ADWG Guideline Value [4]	No. of Samples Exceeding ADWG Guideline Value
		Minimum	5th Percentile	Average	95th Percentile	Maximum		
E. coli (MPN/100 mL)	417	ND	ND	ND	ND	ND	<1 (H)	0
Free Chlorine (mg/L)	401	0.02	0.36	1.33	2.4	3.2	0.2-5.0 (H)	7, 0
pH	364	6.59	7.04	7.30	7.61	8.5	6.5-8.5 (A)	0
Total Coliforms (cfu/100 ML)	343	<1	<1	<1	<1	4		
Turbidity (NTU)	49	0.11	0.176	1.563	4.708	7.2	<=5 (A)	2

Sampling for microbiological testing is undertaken monthly at a minimum. The tests are completed by Mackay Regional Council laboratory. The recorded *E. coli* tests between 2014 to 2021 have returned results with no detections. Chlorine residual is generally maintained above the recommended limit of 0.2 mg/L. Network modelling is in progress and will identify the low-pressure areas where additional sampling may need to be undertaken.

[4] A = aesthetic guideline value; H = health-based guideline value

CLERMONT WATER QUALITY COMPLAINTS

IRC received seven water complaints for Clermont between 2011 and 2012. The description shown on the IRC complaint record did not provide enough details to ascertain the causes of the complaints.

In addition, there have been a number of discoloured water complaints in summer months of 2012/13, and it is understood that the preliminary investigation undertaken by IRC Operation Team identified that elevated manganese levels in the water were responsible.

In the 2015/16 financial year a total of 22 water quality complaints were received – 19 for discoloured water (likely linked to elevated iron and manganese), 2 for tastes and odours and 1 regarding a water leak. An additional 31 complaints were recorded in the 2016/17 financial year, all for discoloured water.

In the 2017/18 financial year a total of 39 water quality complaints were received – 20 for discoloured water, 4 for taste and 15 other.

In 2018/19 financial year a total of 91 water quality complaints were received – 79 for discoloured water, 4 for odour and 8 other. Of the discoloured water complaints, 59 were due to a dosing pump failure with insufficient protections. This issue has been addressed.

In the 2019/20 financial year, a total of 203 water quality complaints were received – 195 for discoloured water, 2 for taste and 6 for odour. The discoloured water complaints received from Clermont were reportedly related to an incident that occurred in March 2020. No complaints were received regarding suspected or confirmed illnesses, and there were no reports of health concerns arising from the water supply system.

In the 2020/21 financial year, a total of 28 water quality complaints were received, all for discoloured water.

Refer to Section 0 for details on the complaint recording procedure.

CLERMONT KEY ISSUES

The following key water quality issues in the Clermont water scheme have been identified:

- Elevated iron and manganese in raw water (Theresa Creek Dam) may lead to aesthetic issues in the water supply network. Results to date show the treated water levels are within the required limits, but this should be regularly monitored.
- Elevated and highly variable levels of colour and turbidity in the raw water may put additional strain on the treatment process, risking aesthetic and possible health issues in the reticulation. Spikes in treated water quality have been seen historically, however recent WTP upgrades should address these issues. This should be regularly monitored to ensure process performance is acceptable.

MORANBAH WATER SCHEME

Raw water supplied to the Moranbah Water Scheme is normally from the Burdekin Dam (also known as the Burdekin Falls Dam), located approximately 300 km north-west of the Moranbah Water Treatment Plant (WTP). The water passes through a number of SunWater managed dams on its way to Moranbah. The raw water flows into a 400 ML turkey's nest dam located adjacent to the Moranbah WTP. Water can also be supplied from the Eungella Dam which is also owned and operated by SunWater.

An overview of the Moranbah Water Scheme is shown in Table 5.1 with further detail in the sections following.

TABLE 0-1: MORANBAH SYSTEM OVERVIEW

System Component	Description
Population Supplied	Total of approximately 4,194 connections, comprising of approximately 8,735 persons.
Water Sources	Burdekin Dam (primary source) Eungella Dam (secondary source when necessary) Both are owned and operated by Sun Water.
Water Storage (Before Treatment)	420 ML total storage volume in three (3) Turkeys Nest Dams located onsite. • 8 ML Turkeys Nest Dam feeds the Boby WTP • 12 ML Turkeys Nest Dam feeds the WTP • 400 ML Turkeys Nest Dam is the main raw water storage and feeds the 8 ML and 12 ML turkeys nest dams when low
Water Treatment	There are two separate process trains at Moranbah – Boby WTP (70 L/s) and WTP (160 L/s). WTP is the duty WTP and the Boby WTP is the assist (currently not in use, but connected and available for emergency use if required). • Raw Water is treated at the Boby WTP as follows: • Sodium hydroxide for pre-pH adjustment • Pre chlorine gas dosing for iron and manganese oxidation; • PAC for taste and odour removal • Coagulation with ACH; • Polymer dosing for flocculation aid; • Flocculation; • Clarification; • Sand filtration; • Sodium hydroxide dosing for post-pH adjustment; • Disinfection with chlorine gas; and • Fluoridation with sodium fluoride. Raw water is treated at WTP as follows: • Pre pH adjustment with sodium hydroxide; • Pre chlorine gas for iron and manganese oxidation;

TABLE 0-1: MORANBAH SYSTEM OVERVIEW	
System Component	**Description**
	• PAC for taste and odour removal; • Coagulation with ACH; • Polymer dosing for flocculation aid; • Flocculation; • Clarification; • Dual media filtration; • Sodium hydroxide dosing for post-pH adjustment; • Disinfection with chlorine gas; and • Fluoridation with sodium fluoride. The wastewater system comprises of: • Wastewater Holding Tanks
Water Storage (After Treatment)	Moranbah has 3 treated water reservoirs onsite, totalling 27.1 ML of storage: • 5.3 ML Treated Water Reservoir 1 • 8.0 ML Treated Water Reservoir 2 • 13.8 ML Treated Water Reservoir 3 There are also 2 additional treated water storages that gravity feed the reticulation network: • 0.45 ML West Water Tower • 0.45 ML East Water Tower All treated water storages are roofed. The inlet weirs to Treated Water Reservoir 1 are not fully enclosed, vermin proofed or secure.
Distribution of Product	Gravity fed from the Water Towers via reticulation mains.
Any Special Controls Required	Quality of chemicals, materials, etc. used in the production and delivery of the product. Manual verification sampling of water from the distribution network. Backflow prevention and trade waste management. Operation and maintenance of all infrastructure to prevent recontamination.

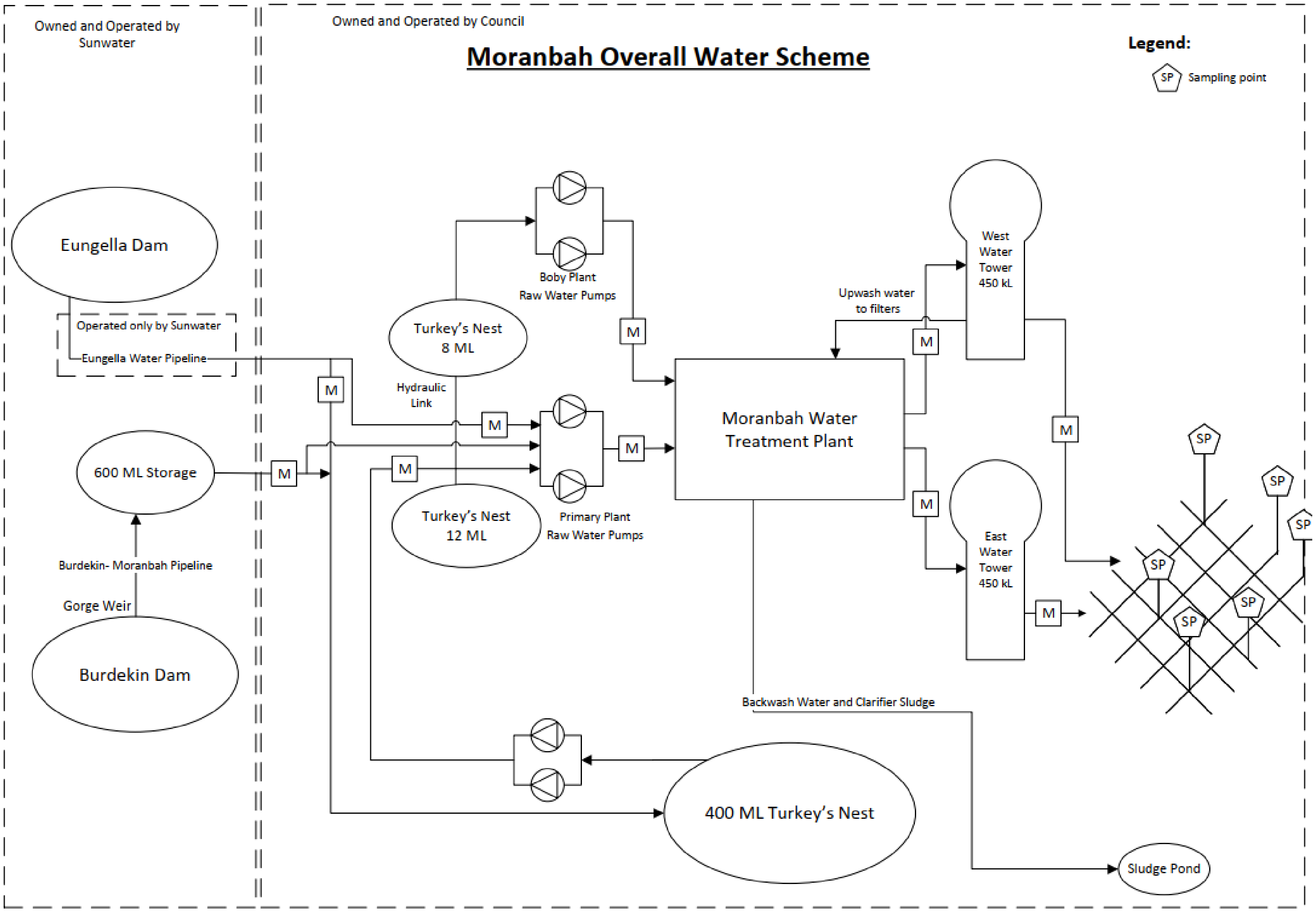


Figure 0-1: Moranbah Overall Water Supply System

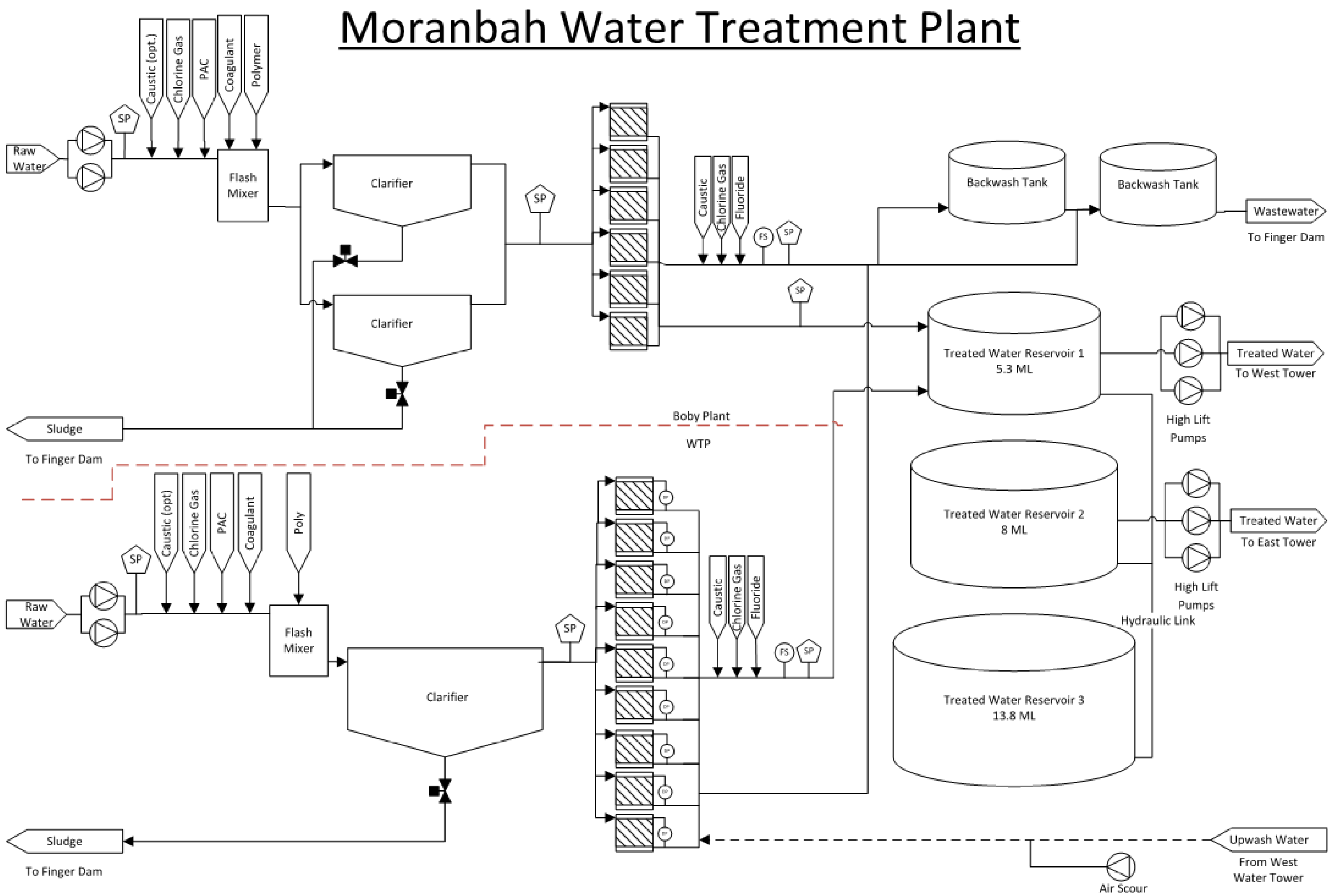


Figure 0-2: Moranbah Water Treatment Plant

MORANBAH CATCHMENTS

Burdekin Dam Catchment

The Burdekin Catchment covers an immense area of remarkable diversity of climate including semi-arid drylands, wooded grasslands, mountainous tropical rainforests, coastal plains, mangroves and wetlands. The Catchment empties into the Great Barrier Reef lagoon. The Catchment comprises four distinct sub catchments:

- Belyando/Suttor;
- Upper Burdekin;
- Bowen/Broken; and
- Lower Burdekin and Coastal Plains.

The Burdekin Dam[5] suffers from an extreme variability in precipitation throughout the entire catchment. Generally, summers (December through April) are very wet and the remainder of the year is dry. Annual rainfall at most gauges within the basin can range from 200 mm to over 1,600 mm depending on the monsoon and the number of cyclones that cross the coast. The Burdekin dam catchment area is 114,240 km².

The Burdekin Dam Catchment has the following uses:

- Raw water supply to other water schemes including Thuringowa and Townsville
- Irrigation
- Low-density grazing of sheep and cattle
- Crops such as cotton and maize
- Mining
- Contact recreation including swimming, sailing, and fishing
- Non-contact recreational including picnicking, bushwalking, and camping
- Proposed future hydro scheme for the dam.

Eungella Dam Catchment

The Eungella Dam Catchment area is 142 km². Aside from being the raw water supply to the Moranbah WTP, the Eungella Dam Catchment has the following uses:

- National Park
- Irrigation
- Contact recreation including swimming, canoeing, and fishing
- Non-contact recreation including picnicking, bushwalking, and camping

[5] Information on the Burdekin Dam taken from CSIRO Land and Water Overview of key Natural Resource Management Issues in the Burdekin Catchment, with particular reference to Water Quality and Salinity, December 2002

MORANBAH RAW WATER

Burdekin and Eungella Dams

There are two water sources for Moranbah: Burdekin Falls Dam and Eungella Dam. The dams, intermediate storages, pump stations and the pipe network up to the flow meters at the inlet to Moranbah WTP, prior to the 400 ML turkeys nest dam, are managed by SunWater.

The Burdekin Falls Dam is connected to Moranbah by the Burdekin-Moranbah pipeline which is 218 km long and designed to deliver 23,000 ML/annum to the mines with an allocated amount for the Moranbah WTP. In addition, there is a 600 ML balancing storage dam, located 35 km north of Moranbah, providing the major storage in the pipeline to ensure supply continuity. There are four booster pump stations located along the pipeline.

Water allocations from the Burdekin Falls Dam are released down the Burdekin River and then extracted at various weirs and pump stations in the Lower Burdekin, including Gorge Weir, Blue Valley Weir, Clare Weir and the Haughton Balancing Storage.

The Eungella Dam is connected to Moranbah by 119 km of pipeline with two pump stations. The capacity of the pipeline is 6,200 ML/annum. The pipe network which runs from the dam to the WTP also supplies water to various mines.

The Eungella Dam supplies water to a number of mines in Moranbah and Nebo coal mining areas, coal-mining developments and associated urban infrastructure within the Bowen Basin around Moranbah and Goonyella, as well as industrial and domestic requirements at Collinsville and Newlands near Glenden.

An inter-basin transfer is provided via two overland pipelines, one belonging to BHP Billiton and the other to the Eungella Water Pipeline Company (a subsidiary of SunWater).

Eungella Dam supplies water for mines and supplements the water available at the Bowen River (or Collinsville) Weir. Water from the weir is pumped via a pipeline to supply the Collinsville coal mine, power station and the Collinsville township. A separate pipeline feeds mining operations at Newlands and the township of Glenden within the catchment.

The two raw water streams are not normally supplied at the same time although they can be if required. Raw water is primarily sourced from Burdekin Dam. The raw water pipe infrastructure is summarised in Table 0-2.

TABLE 0-2: RAW WATER PIPE

Source	Owner	Pipe Diameter	Pipe Length (km)
Eungella Pipeline	BMA	450-600mm	119
Eungella	Eungella Pipeline Co	450-700mm	238
Burdekin Pipeline	Sunwater	750-813mm	217

The main raw water sources for Moranbah are presented below in Figure 0-3.

Figure 0-3: Water Supply Pipelines to Moranbah

Raw Water Turkeys Nest

Raw water from Burdekin or Eungella Dam is delivered via the Sunwater pipelines to the 400 ML Turkeys Nest Dam at the WTP. Raw water is then pumped from the 400 ML dam to the 8 ML and 12 ML Turkeys Nests which are hydraulically linked, totalling a volume of 20 ML. Level sensors in the 8 ML and 12 ML Turkeys Nests control the raw water pump flows from the 400 ML turkeys nest dam. When the water level in the 8 ML and 12 ML Turkeys Nests falls below 2.7 m a pump located at the 400 ML turkeys nest dam is triggered to start transferring water. With two pumps in operation, water stored in the 400 ML Turkeys Nest can be pumped at a flow rate of 305 L/s (22.0 ML per 20 hour day) through the DN450 DICL pipeline.

Raw Water is pumped from the 8 ML or 12 ML Turkeys Nest to the Moranbah WTP depending on whether WTP 1 (Boby Plant) or WTP 2 (WTP) is being used. WTP 1 is supplied by the 8 ML turkeys nest dam and the 12 ML Turkey Nest supplies WTP 2. Raw water is pumped from the turkeys nests to the WTP by two raw water pump stations capable of a total flow of 195 L/s.

Table 0-3 below summarises the raw water supply infrastructure ownership and operational responsibilities.

TABLE 0-3: MORANBAH UPSTREAM WATER INFRASTRUCTURE OWNERS		
Infrastructure	**Owners/Operator**	**Responsibility**
Eungella Dam	Sunwater	Asset owner and operator of the water supply
Eungella Pipeline	BMA	Asset Owner
	Sunwater	Operation and maintenance of water supply pipeline
Burdekin Falls Dam / Pipeline	Sunwater	Asset owner and operator of the water supply pipeline and maintenance
Intermediate Raw Water Storage Dam (from Burdekin Falls Dam)	Sunwater	Operation and maintenance of dams and water supply pipelines

TABLE 0-3: MORANBAH UPSTREAM WATER INFRASTRUCTURE OWNERS		
Infrastructure	**Owners/Operator**	**Responsibility**
Turkey's Nests /Mains Onsite	Isaac Regional Council	Asset owner and operator of raw water storage, pipework and pumps at Moranbah WTP

MORANBAH WATER TREATMENT PLANT

There are two separate treatment processes at the Moranbah WTP: WTP1 (Boby Plant) and WTP2 (WTP). They can work simultaneously (as one plant) or separately (as individual plants) at any set time. Both plants operate in a similar fashion and the WTP is normally the duty (base load) plant with the Boby Plant being the assist (used when high production is required). The Boby Plant starts up automatically according to treated water storage level to cater for peaks in demand.

Raw Water Dosing

Raw Water enters the Moranbah WTP from the turkeys nests via pumps. Each turkey's nest has its own set of raw water pumps to feed either the Boby Plant (8 ML Turkeys Nest Dam) or the WTP (12 ML Turkeys Nest Dam). There is also a hydraulic link between the two dams which allows different feeding arrangements. A number of chemicals are dosed just after the pump at the inlet to both WTPs. All chemical dosing setpoints are selected and adjusted when required by the operators. The chemical dosing stops when no WTP flow is detected.

At the WTP the first dose point is sodium hydroxide which is used occasionally to adjust the pH. The second dose point is chlorine which is dosed at this point to oxidise iron and manganese. PAC can also be dosed on the raw water main prior to the flash mixer for taste and odour removal. The dosing sequence at the inlet of the Boby plant is the same as for the main WTP.

Flash Mixing

Coagulant (ACH) is added to the raw water and coagulation/flocculation occurs in the flash mixers. At the Boby Plant, ACH is dosed into the flash mixer via a hose which enters the top of the tank. ACH dosing into the WTP occurs prior to the flash mixer. PAC is dosed for water odour and taste at this point also to allow for an effective contact time. Polymer is also dosed into both flash mixers as a flocculation aid. The dimensions of the existing flash mixer tanks are as follows:

- Boby Plant Flash Mixer – 1.85 m diameter x approximately 7.0 m height
- WTP Flash Mixer – 1.80 m diameter x approximately 7.2 m height

Based on external inspections both flash mixer tanks appear to be in good condition.

Clarifiers

There are three reactor clarifiers with diameters as follows:

- Boby Plant Clarifier 1 – 7.1 m
- Boby Plant Clarifier 2 – 10.5 m
- WTP Clarifier 3 – 19.5 m

A flocculation chamber is located at the centre of each clarifier.

The flocs that have formed during flocculation settle to the bottom of the clarifiers. Clarified water flows out via the launders and into the filters via the outlet launder.

Sludge is removed by an automated air-actuated de-sludge valve at the bottom of the clarifiers. The de-sludge valve is based on a timer and remains open for a pre-set time that allows the sludge to be removed at a set rate. The sludge flows to the backwash holding tank before being discharged to Finger Dam.

The shells of Clarifiers 1 and 2 at the Boby Plant are constructed from steel, the shell of the Main WTP Clarifier is constructed of concrete. All three clarifiers appear to be in good condition with no sign of external deterioration.

Filtration

The clarified water flows into fifteen sand filters (six for Boby Plant and nine for the Main WTP) by gravity. The diameters of the filters are 2.7 m for Boby Plant and 3.3 m for the Main WTP. The filter backwash sequence is started and controlled manually each day for the Boby Plant and triggered automatically based on head loss for the Main WTP filters.

The filter tank surfaces appear to be in good working condition. Backwash valves and actuators on the Boby Plant filters have been replaced to prevent leaks and reduce reliance on manual operation. Each WTP has its own air compressor which provides air to the filter valve actuators. The compressors can also be cross connected thereby providing duty standby in case of equipment redundancy.

Figure 0-4: Moranbah Boby Plant Filters

When a filter in the Boby Plant starts a backwash, the filtered water from the other operating Boby Plant filters becomes the upwash water instead of flowing to the treated water tanks. Upwash water for the WTP filters flows from the East Water Tower. The filter media in the Boby Plant filters is 1,000 mm sand and in Main WTP the filter media has a depth of 1,250 mm of multimedia. The Main WTP filters have recently been refurbished (completed October 2017), including new media, painting, nozzles, underdrains (including Plenum Floor) and valves.

Treated Water Reservoir

There are three treated water reservoirs at Moranbah WTP; Reservoirs 1 and 2 are constructed of steel on a concrete base with corrugated tin roofs. A new 13.8 ML reservoir was brought into service in 2018. This reservoir is constructed of Concrete with a steel roof. The total capacity of these treated water reservoirs is 27.1 ML (Reservoir 1 having 5.3 ML capacity and Reservoir 2 having 8 ML capacity). The filtered water mains from both WTPs discharge into Treated Water Reservoir 1. The 3 reservoirs are hydraulically linked via an underground DN450 CICL pipe and there are valves to isolate all three treated water reservoirs. Table 0-4 summarises the characteristics of the treated water reservoirs.

TABLE 0-4: MORANBAH TREATED WATER RESERVOIRS			
Volume	5.3 ML	8 ML	13.8 ML
Materials of construction	Steel	Steel	Concrete
Roof	Yes	Yes	Yes
Vermin-Proof	Yes	Yes	Yes

Sodium hydroxide, chlorine and fluoride are injected into the filtered water mains leading to the treated water reservoir. Each WTP has its own pipe into Treated Water Reservoir 1. The inlet weir boxes to the reservoir were previously open to the air and showing signs of corrosion, risking contamination of treated water from vermin or corrosion. These have now been refurbished and enclosed to minimise the risk of contamination.

The treated water reservoirs provide more than the 30 minutes of chlorine contact time required for disinfection.

Figure 0-5: Moranbah Filtered Water Line from Boby WTP into Treated Water Res 1

Figure 0-6: Moranbah Filtered Water Pipeline from WTP into Treated Water Reservoir 1

Sludge Treatment

The WTP has two holding tanks where backwash water and clarifier sludge is collected prior to flowing by gravity to Finger Dam. Supernatant from Finger Dam is returned to the 400 ML turkeys nest dam.

Chemical Dosing

The WTP process currently employs the following chemicals:

TABLE 0-5: CHEMICAL USE IN THE MORANBAH WATER TREATMENT PROCESS

Chemicals	Dosing Location	Uses / Comments
Sodium Hydroxide	Inlet Pipe to WTP Flash Mixer Inlet Pipe to Boby Plant Flash Mixer Filtered Water	Pre-pH adjustment Post-pH correction
Chlorine Gas	Inlet Pipe to WTP Flash Mixer Inlet Pipe to Boby Plant Flash Mixer Filtered Water	Iron and Manganese Oxidation Disinfection
PAC	Inlet Pipe to WTP Flash Mixer Inlet Pipe to Boby Plant Flash Mixer	Taste and Odour
ACH	WTP Flash Mixer inlet Boby Plant Flash Mixer	Coagulant
Polymer	WTP Flash Mixer Boby Plant Flash Mixer	Flocculation Aid
Fluoride	Filtered Water	Fluoridation

All chemical dosing pumps are flow paced to the treatment plant and the dosing rates are adjusted manually. Upgrades to enable flow paced dosing are currently being finalised.

MORANBAH WATER TOWERS

There are two water towers for Moranbah, the Western Tower located at the WTP and the Eastern Tower located at the corner of Clements Street and Mills Avenue in Moranbah East. The Western Tower is constructed of steel with corrugated tin roof and the Eastern Tower shown in Figure 0-7 is constructed of reinforced concrete with a corrugated tin roof. Each of the towers has a storage capacity of 0.45 ML (total capacity of 0.9 ML).

Water from the treated water tanks is pumped into the towers by two sets of high lift pumps. The pumps start and stop based on the water level in the water towers. Each set of high lift pumps has three pumps arranged in duty/standby configuration. One of the standby pumps is a diesel-powered pump which can be operated in the event of power failure. The pump duty is alternated regularly by the operator.

Figure 0-7: Moranbah Eastern Water Tower

MORANBAH RETICULATION

There are two trunk mains feeding east and west Moranbah from the Eastern and Western Water Towers respectively. The West Moranbah trunk main is 450 mm in diameter, and East Moranbah trunk main is 525 mm in diameter. The two water towers are normally isolated from each other due to water pressure issues, although they could be linked if required.

The water reticulation length is approximately 56 km and most of the pipes are over 40 years old. Most of the reticulation pipelines that branch off from the trunk mains are 100 mm or 150 mm. The majority of the existing reticulation is made of Asbestos Concrete (82%). All new reticulation mains being installed are polyethylene.

Operators have observed that some of the galvanised service connections are starting to corrode which is affecting water quality. There are occasional complaints about black water which can be due to either iron and manganese build-up or corrosion of the pipes. Where problems are found to be due to corrosion, the affected sections of pipe are being replaced with polyethylene. It has been noted that some of the existing PVC watermains are becoming brittle. They too are being replaced.

There are pressure sensors at a number of locations around town which are regularly checked. Water meters have recently been installed at each property (sub-meters installed when there are multiple units at a property). Households that use excess water will then be charged an excess water rate. Smart Meters have recently been installed for improved understanding of water usage and losses, and better indication of leaks and mains breaks.

The operators have not observed any issues of low water pressure or flow stagnation. There is no pressure boosting station in the area.

MORANBAH WATER SUPPLY SYSTEM CAPACITY

A recent plant audit[6] has estimated the capacity of Moranbah Boby Plant and WTP as 70 and 160 L/s respectively. It should be noted that the full theoretical capacity of the WTP could be realised with improvement works being undertaken around the raw water pumps and the flash mixer.

Despite there being no capacity bottleneck experienced at present, Council is monitoring the mining development and the housing demand in the area.

MORANBAH STAKEHOLDERS

The important stakeholders in Moranbah are presented below in Table 0-6

TABLE 0-6: MORANBAH STAKEHOLDERS

Organisation	Contact Name and Details	Relevance to Management of Drinking Water Quality	How the Stakeholder is Engaged in the DWQMP
BMA		Owners of raw water infrastructure	Not engaged
SunWater		Contracted maintenance / operation of BMA's infrastructure assets	Not engaged
Fire Department		Quality not relevant but reticulation pressure	Not engaged
Residential Users		Supplied with reticulated water from the Moranbah scheme	Not engaged

[6] Moranbah WTP Capacity Review (Harrison Grierson, June 2010)

MORANBAH WATER QUALITY

Water quality in Moranbah has been tested and recorded since 2006. The monitoring data is discussed below.

OPERATIONAL MONITORING

The operational monitoring currently undertaken at Moranbah is detailed in the following table. Testing parameters are separated by process step.

TABLE 0-1: MORANBAH OPERATIONAL MONITORING

Process Step	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Operator Sampling							
Raw Water entering WTP	pH	High or Low pH	Online	N/A	Chemical dosing adjusted as pH changes	N/A	N/A
Raw Water entering WTP	Turbidity	High Turbidity	Online	N/A	Chemical dosing adjusted as per operator's charts or as per jar tests turbidity/colour increases	N/A	N/A
Raw Water entering WTP	True Colour	High Colour	Daily	N/A	Chemical dosing adjusted as per operator's charts or as per jar tests turbidity/colour increases	N/A	N/A
Raw Water entering WTP	Dissolved Manganese	High Manganese	Weekly	N/A	Increase potassium permanganate or pre- chlorine dose to oxidise	N/A	N/A
Raw Water entering WTP	Dissolved Iron	High Iron	Weekly	N/A	Increase potassium permanganate or pre- chlorine dose to oxidise	N/A	N/A
Raw Water entering WTP	Total Manganese	High Manganese	Weekly	<0.05 mg/L (in treated water)	Increase potassium permanganate or pre- chlorine dose to oxidise	N/A	N/A
Raw Water entering WTP	Total Iron	High Iron	Weekly	<0.3 mg/L (in treated water)	Increase potassium permanganate or pre- chlorine dose to oxidise	N/A	N/A
Raw Water entering WTP	Alkalinity	Coagulation failure	Weekly	N/A	Assess soda ash dosing requirements	N/A	N/A
Raw Water entering WTP	Hardness	None in raw water	Weekly	N/A	Monitoring only	N/A	N/A
Raw Water entering WTP	Fluoride	None in raw water	Weekly	N/A	Monitoring only	N/A	N/A
Settled Water (outlet of clarifier)	Turbidity	Pathogens	Daily	<2 NTU	Check coagulation pH. Adjust coagulant and/or soda ash dose rates.	N/A	N/A
Settled Water (outlet of clarifier)	True Colour	High Colour	Daily	N/A	Assess chemical dosing requirements of raw water if colour is high	N/A	N/A
Settled Water (outlet of clarifier)	pH	6.5-8.5	Daily	N/A	Assess pH adjustment dosing in raw water if pH becomes high or low.	N/A	N/A

TABLE 0-1: MORANBAH OPERATIONAL MONITORING							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if Target Limit Exceeded**	**Critical Limit**	**Action if Critical Limit Exceeded**
Settled Water (outlet of clarifier)	Total Manganese	High Manganese	Weekly	N/A	Increase potassium permanganate or pre- chlorine dose to oxidise	N/A	N/A
Filtered Water (outlet of filters)	pH	High or Low pH	Online	7.0 – 7.5	Adjust soda ash dose for filtered water	N/A	N/A
Filtered Water (outlet of filters)	True Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Daily	< 15 HU	Adjust WTP chemical dosing	N/A	N/A
Filtered Water (outlet of filters)	Free Chlorine	High Manganese	Online	> 0.1 mg/L	Adjust WTP chemical dosing	N/A	N/A
Filtered Water (outlet of filters)	Turbidity	High Turbidity	Online	< 0.2 NTU	See Critical Control Points for Moranbah.		
Filtered Water (outlet of filters)	Total Manganese	High Manganese (health/ aesthetic)	Weekly	N/A	Adjust potassium permanganate or pre-chlorine dose to oxidise	N/A	N/A
Treated Water	pH	High or Low pH	Online	7 – 7.5	See Critical Control Points for Moranbah.		
Treated Water	Turbidity	Pathogens	Online	< 0.5 NTU	See Critical Control Points for Moranbah.		
Treated Water	Free chlorine	Pathogens	Online	1.5 - 2.5 mg/L	See Critical Control Points for Moranbah.		
Treated Water	Fluoride	High fluoride is a risk to human health	Daily	0.6 to 0.8mg/L	See Critical Control Points for Moranbah.		
Treated Water	True Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Daily	< 15 HU	Adjust WTP chemical dosing	N/A	N/A
Treated Water	Total Manganese	High Manganese (health/ aesthetic)	Daily	<0.05 mg/L	Increase potassium permanganate or and/or pre-chlorine dose to oxidise (ADWG Health limit 0.5 mg/L)	N/A	N/A
Treated Water	Dissolved Manganese	High Manganese (health/ aesthetic)	Weekly (more frequently if required)	<0.05	Increase potassium permanganate or and/or pre-chlorine dose to oxidise (ADWG Health limit 0.5 mg/L)		
Treated Water	Dissolved Iron	High Iron	Weekly	<0.3 mg/L	Potassium permanganate and/or pre-chlorine dosing should be adjusted.	N/A	N/A
Treated Water	Total Iron	High Iron (aesthetic)	Weekly (more frequently if required)	<0.3 mg/L	Increase potassium permanganate or and/or pre-chlorine dose to oxidise	N/A	N/A

TABLE 0-1: MORANBAH OPERATIONAL MONITORING							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if Target Limit Exceeded**	**Critical Limit**	**Action if Critical Limit Exceeded**
Treated Water	Aluminium	High Aluminium	Weekly	<0.2 mg/L	Check coagulant dose (overdosing may be occurring)	N/A	N/A
Treated Water	Alkalinity	Corrosion	Weekly	20 – 200 mg/L $CaCO_3$	Adjust soda ash dose	N/A	N/A
Treated Water	Hardness	Aesthetic issues	Weekly	60 - 200 mg/L $CaCO_3$	(<60 mg/L soft, but corrosive) Aesthetic issue only. No further treatment options currently available	N/A	N/A
Potable Water	Free chlorine	Pathogens	Weekly	>0.2 mg/L	Adjust post- chlorine gas dose rate	N/A	N/A
Potable Water	pH	High or Low pH	Weekly	6.5 – 8.5	Adjust soda ash dose rate.	N/A	N/A
Potable Water	Fluoride	High fluoride is a risk to human health	Weekly	0.65 to 0.75mg/L	Check dosing system, Check background fluoride level	N/A	N/A
Potable Water	Turbidity	Pathogens	Weekly	< 0.5 NTU	Monitoring only	N/A	N/A
Potable Water	True Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Weekly	< 15 HU	Monitoring only	N/A	N/A
Potable Water	Total Manganese	High Manganese (health/ aesthetic)	Weekly	<0.05 mg/L	Monitoring only	N/A	N/A

CRITICAL CONTROL POINTS

Table 0-2 details the critical control points (CCPs), limits and rectification actions for Moranbah WTP. Target limits are in line with ADWG best practice operation guidelines and critical limits are as per ADWG health limits.

TABLE 0-2: MORANBAH CRITICAL CONTROL POINTS							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if target limit exceeded**	**Critical Limit**	**Action if critical limit exceeded**
Filtered Water (outlet of individual filters)	Turbidity	Pathogens	Online	<0.2 NTU	Optimise coagulation dose rate and coagulation pH. Backwash filter if turbidity continues to approach critical limit.	0.5 NTU	Backwash filter immediately then continue actions per Target Limit Advise W&WW Manager if critical limit exceeded

TABLE 0-2: MORANBAH CRITICAL CONTROL POINTS							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if target limit exceeded**	**Critical Limit**	**Action if critical limit exceeded**
Treated Water	pH	High or Low pH	Online	7.2 – 7.5	Adjust soda ash dose for filtered water	<7.0 or >8.0	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Turbidity	High Turbidity	Online	<0.5 NTU	Adjust WTP chemical dosing Backwash filter(s) if required	1.0 NTU	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria. High chlorine increases risk of by-products	Online	1.5 - 2.5 mg/L	Target limit is set to ensure that there is sufficient residual maintained throughout reticulation. If concentration is high or low, adjust chlorine dose rate	< 1.0 or >3.0 mg/L	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit ADWG allows residual between 0.2 and 5.0mg/L. However, chlorine dose rate should be adjusted prior to reaching the low/high limits Action is critical if the concentration is below 1mg/L. If the concentration is too low at the exit of the plant, an adequate residual is unlikely to be maintained in the reticulation Advise W&WW manager of non-compliant water
Treated Water	Fluoride	High fluoride is a risk to human health	Daily	0.65 to 0.75 mg/L	Check dosing system, Check background fluoride level	0.9 mg/L	Immediately shutdown fluoride dosing system Investigate and continue actions per Target Limit Advise W&WW manager of non-compliant water

MORANBAH RAW WATER QUALITY

Presented below are the results of raw water testing.

TABLE 0-3: MORANBAH RAW WATER QUALITY

Moranbah Raw Water (July 2014 – Nov 2021)									
Parameter	**Units**	**Sampling Location**	**Summary of Results**						**Comments**
			No of Samples	**Minimum**	**5th Percentile**	**Average**	**95th Percentile**	**Maximum**	
Colour (Apparent)	HU	Burdekin Dam/ Eungella Dam - Inline Sampling Point/ WTP Inlet Sampling Point	537	3.0	15.0	157.7	664.0	974.0	Raw water turbidity and colour can increase rapidly, particularly when it rains. True colour has been measured since July 2016.
Colour (True)	HU		1284	1.0	16.0	84.1	253.6	2257.0	
Turbidity	NTU		1689	1.1	2.3	22.7	77.8	162.0	
pH	pH unit		1688	7.02	7.48	8.08	8.81	9.45	
Alkalinity	mg/L		226	30.0	38.0	62.9	106.0	128.0	
Hardness	mg/L as $CaCO_3$		226	10.0	37.3	64.3	108.8	230.0	
Total Iron	mg/L		274	0.010	0.020	0.301	0.950	2.450	Occasional spikes in raw water iron must be monitored for management of oxidation process.
Dissolved Iron	mg/L		244	0.000	0.000	0.127	0.529	1.180	
Total Manganese	mg/L		265	0.007	0.021	0.089	0.277	1.376	Occasional spikes in raw water manganese must be monitored for management of oxidation process.
Dissolved Manganese	mg/L		221	0.000	0.004	0.158	0.108	27.000	
Fluoride	mg/L		222	0.00	0.01	0.09	0.14	0.77	

Raw water quality at Moranbah is generally good to both plants, with the exception of elevated true and apparent colour and occasional iron and manganese spikes.

MORANBAH TREATED WATER QUALITY

Daily samples of treated water are collected for onsite analysis. The available recorded data from these samples is provided in Table 0-4: Moranbah Treated Water Quality table.

TABLE 0-4: MORANBAH TREATED WATER QUALITY

Moranbah Water Treatment Plant (July 2014 – June 2021)

Parameters	Units	Sampling Location	Summary of Results						CCP		ADWG		Comments
			No. of samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	Critical Limits	Exceptions	Guideline Value [7]	Exceptions	
Colour	HU	Inlet to Treated Water Reservoir	2550	0.0	0.0	0.2	0.0	91.0	N/A	0	<=15 (A)	7	Colour occasionally exceeds the ADWG aesthetic guideline value. High colour may indicate organics which can present a THM risk when chlorinated.
Turbidity	NTU		2517	0.0	0.1	0.5	1.3	30.1	1	217	<=1 (H)[8]	217 (H)	Turbidity was often higher than 1 NTU which ADWG recommends as the limit at the point of disinfection with chlorine but has significantly improved since 2017.
pH	pH units		2516	6.30	7.10	7.44	7.87	8.53	7.0-8.5	46,1	6.5-8.5 (A)	3,1	Was sometimes outside CCP limits and occasionally exceeds ADWG aesthetic guideline but has had only one out of limit sample since June 2019
Chlorine	mg/L		2509	0.07	1.20	1.72	2.41	4.12	1.0-3.0	32, 19	0.2-5.0 (H)	1,0	Was sometimes outside CCP limits but has been consistently within limits since late 2018.
Fluoride	mg/L		2501	0.15	0.50	0.64	0.77	0.94	0.9	2	<=1.5 (H)	0	
Alkalinity	mg/L $CaCO_3$		333	0.3	27.2	58.5	100.0	170.0	N/A	0	N/A	0	
Hardness	mg/L $CaCO_3$		333	21.0	37.0	65.1	100.0	215.0	N/A	0	60-200 (A)	1	Often potentially corrosive, rarely scaling
Dissolved Iron	mg/L		231	0.000	0.000	0.008	0.020	0.100	N/A	0	<=0.3 (A)	0	

[7] A = aesthetic guideline value; H = health-based guideline value

[8] Recommended at the point of disinfection with chlorine

TABLE 0-4: MORANBAH TREATED WATER QUALITY

Moranbah Water Treatment Plant (July 2014 – June 2021)

Total Iron	mg/L		345	0.000	0.000	0.014	0.030	0.300	N/A	0	<=0.3 (A)	0	
Dissolved Manganese	mg/L		444	0.000	0.000	0.005	0.010	0.151	N/A	0	<=0.5 (H) <=0.1 (A)	0 (H) 6 (A)	Manganese levels have not exceeded ADWG aesthetic guideline since early 2018
Total Manganese	mg/L		1502	0.000	0.002	0.006	0.012	0.273	N/A	0	<=0.5 (H) <0.1 (A)	0 (H) 6 (A)	
Aluminium	mg/L		329	0.000	0.000	0.024	0.039	0.540	N/A	0	<=0.2 (A)	2	Has only had two ADWG aesthetic exceedances in late 2018, early 2019

As shown in the following graphs, treated water turbidity and colour have significantly improved since early 2017. Note that only true colour is available for raw water from June 2017 onward. There was also a short-lived spike in treated water colour in July-September 2020, which has since been resolved.

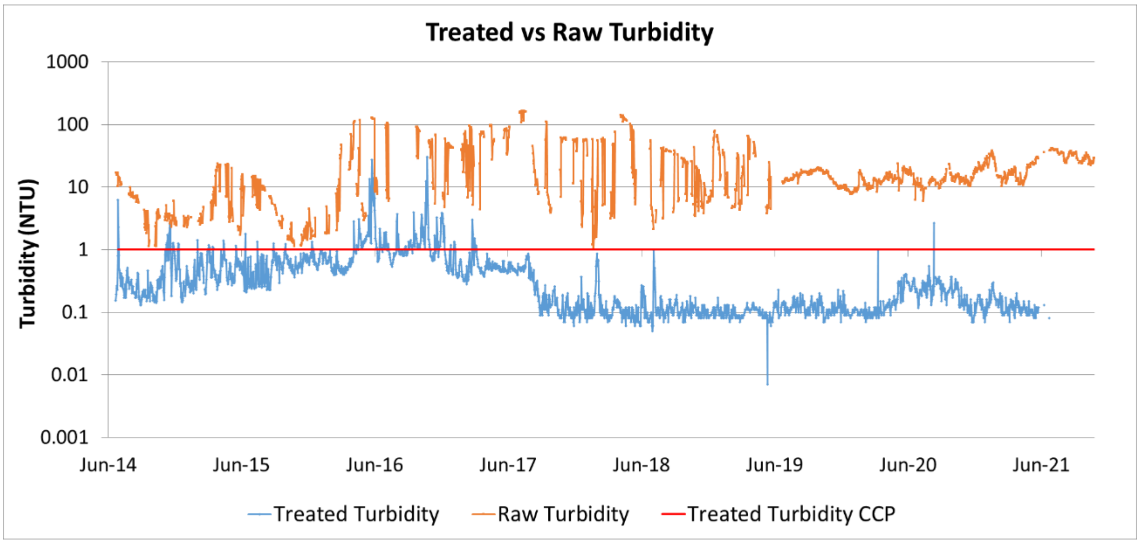


Figure 0-1: Moranbah Raw and Treated Water Turbidity

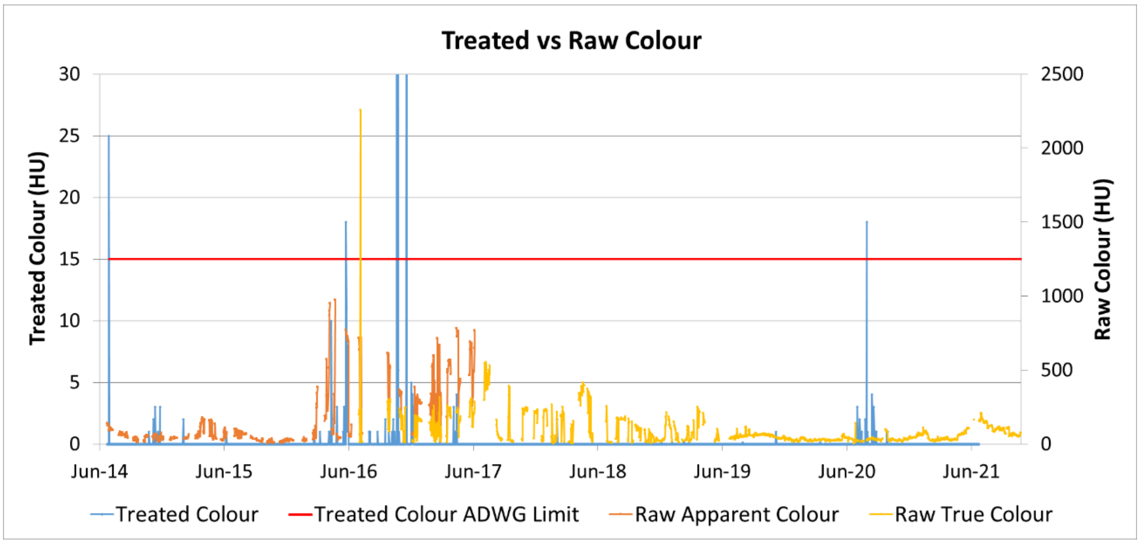


Figure 0-2: Moranbah Raw and Treated Water Colour

Figure 0-3 below depicts the free chlorine residual in the treated water for the period July 2014 – June 2021. Compliance with the Chlorine CCP limits are seen to improve with fewer values outside of the CCP limits from 2016 onwards.

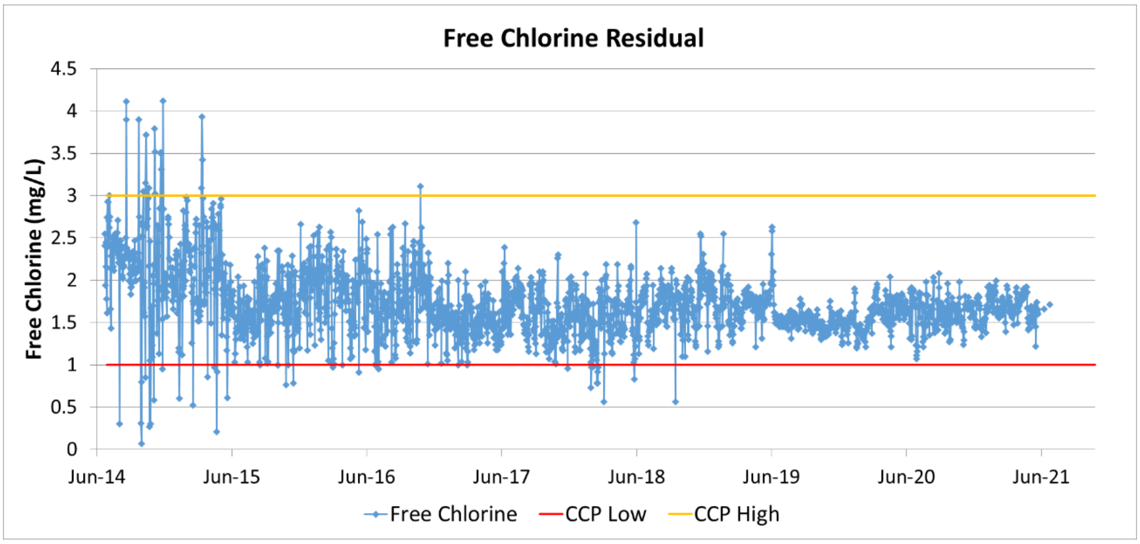


Figure 0-3: Moranbah Free Chlorine Residual in treated water

Figure 0-4 and Figure 0-5 present the iron and manganese concentrations in the treated water at Moranbah.

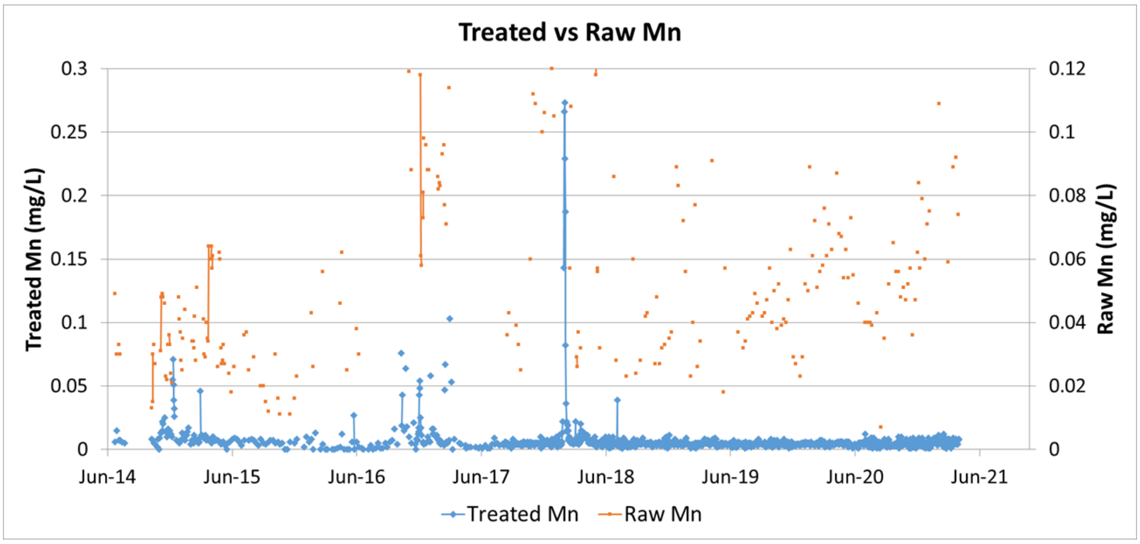


Figure 0-4: Moranbah Raw and Treated Water Manganese

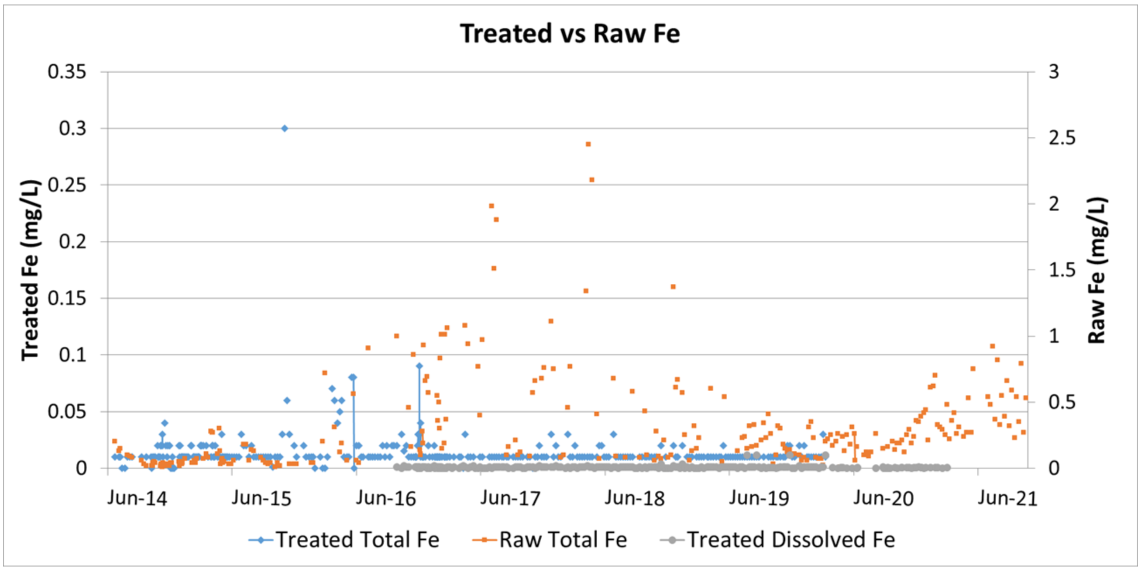


Figure 0-5: Moranbah Raw and Treated Water Iron

The health limit for manganese is 0.5 mg/L and the aesthetic limit is 0.1 mg/L. The aesthetic limit for iron is 0.3 mg/L. Figure 0-5 shows that iron concentrations have never exceeded the ADWG aesthetic limit. Figure 0-4 shows that manganese concentrations exceeded the ADWG aesthetic guideline during one week in February 2019 only but has never exceeded the health limit.

Figure 0-6 below indicates that the WTP does not have much effect on the hardness of the raw water. This is not considered a problem as the hardness is generally within ADWG aesthetic guidelines, although sometimes potentially corrosive.

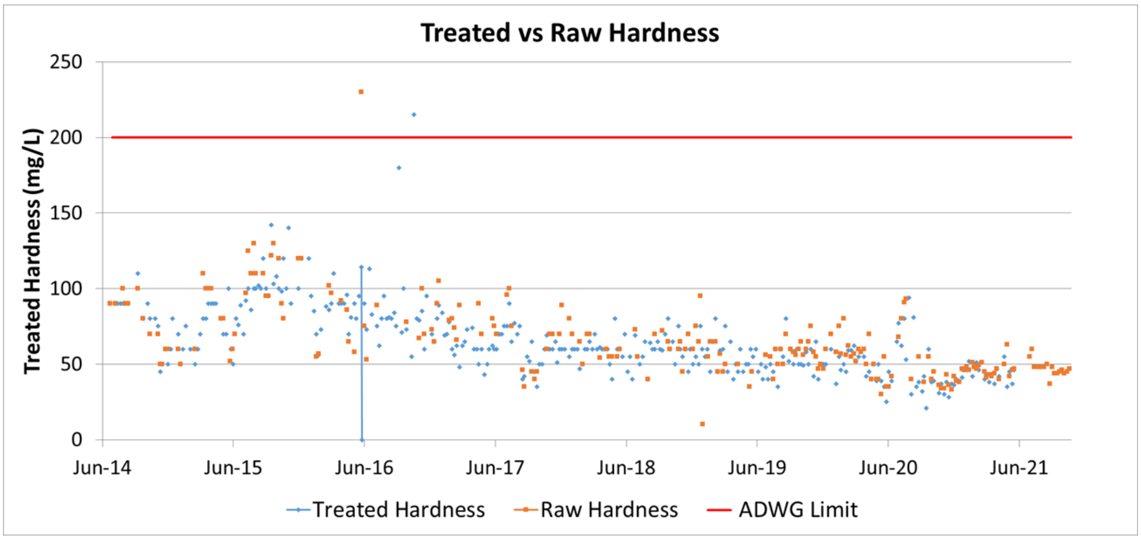


Figure 0-6: Moranbah Treated Water Hardness

MORANBAH RETICULATED WATER QUALITY

E.*coli* has not been detected in the reticulation since July 2010, chlorine residual is generally maintained above the recommended limit of 0.2 mg/L of free chlorine at the extremities of the reticulation. Chlorine meters which alarm on low chlorine exiting the treated water reservoirs have been installed to aid in maintaining an adequate chlorine concentration throughout the reticulation. Online chlorine analysers are installed on the filtered water mains prior to the Reservoir 1 inlet. The treated water test results are shown below in Table 0-5: Moranbah Reticulated Water Quality (January 2014 to October 2021) table.

TABLE 0-5: MORANBAH RETICULATED WATER QUALITY (JANUARY 2014 TO OCTOBER 2021)

Samples taken at: Belyando Avenue, Jackson Avenue, Archer Drive, Binda Park, O'Neill Street

Parameter	No. of Samples	Summary of Results					ADWG Guideline Value [9]	No. of Samples Exceeding ADWG Guideline Value
		Minimum	5^{th} Percentile	Average	95^{th} Percentile	Maximum		
E. coli (MPN/100 mL)	707	ND	ND	ND	ND	ND	<1 (H)	0
Fluoride (mg/L)	423	0.057	0.280	0.623	0.833	0.903	<1.5 (H)	0
Free Chlorine (mg/L)	701	0.02	0.45	1.21	1.87	3.32	0.2-5.0 (H)	14, 0
pH	603	6.52	7.04	7.44	7.828	8.84	6.5-8.5	0,1
Total Coliforms (cfu/100 mL)	580	<1	<1	<1	<1	4		

[9] A = aesthetic guideline value; H = health-based guideline value

MORANBAH WATER QUALITY COMPLAINTS

There were four water complaints recorded by IRC between 2011 and 2012.

There have been numerous water quality complaints recorded for Moranbah in recent years:

- 21 in the 2013/14 financial year (cause unknown)
- 8 in 2014/15 (cause unknown)
- 21 in 2015/16 (mostly for colour)
- 90 in 2016/17 (mostly relating to discoloured water complaints, likely arising from switching raw water sources and insufficient monitoring and operational changes)
- 67 in 2017/18 (many relating to discoloured water, some relating to taste and odour and the majority cause unknown).A significant improvement was noted in 2018/19 with a total of 8 complaints (mostly relating to discoloured water or taste).
- In the 2019/20 financial year, a total of 15 water quality complaints were received – 13 for discoloured water and 2 categorised as other.
- In the 2020/21 financial year, a total of 4 water quality complaints were received, all for discoloured water.

Refer to Section 0 for details of complaint recording procedures.

MORANBAH KEY ISSUES

- No key water quality issues in the Moranbah water scheme have been identified. Council will continue to monitor treated water quality to optimise treatment processes and ensure plant performance is acceptable.

NEBO WATER SCHEME

Nebo currently has 6 bores in operation that can be used for abstracting raw water. All bores have recently been refurbished and redrilled for improved water quality and bore protection. Bore 6 had previously been decommissioned due to quality concerns but has been reinstated as part of the overall bore field refurbishment. Bore 1 was used in the past but has also since been decommissioned. A new bore, bore 7, has also been commissioned. A new water softening plant and treated water storage have been constructed at Nebo. shows the Nebo water supply scheme.

An overview of the Nebo Water Scheme is shown in Table 0-1 with further detail in the sections following.

TABLE 0-1: NEBO SYSTEM OVERVIEW	
System Component	**Description**
Population Supplied	Total connections of approximately 401 comprising approximately 753 persons.
Water Sources	Six (6) bores supply groundwater from the Nebo Creek aquifer. Bores are grouped to blend the water from nominated bores: • Group 1 – 2, 4, 6 • Group 2 – 3, 5, 7.
Water Treatment	Bore water is treated by the following processes: • Pre-chlorine dosing for metals oxidation, if required • Dual media (glass and filter coal) filtration • Ion exchange for softening • Sodium hydroxide for pH correction • UV Disinfection • Chlorine gas dosing for disinfection residual and additional trim dosing
Storage After Treatment	Nebo has two (2) treated water reservoirs: • 2 ML Treated Water Reservoir • 250 kL Treated Water Tower Both are roofed and vermin proof.
Distribution of Product	Gravity fed from the Water Tower via approximately 11km of reticulation mains.
Any Special Controls Required	Quality of chemicals, materials, etc. used in the production and delivery of the product. Manual verification sampling of water from the distribution network. Backflow prevention and trade waste management. Operation and maintenance of all infrastructure to prevent recontamination.

Nebo Overall Water Supply Scheme

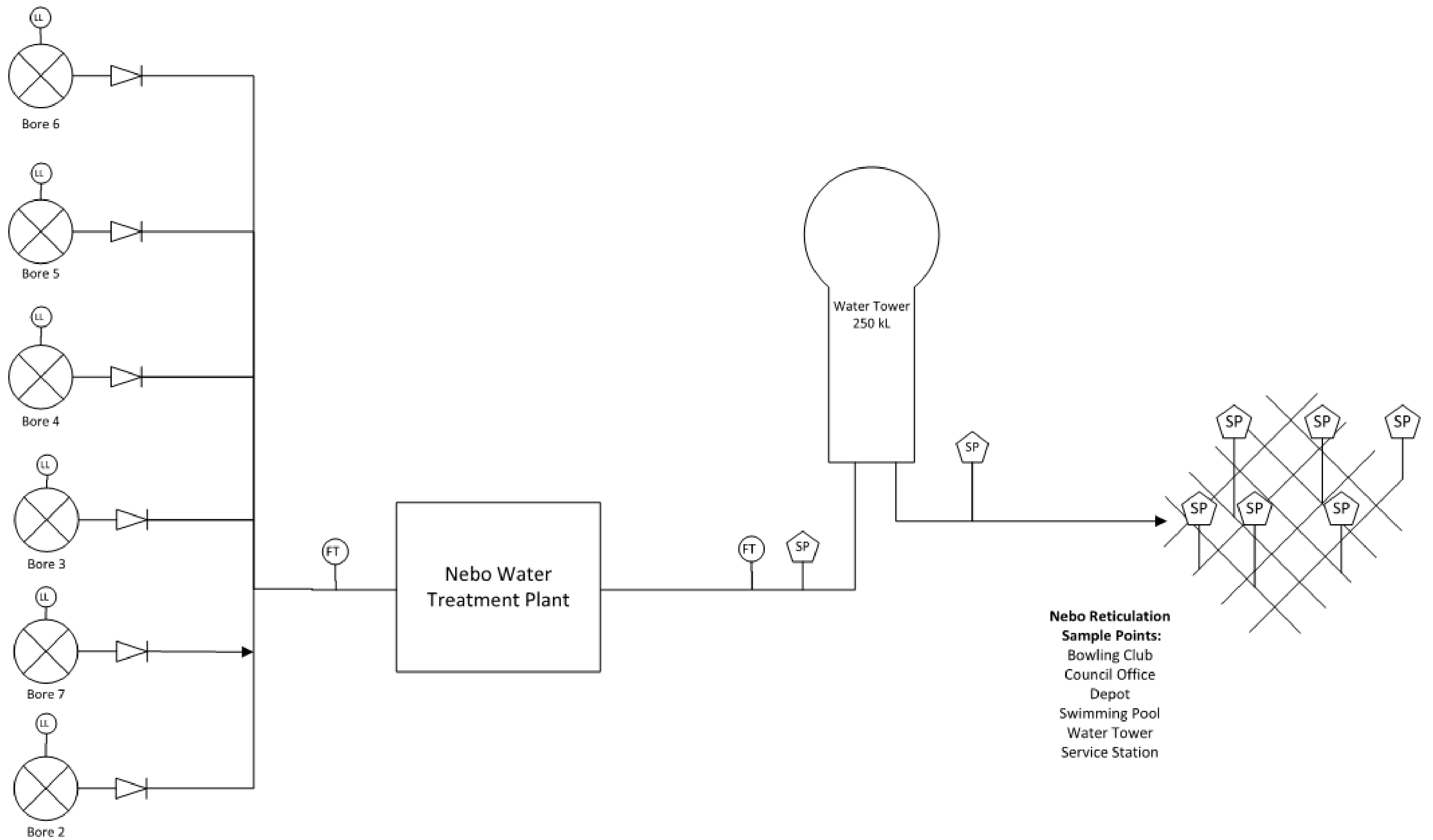


Figure 0-1: Nebo Overall Water Supply System

Nebo Water Treatment Plant

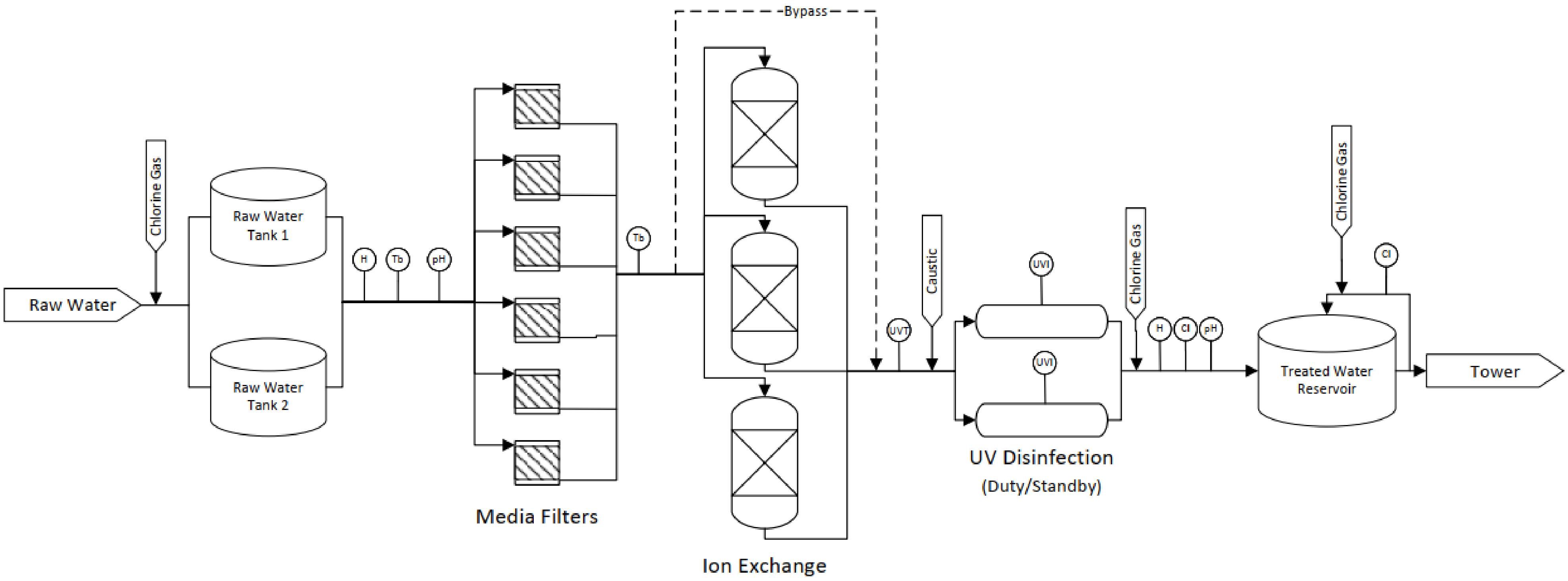


Figure 0-2: Nebo Water Treatment Plant

NEBO CATCHMENT

Major tributaries to the groundwater at Nebo are Cooper, Denison and Nebo Creeks within the 1,080 km^2[10] Fitzroy Basin. The water is from an alluvial aquifer that ranges in depth of 11 m to 16 m at the bore locations. Figure 0-3 from the Australian Natural Resources Atlas shows the shallow nature of the aquifer at Nebo.

The Nebo area has a sub-tropical to tropical climate. The average annual rainfall is approximately 730 mm, with the majority of annual rainfall occurring between the months of December and April.[11]

The catchment has the following uses:

- Cattle grazing;
- Some limited agricultural development on the higher alluvial terraces;
- Mining and industrial activities.

[10]Information from http://www.anra.gov.au/topics/water/availability/qld/gmu-braeside-nebo.html#char
[11]Information from http://www.anra.gov.au/topics/water/overview/qld/gmu-braeside-nebo.html

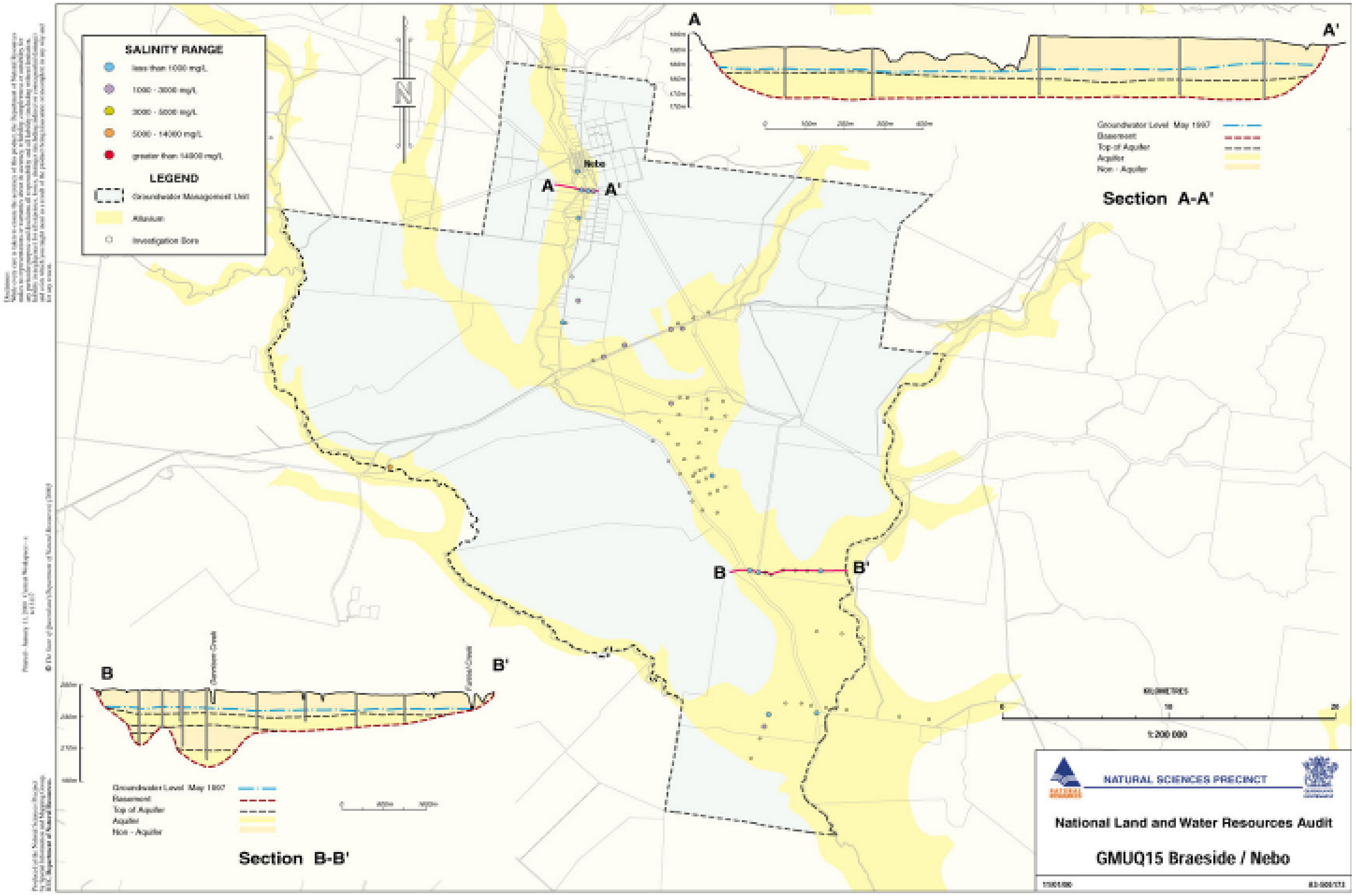


Figure 0-3: Nebo-Braeside Cross Sectional Diagram[12]

[12] Sourced from http://www.anra.gov.au/topics/water/availability pro/qld/gmu-braeside-nebo.html

NEBO RAW WATER

The bores are typically operated in one of 2 groupings to manage extraction allocations and water quality characteristics for treatment. Bore Group 1 consists of Bores 2, 4 and 6 and Bores 3, 5 and 7 make up Group 2. These groupings allow for hardness and metals (iron and manganese) concentrations to be managed by blending ratios for treatment.

The current total annual allocation of water from the bores is 250 ML/year. There is an application with RDMW currently to increase the allocation to meet future community demand. Bores 2 and 3 have an allocation of 75 ML/year, Bores 4 and 5 also have an allocation of 75 ML/year and Bores 6 and 7 have an allocation of 100 ML/year. Bores 2, 3, 4, 6 and 7 have a pump rate of 8 L/s each and are linked to the Nebo Creek Aquifer. Bore 5 has an approved pump rate of 6 L/s.

The locations of the Nebo bores are shown in Figure 0-4 : Nebo Bore Locations. As shown, all five bores are located south of the township. The current total annual allocation for the bores is 250 ML/year. Bores 2, 3 and 7 are located on the eastern side of Nebo Creek and the other bores, 4, 5, and 6 are located on the western side. During the wet season, the creek level can rise and cut-off access to Bores 4, 5 and 6 so inspection checks and maintenance cannot be performed

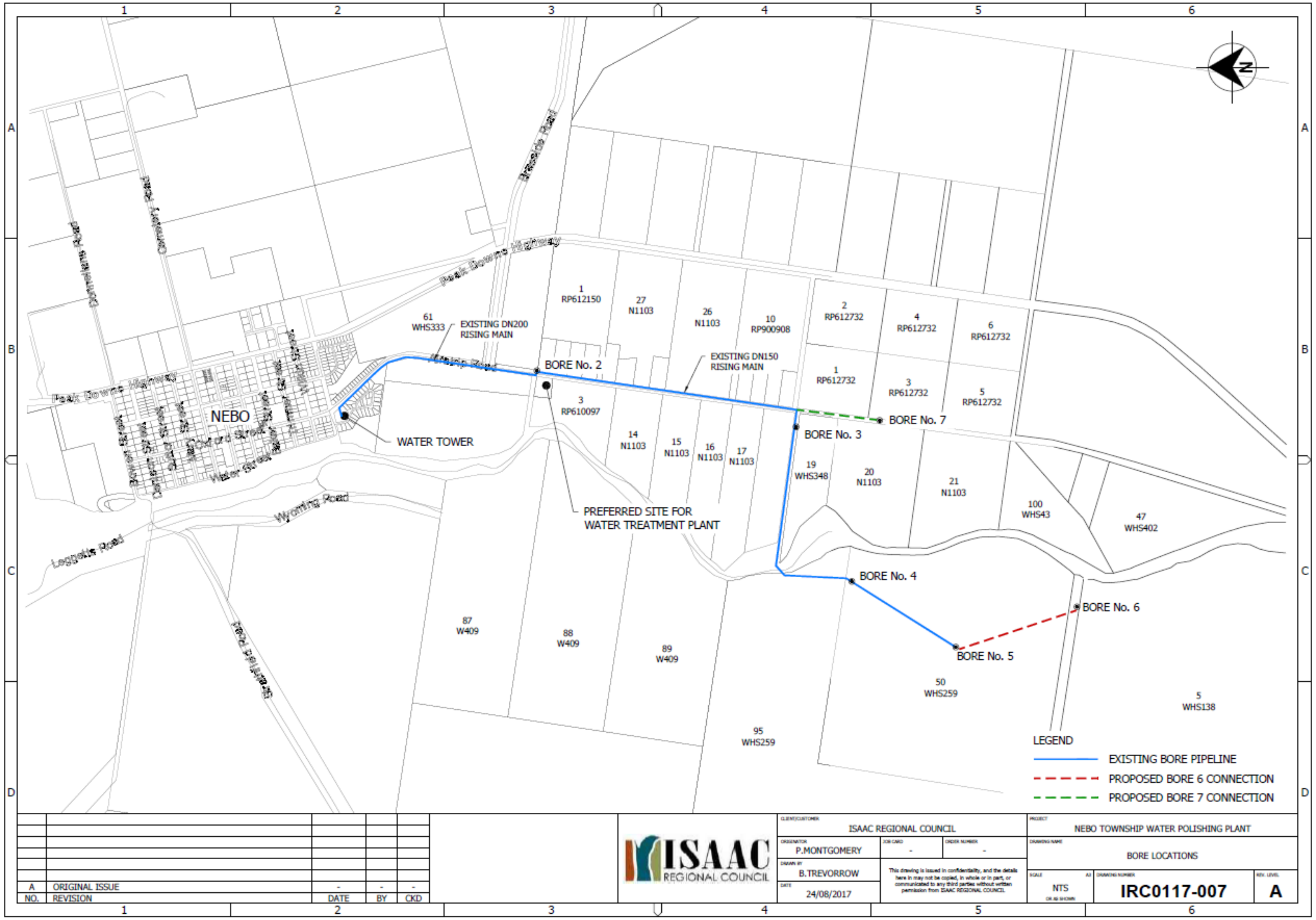


Figure 0-4 : Nebo Bore Locations

All Bores are operated and rotated as required to maintain a suitable influent water quality to the new WTP and stay within allocation limits. The clear water lift pumps at the WTP operate until the water tower reaches a high level (i.e. the stop level). When the water tower level drops to 60% then the standby clear water lift pump starts. The level of the water tower is operated on 4 different indicators of Low Low Level, Low Level, High Level and High High Level.

Bores 2, 6 and 7 are located within road reserves and are fenced. Bores 3, 4 and 5 have easements through private properties. The IRC operational staff advised that all operating bore pumps are well fenced off. These minimise the potential for contamination by farm animals.

Bores 2, 3 and 4 were redrilled during 2019 as the existing casings were deemed past their operational life. Bores 5 & 6 are approximately 10 years old and Bore 7 was a new bore developed in 2016. Bores 2 – 6 were fitted with new pumps, telemetry, switchboards, flowmeters and valves.

NEBO WATER TREATMENT PLANT

The WTP is rated for 25 L/s. Water production can occur at any time but will automatically start each morning and continue until the reservoir is full. This means the plant typically operates for one continual period throughout the day. The WTP can start based on the level in the Treated Water Storage Tank, however this is not its typical operating mode.

Raw Water Dosing

Raw water flow entering the Nebo WTP is monitored by a magnetic flowmeter. Raw water from the bores flows into 2 linked raw water tanks, which can be configured to run either in parallel or series. Chlorine gas can be dosed into the raw water main for oxidation of iron and manganese, if required. The raw water tanks provide up to 60 minutes retention time for oxidation and buffering. Chemical dosing setpoints are selected and manually adjusted by the operators as required. The chemical dosing ceases when raw water flow has stopped.

Hardness, turbidity and pH are all continuously monitored on the combined outlet of the raw water tanks.

Filtration

Water from the raw water tanks is pumped to the media filters to remove suspended solids. At least 3 of the 6 filters need to be online and in service for WTP operation. The filters are arranged in two banks of 3 filters each. Combined filtered water turbidity is continuously monitored for each bank of filters. The filter bed is a dual media configuration of filter coal and glass media.

Filter backwash is triggered manually by the operators or automatically on headloss and run time. Backwash water is sourced from the soft water tank.

The backwash sequence is automatic and consists of draining the filters for a pre-set time, running the backwash pump, stopping the backwash pump and conducting a forward rinse (for filter ripening) before re-commencing filtration. Air scour is not included in the backwash sequence.

The media filters have a filtration area of approximately 0.5 m^2 and filtration rate of 8-12 m/h.

Ion Exchange (Softening)

Filtered water is passed through the ion exchange units to remove hardness. There are 3 ion exchange units that operate in parallel, up to 2 units will be in use at any time depending on raw water quality and softening requirements.

A partial bypass of the ion exchange process to divert some of the filtered water directly to the combined ion exchange outlet is used to achieve the desired target water quality.

The ion exchange resin is periodically regenerated using a brine solution to refresh the resin with sodium and chloride ions. The backwash sequence is automatic and consists of draining the vessel for a pre-set time, backwashing the vessel with water from the soft water tank, drawing the brine solution through the resin bed, rinsing the resin with soft water and returning the vessel to service.

The ion exchange vessels have an area of approximately 0.5 m^2 and loading rate of 10-30 m/h.

The resin beads are susceptible to damage from chlorine and therefore operation of pre-chlorination practices must be carefully controlled and monitored.

Disinfection

Two-stage disinfection is used at Nebo WTP – UV disinfection for primary pathogen inactivation and chlorine dosing for residual protection against recontamination. There are two UV units that operate in a duty/ standby arrangement. The duty unit is rotated weekly or on manual selection.

UV Transmittance (UVT) and UV Intensity (UVI) are continuously monitored to ensure sufficient disinfection is being achieved.

Chlorine gas is dosed into the treated water main after the UV units. The treated water storage tank provides sufficient volume and residence time to achieve the desired Ct for effective disinfection. A recirculation line with booster chlorine dosing is used to maintain target chlorine residuals in the treated water storage tank during periods of low consumption in the town.

Treated water can be dosed with sodium hydroxide prior to the UV units for post-pH correction if required.

Hardness, chlorine residual and pH are all continuously monitored prior to the treated water storage tank. A chlorine residual analyser also monitors chlorine concentration on the recirculation line.

Sludge Treatment

Wastewater from filter backwashing and ion exchange regeneration is collected in 2 tanks onsite for buffering and controlled dilution prior to being pumped to sewer for discharge.

Chemical Dosing

The WTP process currently uses the following chemicals:

TABLE 0-2: CHEMICAL USE IN THE NEBO WATER TREATMENT PROCESS

Chemicals	Dosing Location	Uses / Comments
Chlorine Gas	Raw Water Tanks Inlet Treated Water Storage Tank Inlet Treated Water Recirculation Line	Iron and manganese oxidation Disinfection residual
Sodium Hydroxide	UV Inlet	pH correction
Brine	Ion Exchange Inlets	Resin regeneration

NEBO WATER TOWER

The treated water is pumped from the 2 ML Treated Water Storage Tank to the 250 kL water tower via a DN200 line. The water tower is fully enclosed and made of reinforced concrete.

Figure 0-5: Nebo Water Tower

NEBO RETICULATION

The current location of the water tower is at the low point of the reticulation, therefore there have been intermittent issues with water pressure at higher parts of town.

The existing total reticulation (approximately 11 km) that services Nebo is made of AC, PVC and PE (sizes include DN100, DN 150 and DN200). Some of the pipes were installed over 50 years ago. There is no additional boosting pump station or supplementary disinfection point in the reticulation. All new reticulation in Nebo is specified to be Blue Brute.

The operators have advised that they have not experienced any flow stagnation issues.

New pipework has been laid between the water tower, Bore 2 and Bore 3 to remove user connections prior to the water tower that risk insufficient disinfection. The risk of insufficient disinfection is also mitigated by the additional treated water storage and treated water recirculation with chlorine booster at the new WTP.

NEBO WATER SUPPLY SYSTEM CAPACITY

With the construction of the new Nebo WTP the supply system capacity has greatly increased. The WTP is designed to provide up to 1.8 ML/d of treated water with an additional 2 ML of treated water storage onsite, bringing the supply system's total storage to 2.25 ML. Nebo's raw water allocations have also been increased to 250 ML/year by the addition of 2 new bores, making an extra 100 ML/year available.

There are 3 treated water high lift pumps that feed the water tower in a duty/duty assist/standby arrangement depending on demand. This provides a transfer capacity of up to 60 L/s. The pumps, reservoirs and reticulation now achieve the current and future demand requirements of DNRME's planning guidelines.

Council is monitoring the mining development and the housing demand in the area as they are aware of the potential new mine development which may result in significant increase in population and water demand.

NEBO STAKEHOLDERS

The stakeholders to the Nebo scheme are presented in Table 0-3 below.

TABLE 0-3: NEBO STAKEHOLDERS			
Organisation	**Contact Name and Details**	**Relevance to Management of Drinking Water Quality**	**How the Stakeholder is Engaged in the DWQMP**
Residential Users		Supplied with reticulated water from the Nebo scheme	Not engaged

NEBO WATER QUALITY

All bores are tested for hardness and dissolved and total iron and manganese as part of routine operational monitoring to ensure the best mix of raw water sources is being used. In the past, iron and manganese concentrations in Bores 4 and 5 were reported as being high, however there was no evidence of testing raw water for these parameters and limited verification monitoring has been conducted. Chlorine dosing at the head of the treatment process is available for oxidation of these metals when required. Raw water hardness in each bore is closely monitored to manage influent concentrations to the treatment plant. Bores 6 and 7 are the hardest with concentrations of up to 400 mg $CaCO_3$/L compared to Bore 4 which only has up to 100 mg $CaCO_3$/L. The other bores tend to average 300 mg $CaCO_3$//L.

OPERATIONAL MONITORING

The operational monitoring currently undertaken at Nebo is detailed in Table 0-1: Nebo Operational Monitoring table. Testing parameters are separated by process step.

TABLE 0-1: NEBO OPERATIONAL MONITORING

Process Step	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Operator Sampling							
Raw Water	pH	Acidic or alkaline water	Online	6.5 – 8.4	On high pH shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded	N/A	N/A
Raw Water	Turbidity	High turbidity	Online	<5 NTU	Bench test to confirm result. Inform supervisor and change to alternative bore train if required. Check bores.	< 20 NTU	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Raw Water	Colour	High colour	Daily	N/A	Monitoring Only	N/A	N/A
Raw Water	Hardness	High hardness	Online	<600 mg/L as $CaCO_3$	Bench test via titration to confirm result. Inform supervisor and change to alternative bore train if required.	N/A	N/A
Raw Water	Alkalinity		Daily	N/A	Monitoring Only	N/A	N/A
Raw Water	Conductivity	High conductivity	Daily	N/A	Monitoring Only	N/A	N/A

TABLE 0-1: NEBO OPERATIONAL MONITORING

Process Step	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Raw Water	Total Iron	High iron	Daily	N/A	Monitoring Only	N/A	N/A
Raw Water	Total Manganese	High manganese	Daily	N/A	Monitoring Only	N/A	N/A
Treated Water	pH	Acidic or alkaline water	Online	6.5 – 8.5	See Critical Control Points for Nebo		
Treated Water	Turbidity	High Turbidity reduces effectiveness of disinfection	Daily	< 1.0 NTU	See Critical Control Points for Nebo		
Treated Water	Alkalinity	Aesthetic	Daily	No Target set	Monitoring only (aesthetic)	N/A	N/A
Treated Water	Hardness	Aesthetic	Online	< 250 mg/L	Investigate and continue to monitor. Report to supervisor.	N/A	N/A
Treated Water	Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Daily	< 15 HU	Monitoring only (no treatment options available)	N/A	N/A
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria. High chlorine increases risk of by-products	Online	1.5 - 2.5 mg/L	See Critical Control Points for Nebo		
Treated Water	Total Iron	High iron (aesthetic)	Daily				
Treated Water	Total Manganese	High Manganese (health/ aesthetic)	Daily				

CRITICAL CONTROL POINTS

Table 0-2 details the critical control points (CCPs), limits and rectification actions for the Nebo WTP. Target limits are in line with ADWG best practice operation guidelines and critical limits are as per ADWG health limits.

TABLE 0-2: NEBO CRITICAL CONTROL POINTS

Process Step / Critical Control Point / Location in System	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Filtered Water	**Turbidity**	**Inadequate disinfection, pathogen risk.**	**Daily**	**0.2 NTU**	Investigate and re-sample.	**1.0 NTU**	Backwash filter(s) immediately. Follow water quality non-compliance procedure (Table 0-2). Advise W&WW Manager of non-compliance.
Treated Water	pH	Acidic or alkaline water	Online	7 – 7.5	Investigate and re-sample.	<6.5 or >8.5	Shutdown plant if immediate correction cannot be made Follow water quality non-compliance procedure (Table 0-2) Advise W&WW Manager of non-compliance
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria. High chlorine increases risk of by-products	Online	1.5 - 2.5 mg/L	Target limit is set to ensure that there is sufficient residual maintained throughout reticulation. If concentration is high or low, adjust chlorine dose rate.	< 1.0 or >3.0 mg/L	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit ADWG allows residual between 0.2 and 5.0 mg/L. However, chlorine dose rate should be adjusted prior to reaching the low/high limits Action is critical if the concentration is below 1mg/L. If the concentration is too low at the exit of the plant, an adequate residual is unlikely to be maintained in the reticulation Advise W&WW manager of non-compliant water
Treated Water	UV Dose	Pathogens	Online	>40 mJ/ cm^2	Investigate and continue monitoring.	<40 mJ/ cm^2	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Follow water quality non-compliance procedure (Table 0-2). Advise W&WW Manager of non-compliance.
Treated Water	UVT	Pathogens	Online	>95%	Investigate and continue monitoring.	<90%	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Follow water quality non-compliance procedure (Table 0-2). Advise W&WW Manager of non-compliance.

NEBO RAW WATER QUALITY

Raw water at Nebo was historically only tested for pH, as the treatment process previously consisted of only chlorine disinfection. Other raw water parameters have been tested since September 2017.

TABLE 0-3: NEBO BORES RAW WATER QUALITY

Parameter	Units	Sampling Location	Summary of Results (July 2014 – October 2021)						Comments
			No of Samples	Minimum	5th percentile	Average	95th percentile	Maximum	
pH	pH units	Raw water inlet to WTP	2644	6.08	6.72	7.45	7.2	677	
Turbidity	NTU		1482	0.0	0.01	0.40	0.79	65	Measured commencing September 2017
Colour	HU		1481	0.0	0.0	1.5	5.0	210	
Hardness	mg/L		1390	3.15	85	217	358	1145	
Alkalinity	mg/L		1487	17	125	198.68	260	760	
Total Fe	mg/L		1325	0.000	0.000	0.019	0.060	1.65	
Total Mn	mg/L		1307	0.000	0.000	0.006	0.029	0.500	

NEBO TREATED WATER QUALITY

Daily samples of treated water are collected for onsite analysis. Records of these samples are summarised in the table below. Note that these results are from a combination of the former chlorine-only process, and the new water treatment plant which was commissioned in late 2019.

TABLE 0-4: NEBO TREATED WATER QUALITY

Nebo Bores													
Parameters	Units	Sampling Location	Summary of Results (July 2014 – October 2021)						CCP		ADWG		Comments
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	Critical Limit	Exceptions	Guideline Value [13]	Exceptions	
pH	pH units	After chlorine dosing	2656	6.36	6.80	7.03	7.45	7.95	7.0-8.5	1347, 0	6.5-8.5 (A)	5	50.7% of samples were below CCP limit
Chlorine	mg/L		2665	0.00	0.26	0.92	1.60	2.91	1.0-3.0	1586, 0	<=5 (H)	0	59.5% of samples were below CCP lower limit
Alkalinity	mg/L $CaCO_3$		2651	55	115	195	270	450	N/A	0	N/A	0	
Hardness	mg/L $CaCO_3$		2537	50	90	175	265	510	N/A	0	60-200 (A)	7, 652	25.7% of samples above ADWG guideline
Turbidity	NTU		2619	0.00	0.01	0.17	0.32	3.36	1	2	<=1 (H)[14]	2 (H)	2 samples measured above the ADWG and CCP limit
Colour	HU		2673	0.0	0.0	0.2	0.0	30	N/A	0	<=15	5	5 colour measurements exceeded the ADWG aesthetic threshold
Total Iron	mg/L		1039	0.00	0.000	0.055	0.110	1.7	N/A	0	<=0.3 (A)	39	Measured from September 2017. Experienced a period of ADWG exceedances in May 2020 which has since resolved
Total Manganese	mg/L		1427	0.00	0.001	0.006	0.020	0.16	N/A	0	<=0.5 (H) <=0.1 (A)	0 2	2 samples measured above ADWG aesthetic threshold since September 2017

13 A = aesthetic guideline value; H = health-based guideline value

14 Recommended at the point of disinfection with chlorine

Figure 0-1 and Figure 0-2 below show the recorded turbidity and colour data for the Nebo scheme. Both parameters have mostly been within the compliance limits set out in the ADWG (5 NTU and 15 HU respectively) in the past three years, with the exception of 2 turbidity exceedances and 5 colour exceedances, respectively. The results are variable with occasional spikes and do not appear to follow a seasonal pattern, with a slight increase in colour spike incidences in recent years.

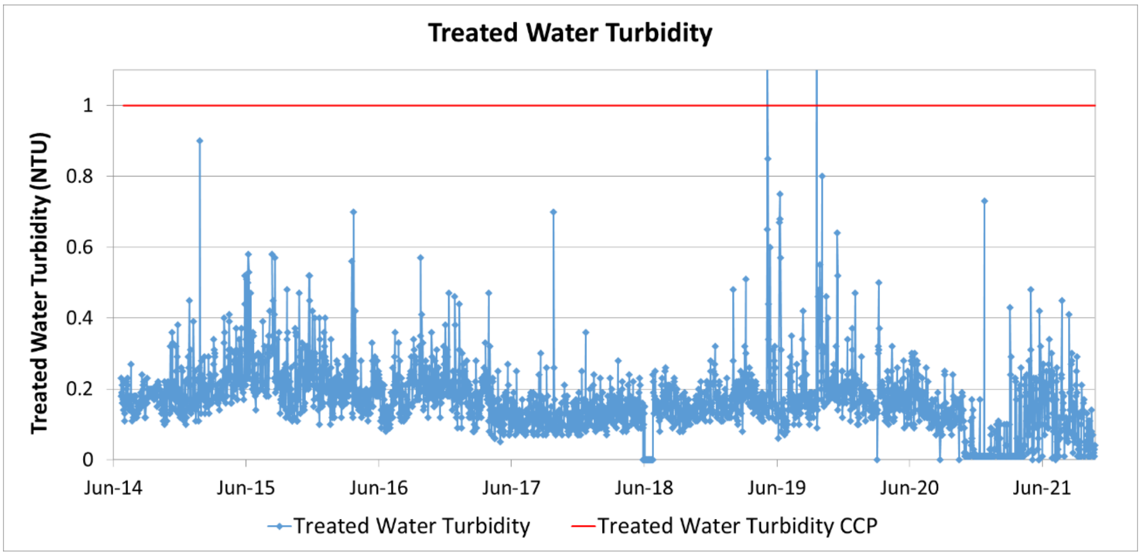


Figure 0-1: Nebo Treated Water Turbidity

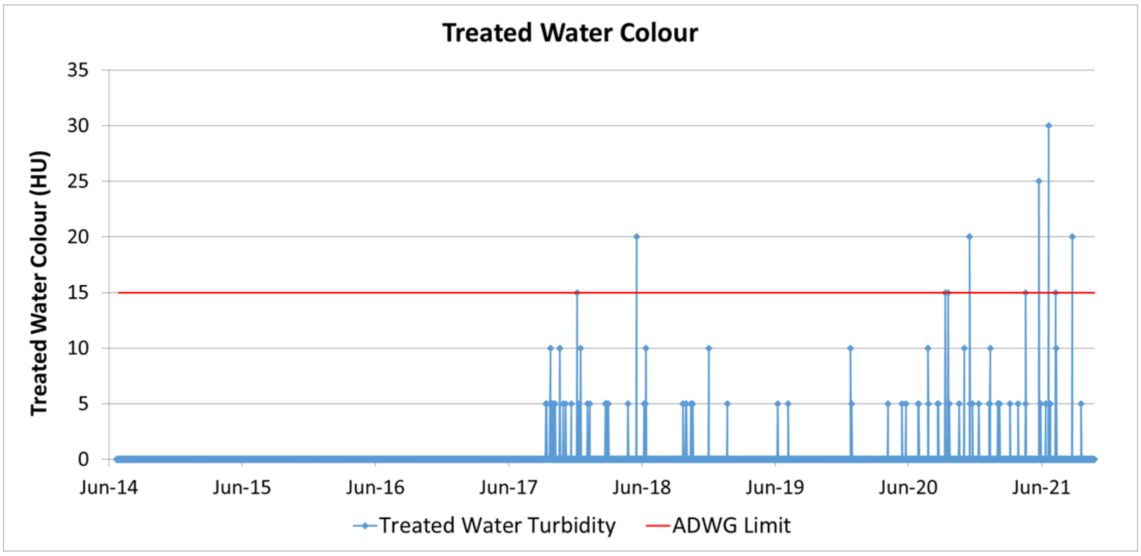


Figure 0-2: Nebo Treated Water Colour

Figure 0-3 below shows that hardness often exceeds the ADWG limit of 200 mg/L. The results are variable and there does not appear to be a seasonal pattern. A new softening plant has been commissioned at Nebo to address issues with hardness. Hardness levels have since lowered but still consistently straddle the ADWG aesthetic threshold. Further WTP optimisation works are scheduled for early 2022 to improve performance of the treatment process.

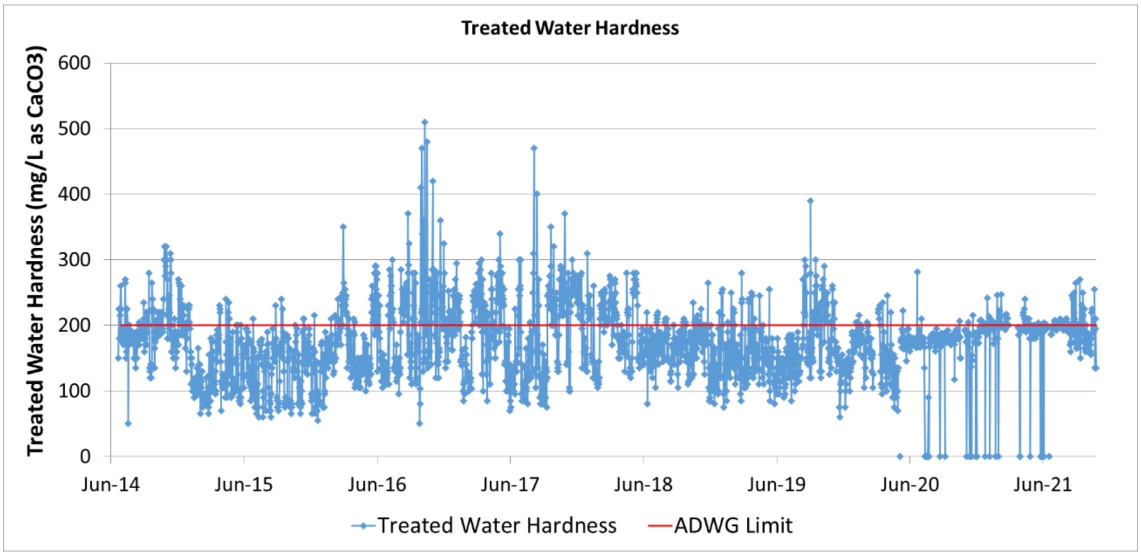


Figure 0-3: Nebo Treated Water Hardness

Figure 0-4 below shows the free chlorine concentration of the treated water for Nebo. The residual was often below the CCP limit of 1 mg/L however there was significant improvement from 2018. Chlorine residuals again dipped below 1 mg/L for a period around December 2019 but have since stabilised to high levels. It is important to maintain an adequate free chlorine residual to provide evidence of initial disinfection and prevent recontamination in the reticulation.

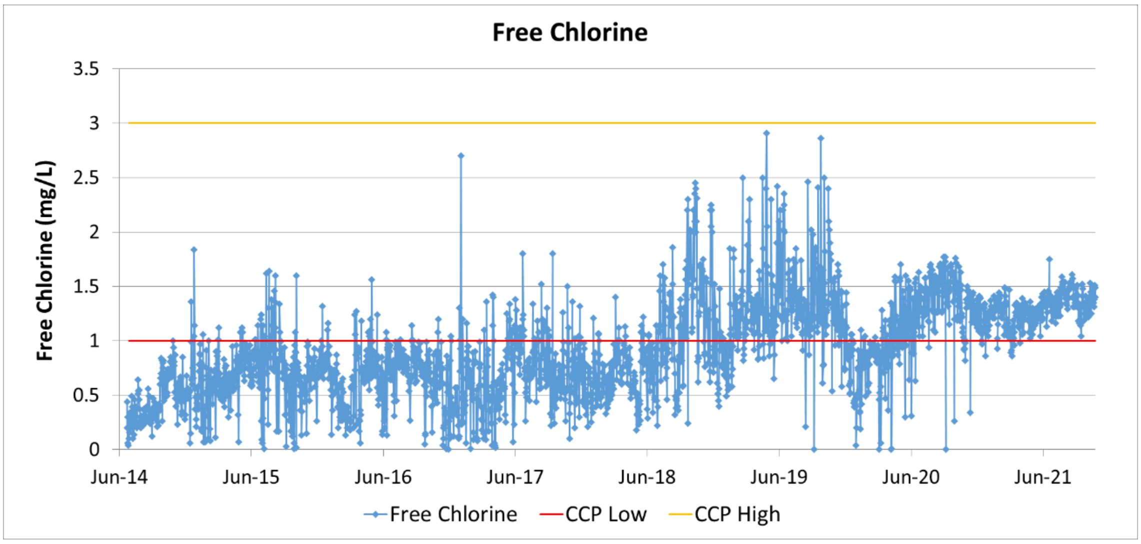


Figure 0-4: Nebo Treated Water Free Chlorine Concentration

NEBO RETICULATED WATER QUALITY

The sample results from Nebo reticulated water quality are presented below. There were 10 detections of *E.coli* in the reticulation from January 2009 to August 2016. Historically, low chlorine residual was often noted in the reticulation but this has improved in recent years.

Note that this table includes data from both prior to and after commissioning of the new Nebo WTP.

TABLE 0-5: NEBO RETICULATED WATER QUALITY (JANUARY 2014 TO OCTOBER 2021)

Sampling Location: Depot, Office, Service Station, Swimming Pool, Airstrip Rd, CIVEO

Parameter	No. of Samples	Summary of Results					ADWG Guideline Value	No. of Samples Exceeding ADWG Guideline Value
		Minimum	5th Percentile	Average	95th Percentile	Maximum		
E. coli (MPN/100 mL)	389	<1	<1	<1	<1	1	<1 (H)	2
Free Chlorine (mg/L)	402	0.02	0.24	0.90	1.59	2.5	0.2,5 (H)	10,0
pH	331	6.65	6.8	7.12	7.6	7.85	6.5-8.5 (A)	1
Total Coliforms (cfu/100 mL)	322	<1	<1	<1	<1	11		

NEBO WATER QUALITY COMPLAINTS

No water complaint was recorded by IRC between 2011 and 2012 or in the 2014/15 or 2015/16 financial years. One complaint was received in the 2013/14 financial year, however the cause was not recorded.

In 2017/18 three complaints were recorded (one for odour and the others cause unknown).

In 2018/19 one complaint was recorded (cause unknown).

In 2019/20, four complaints were recorded (1 for discoloured water, 2 for taste and 1 for odour).

In 2020/21, one water quality complaint was recorded. This complaint was related to white specs appearing on the car after washing. Council recommended using a chamois cloth to dry down the vehicle because if left to air dry the mineral deposits (arising from the calcium and magnesium ions) can remain.

NEBO KEY ISSUES

A comprehensive water quality risk assessment needs to be undertaken, utilising the past 2 years of performance data for analysis.

GLENDEN WATER SCHEME

Raw water for the Glenden Water Scheme is provided from the Newlands Coal Mine (Xstrata) Dam. The raw water enters the Glenden WTP at the raw water turkeys nest. The water system from the turkeys nest onward is owned and operated by Council. The raw water from the turkeys nest is used to feed the WTP. Water from the WTP is provided to the residents of Glenden via a gravity reticulation network. The infrastructure for the overall scheme is shown schematically in Figure 0-1. The WTP process is shown schematically in Table 0-1: Glenden System Overview table.

An overview of the Glenden Water Scheme is shown in Table 0-1 with further details in the sections following.

TABLE 0-1: GLENDEN SYSTEM OVERVIEW

System Component	Description
Population Supplied	Total connections of approximately 590 comprising approximately 620 persons.
Water Sources	Surface water from the Bowen River Weir (operated by SunWater on behalf of Xstrata) 1,690 ML annual allocation
Water Storage (Before Treatment)	6 ML onsite Turkeys Nest Dam
Water Treatment	Surface Water from the Bowen River is treated at Glenden WTP as follows: • PAC dosing for removal of tastes and odours (when required); • Coagulation with alum; • Polymer dosing for flocculation aid (when required); • Flocculation; • Clarification; • Sand filtration; • Post-pH adjustment with sodium hydroxide; and • Disinfection with sodium hypochlorite. The wastewater system comprises of: • Filter Backwash Tank (supernatant from this tank is used for onsite irrigation); • Sludge ponds (x4); and • Supernatant return to Turkeys Nest Dam.
Water Storage (After Treatment)	• 6.0 ML Clearwater Tank located onsite • 0.5 ML Water Tower located onsite All treated water storages are roofed and vermin proofed.
Distribution of Product	Gravity fed from the Water Tower via approximately 19km of reticulation mains.
Any Special Controls Required	Quality of chemicals, materials, etc. used in the production and delivery of the product. Sodium hypochlorite storage and turnover to reduce likelihood of chlorate formation

TABLE 0-1: GLENDEN SYSTEM OVERVIEW	
System Component	**Description**
	Manual verification sampling of water from the distribution network. Backflow prevention and trade waste management. Operation and maintenance of all infrastructure to prevent recontamination.

Glenden Overall Water Supply Scheme

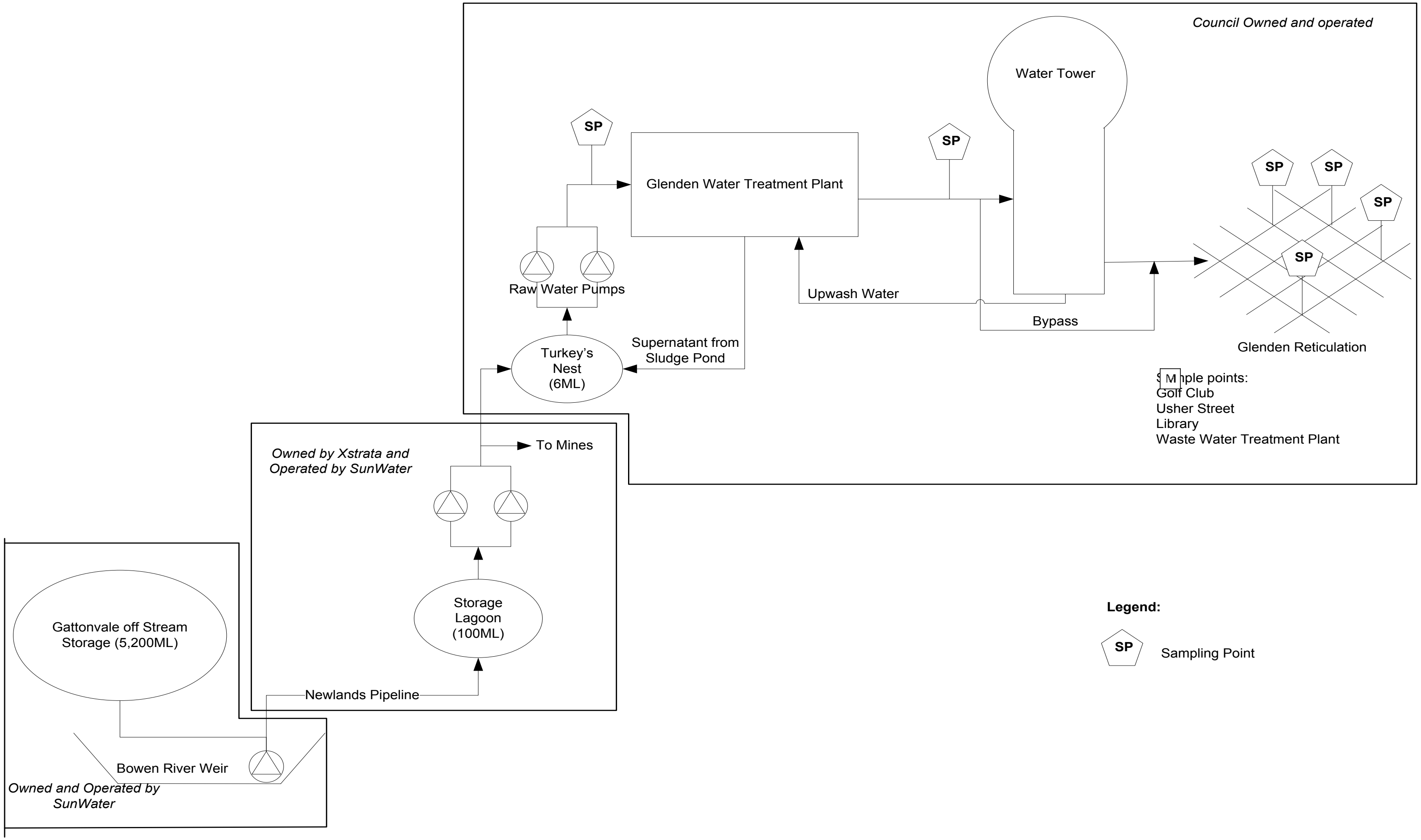
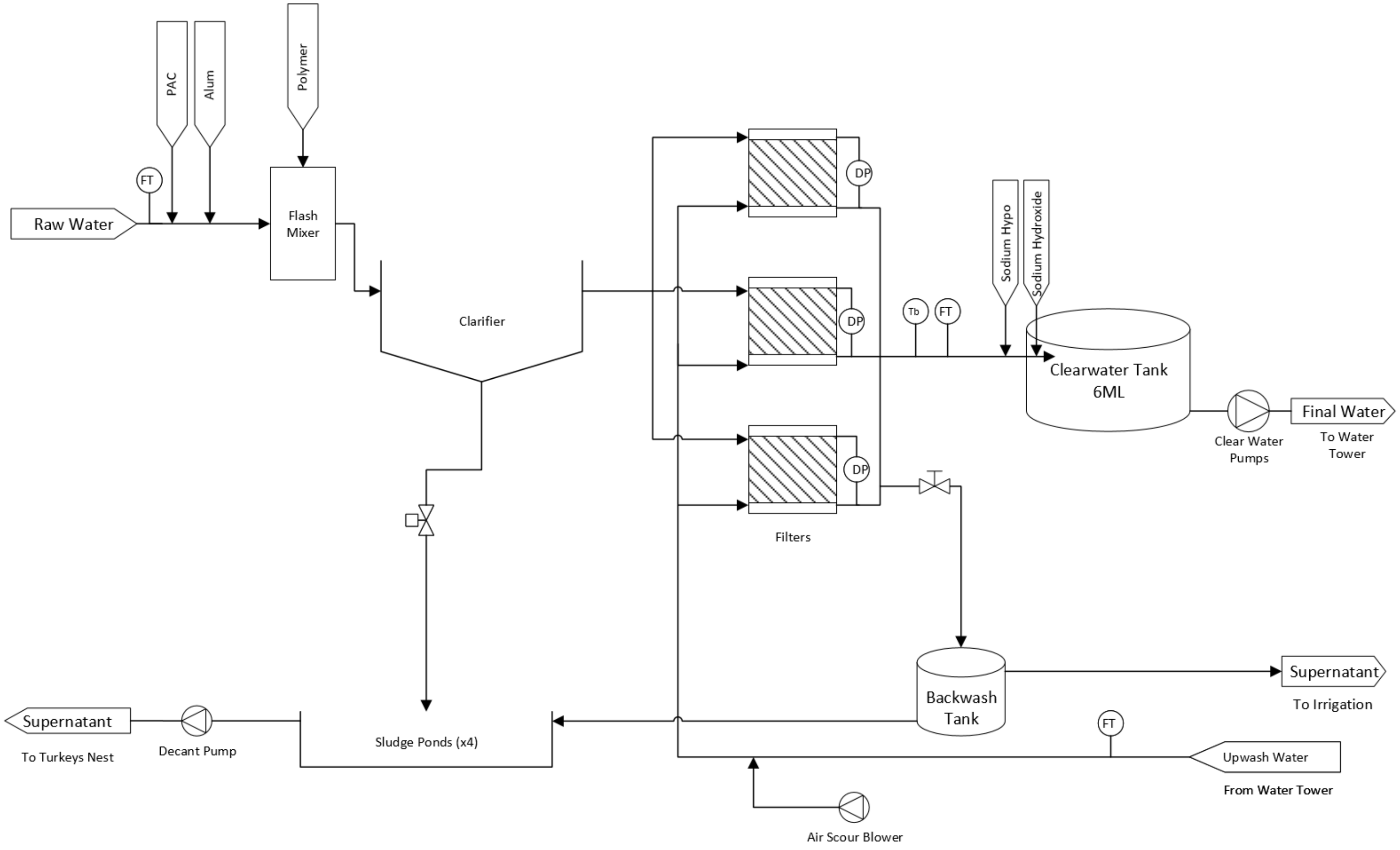


Figure 0-1: Glenden Overall Water Supply Scheme

Glenden Water Treatment Plant



GLENDEN CATCHMENT

Raw water for the Glenden Water Scheme is provided from the Newlands Coal Mine (Xstrata) Dam. The raw water for this dam is abstracted from the Bowen River at the Bowen River weir, approximately 80 kilometres away. The Gattonvale off-stream storage dam provides 5200 ML of storage at the Bowen River Weir. This has been put in place as a risk reducing measure in case of drought. SunWater operated the pipeline on behalf of Xstrata from the Bowen River Weir to the 6 ML turkeys nest located at the Glenden WTP. There is a 1,690 ML/annum water allocation for Glenden.

There are farming, water irrigation and mining activities in the Bowen River catchment. These activities have been included in the risk assessment.

GLENDEN RAW WATER

Raw water for the Glenden Water Scheme is taken from Bowen River Weir (and the Gattonvale off-stream storage) via the Newlands pipeline to a 100 ML storage lagoon at Newlands Coal Mine (Xstrata), which is then pumped to the raw water turkeys nest at Glenden WTP. The storage lagoon at Newlands coal mine along with the pipe and pump station is currently operated and maintained on behalf of Xstrata by SunWater. The turkey's nest at the WTP has storage of 6 ML. From the turkeys nest onwards, the equipment is owned and operated by Council.

The pipeline between the Bowen River Weir and Newlands Coal Mine is 54 km long and has a diameter of 450 mm. There is one pump station along this pipeline. The WTP has an annual allocation of 1,690 ML.

Figure 0-2: Glenden Raw Water Turkeys Nest

Table 0-2 below presents the owners for the upstream water infrastructure.

TABLE 0-2: GLENDEN UPSTREAM WATER INFRASTRUCTURE OWNERS		
Infrastructure	**Owners/Operator**	**Responsibility**
Bowen River Weir and pipeline	Sunwater	Asset Owner and Operator for the raw water dam and water supply pipeline
Newlands Mine Water Dam/ water supply pipeline	Xstrata	Asset owner
	Sunwater	Operation and maintenance of raw water dams and water supply pipelines

TABLE 0-2: GLENDEN UPSTREAM WATER INFRASTRUCTURE OWNERS		
Infrastructure	**Owners/Operator**	**Responsibility**
Turkey nest and Raw water pumps at Glenden WTP	Isaac Regional Council	Asset owner and operator of the raw water storage and raw water supply at Glenden WTP

GLENDEN WATER TREATMENT PLANT

Flash Mixing and Flocculation

Raw water is pumped to the Glenden WTP from the turkeys nest by two pumps operated in duty/ standby configuration and the flow is measured by a magnetic flowmeter. The raw water pumps are fixed speed and operate at 60 L/s. The existing flash mixer tank is 1.5 m in diameter and approximately 7.2 m high. A number of chemicals are dosed at the flash mixer. All chemical dosing set points are manually adjusted (when required) by the operators. The chemical dosing stops when no WTP flow is detected.

The first dose point is PAC which is dosed when algae and/or taste and odour compounds are detected in the raw water. This is followed by liquid alum dosing for coagulation and then polymer which is dosed into the flash mixer as a flocculation aid. Each chemical system has two dosing pumps which operate in a duty/ standby configuration. The pump duty is changed over manually by the operators. Mixing occurs hydraulically in the flash mixer tank.

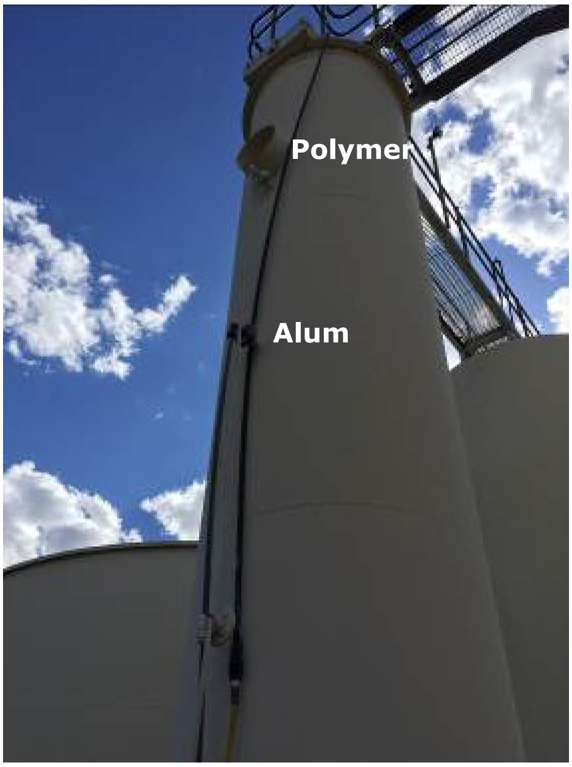


Figure 0-3: Flash Mixer and Dosing Points

Water flows by gravity from the flash mixer to the flocculation chamber in the centre of the clarifier.

Clarification

The flocs that have formed during flocculation settle to the bottom of the clarifier. Clarified water flows out via the launders and into the filters via the outlet channel.

Sludge is released by opening an air-actuated de-sludge valve at the bottom of the clarifier. The de-sludge valve opens automatically based on a timer setting. Manual desludging occurs every 4-5 months.

The clarifier is 14.7 m in diameter and is constructed of welded steel. Based on visual inspection the clarifier appears to be in fairly good condition, but with some signs of corrosion in the flocculation zone.

Filtration

The clarified water flows into three sand filters by gravity. The diameters of the filters are 3.4 m. The filters are connected by a filtered water manifold and there is an inline combined filtered water turbidity monitor. Flow split between the filters is controlled manually by adjusting the filter inlet valves.

Filter backwash sequences are manually initiated by the operators based on pressure differential (headloss). Backwashing can be completed through an automated sequence or manually if required.

Sodium hypochlorite is occasionally used to super chlorinate the filters when treated water quality is declining. This can assist in the removal of any organic growth in the filter bed and also oxidise dissolved iron and manganese present. However, if the metals are not continually maintained in an oxidised state as a coating on the media, they can reduce back to the soluble form and re-contaminate the treated water. Therefore, it is recommended that chlorine be continually dosed prior to the filters to maintain a manganese oxide coating instead of super chlorinating. This has been included as an action in the Improvement Programme.

Treated Water Reservoir

The filtered water main to the treated water reservoir is a DN375 line. Sodium hypochlorite is dosed for disinfection into the filtered water main leading to the treated water reservoir. The treated water reservoir provides adequate retention time for disinfection. Sodium hypochlorite dose is adjusted according to a target chlorine residual on the outlet of the water tower. An inline chlorine residual analyser is installed but is not connected to any telemetry or alarms. The instrument is rarely cleaned or calibrated and is therefore often inaccurate and not relied upon by the operators. There is also a sodium hydroxide dosing point on the filtered water main for post-pH adjustment.

The WTP processes water at a fixed operator-selected flow setpoint (nominally 60 L/s) and is automatically stopped and re-started based on the water level in the treated water reservoir. The treatment plant starts when the float level sensor in the treated water reservoir is at 5.2 m and stops when the float is at 5.8 m. Information pertaining to the Glenden reservoir is summarised in Table 0-3.

TABLE 0-3: GLENDEN RESERVOIR	
Volume	**6 ML**
Materials of construction	Steel
Roof	Yes
Vermin-Proof	Yes

Sludge and Backwash Treatment

Backwash water is collected in the Backwash Recovery Tank. The backwash water collected is settled and used for site irrigation or occasionally sent to the sewage treatment plant. Sludge from the backwash recovery tank can be discharged to the sludge ponds. The backwash recovery tank has limited capacity with sufficient storage for a single backwash only.

The sludge ponds also receive the clarifier sludge. A decant pump located at the ponds recycles the supernatant back to the raw water turkeys nest.

Chemical Dosing

The WTP process currently employs the following chemicals:

TABLE 0-4: CHEMICAL USE IN THE GLENDEN WATER TREATMENT PROCESS		
Chemicals	**Dosing Location**	**Uses / Comments**
PAC	Flash Mixer inlet	Taste and Odour (algae in dam water)
Alum	Flash Mixer Inlet	Coagulant and Flocculation
Polyelectrolyte	Flash Mixer	Flocculation
Sodium Hypochlorite	Filtered water	Disinfection
Sodium Hydroxide	Filtered water	Post-pH adjustment

All chemical dosing pumps are interlocked with the flow to the treatment plant and the dosing rates are manually adjusted. No dilution water is available for chemical dosing. The treatment plant is pictured in Figure 0-4.

Figure 0-4: Glenden WTP

Sodium hypochlorite is stored in black chemical tanks in an outdoor enclosed and ventilated shed. A single duty dosing pump is installed for the disinfection system.

Figure 0-5: Sodium Hypochlorite System

GLENDEN WATER TOWER

Water from the Treated Water Reservoir is pumped using high lift pumps (130 L/s capacity) to the water tower (0.5 ML). Float levels in the water tower trigger the pumps to start and stop. The pumps start when the level is 27 m and stop when the level is 32 m.

The water tower has an overflow which allows water above 32 m to flow back to the treated water reservoir.

Water flows by gravity from the water tower through the Glenden reticulation network.

GLENDEN RETICULATION

Glenden has approximately 19 km of reticulation pipelines. The majority (86%) of the existing pipelines are asbestos cement and were installed over 30 years ago. All new and replacement pipe is being constructed of Blue Brute.

Operators have not observed any issues such as low water pressure or flow stagnation in the reticulation network. There is also no pressure boosting station in the area.

GLENDEN WATER SUPPLY SYSTEM CAPACITY

The raw water conveyance infrastructure (pumps and mains) is rated for 90 L/s.

The theoretical capacity of the treatment plant is 76 L/s and is limited by the sand filter capacity (based on a filtration rate of 10 m/h). No capacity constraint has been observed based on the previous water production data (see Section 0).

The high lift pumps from the Clearwater tank to the water tower are rated for 130 L/s.

Council is monitoring the mining development and the housing demand in the area as they are aware of the potential for new mine development.

GLENDEN STAKEHOLDERS

The following table details the stakeholders for the Glenden water scheme.

TABLE 0-5: GLENDEN STAKEHOLDERS

Organisation	Contact Name and Details	Relevance to Management of Drinking Water Quality	How the Stakeholder is Engaged in the DWQMP
SunWater		Contracted maintenance / operation of the raw water infrastructure owned by Xstrata	Not engaged
Fire Department		Quality not relevant but reticulation pressure	Not engaged
Residential Users		Supplied with reticulated water from the Glenden scheme	Not engaged

GLENDEN WATER QUALITY

Treated water quality has been measured and recorded by operators at Glenden since January 2000. The water quality has been variable as is shown in the following sections which summarise the data. It should be noted that there was a historical problem with keeping instruments cleaned and calibrated and this would have led to some inaccurate measurements, especially with turbidity. The operational staff have advised that the on-site testing equipment has been accurate over the past two years.

OPERATIONAL MONITORING

The operational monitoring currently undertaken at Glenden is presented in Table 0-1 below. Testing parameters are separated by process step

TABLE 0-1: GLENDEN OPERATIONAL MONITORING

Process Step	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Operator Sampling							
Raw Water (since 2012)	pH	High or low pH	Daily	N/A	Information only, an additional indicator to adjust sodium hydroxide dose	N/A	N/A
Raw Water (since 2012)	Alkalinity	Coagulation failure	Daily	N/A	Assess sodium hydroxide dosing requirements	N/A	N/A
Raw Water (since 2012)	Apparent Colour	High Colour	Daily	N/A	Monitoring only. An additional indicator to adjust coagulant dosing	N/A	N/A
Raw Water (since 2012)	Turbidity	High Turbidity	Daily	N/A	Monitoring only. An additional indicator to adjust coagulant dosing	N/A	N/A
Raw Water (since 2012)	Total Iron	High Iron	Daily	N/A	Assess chemical dosing requirements	N/A	N/A
Raw Water (since 2012)	Total Manganese	High Manganese	Daily	N/A	Assess chemical dosing requirements	N/A	N/A
Settled Water (since 2012)	pH	High or Low pH	Daily	N/A	Information only, an additional indicator to adjust sodium hydroxide dose	N/A	N/A
Settled Water (since 2012)	Colour	High Colour	Daily	N/A	Monitoring only. An additional indicator to adjust coagulant dosing	N/A	N/A
Settled Water (since 2012)	Turbidity	Pathogens	Daily	<2.0 NTU	Check coagulation pH. Adjust coagulant and/or sodium hydroxide dose rates.	N/A	N/A
Filtered Water	pH	High or low pH	Daily				
Filtered Water	Turbidity	High turbidity	Online				
Filtered Water	Alkalinity		Daily				
Filtered Water	True Colour	High colour	Daily				
Treated Water	pH	High or Low pH	Daily	7 – 7.5	See Critical Control Points for Glenden.		
Treated Water	Turbidity	Pathogens	Daily	<0.5 NTU	See Critical Control Points for Glenden.		

TABLE 0-1: GLENDEN OPERATIONAL MONITORING							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if Target Limit Exceeded**	**Critical Limit**	**Action if Critical Limit Exceeded**
Treated Water	Free chlorine	Pathogens	Daily	1.2 - 2.0 mg/L	See Critical Control Points for Glenden.		
Treated Water	True Colour	Formation of disinfection by-products (DBPs) from high colour	Daily	< 15 HU	Adjust WTP chemical dosing	N/A	N/A
Treated Water	Alkalinity	N/A	Daily	N/A	Monitoring only	N/A	N/A
Treated Water	Aluminium	High Aluminium	Daily	<0.2 mg/L	Check and adjust coagulant dose as it may be excessive	N/A	N/A
Treated Water	Total Iron	High Iron	Daily	N/A	Adjust raw water chemical dosing	N/A	N/A
Treated Water	Total Manganese	High Manganese (health/ aesthetic)	Daily	N/A	Adjust raw water chemical dosing	N/A	N/A
Potable Water (Town Water)	pH	High or Low pH (aesthetic)	Weekly	6.5 – 8.5	Adjust sodium hydroxide dose rate.	N/A	N/A
Potable Water (Town Water)	Free chlorine	Pathogens	Weekly	0.2 – 1.0 mg/L	Adjust sodium hypochlorite dose rate.	N/A	N/A
Potable Water (Town Water)	Turbidity	High turbidity	Weekly	< 0.5 NTU			

CRITICAL CONTROL POINTS

Table 0-2 details the critical control points (CCPs), limits and rectification actions for Glenden WTP. Target limits are in line with ADWG best practice operation guidelines and critical limits are as per ADWG health limits.

TABLE 0-2: GLENDEN CRITICAL CONTROL POINTS							
Critical Control Point Location	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if Target Limit Exceeded**	**Critical Limit**	**Action if Critical Limit Exceeded**
Filtered Water	Turbidity	Pathogens	As frequently as practicable, minimum daily. (Target online ASAP)	<0.2 NTU	Optimise coagulation, i.e. adjust coagulant dose rate and coagulation pH. Backwash filter if turbidity continues to approach critical limit.	0.5 NTU	Backwash filter immediately then continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	pH	High or Low pH	Daily	7 – 7.5	Adjust soda ash dose for filtered water	<7.0 or >8.5	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Turbidity	Pathogens	Daily	0.5 NTU	Adjust WTP chemical dosing Backwash filter(s) if required	1.0 NTU	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Free chlorine	Pathogens	As frequently as practicable, minimum daily. (Target online ASAP)	1.2 - 2.0 mg/L	Target limit is set to ensure that there is sufficient residual maintained throughout reticulation. If concentration is high or low, adjust chlorine dose rate	< 1.0 or >3.0 mg/L	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit ADWG allows residual between 0.2 and 5.0mg/L. However, chlorine dose rate should be adjusted prior to reaching the low/high limits Action is critical if the concentration is below 1mg/L. If the concentration is too low at the exit of the plant, an adequate residual is unlikely to be maintained in the reticulation Advise W&WW manager of non-compliant water

GLENDEN RAW WATER QUALITY

Table 0-3: Glenden Raw Water Quality table summarises the on-site raw water results (July 2014 to October 2021).

TABLE 0-3: GLENDEN RAW WATER QUALITY									
Parameter	Units	Sample Location	Summary of Results (July 2014 – October 2021)						Comments
			No. of Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	
pH	pH units	WTP inlet	2478	7.2	7.85	8.09	8.4	9.65	
Alkalinity	mg/L		2457	40	50	76.31	110	170	
Turbidity	NTU		2466	1.09	3.24	12.18	25.68	141.00	Raw water turbidity generally low
Apparent Colour	HU		2454	0	30	94.1	203.5	790	Raw water colour can spike very rapidly
Total Iron	mg/L		1277	0.000	0.000	0.010	0.050	0.140	Measured from July 2017 only
Total Manganese	mg/L		1375	0.000	0.001	0.006	0.015	0.130	

GLENDEN TREATED WATER QUALITY

The results of the onsite water quality testing are provided in the table below.

TABLE 0-4: GLENDEN TREATED WATER QUALITY

Parameters	Units	Sampling Location	Summary of Results (July 2014 – October 2021)						CCP		ADWG		Comments
			No. of Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	Critical Limit	Exceptions	Guideline Value [15]	Exceptions	
pH	pH units	Inlet to water tower	2571	6.75	6.95	7.16	7.40	7.80	7.0, 8.5	164,0	6.5-8.5 (A)	0	6.4% of samples outside of CCP range.
Chlorine	mg/L		2571	0.07	0.72	1.35	2.20	3.17	1.0, 3.0	543, 2	0.2-5.0 (H)	3, 0	21.2% of samples out of CCP range, frequently falling below the minimum residual
Alkalinity	mg/L		2554	5	35	58	90	145	N/A	0	N/A	0	
Aluminium	mg/L		2542	0.000	0.010	0.033	0.070	1.300	NA	0	<=0.2 (A)	1	1 sample above ADWG aesthetic limit
Turbidity	NTU		2561	0.00	0.01	0.18	0.40	1.09	1	2	<=1 (H)[16]	2 (H)	Rarely exceeded CCP limit and ADWG recommendation at the point of disinfection with chlorine
Colour	HU		2564	0.0	0.0	0.1	0.0	5.0	NA	0	<=15 (A)	0	
Total Iron	mg/L		1379	0.000	0.000	0.002	0.020	0.100	NA	0	<=0.3 (A)	0	Measured since July 2017 only
Total Manganese	mg/L		1431	0.000	0.001	0.008	0.020	0.130	NA	0	<=0.5 (H) <=0.1 (A)	0 (H) 1 (A)	

[15] A = aesthetic guideline value; H = health-based guideline value

[16] Recommended at the point of disinfection with chlorine

The chart below shows raw and treated water colour for Glenden WTP. There have been times in the past (December 2015, July 2017 and December/January 2019) when colour has been high. However, treated water colour has not exceeded 5 HU, but this could potentially be as a result of the current testing equipment and/or program. Regardless, treated water colour has remained low since January 2019 irrespective of raw water colour spikes.

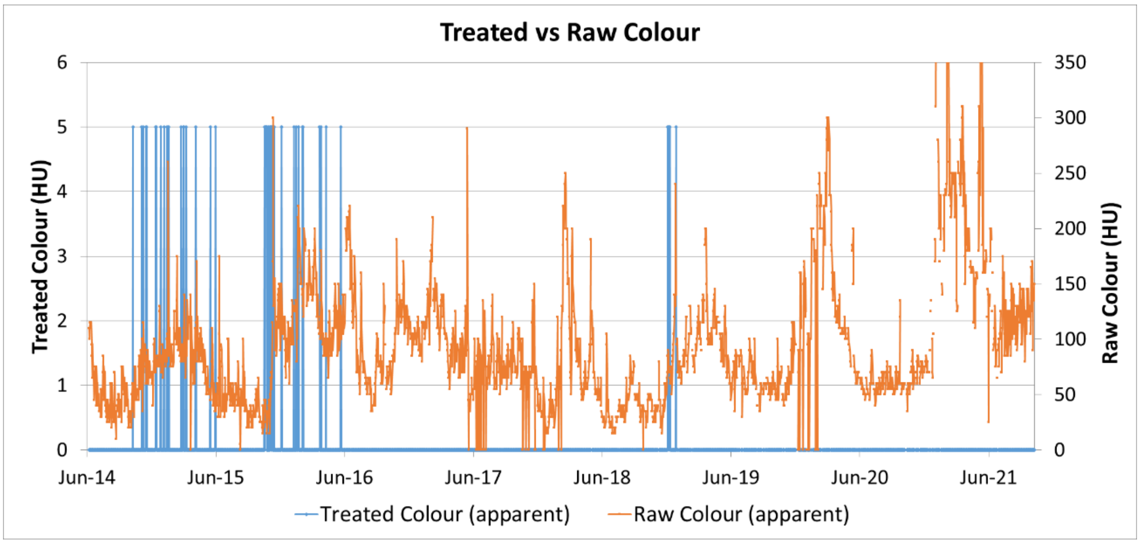


Figure 0-1: Glenden Raw and Treated Water Colour

The graph below shows raw and treated water turbidity on a logarithmic scale. This graph shows that there have been no spikes in treated water turbidity, regardless of raw water turbidity since November 2015.

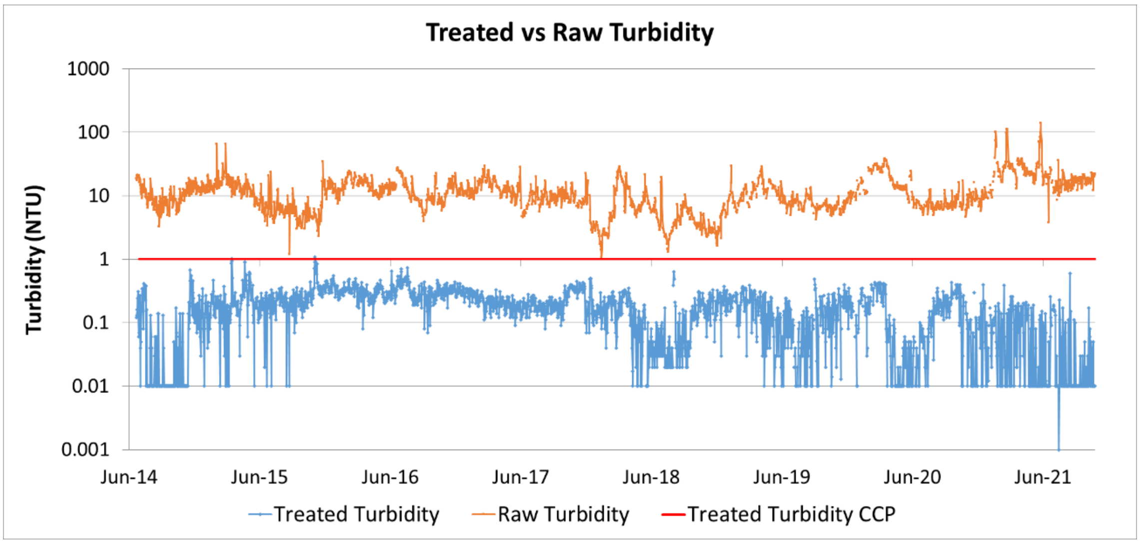


Figure 0-2: Glenden Raw and Treated Water Turbidity (In-house Results)

Figure 0-3 shows free chlorine residual of the treated water leaving Glenden WTP. From July 2014 until February 2016 there are large fluctuations in the free chlorine residual indicating the dosing system was not well controlled. Since this time there has been increased monitoring and the chlorine residual has stabilised, with fewer samples below the CCP limit of 1 mg/L. Chlorine residuals do still fluctuate, however, with a period of heightened variation occurring in early 2020.

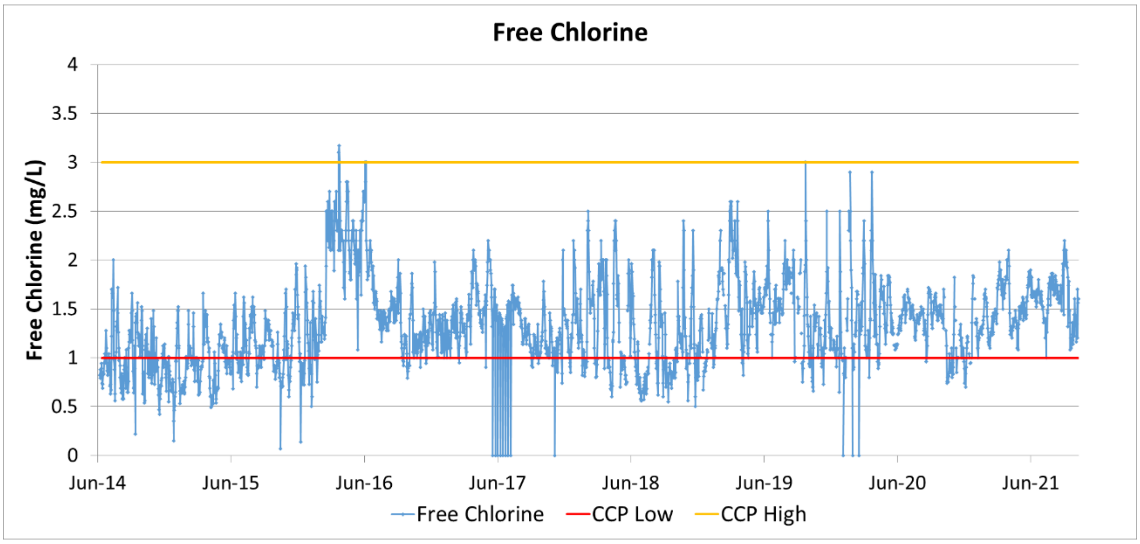


Figure 0-3: Glenden Treated Water Free Chlorine Residual

GLENDEN RETICULATED WATER QUALITY

The reticulated water quality data for Glenden is summarised below in Table 0-5: Glenden Reticulated Water Quality (January 2014 to October 2021) table. A chlorine meter with an alarm for chlorine leaving the plant would be beneficial to ensure that an adequate chlorine concentration is maintained throughout the reticulation.

TABLE 0-5: GLENDEN RETICULATED WATER QUALITY (JANUARY 2014 TO OCTOBER 2021)

Samples taken at: Golf Club, 7B Usher Tce, Depot, Library

Parameter	No. of Samples	Summary of Results					ADWG Guideline Value	No. of Samples Exceeding ADWG Guideline Value
		Minimum	5th Percentile	Average	95th Percentile	Maximum		
E.coli	369		<1	<1	<1	<1	<1	0
Free Chlorine	368		0.02	0.40	1.02	1.79	0.2,5 (H)	4, 0
pH	314		6.85	7.00	7.25	7.55	6.5-8.5 (A)	0
Total Coliforms (cfui/100 mL)	301		<1	<1	<1	<1		

GLENDEN WATER QUALITY COMPLAINTS

There was no water quality complaint recorded for Glenden between 2011 and the end of June 2015. IRC received 2 dirty water complaints for Glenden in the 2015/16 financial year.

No water quality complaints were recorded in 2017/18 or 2018/19.

In the 2019/20 financial year, 3 water quality complaints were received. Of these complaints, 2 were for discoloured water and 1 for taste.

In the 2020/21 financial year, no water quality complaints were recorded.

GLENDEN KEY ISSUES

The following key water quality issues in the Glenden water scheme have been identified:

- Filtered water turbidity is continuously monitored but not alarmed. There is no online monitoring with alarms for chlorine or pH. This results in reliance on manual operator monitoring and intervention.
- SCADA and instrumentation upgrades are recommended to improve monitoring and control of the treatment process.
- Current chlorine dosing system is at risk of not providing sufficient disinfection effectiveness. Changing to chlorine gas or improving insulation of the chlorine shed to minimise chlorine degradation would address this.

ST LAWRENCE WATER SCHEME

Raw water for the St Lawrence Water Scheme is abstracted from the St Lawrence Creek Weir located approximately 10 km from St Lawrence Water Treatment Plant (WTP). The creek is surrounded by rural grazing areas and is upstream of the township.

Water from the St Lawrence WTP is provided to the residents of St Lawrence via a gravity reticulation network.

An overview of the St Lawrence Water Scheme is shown in Table 0-1 with further details in the sections following.

TABLE 0-1: ST LAWRENCE SYSTEM OVERVIEW

System Component	Description
Population Supplied	Total connections of approximately 137 comprising approximately 235 persons.
Water Sources	Surface water from the St Lawrence Creek Weir
Water Treatment	Raw water is treated at St Lawrence WTP as follows: • Oxidation of iron and manganese with potassium permanganate (calcium hypochlorite is also available but not preferred); • Coagulation with All Clear 300; • Pre-pH correction with soda ash; • Flocculation; • Clarification; • PAC dosing (when required); • Glass media filtration; and • Calcium hypochlorite dosing for final disinfection; The wastewater system comprises of: • Sludge settling ponds (x4);
Storage After Treatment	• 0.3 ML Treated Water Reservoir located onsite The reservoir is roofed and vermin proof.
Distribution of Product	Gravity fed from the Water Reservoir via reticulation mains
Any Special Controls Required	Quality of chemicals, materials, etc. used in the production and delivery of the product. Manual verification sampling of water from the distribution network. Backflow prevention and trade waste management. Operation and maintenance of all infrastructure to prevent recontamination.

The infrastructure for the overall scheme is shown schematically in **Error! Reference source not found.** and a schematic of the WTP is shown in

St Lawrence Overall Water Supply Scheme

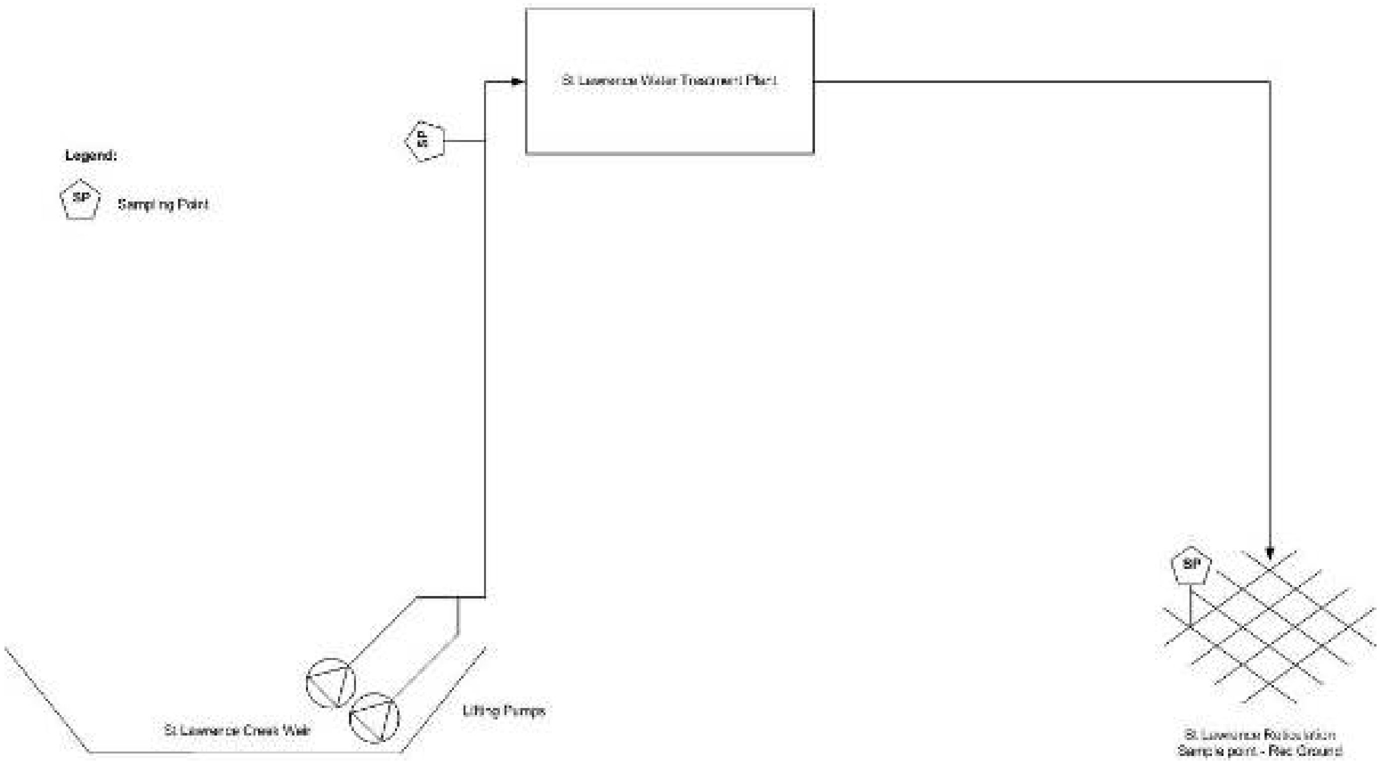


Figure 0-1: St Lawrence Overall Water Supply Scheme

St Lawrence Water Treatment Plant

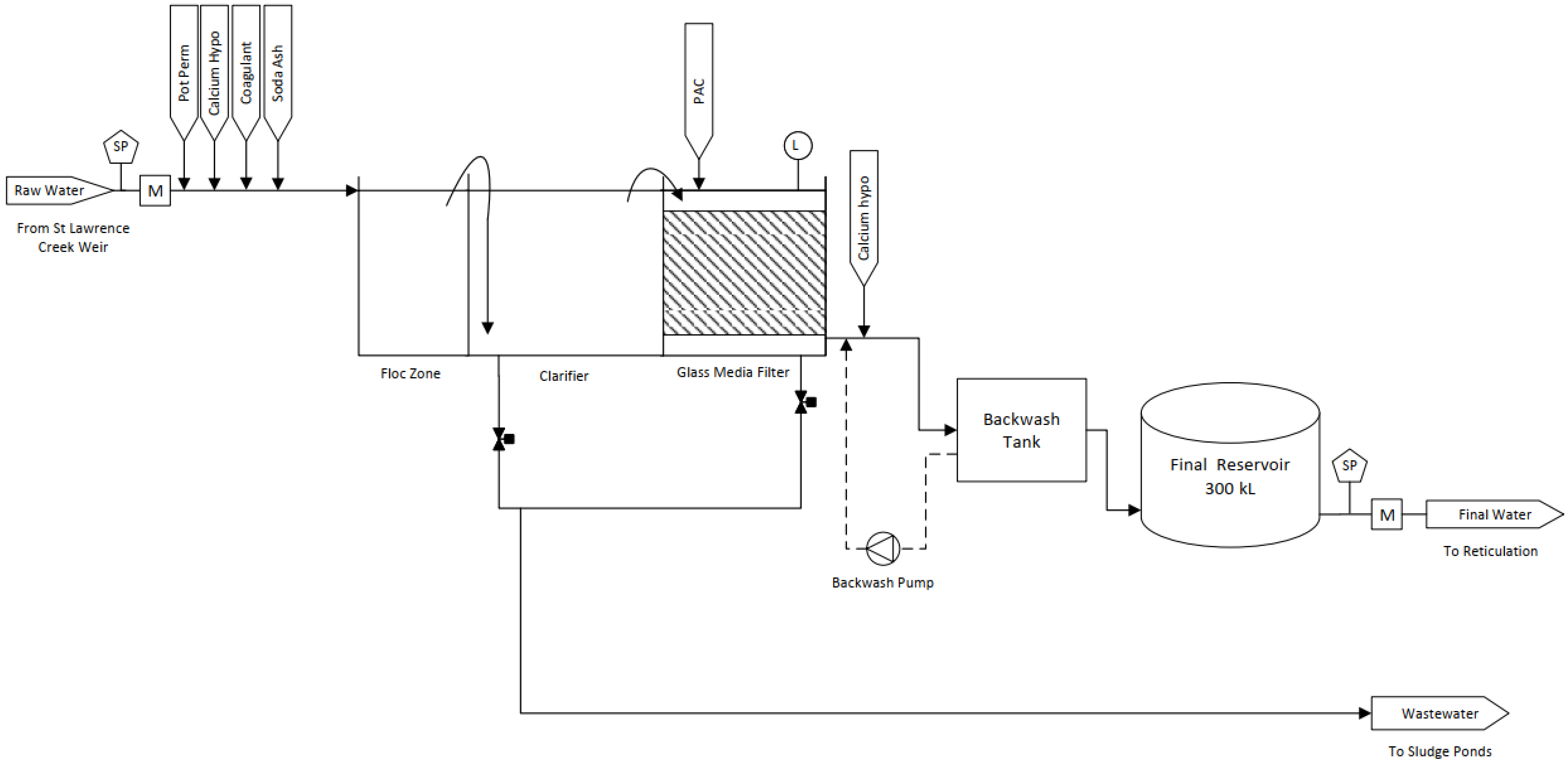


Figure 0-2: St Lawrence Water Treatment Plant

ST LAWRENCE CREEK CATCHMENT

Raw water for the St Lawrence Water Scheme is taken from the St Lawrence Creek approximately 500 m upstream from the St Lawrence Creek Weir. The Weir acts as a tidal barrier and provides a total storage capacity of 210 ML[17]. The operational staff noticed that when the water level in the St Lawrence Creek was low there was a decrease in quality of the raw water. This is possibly due to water becoming saline as saltwater seeps through the Weir.

Figure 0-3: St Lawrence Creek Weir

The St Lawrence Creek is in a wetland region. The creek is inhabited by crocodiles and is used recreationally for fishing activities.

St Lawrence Creek is highly tidal and this creates large changes in water level at the Weir. In extreme high tides, saline water can go over the Weir into the raw water storage.

The catchment area has no known pesticides sprayed and only cattle farming is carried out.

[17] Broadsound Shire Council Strategic Asset Management Plan for Water Supply and Sewerage Services

ST LAWRENCE RAW WATER

Raw Water Pump Station

Two high lift pumps are used in a duty/standby arrangement to pump the raw water from St Lawrence Creek Weir to the WTP. The pumps are submersed with one reaching deeper into the creek. The pump set at a higher position is generally the duty pump. This mitigates elevated levels of turbidity, iron and manganese content found in the raw water deeper in the creek. Pumps are equipped with call out alarms on failure.

A 100 mm diameter rising main constructed from AC and uPVC pipe connects the raw water pump station to the St Lawrence WTP. The raw water pumps are presented below in Figure 0-4.

Figure 0-4: Raw Water Pumps at St Lawrence Weir

ST LAWRENCE WATER TREATMENT PLANT

Raw Water Dosing

The flow of the raw water entering the St Lawrence WTP is monitored via a flowmeter. The WTP starts and stops automatically based on level in the Final Water Reservoir. The manual valve on the plant inlet is left open to allow unattended start and stop of the WTP. Potassium permanganate and coagulant (All Clear 300) are dosed just after the flowmeter at the inlet to the WTP. Soda ash dosing is also available for pH correction prior to the flash mixer, however is rarely used. All chemical dosing setpoints are selected and manually adjusted when required by the operators. The chemical dosing stops when no WTP flow is detected.

Potassium permanganate is dosed when required for oxidation of iron and manganese. Calcium hypochlorite is also available for oxidising iron and manganese but is not preferred due to its tendency to also react with organics to form THMs.

Flash Mixing

After raw water dosing the water flows into the flash mixer. The flash mixer has one mixer and a volume of 6 kL.

Figure 0-5: Flash Mixer/Flocculation Chamber

Some corrosion was evident in the flocculation chamber. The external structure is in good condition.

Clarification

Flocs that have formed in the flash mixer settle in the clarifier and the clarified water flows through the clarifier launders to the filter for treatment.

Sludge is released automatically by opening a de-sludge valve at the bottom of the clarifier. This de-sludge valve is set to a timer, the frequency of which is determined by the operator depending on the quality and quantity of the raw water. The sludge is released to sludge settling ponds.

Figure 0-6: Clarifier and Glass Media Filter

Corrosion and significant iron sediment was present in the clarifier, sand blasting and refurbishment was completed in 2017 to address this. External surfaces were in good condition and recently repainted.

Media Filtration

The clarified water flows into the glass media filter through the clarifier launders. PAC can be dosed into the top of the filters when required to address tastes and odours. Filtered water flows first to the backwash tank until full and then to the final reservoir. Calcium hypochlorite is dosed on the outlet of the filter for disinfection. The glass media filter has a filtration area of 1.8 m^2 and typical filtration rate of 6 m/h.

Filter backwash is triggered automatically when headloss across the media bed increases and the water level rises. A primitive level float sensor is installed in the filter (Figure 0-7) to trigger backwash initiation.

Figure 0-7: Primary Filter Level Float Sensor

Figure 0-8: Backwash Pump

As WTP operation is automatic and the plant cannot be attended all day (due to duties at Carmila WTP) by the operator, all manual valves are left in their operating position during shut down. The air actuated automatic valve on the filter outlet is closed by a tele meted signal to allow for backwashing and opens/closes with plant start/stop to prevent dry bedding.

Treated Water Reservoir

The treated water from the St Lawrence WTP is gravity fed through a 100 mm diameter line to the treated water reservoir. It is constructed of concrete and has a capacity of 300 kL as is shown below in Figure 0-9. The reservoir is located at the WTP and the connecting pipe is approximately 25 m in length.

TABLE 0-2: ST LAWRENCE TREAT WATER RESERVOIR	
Volume	300 kL
Materials of construction	Concrete
Roof	Yes
Vermin-Proof	Yes

The level in the treated water reservoir controls the WTP's throughput. When the level reaches a certain low level a trigger is activated, this causes the pumps at the St Lawrence Creek Weir to supply raw water to the WTP, and the raw water inlet valve to open.

Chlorine contact is achieved by the retention time in the reservoir and the pipeline between the reservoir and the township.

Figure 0-9: Treated Water Reservoir

The reservoir roof has been replaced to prevent recontamination of treated water. Planning for a new WTP in a new location is currently being considered in line with assessment of asset condition and requirements of population growth in the area.

Sludge and Backwash Treatment

Clarifier sludge and waste backwash water are sent to the sludge ponds for drying. When required, the sludge is manually shovelled out of the shallow pans and disposed of off-site.

Chemical dosing

The WTP process currently employs the following chemicals:

TABLE 0-3: CHEMICAL USE IN THE ST LAWRENCE WATER TREATMENT PROCESS		
Chemicals	Dosing Location	Uses / Comments
Potassium permanganate	Flash Mixer inlet	Optional for Iron and Manganese Removal (preferred)
Calcium Hypochlorite	Flash Mixer Inlet Filtered water pipe upstream of backwash tank	Optional for Iron and Manganese Removal (alternate) Disinfection
All Clear 300	Flash Mixer Inlet	Coagulation
Soda Ash	Flash Mixer Inlet	Pre-pH correction
PAC	Filter Inlet	Taste and Odour

All chemical dosing pumps are interlocked with the flow into the treatment plant and the dosing rates are manually adjusted.

The chemicals are received in powder form. The chemicals are mixed with water in batching tanks housed inside the operating shed from where they are fed to the appropriate part of the treatment process.

There is no duty/ standby arrangement for coagulant, and there are no alarms for pump failure or auto-changeover on fault. Calcium hypochlorite has duty pre- and post-dosing pumps only and soda ash has pre-dosing duty pump only. No dilution water is provided for any chemical dosing systems.

ST LAWRENCE RETICULATION

Water from the treated water reservoir is gravity fed to the St Lawrence reticulation network. The reticulation pipework was installed in 1965, and most of the original pipework has been retained. The reticulation mains are 17.6 km[18] long and constructed of AC with a combination of 100 mm or 150 mm diameters. Some sections of the reticulation pipes are constructed of steel or uPVC with the majority having a diameter of 20 mm or 25 mm.

The operator has advised that they have not experienced any low pressure or long detention time issue. Pressure head between the elevated reservoir and the township generates adequate pressure for the reticulation network, so there is no pressure boosting station in the area.

The St Lawrence reticulation network has a number of dead ends and due to the age and configuration of the pipe network is mostly unsuitable for conventional mains flushing programs. As part of Council's mains CAPEX program, dead ends are being removed and damaged pipework replaced. A proactive flushing program has also improved network maintenance and reduced water quality complaints.

ST. LAWRENCE WATER SUPPLY SYSTEM CAPACITY

As per Council's 2011 Asset Management Plan, the raw water pumps and the water treatment plant are rated for 5.4 L/s. This is higher than the water demand observed in St. Lawrence (ADD ~ 70 kL/day and MDMM ~ 130 kL/day).

[18] IRC Asset and Services Management Plan Part C (2010)

ST LAWRENCE STAKEHOLDERS

TABLE 0-4: ST LAWRENCE STAKEHOLDERS			
Organisation	**Contact Name and Details**	**Relevance to Management of Drinking Water Quality**	**How the Stakeholder is Engaged in the DWQMP**
Residential Users		Supplied with reticulated water from the St Lawrence scheme	Not engaged

ST LAWRENCE WATER QUALITY

Water quality has been tested and an electronic record kept since November 2009. Water quality trends have been analysed for the period July 2014 to June 2019.

OPERATIONAL MONITORING

The operational monitoring currently undertaken at St Lawrence is detailed in the following table. Testing parameters are separated by process step as well as operator versus external testing.

TABLE 0-1: ST LAWRENCE OPERATIONAL MONITORING							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if Target Limit Exceeded**	**Critical Limit**	**Action if Critical Limit Exceeded**
Operator Sampling							
Raw Water	Total Manganese	High Manganese	Daily	N/A	Assess chemical dosing requirements if manganese results vary	N/A	N/A
Raw Water	Total Iron	High Iron	Daily	N/A	Assess chemical dosing requirements if iron results vary	N/A	N/A
Raw Water	pH	Acidic or alkaline water	Daily	N/A	Assess chemical dosing requirements if pH becomes high or low	N/A	N/A
Raw Water	True Colour	High colour	Daily	N/A	Assess chemical dosing requirements if colour is high	N/A	N/A
Raw Water	Turbidity	High Turbidity	Daily	N/A	Assess chemical dosing requirements if turbidity is high	N/A	N/A
Raw Water	Hardness		Weekly				
Raw Water	Alkalinity	Coagulation failure	Weekly				
Treated Water	pH	Acidic or alkaline water	Daily	7 – 7.5	See Critical Control Points for St Lawrence		
Treated Water	Turbidity	High Turbidity	Daily	<0.5 NTU	See Critical Control Points for St Lawrence		
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria. High chlorine increases risk of by-products	Daily	1.5 – 2.5 mg/L	See Critical Control Points for St Lawrence		
Treated Water	Total Manganese	High Manganese	Weekly	<0.05mg/L	This level causes possible staining. Chlorine dosing should be adjusted (ADWG Health limit 0.5 mg/L)	N/A	N/A
Treated Water	Total Iron	High Iron (aesthetic)	Weekly	<0.3 mg/L	Commence/adjust calcium hypochlorite dosing rate	N/A	N/A

TABLE 0-1: ST LAWRENCE OPERATIONAL MONITORING							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if Target Limit Exceeded**	**Critical Limit**	**Action if Critical Limit Exceeded**
Treated Water	True Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Daily	< 15 HU	Adjust WTP chemical dosing	N/A	N/A
Treated Water	Hardness		Weekly				
Treated Water	Alkalinity		Weekly				
Treated Water	Aluminium	High Aluminium	Weekly	<0.2 mg/L	Check coagulant dose (overdosing may be occurring)		
Town Water	pH	Acidic or alkaline water	Daily	7 – 7.5	Adjust soda ash dose for filtered water	N/A	N/A
Town Water	Chlorine residual	Low chlorine increases the risk of bacteria. High chlorine increases risk of by-products	Daily	1.0 - 2.0 mg/L	Target limit is set to ensure that there is sufficient residual maintained throughout reticulation. If concentration is high or low, adjust chlorine dose rate	N/A	N/A
Town Water	Turbidity	High turbidity	Daily	< 0.5 NTU			
Town Water	True Colour	High colour	Daily	< 15 HU			
Town Water	Total Manganese	High Manganese	Weekly	< 0.05 mg/L	This level causes possible staining. Chlorine dosing should be adjusted (ADWG Health limit 0.5 mg/L)	N/A	N/A

CRITICAL CONTROL POINTS

Table 0-2 details the critical control points (CCPs), limits and rectification actions for St Lawrence WTP. Target limits are in line with ADWG best practice operation guidelines and critical limits are as per ADWG health limits.

TABLE 0-2: ST LAWRENCE CRITICAL CONTROL POINTS							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if target limit exceeded**	**Critical Limit**	**Action if critical limit exceeded**
Filtered Water (outlet of filters)	Turbidity	Pathogens	As frequently as practicable, minimum daily. (Target online ASAP)	<0.2 NTU	Optimise coagulation, i.e. adjust coagulant dose rate and coagulation pH. Backwash filter if turbidity continues to approach critical limit	0.5 NTU	Backwash filter immediately then continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	pH	High or Low pH	Daily	7 – 7.5	Adjust soda ash dose for filtered water	<7.0 or >8.5	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Turbidity	High Turbidity	Daily	<0.5 NTU	Adjust WTP chemical dosing Backwash filter(s) if required	1.0 NTU	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria. High chlorine increases risk of by-products	As frequently as practicable, minimum daily. (Target online ASAP)	1.5 – 2.5 mg/L	Target limit is set to ensure that there is sufficient residual maintained throughout reticulation. If concentration is high or low, adjust hypochlorite dose rate	< 1.0 or >3.0 mg/L	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit ADWG allows residual between 0.2 and 5.0mg/L. However, chlorine dose rate should be adjusted prior to reaching the low/high limits Action is critical if the concentration is below 1mg/L. If the concentration is too low at the exit of the plant, an adequate residual is unlikely to be maintained in the reticulation Advise W&WW manager of non-compliant water

ST LAWRENCE RAW WATER QUALITY

Presented below are the results of raw water testing for the period July 2014 – October 2021.

TABLE 0-3: ST LAWRENCE RAW WATER QUALITY

St Lawrence Raw Water – St Lawrence Creek Weir									
Parameter	Units	Summary of Results (July 2014 – October 2021)							Comments
		Sampling Location	No of Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	
pH	pH units	WTP Inlet	1185	6.50	6.80	6.97	7.30	7.80	
Turbidity	NTU		1121	0.40	1.17	13.15	45.00	360.00	
Colour	HU		929	6.0	13.0	103.4	380.0	1180.0	
Iron	mg/L		1178	0.004	0.040	0.581	1.510	9.010	Measured weekly January 2015 – June 2017, then daily July 2017 onward
Manganese	mg/L		1186	0.004	0.030	0.488	1.308	2.610	
Hardness	mg/L as $CaCO_3$		310	20.0	20.0	45.2	67.8	155.0	Measured daily from August 2017 – December 2017 then weekly from December 2017 onwards
Alkalinity	mg/L as $CaCO_3$		310	30.0	35.0	57.9	90.0	130.0	

ST LAWRENCE TREATED WATER QUALITY

Daily samples of treated water are collected for onsite analysis. The results of those which were available are provided in Table 0-4:St Lawrence Treated Water Quality table below.

TABLE 0-4: ST LAWRENCE TREATED WATER QUALITY

St Lawrence Water Treatment Plant (July 2014 – October 2021)													
Parameters	Units	Sampling Location	Summary of Results						CCP		ADWG		Comments
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	Limit	Exceptions	Guideline Value [19]	Exceptions	
pH	pH units	WTP	1847	6.85	7.20	7.44	7.70	8.0	7.0-8.5	11, 0	6.5-8.5 (A)	0	0.60% of samples below CCP limit of 7.0
Chlorine	mg/L		1839	0.00	1.50	2.47	3.00	4.8	1.0-3.0	5, 61	0.2-5.0 (H)	1, 0	0.27% of samples below CCP lower limit of 1 mg/L 3.32% of samples above CCP limit of 3 mg/L
Iron	mg/L		554	0.000	0.000	0.010	0.020	0.900	N/A		<=0.3 (A)	2	0.36% of samples about aesthetic ADWG limit.
Manganese	mg/L		561	0.000	0.000	0.024	0.080	0.900	N/A		<=0.5 (H) <=0.1 (A)	1 (H) 19 (A)	3.39% of samples about aesthetic ADWG limit. One sample above ADWG health limit
Turbidity	NTU		1772	0.00	0.08	0.21	0.40	2.10	<=1	7	<=1 (H)[20]	7	0.25% of samples above CCP limit of 1 NTU.
Colour	HU		1342	0	0	1	2	8	N/A	0	<=15 (A)	0	
Hardness	mg/L as $CaCO_3$		314	10	25	46	67	110	N/A	0	60-200 (A)	0	
Alkalinity	mg/L as $CaCO_3$		315	30	35	62	86.5	115	N/A	0	N/A	0	
Aluminium	mg/L		360	0.007	0.007	0.058	0.140	0.450	N/A	0	<=0.2 (A)	3	0.83% of samples above ADWG aesthetic limit

[19] A = aesthetic guideline value; H = health-based guideline value

[20] Recommended at the point of disinfection with chlorine

Figure 0-1 shows raw and treated water turbidity for St Lawrence WTP on a logarithmic scale. Increasing raw water turbidity can be seen to have a minor impact on treated water turbidity, however, the treatment process is usually sufficient to maintain turbidity at acceptable levels. The two exceedances seen in March 2017 correspond to increased raw water turbidites of over 150 NTU. More recently, 4 exceedances were seen in March – August 2021 and also appear to coincide with raw water turbidity spikes.

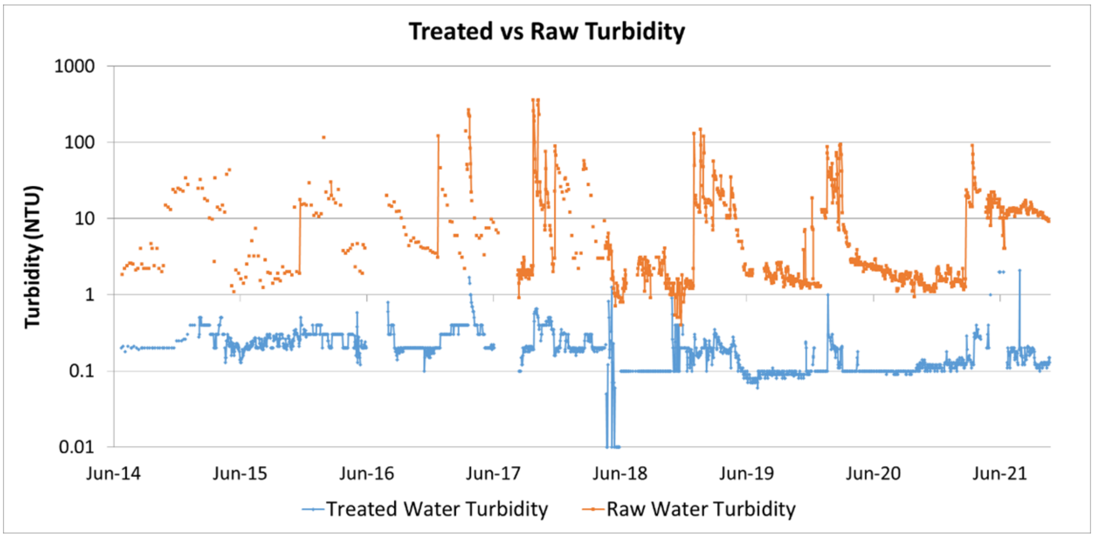


Figure 0-1: St Lawrence Raw and Treated Water Turbidity

The figure below shows free chlorine residual for treated water at St Lawrence. Large fluctuations in free chlorine residual are seen from May – August 2017 and again in May 2018. Lower turbidity seen in August 2017 (around 2 NTU) corresponds with a stabilisation of the free chlorine residual. Chlorine residuals have remained stable and slightly high since December 2020, often exceeding the upper CCP limit of 3 mg/L, however these have recently been trending downwards.

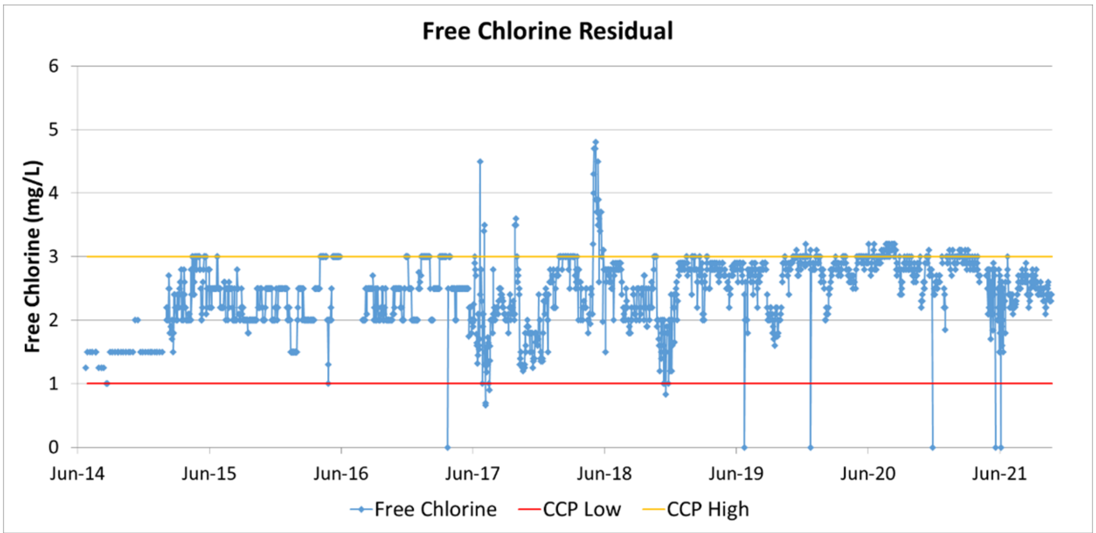


Figure 0-2: St Lawrence Treated Water Free Chlorine Residual

Figure 0-3 and Figure 0-4 show raw and treated water, manganese and iron levels (respectively). Both parameters experience some spikes iron and manganese, however, all treated water samples have historically fallen well below the ADWG recommended limits. Both treated water manganese and iron spiked above ADWG guidelines in June 2021, coinciding with spikes in raw water concentrations.

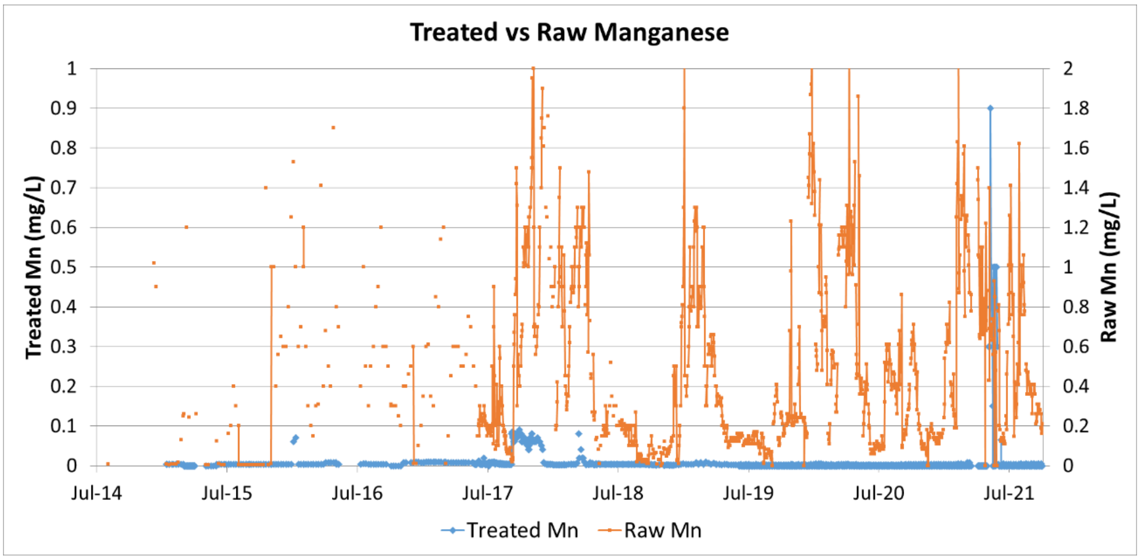


Figure 0-3: St Lawrence Raw and Treated Water Manganese

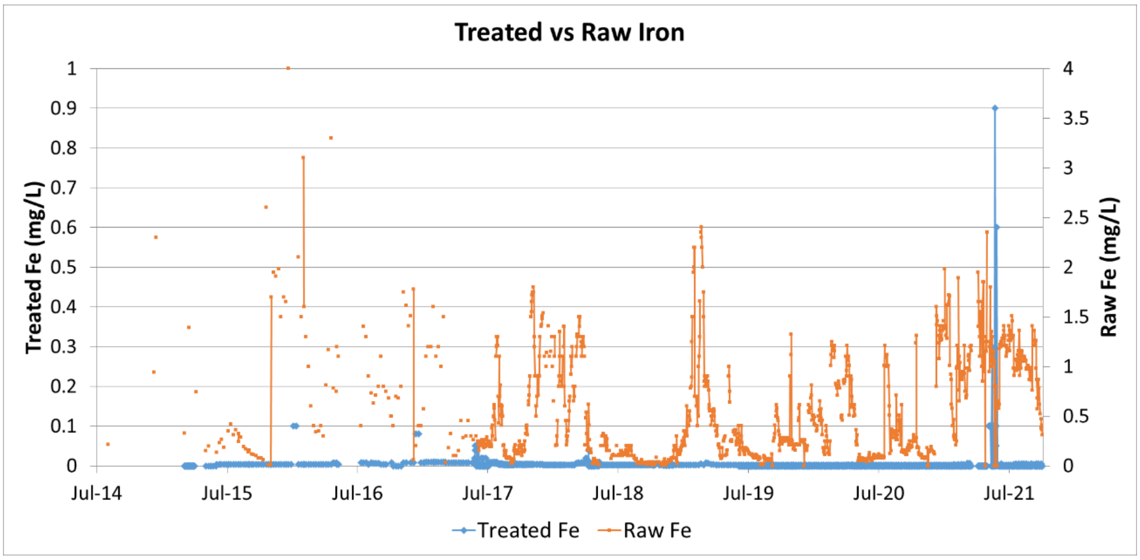


Figure 0-4: St Lawrence Raw and Treated Water Iron

The figure below shows raw and treated water colour on a logarithmic scale. St Lawrence experiences some spikes in raw water colour, however the graph shows there have been no exceedances of the ADWG limit (15 HU) for treated water colour.

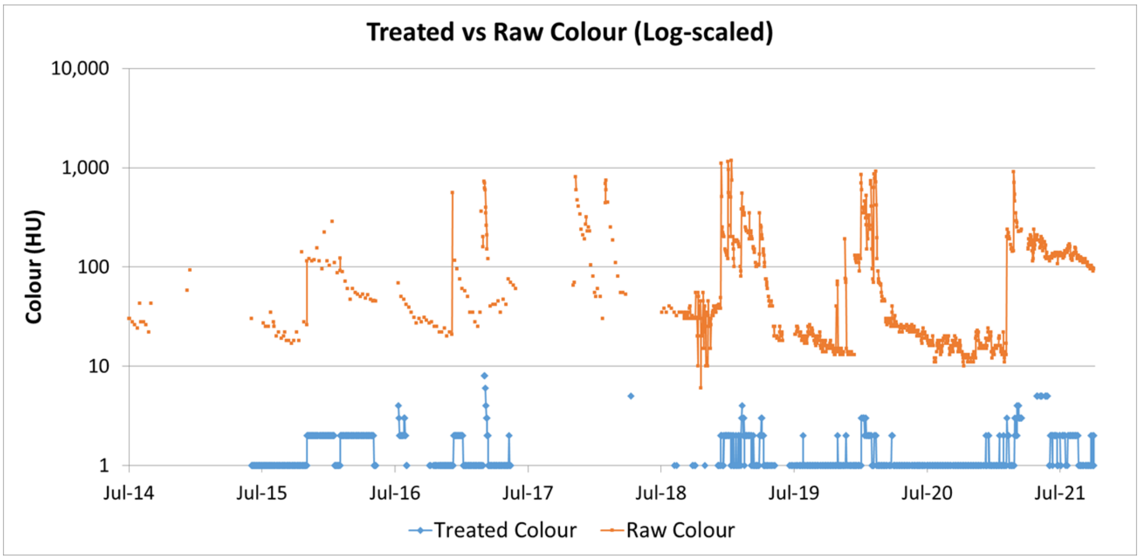


Figure 0-5: St Lawrence Raw and Treated Water Colour

ST LAWRENCE RETICULATED WATER QUALITY

The sample results from St Lawrence reticulated water quality are presented in Table 0-5: St Lawrence Reticulated Water Quality (January 2014 to October 2021) table below.

Chlorine residuals sometimes become low in the reticulation system. The most recent E. coli detection was in October 2017.

TABLE 0-5: ST LAWRENCE RETICULATED WATER QUALITY (JANUARY 2014 TO OCTOBER 2021)

Scheme Sampling Locations: Arthur St, McCartney St, Depot

Parameter	No. of Samples	Summary of Results					ADWG Guideline Value [21]	No. of Samples Exceeding ADWG Guideline Value
		Minimum	5th Percentile	Average	95th Percentile	Maximum		
E. coli (MPN/100 mL)	301	<1	<1	<1	<1	<1	<1 (H)	1
Free Chlorine (mg/L)	301	0.03	0.12	0.32	0.7	1.9	0.2-5.0 (H)	38, 0
pH	301	6.9	7.1	7.43	7.8	7.9	6.5-8.5 (A)	0
Total Coliforms (cfu/100 mL)	233	<1	<1	1.99	<1	165		

[21] A = aesthetic guideline value; H = health-based guideline value

ST LAWRENCE WATER QUALITY COMPLAINTS

There was one water quality complaint recorded for St. Lawrence between 2011 and 2012. The customer complained about dirty water, but it is understood from the supervisor that no specific cause has been identified.

Two water quality complaints were reported in the 2017/18 financial year – both for discoloured water.

No water quality complaints were reported in the 2013/14, 2014/15, 2015/16, 2016/17 or 2018/19 financial years.

One water quality complaint was reported in the 2019/20 financial year for discoloured water.

No water quality complaints were reported in the 2020/21 financial year.

ST. LAWRENCE KEY ISSUES

The following key water quality issues in the St Lawrence water scheme have been identified:

- There is no online water quality monitoring with alarms. This results in reliance on manual monitoring and intervention by the operator.
- Rapid changes in raw water turbidity and colour often occur. The system is currently reliant upon timing of operational monitoring samples and adjustment of treatment to deal with these rapid changes. Online monitoring with alarms would assist the operator with these rapid changes.
- Remote access via SCADA to monitor and control the WTP would assist the operator to respond to changes in water quality, particularly when the WTP is unattended.

CARMILA WATER SCHEME

Raw water for the Carmila Water Scheme is abstracted from two shallow raw water bores located near the Carmila Creek, which is approximately 1 km from Carmila Water Treatment Plant (WTP). Raw water is then pumped to the WTP for treatment. From there it is pumped to an elevated reservoir before it is supplied to the residents of Carmila via a gravity reticulation network. The infrastructure for the overall scheme and WTP is shown schematically in Figure 0-1.

An overview of the Carmila Water Scheme is shown in Table 0-1 with further detail in the sections following.

TABLE 0-1: CARMILA SYSTEM OVERVIEW

System Component	Description
Population Supplied	Total connections of approximately 71 comprising approximately 333 persons.
Water Sources	Raw groundwater is taken from two shallow raw water bores near Carmila Creek.
Water Treatment	Raw Water from the bores is treated at Carmila WTP as follows: • Coagulation with alum; • Calcium hypochlorite dosing for iron and manganese oxidation and final disinfection; • Polymer dosing as a flocculation aid; • Flocculation; • Clarification; and • Media filtration. The wastewater system comprises: • Sludge drying beds (x3).
Storage After Treatment	• 16 kL Clearwater Tank onsite • 228 kL Elevated Treated Water Reservoir Both are roofed and vermin proofed.
Distribution of Product	Gravity fed from the Elevated Treated Water Reservoir via reticulation mains.
Any Special Controls Required	Quality of chemicals, materials, etc. used in the production and delivery of the product. Manual verification sampling of water from the distribution network. Backflow prevention and trade waste management. Operation and maintenance of all infrastructure to prevent recontamination.

Carmila Overall Water Supply Scheme

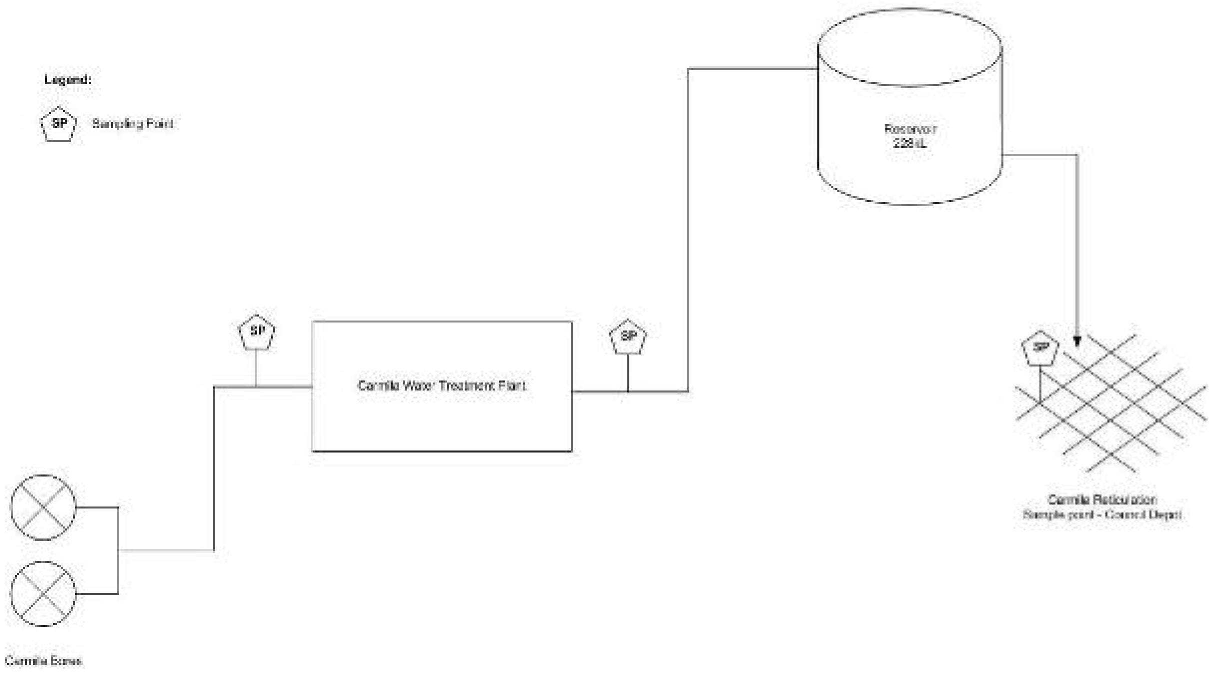


Figure 0-1: Carmila Overall Water Supply Scheme

Carmila Water Treatment Plant

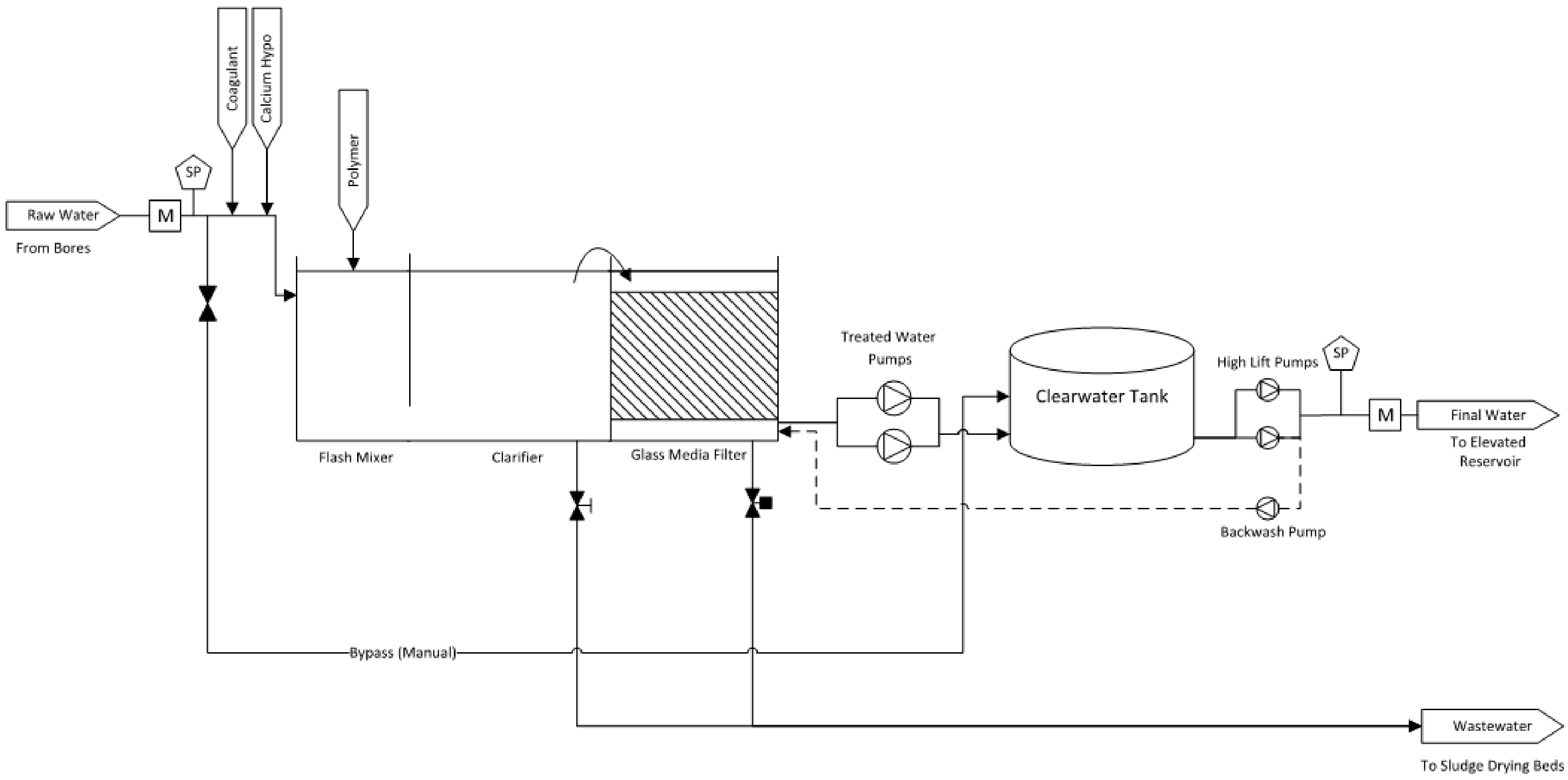


Figure 0-2: Carmila Water Treatment Plant

CARMILA CATCHMENT

Raw water for the Carmila Water Scheme is taken from two raw water bores in the Carmila Creek. Carmila Creek receives water from the upstream creeks including Prendergast Creek and McCafferry Creek. The waterbody is also used for farm irrigation, stock water and recreation use. The operator advised that the raw water quality normally changes after rainfall events due to increase water flow in the creek. High iron and manganese levels are often observed in the raw water.

Bore information has previously been requested from the Department of Natural Resources, Mines and Energy (DNRME, now DRDMW) but no specific information could be provided for the two Carmila bores.

CARMILA RAW WATER

Raw water for the Carmila Water Scheme is taken from two raw water bores in the Carmila Creek. The bores operate in a duty/standby arrangement. The bores are approximately 6 m deep (from IRC Operator's verbal information). Given the depth, it is likely that the aquifer is unconfined.

The bores each have a capacity of 2.6 L/s at 51.8 m head.

CARMILA WATER TREATMENT PLANT

The WTP is rated at 3 L/s. The water production is not continuous, because the WTP starts and stops as required by the level in the Treated Water Reservoir.

Raw Water Dosing

Raw water flow entering the Carmila WTP is monitored by a magnetic flowmeter. A number of chemicals are dosed immediately after the inlet flowmeter. All chemical dosing setpoints are selected and manually adjusted by the operators as required. The chemical dosing ceases when raw water flow has stopped.

Alum for coagulation and calcium hypochlorite for iron and manganese oxidation are added prior to the flash mixer. Polymer is dosed as a flocculation aid directly into the flash mixer. The operator advised that calcium hypochlorite dosing at this location is usually sufficient to provide primary kill and an appropriate chlorine residual at the ends of the reticulation.

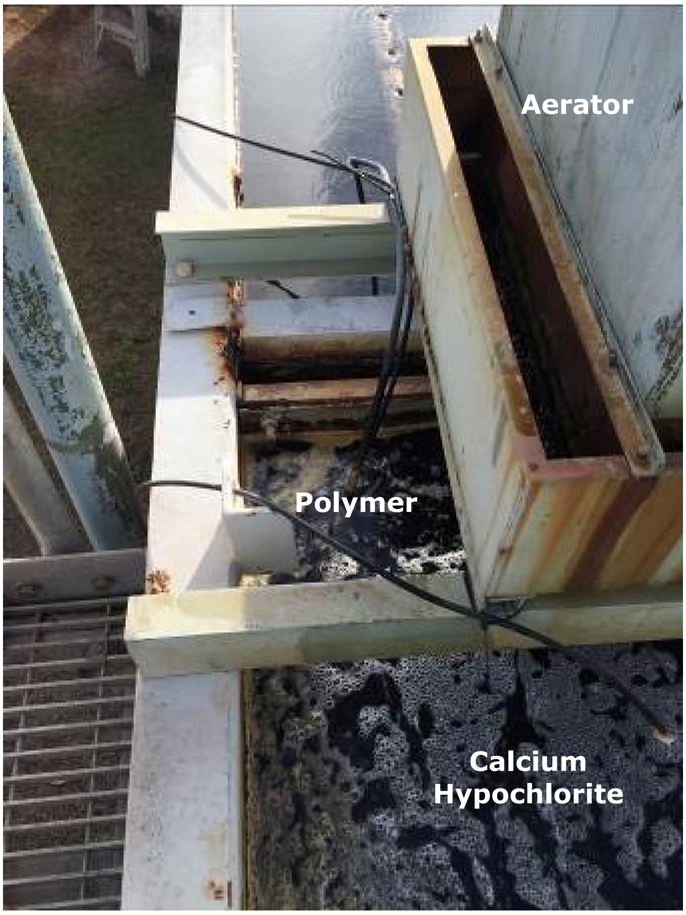


Figure 0-3: Chemical Dosing into Flash Mixer

Sand blasting and refurbishment of the package plant interior was completed in 2016 and included filter media replacement.

Clarification

Flocs settle in the clarifier and the clarified water flows via launders to the filter for treatment.

Sludge is released by manually opening a de-sludge valve at the bottom of the clarifier. The frequency of this is determined by the operator depending on the quality and quantity of the raw water being treated. This process is generally conducted on a weekly basis with the sludge released to one of the three sludge drying beds.

Figure 0-4: Clarifier

Filtration

The clarified water flows into the media filter via gravity. During WTP operation, the water level in the filter rises which triggers a float to open the filtered water outlet valve (Figure 0-5).

Filter backwash is initiated when the filter has operated for 12 hours and the sequence is automatically activated by a timer. The backwash sequence is automatic and consists of draining the filters to a pre-set level, starting the backwash pump, and running the backwash pump before re-commencing filtration. Air scour is not included in the backwash sequence even though polymer is dosed.

The media filter has a filtration area of 1.5 m^2 and rate of approximately 7.2 m/h. The filter is pictured in Figure 0-5.

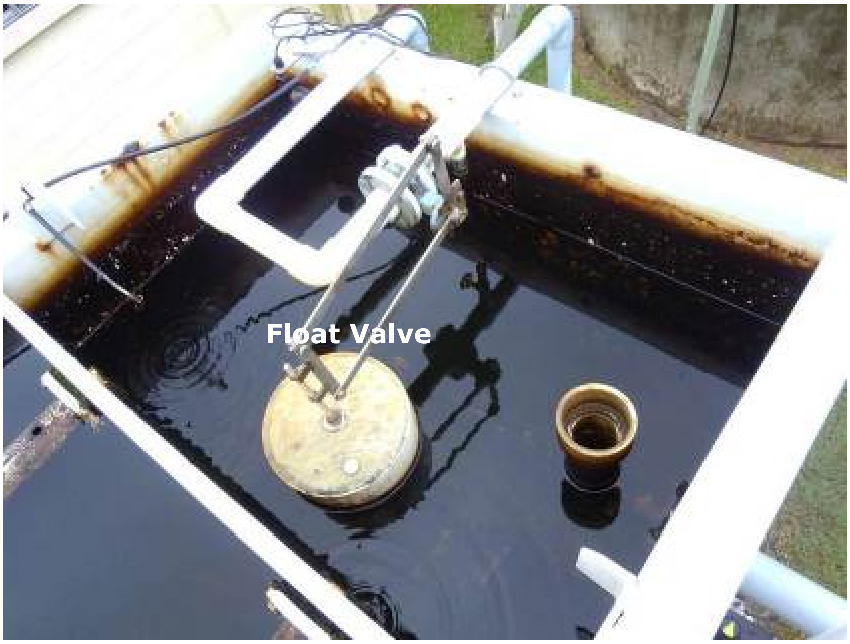


Figure 0-5: Filter

Clearwater Tank and High Lift Pumps

The treated water is pumped by two pumps in a duty/standby arrangement from the filter to the clearwater tank.

The clearwater tank is constructed from concrete and has a volume of 16 kL. The water is pumped from the clearwater tank to the treated water reservoir via two high lift pumps operating in a duty/standby arrangement. The treated water pumps, clear water tank, high lift pumps and backwash pumps are pictured in Figure 0-6 and Figure 0-7.

Figure 0-6: Treated Water Pumps

Figure 0-7: Clearwater Tank, High Lift Pumps and Backwash Pump

The clear water tank is in good condition and the access hatch has recently been replaced to improve safety of operation and water storage security against contamination.

Sludge and Backwash Treatment

There are three sludge drying beds which receive the clarifier sludge and waste backwash water. The drying beds operate in parallel and the operator manually directs the sludge to the selected sludge drying bed.

The amount of sludge accumulated in the clarifier is very small. This results in infrequent sludge disposal from the drying beds.

Figure 0-8: Sludge Drying Beds

Chemical Dosing

The WTP process currently employs the following chemicals:

TABLE 0-2: CHEMICAL USE IN THE CARMILA WATER TREATMENT PROCESS		
Chemicals	**Dosing Location**	**Uses / Comments**
Aluminium Sulphate	Clarifier Inlet	Coagulation
Calcium Hypochlorite	Flash Mixer	Iron and Manganese oxidation and Disinfection
Polymer	Flash Mixer	Flocculation Aid

Soda ash dosing facilities and dosing points are available at Carmila WTP, however have not been used for some time.

All chemical dosing pumps are interlocked with the flow to the treatment plant and the dosing rates are manually adjusted.

The chemicals are received and stored in powder form. The chemicals are combined with water and batched to the correct concentration in drums housed inside the operating shed and fed from there to the WTP.

CARMILA TREATED WATER RESERVOIR

The treated water from the Carmila WTP is pumped using two high lift pumps to the treated water reservoir. The reservoir is located approximately 5 km east of the WTP and an 825 m AC line connects the reservoir to the WTP. The long rising main and the reservoir provide adequate chlorine contact time for effective disinfection.

The treated water reservoir is a 228 kL concrete tank. The original concrete roof has recently (early 2015) been replaced with a black poly roof. The reservoir is fully enclosed and secure. The transmitter at the treated water reservoir is solar powered. Table 0-3 presents a summary of the information about the treated water reservoir.

TABLE 0-3: CARMILA TREATED WATER RESERVOIR	
Volume	228 kL
Materials of construction	Concrete
Roof	Yes
Vermin-Proof	Yes

The level in the treated water reservoir controls the WTP's throughput. When the level reaches the low level setpoint, the bore pumps are triggered to start and supply raw water to the WTP. The treated water reservoir is pictured in Figure 0-9.

Figure 0-9: Carmila Treated Water Reservoir

CARMILA RETICULATION

Water from the treated water reservoir is gravity fed to the Carmila reticulation. The static head of the elevated reservoir is adequate to pressurise the reticulation network without any boosting station. The reticulation pipes were installed in 1971 and the total length is approximately 4.2 km. The reticulation mains are constructed of AC with a combination of 100 mm and 150 mm diameters. Part of the reticulation pipes are constructed of uPVC with majority with a diameter of 20 mm or 25 mm.

The operator advised that he has not experienced any operational issues such as low water pressure or flow stagnation in the reticulation.

CARMILA WATER SUPPLY SYSTEM CAPACITY

As per Council's asset management plan, the bores are rated for 2.6 L/s and the treatment plant is rated for 3 L/s. When comparing with the recent water production, the treatment plant has adequate capacity to meet the peak day demand (~140 kL/day).

It is noted that no significant growth is anticipated for the area.

CARMILA STAKEHOLDERS

The relevant stakeholders for the Carmila scheme are presented in **Error! Reference source not found.**.

TABLE 0-4: CARMILA STAKEHOLDERS			
Organisation	**Contact Name and Details**	**Relevance to Management of Drinking Water Quality**	**How the Stakeholder is Engaged in the DWQMP**
Residential Users		Supplied with reticulated water from the Carmila scheme	Not engaged

CARMILA WATER QUALITY

Raw water quality at Carmila is generally good. However, the iron and manganese levels are usually high. Water quality data has been measured since 2014 but there are gaps in the records. Treated water quality results are all compliant with the ADWG. The following sections detail the current operational and verification monitoring, as well as water quality data summary.

OPERATIONAL MONITORING

The operational monitoring currently undertaken at Carmila is detailed in the following table.

TABLE 0-1: CARMILA OPERATIONAL MONITORING							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if Target Limit Exceeded**	**Critical Limit**	**Action if Critical Limit Exceeded**
Operator Sampling							
Raw Water	Total Manganese	None in raw water	Daily	N/A	Increase pre- chlorine dose to oxidise	N/A	N/A
Raw Water	Total Iron	None in raw water	Daily	N/A	Increase pre- chlorine dose to oxidise	N/A	N/A
Raw Water	pH	None in raw water	Daily	N/A	Assess chemical dosing requirements of raw water if pH becomes high or low	N/A	N/A
Raw Water	True Colour	None in raw water	Daily	N/A	Assess chemical dosing requirements of raw water if colour is high	N/A	N/A
Raw Water	Turbidity	None in raw water	Daily	N/A	Assess chemical dosing requirements of raw water if turbidity is high	N/A	N/A
Raw Water	Hardness	None in raw water	Weekly	N/A	Monitoring only (aesthetic)	N/A	N/A
Raw Water	Alkalinity	None in raw water	Weekly	N/A	Monitoring only (aesthetic)	N/A	N/A
Treated Water	pH	Acidic or alkaline water	Daily	7 – 7.5	See Critical Control Points for Carmila		
Treated Water	Turbidity	High Turbidity	Daily	<0.5 NTU	See Critical Control Points for Carmila		
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria. High chlorine increases risk of by-products	Daily	1.5 – 2.5 mg/L	See Critical Control Points for Carmila		
Treated Water	True Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Daily	< 15 HU	Adjust WTP chemical dosing	N/A	N/A

TABLE 0-1: CARMILA OPERATIONAL MONITORING							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if Target Limit Exceeded**	**Critical Limit**	**Action if Critical Limit Exceeded**
Treated Water	Total Manganese	High Manganese	Daily	<0.05 mg/L	This level causes possible staining. Chlorine dosing should be adjusted (ADWG Health limit 0.5 mg/L)	N/A	N/A
Treated Water	Total Iron	High Iron (aesthetic)	Weekly	<0.3 mg/L	This level causes possible staining. Chlorine dosing should be adjusted.	N/A	N/A
Treated Water	Hardness	Aesthetic and problems with lathering	Weekly	< 200 mg/L	Monitoring only (if hardness is a continuous problem, consider water softening equipment)	N/A	N/A
Treated Water	Alkalinity	Corrosion	Weekly	20-200 mg/L	Monitoring only (aesthetic)	N/A	N/A
Treated Water	Aluminium	High Aluminium	Weekly	< 0.2 mg/L	Check coagulant dose (overdosing may be occurring)	N/A	N/A
Town Water	Free chlorine	Pathogens	Daily	>0.2 mg/L	Adjust post- chlorine gas dose rate	N/A	N/A
Town Water	pH	High or Low pH	Daily	6.5 – 8.5	Adjust soda ash dose rate.	N/A	N/A
Town Water	Turbidity	High turbidity	Daily	< 0.5 NTU			
Town Water	True Colour	High colour	Daily	< 15 HU			
Town Water	Total Manganese	High manganese	Twice Weekly	< 0.05 mg/L			

CRITICAL CONTROL POINTS

Table 0-2 details the critical control points (CCPs), limits and rectification actions for Carmila WTP. Target limits are in line with ADWG best practice operation guidelines and critical limits are as per ADWG health limits.

TABLE 0-2: CARMILA CRITICAL CONTROL POINTS

Process Step	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Filtered Water (outlet of filters)	Turbidity	Pathogens	As frequently as practicable, minimum daily. (Target online ASAP)	<0.2 NTU	Optimise coagulation, i.e. adjust coagulant dose rate and coagulation pH. Backwash filter if turbidity continues to approach critical limit	0.5 NTU	Backwash filter immediately then continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	pH	Acidic or alkaline water	Daily	7 – 7.5	Adjust soda ash dose for filtered water	<6.5 or >8.5	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Turbidity	High Turbidity	Daily	<0.5 NTU	Adjust WTP chemical dosing Backwash filter(s) if required	1.0 NTU	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria. High chlorine increases risk of by-products	As frequently as practicable, minimum daily. (Target online ASAP)	1.5 – 2.5 mg/L	Target limit is set to ensure that there is sufficient residual maintained throughout reticulation. If concentration is high or low, adjust hypochlorite dose rate.	< 1.0 or >3.0 mg/L	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit ADWG allows residual between 0.2 and 5.0mg/L. However, chlorine dose rate should be adjusted prior to reaching the low/high limits Action is critical if the concentration is below 1mg/L. If the concentration is too low at the exit of the plant, an adequate residual is unlikely to be maintained in the reticulation Advise W&WW manager of non-compliant water

CARMILA RAW WATER QUALITY

Presented below are the results of raw water testing.

TABLE 0-3: CARMILA RAW WATER QUALITY									
Carmila Raw Water – Bores (July 2014 – June 2019)									
Parameter	Units	Sampling Location	Summary of Results						Comments
			No of Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	
pH	pH units	WTP Inlet	1265	6.80	7.10	7.34	7.49	7.90	
Turbidity	NTU		1221	0.06	0.11	0.97	2.60	50.00	
Colour	HU		874	1	1	7	22	155	Samples measured weekly Jan 15 – Jun 17, then daily Jul17 onward
Iron	mg/L		1174	0.006	0.050	0.896	1.854	3.000	Samples measured weekly Jan 15 – Jun 17, then daily Jul 17 onward Elevated levels of iron and manganese require treatment
Manganese	mg/L		1163	0.002	0.050	0.784	1.820	2.610	
Hardness	mg/L as $CaCO_3$		295	50	55	95	110	220	Sampling commenced daily Sep 17
Alkalinity	mg/L as $CaCO_3$		295	55	70	101	130	205	Sampling commenced daily Sep 17

CARMILA TREATED WATER QUALITY

Daily samples of treated water are collected for onsite analysis. The results of these from available recorded data are provided below. The results show that the parameters tested in the treated water are compliant with ADWG guideline values, with the exception of a single health exceedance for Chlorine in May 2018 and 2 exceedances of the Manganese health limit in June 2021.

TABLE 0-4: CARMILA TREATED WATER QUALITY

Carmila Water Treatment Plant													
Parameter	Units	Sample Location	Summary of Results (July 2014 – October 2021)						CCP		ADWG		Comments
			No. of Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	Limit	Exceptions	Guideline Value [22]	Exceptions	
pH	pH units	WTP	1850	6.85	7.30	7.67	7.90	8.00	6.5-8.5	0	6.5-8.5 (A)	0	
Chlorine	mg/L		1849	0.40	1.00	1.66	2.30	5.40	1.0-3.0	21, 3	0.2-5.0 (H)	0, 1	1.14% of samples below CCP limit of 1 mg/L 0.16% of samples above CCP limit of 3 mg/L and one exceedance of ADWG health limit.
Iron	mg/L		596	0.001	0.002	0.006	0.008	0.350	N/A	1	<=0.3 (A)	1	1 exceedance of the ADWG aesthetic limit
Manganese	mg/L		597	0.001	0.002	0.015	0.008	0.650	N/A	0	<=0.5 (H) <=0.1 (A)	2 (H) 16 (A)	2.68% of samples above the ADWG aesthetic threshold and 0.34% of samples above the ADWG health threshold
Hardness	mg/L as $CaCO_3$		383	0.1	0.1	75.3	105.0	120.0	N/A	0	60-200 (A)	0	
Turbidity	NTU		1796	0.01	0.09	0.15	0.30	0.70	1	0	<=1 (H)[23]	0	
Colour	HU		1403	0.0	0.0	0.8	1.0	5.0	N/A	0	<=15 (A)	0	
Alkalinity	mg/L as $CaCO_3$		116	40	55	96	136	190	N/A				
Aluminium	mg/L		123	0.018	0.019	0.044	0.124	0.384	N/A		<=0.2 (A)	1	One exceedance of the ADWG aesthetic limit

[22] A = aesthetic guideline value; H = health-based guideline value

[23] Recommended at the point of disinfection with chlorine

Figure 0-1 shows raw and treated water for Carmila WTP on a logarithmic scale. The red line shows the CCP limit of 1 NTU for treated water turbidity. Raw water turbidity is generally quite low at Carmila WTP, consequently treated water turbidity is also generally quite low and always below the CCP limit. There is a period in October 2016 where raw water turbidity is lower than treated water turbidity, likely due to poor coagulation and filter operation. Raw turbidity has remained generally low since February 2019 with only occasional spikes since. Despite these, treated water turbidity has remained stable and satisfactory.

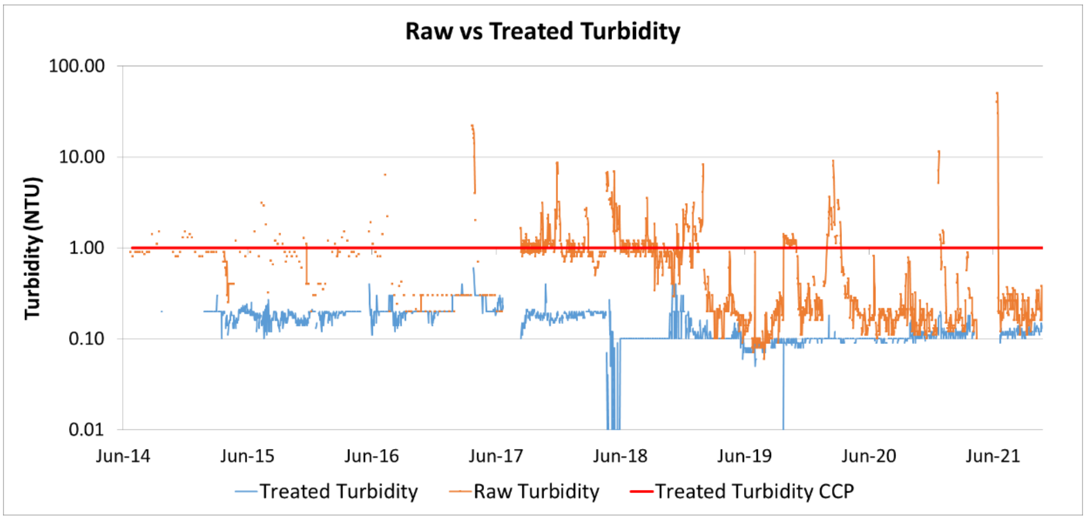


Figure 0-1: Carmila Raw and Treated Water Turbidity

The figure below shows the treated water chlorine residual for Carmila WTP. Chlorine residual is generally maintained within the limits set out by the chlorine CCP (1-3 mg/L), however there was a number of exceptions in 2017 and 2018 and an exceedance of the ADWG health guideline value in May 2018. These results suggest there was a loss of dosing or control during these times. Chlorine has remained stable around 2 mg/L since December 2019, barring a brief period of fluctuation in June 2021.

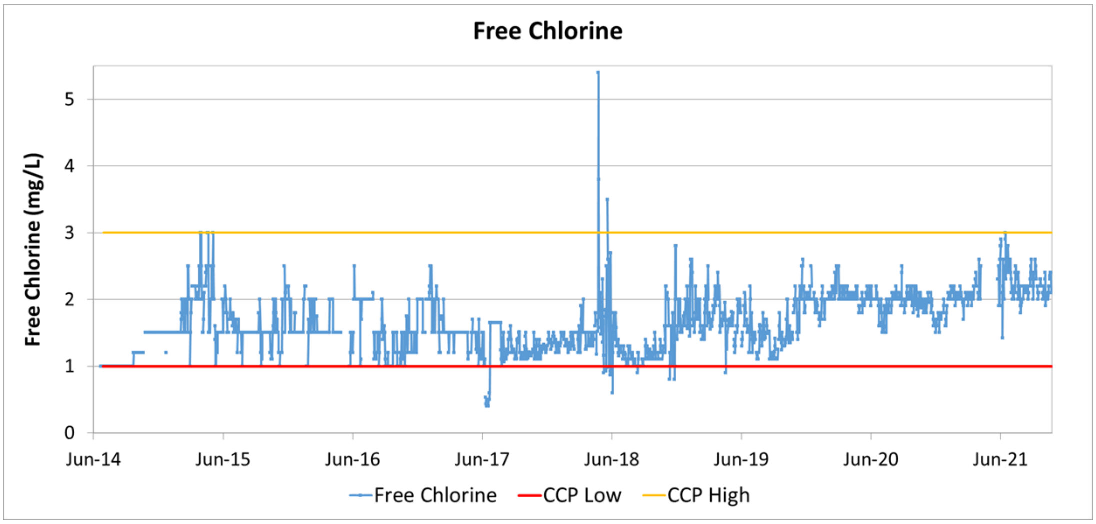


Figure 0-2: Carmila Raw and Treated Water Free Chlorine

Figure 0-3, Figure 0-4 and Figure 0-5 show levels for colour, manganese and iron in the raw and treated water at Carmila. All three parameters show elevated levels in early to mid 2017. Colour falls well below the ADWG guidelines while iron and manganese experienced a brief spike above the ADWG thresholds in June 2021, seemingly independent of the raw water concentrations.

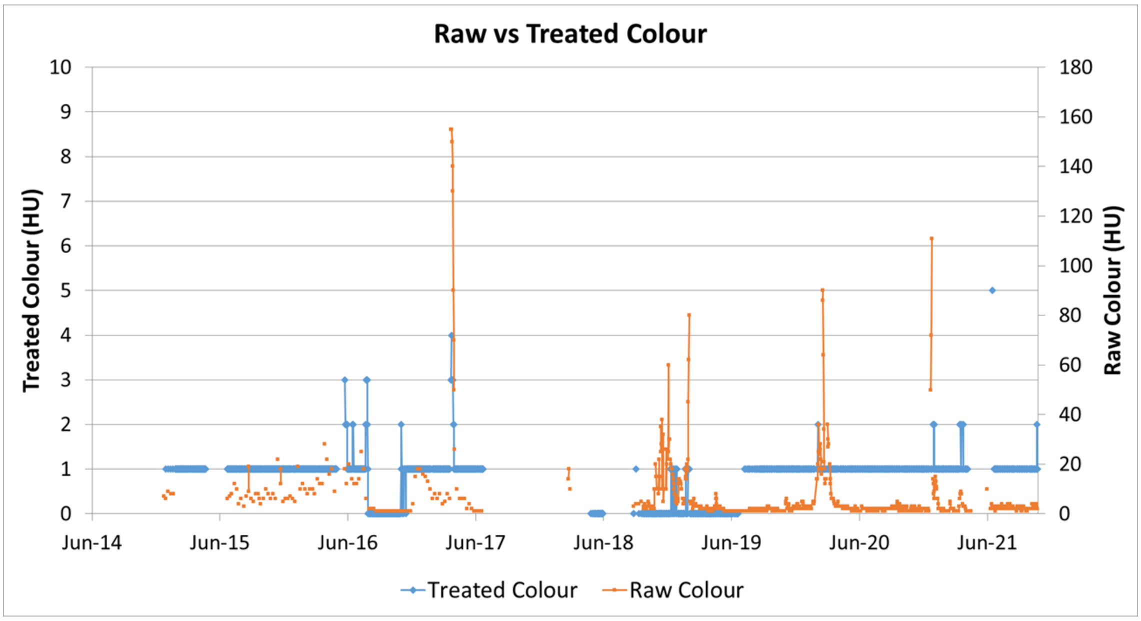


Figure 0-3: Carmila Raw and Treated Water Colour

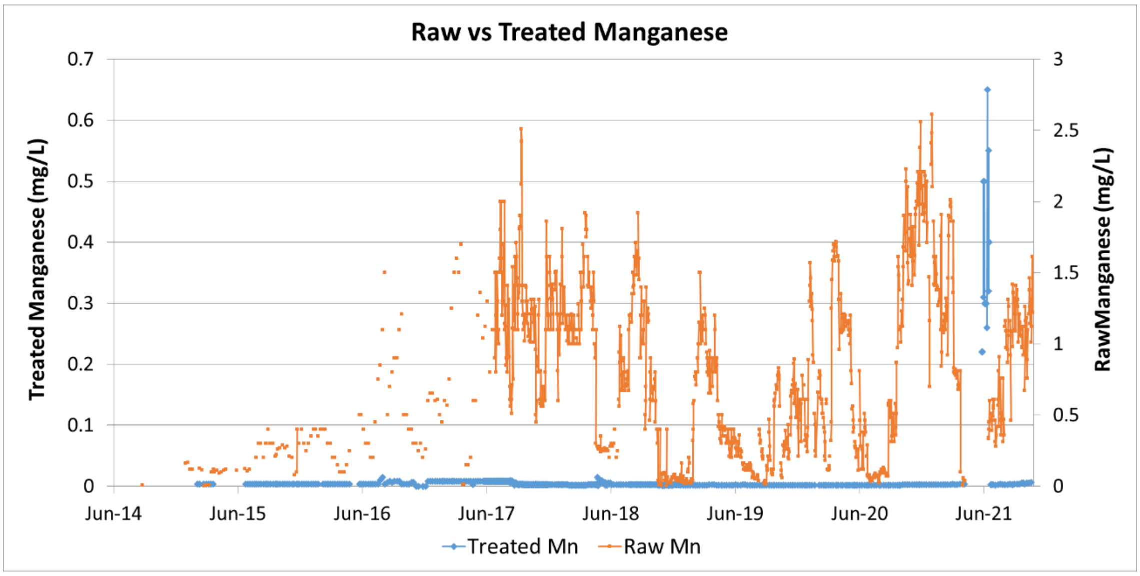


Figure 0-4: Carmila Raw and Treated Water Manganese

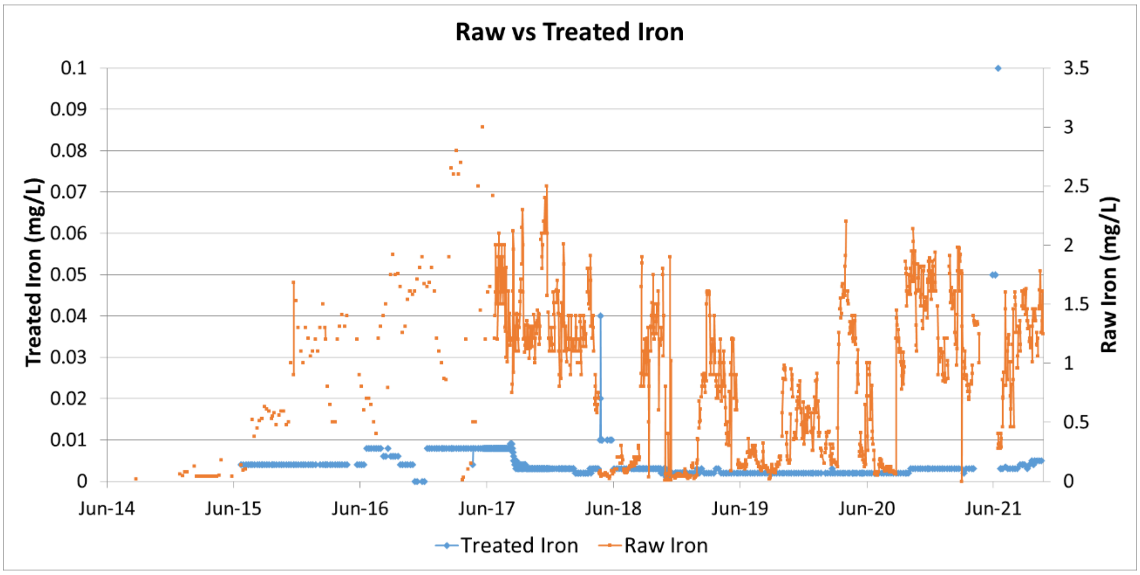


Figure 0-5: Carmila Raw and Treated Water Iron

CARMILA RETICULATED WATER QUALITY

The sample results from Carmila reticulated water quality are presented in Table 0-5: Carmila Reticulated Water Quality (January 2014 to October 2021) table below.

TABLE 0-5: CARMILA RETICULATED WATER QUALITY (JANUARY 2014 TO OCTOBER 2021)								
Sampling Location: Music St, Depot, Lab Sink								
Parameter	No. of Samples	Summary of Results					ADWG Guideline Value [24]	No. of Samples Exceeding ADWG Guideline Value
		Minimum	5th Percentile	Average	95th Percentile	Maximum		
E. Coli	304	ND	ND	ND	ND	ND	<1 (H)	0
Free Chlorine (mg/L)	302	0.06	0.20	0.38	0.80	2.30	0.2-5.0 (H)	9, 0
pH	302	7	7.3	7.7	7.8	8.0	6.5-8.5 (A)	0
Total Coliforms (cfu/100 mL)	233	<1	<1	<1	<1	2		

[24] A = aesthetic guideline value; H = health-based guideline value

CARMILA WATER QUALITY COMPLAINTS

As per IRC's complaint register, there was no water quality complaint recorded between 2011 and the end of June 2016, nor between July 2017 and June 2021. Two dirty water complaints were received in the 2016/17 financial year.

CARMILA KEY ISSUES

The following key water quality issues in the Carmila water scheme have been identified:

- No online water quality monitoring with alarms. This results in reliance on manual monitoring and intervention by operators.
- Remote access via SCADA to monitor and control the WTP would assist the operator to respond to changes in water quality, particularly when the WTP is unattended.

DYSART WATER SCHEME

Raw water for the Dysart Water Scheme is abstracted at the Bingegang Weir. The raw water comes from the Mackenzie River and flows into a turkey's nest adjacent to the WTP. Norwich Park (also known as Calvert's) Dam was bypassed in late 2013 due to poor water quality contributing tastes and odours and blue-green algae to the water but has since been brought back online after implementation of operational improvements. Water from the turkey's nest is provided to the Dysart WTP. The raw water scheme from the Bingegang Weir to the turkey's nest is owned by BMA but operated and maintained by SunWater.

Water from the WTP is provided to the residents of Dysart via a gravity reticulation network. The infrastructure for the overall scheme is shown schematically in Figure 0-1. The WTP process is shown schematically in Figure 0-2.

An overview of the Dysart Water Scheme is shown in Table 0-1 with further detail in the sections following.

TABLE 0-1: DYSART SYSTEM OVERVIEW

System Component	Description
Population Supplied	Total connections of approximately 1,500 comprising approximately 2,991 persons.
Water Sources	Surface water from the Mackenzie River via the Bingegang Weir (owned by BMA and operated by SunWater)
Water Storage (Before Treatment)	Raw water is stored in a BMA-owned aerated 14 ML Turkeys Nest Dam next to the WTP before being pumped into a 5 ML raw water tank prior to treatment.
Water Treatment	Surface Water from the Bingegang Weir is treated at Dysart WTP as follows: • Dissolved air flotation (DAF) during periods of high algae and/or organics with ACH dosing for improved float formation; • Sodium hydroxide dosing for pH adjustment prior to oxidation • Hydrochloric acid dosing for pH adjustment prior to oxidation • Potassium permanganate dosing for oxidation of metals (preferred method of oxidation); • Chlorine gas dosing for oxidation of metals (alternative oxidant); • PAC Dosing for taste and odour removal; • Coagulation with Aluminium Chlorohydrate (ACH); • Polymer dosing for flocculation aid; • Flocculation; • Clarification; • Dual media filtration; • Granular activated carbon (GAC) filtration (if required); and • Disinfection with chlorine gas. The wastewater system comprises:

TABLE 0-1: DYSART SYSTEM OVERVIEW	
System Component	**Description**
	• Filter Backwash Recovery Tank (supernatant from this tank is used for onsite irrigation); • Drying beds (x8); • Supernatant recycle to the raw water tank (optional).
Water Storage (After Treatment)	• 500 kL Clearwater Tank • 5.25 ML Town Reservoir • 3.75 ML Town Reservoir All treated water storages are roofed and vermin proofed.
Distribution of Product	Gravity fed from the Water Tower via approximately 33km of reticulation mains.
Any Special Controls Required	Quality of chemicals, materials, etc. used in the production and delivery of the product. Manual verification sampling of water from the distribution network. Backflow prevention and trade waste management. Operation and maintenance of all infrastructure to prevent recontamination.

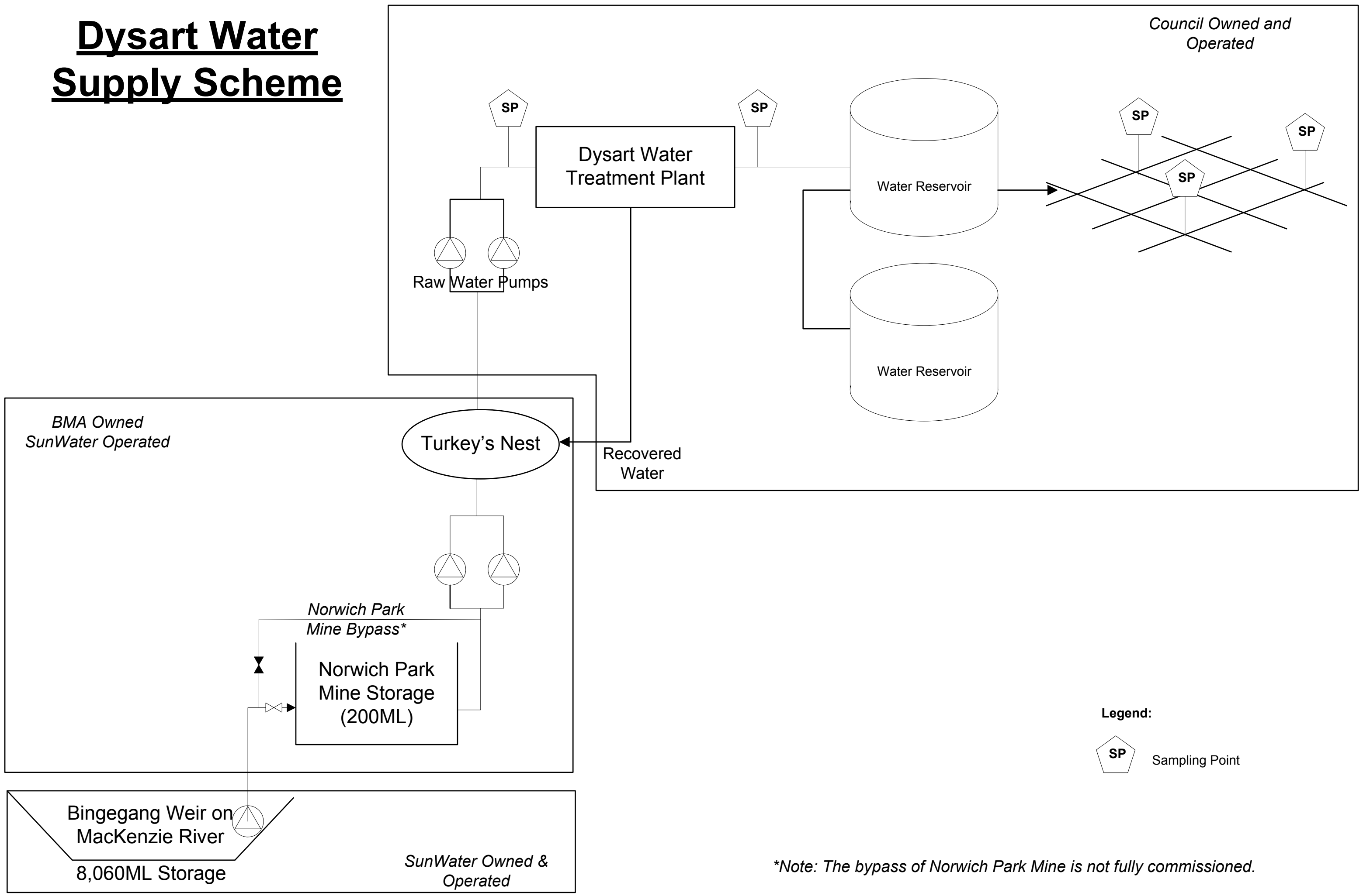


Figure 0-1: Dysart Overall Water Supply Scheme

Dysart Water Treatment Plant

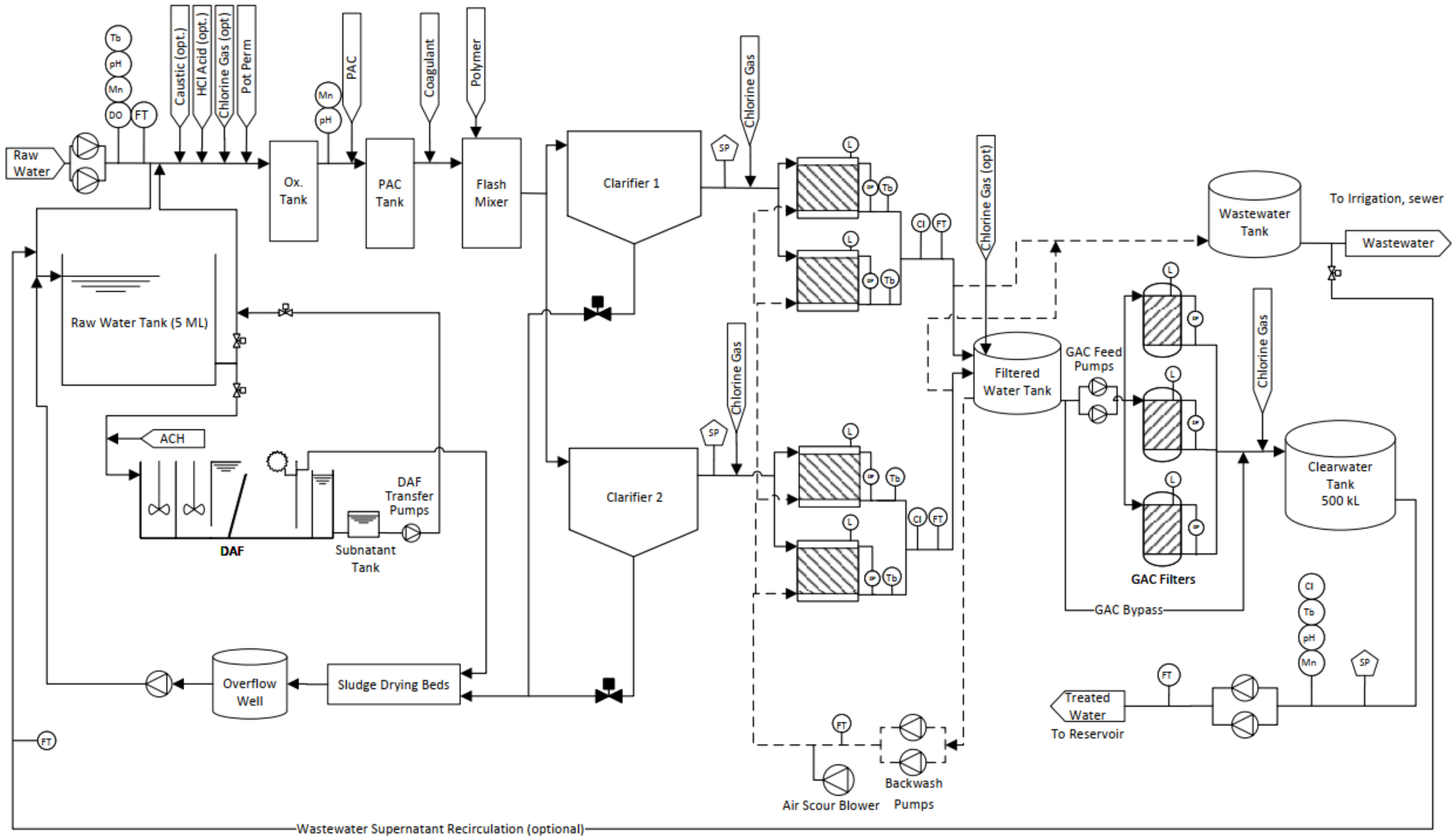


Figure 0-2: Dysart Water Treatment Plant

DYSART CATCHMENT

The Bingegang Weir is located in the Nogoa/Mackenzie system which is 79,615 km^2. The mean annual rainfall in the area is 550-650 mm[25]. Aside from being raw water supply to the Dysart WTP and Middlemount WTP; the catchment has the following uses:

- Grazing
- Contact recreation including swimming, sailing, fishing
- Supplying mining facilities
- Supplying other domestic users

Figure 0-3 shows the location of the Bingegang Weir, Dysart and the BMA Mine.

[25] http://www.anra.gov.au/topics/water/overview/qld/swma-nogoa-mackenzie.html

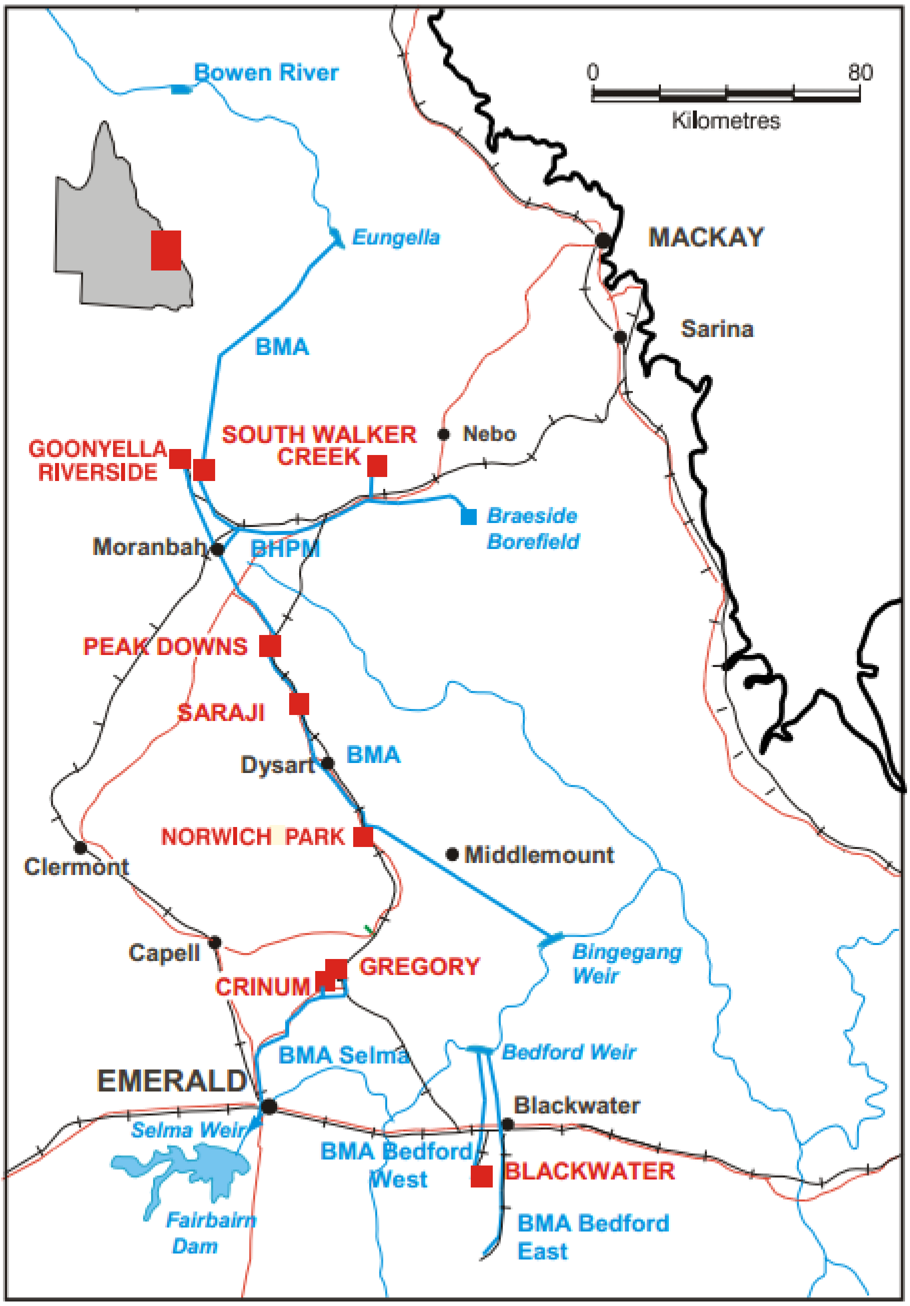


Figure 0-3: Location of Mines and Water Infrastructure Near Isaac Regional Council[26]

DYSART RAW WATER

The raw water pipeline between the Bingegang Weir and BMA's Norwich Park Mine is 134 km long and has a diameter of 375-395 mm. There are six pump stations along this pipeline. This pipeline supplies various other users including mines, farms and Middlemount WTP. The diagram below is a schematic showing storage, pump and user information.

[26] *Evans, R., Roe, P., & Joy, J.(2003). p 7 Joy, J 2003, online, 'Water use and sustainable development in coal mining – A case study from Central Queensland.* Retrieved from online.

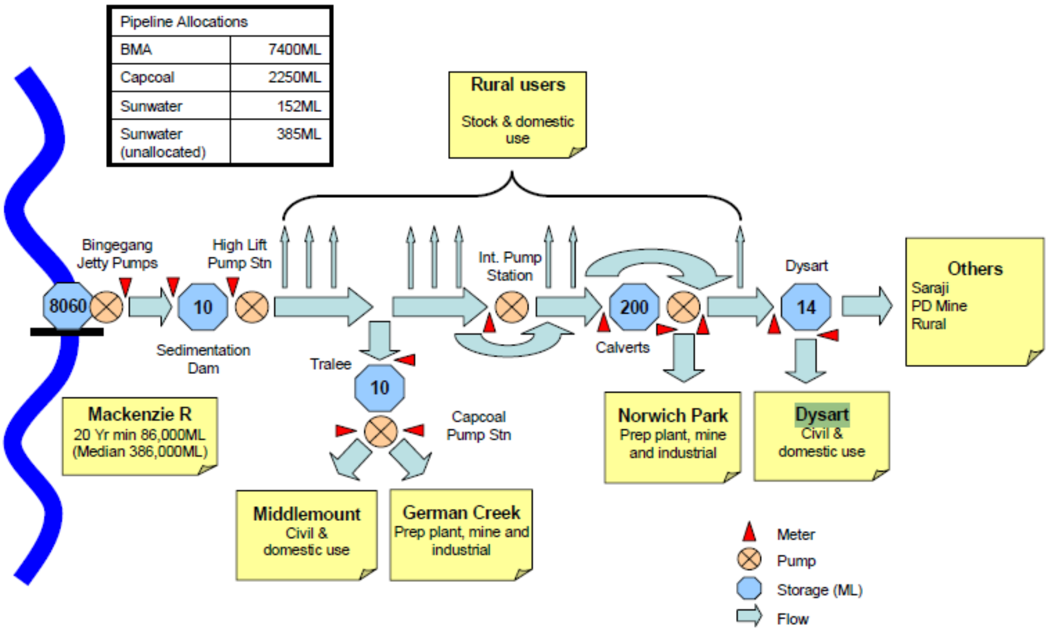


Figure 0-4: Bingegang Weir Water Allocations27

The raw water passes through a turkeys nest before being pumped by a duty/standby pump set to the Dysart WTP inlet. Algal blooms have been a problem at the Dysart Turkeys Nest due to long residence time in the various storage locations along the pipeline. This has been exacerbated since the Norwich Park Mine, which previously supplied water to the Dysart Turkeys Nest, is not currently operational. The result of the slow turnover rate along the delivery route, including at the Norwich Park Mine, has increased the taste and odour of the water provided to Dysart residents.

An aeration system has been installed in the turkeys nest dam adjacent to Dysart WTP to help manage influent water quality and minimise algal blooms. Council has also constructed a raw water tank to provide an alternate water storage and buffering capacity during periods of poor raw water quality, as well as additional algae removal and treatment processes at the WTP – DAF for cell removal and GAC filters for polishing removal of residual tastes and odours and toxins.

[27] *Evans, R., Roe, P., & Joy, J. (2003), Water use and sustainable development in coal mining – A case study from Central Queensland.* Paper presented at Minerals Council of Australia Sustainable Development Conference; retrieved from online.

TABLE 0-2: DYSART UPSTREAM WATER INFRASTRUCTURE OWNERS		
Infrastructure	**Owners/Operator**	**Responsibility**
Bingegang Dam	Sunwater	Asset Owner
	Sunwater	Operation and maintenance of water supply pipeline
Intermediate raw water storage dams	BMA	Asset Owner
	Sunwater	Operation and maintenance of raw water dams and water supply pipeline
Turkey nest next to Dysart WTP	BMA	Asset Owner
	Sunwater	Operator of the turkey nest
Raw water pumps	Isaac Regional Council	Asset owner, Operation and maintenance of raw water pumps to the Dysart WTP

DYSART WATER TREATMENT PLANT

Raw Water Delivery

Raw water flow entering the Dysart WTP is monitored by a magnetic flowmeter. The raw water pumps are variable speed and capable of delivering up to 112 L/s. The raw water pumps can be used to either directly feed the WTP or to fill the 5 ML raw water tank. The WTP can be gravity fed from the raw water tank.

Raw Water Dosing

A number of chemicals can be dosed after the inlet flowmeter. All chemical dosing is flow paced, with setpoints and dose rates selected and adjusted by the operators via the WTP SCADA as required. The chemical dosing ceases when raw water flow has stopped.

Sodium hydroxide and hydrochloric acid are available on the raw water inlet for pH adjustment prior to oxidation. Manganese oxidation with potassium permanganate is most effective at pH 7.5 – 8.5 and ACH coagulation is most effective at pH 6 – 9. An optional chlorine dosing point is also available on the raw water inlet but due to the presence of organics this is typically not used to minimise the risk of disinfection by-product formation.

Online monitoring of the raw water is conducted at the pump station. Parameters monitored include:, manganese, turbidity, pH, and dissolved oxygen.

Dissolved Air Flotation

During periods of elevated algae concentrations in the raw water, DAF can be used to remove cells prior to the rest of the conventional treatment process. The DAF unit consists of 2 flocculation stages and a flotation chamber with float scraper. Raw water is dosed with ACH prior to the flocculation tank to improve float formation and integrity.

Figure 0-5: DAF Unit at Dysart WTP

The float is removed periodically based on a timer and drains to a sludge tank before being pumped to the sludge drying beds. DAF sub natant is pumped back into the raw water main upstream of the raw water dosing points and oxidation tank.

Oxidation Tank

Potassium permanganate is dosed into the raw water main upstream of the new oxidation tank. Potassium permanganate is a strong oxidant dosed to oxidise any soluble metals present in the raw water, particularly iron and manganese. The oxidation tank provides 20 minutes contact time at maximum flow and employs a mechanical mixer for improved chemical distribution and contact efficiency. Potassium permanganate is part of a multi-barrier treatment approach to removing manganese.

Dysart WTP also has an optional chlorine gas dose point prior to the oxidation tank for removal of iron and manganese (see Figure 0-7). This dose point is not currently used to minimise the risk of releasing cyanotoxins from the high levels of algae in the raw water or forming disinfection by-products from reaction with organics.

Figure 0-6: Oxidation Tank

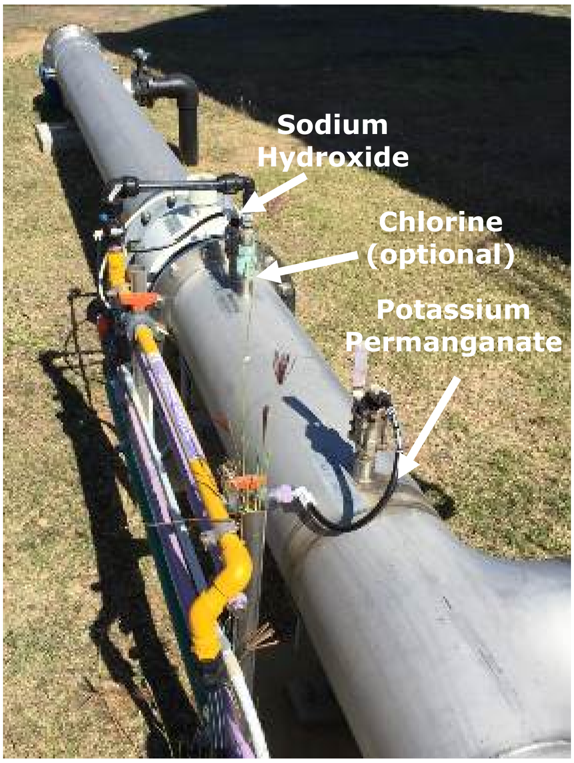


Figure 0-7: Potassium Permanganate Dosing Point

PAC Contact Tank

PAC is dosed into the raw water upstream of the PAC contact tower. PAC dosing is intended to prevent taste and odour issues caused by cyanotoxins, MIB and Geosmin from algal growth in the upstream dams. Dysart WTP has a PAC batching and dosing system with duty/ standby dosing pumps that are equipped with auto-changeover on fault through the plant SCADA. Two dose points are available upstream of the contact tank for PAC dosing, however the injection point closest to the tank inlet is currently used.

Figure 0-8: Dosing Points on Contact Tank Inlet

Flash Mixing

The flash mixer at Dysart WTP does not contain a mechanical mixer. Instead it is equipped with a blower for aeration, which promotes mixing near the outlet. Aluminium Chlorohydrate (ACH) is the coagulant used and it has two dosing pumps operating as duty/standby. ACH is currently dosed on the inlet to the flash mixer. Dose rate is flow paced to raw water flow but is adjusted by operators via the SCADA system when required. Pumps are equipped with auto-changeover on fault. The chemical dosing stops when no WTP flow is detected at the inlet flowmeter.

Water flows by gravity from the flash mixer to the flocculation chamber in the centre of one of two clarifiers.

Clarification

The flocs that have formed in the flocculation chamber settle to the bottom of the clarifier. Clarified water flows out via the launders and into the filters through the clarifier outlet channel.

Sludge is released by opening an air-actuated de-sludge valve at the bottom of the clarifier. The de-sludge valve opens automatically on a timer setting which can be adjusted by operators via the plant SCADA.

Filtration

The clarified water flows into four dual media filters (two filters dedicated to each clarifier) by gravity. The filter pressure differential, level and individual outlet turbidity and chlorine residual is continuously monitored. The backwash sequence is initiated either manually by the operator or automatically based on pre-programmed set points that are operator adjustable through the SCADA system. Backwash triggers include run time, headloss and turbidity.

Figure 0-9: Filtered Water Manifold to Clearwater Tank

Clarified water is dosed with chlorine prior to entering the filters to oxidise any remaining soluble manganese present in the water stream. To ensure effectiveness of this oxidation, a chlorine residual is targeted out of each filter. Manganese oxide coated filter media is also used as another barrier to reduce manganese in the treated water.

Granular Activated Carbon Filtration

During periods of elevated algae and/or organics concentrations in the raw water, the filtered water is also passed through 3 GAC filters. Filtered water from the dual media filters is pumped from a filtered water tank to the GAC filters. GAC is used as a polishing step to remove any residual organic contaminants such as algal toxins and trace taste and odour compounds. The filter pressure differential and level are continuously monitored.

The backwash sequence is initiated either manually by the operator or automatically based on pre-programmed set points that are operator adjustable through the SCADA system. Backwash triggers include run time and headloss.

Figure 0-10: GAC Filters

Clearwater Tank

The filtered water is disinfected with chlorine gas at the inlet to the clear water tank. From the clear water tank, a set of two high lift pumps transfer water into two high level reservoirs.

The WTP is operated automatically based on the level of the reservoirs. The treatment plant starts when the float level sensors in the treated water reservoir indicate a low level and stops when a high level is reached. These levels can be monitored and adjusted by operators through the SCADA system.

Sludge and Backwash Treatment

The WTP has a holding tank where backwash water is collected. Filter backwash water is used for irrigation around the WTP. New wastewater recirculation capabilities have been connected and can be used to return supernatant from the holding tank to the inlet of the raw water tank. Excess wastewater and sludge from the holding tank that cannot be recycled through irrigation or supernatant return is discharged to sewer

The drying beds also receive the clarifier sludge and DAF float. A decant pump located at the ponds takes the supernatant back to the raw water tank or sewer.

Chemical Dosing

The WTP process currently employs the following chemicals:

TABLE 0-3: CHEMICAL USE IN THE DYSART WATER TREATMENT PROCESS		
Chemicals	**Dosing Location**	**Uses**
Sodium Hydroxide	Raw Inlet prior to Oxidation Tank	pH Adjustment
Hydrochloric acid	Raw Inlet prior to Oxidation Tank	pH Adjustment
Potassium Permanganate	Oxidation Tank Inlet	Manganese Oxidation
PAC	PAC Contact Tank Inlet	Taste and Odour
ACH	Prior to DAF Prior to Flash Mixer	Coagulant and Flocculation
LT20 Polyacrylamide	Flash Mixer	Flocculation Aid
Chlorine Gas	Oxidation Tank Inlet (unused) Filter Inlets Filtered water	Manganese Oxidation Manganese Oxidation Disinfection
Sodium Hydroxide	Raw Inlet prior to Oxidation Tank	pH Adjustment

All chemical dosing pumps are flow-paced and interlocked with the flow to the treatment plant and the dosing rates are adjusted by operators through SCADA.

DYSART RESERVOIRS

Water from the Clear Water Tank is pumped to two hydraulically linked reservoirs (5.25 ML and 3.75 ML), which are located approximately 2.8 km northwest of the WTP. Water flows by gravity from the elevated reservoirs through the Dysart reticulation network, and no additional pressure boosting is required. The reservoirs are fenced to prevent unauthorised access and the roofs are enclosed to keep out vermin and birds.

TABLE 0-4: DYSART RESERVOIRS		
Volume	5.25 ML	3.75 ML
Materials of construction	Concrete	Concrete
Roof	Yes	Yes
Vermin-Proof	Yes	Yes

Figure 0-11: Dysart Treated Water Reservoir

DYSART RETICULATION

Dysart has approximately 33 km of reticulation pipelines. The majority (97%) of the existing pipelines are asbestos cement. Other pipeline materials are also used including MDPE.

The operators have advised that they have not experienced any issue of low water pressure and flow stagnation.

DYSART WATER SUPPLY SYSTEM CAPACITY

The raw water pumps and pipeline from the turkey nest to the treatment plant inlet is rated for 112 L/s.

A recent plant audit[28] indicated that the treatment plant capacity is around 80 to 90 L/s, with possible process bottleneck around the clarifiers. Some improvement works have been identified in a plant audit.

Council has been monitoring the growth in the area and will commission plant upgrade works as required.

High lift pumps and reservoirs were assessed using DERM's planning guidelines. The high lift pumps have a capacity of 200 L/s and the reservoirs have a capacity of 9 ML. Both meet the guidelines for current and future demand.

The combination of the clearwater tank, rising main and reservoirs are adequate to provide the 30 minutes minimum chlorine contact time.

DYSART STAKEHOLDERS

The Dysart water scheme has stakeholders as detailed in the table below.

Organisation	Contact Name and Details	Relevance to Management of Drinking Water Quality	How the Stakeholder is Engaged in the DWQMP
BMA		Owner of raw water infrastructure.	Not engaged
SunWater		Contractor engaged for maintenance / operation of raw water infrastructure	Not engaged
Residential Users		Supplied with reticulated water from the Dysart scheme	Not engaged

[28] Dysart WTP Plant audit (Harrison Grierson, Draft, September 2012)

DYSART WATER QUALITY

The quality of raw water at Dysart WTP is generally good with the exception of the taste and odour caused by cyanotoxins and other taste and odour causing compounds released from the high levels of algae. Although PAC is dosed, taste and odour problems can remain through to the treated water, however recent upgrades and optimisation have helped to address this. High concentrations of dissolved manganese in the raw water are also common, particularly in summer and following heavy rainfall. Potassium permanganate dosing and manganese oxide coated filter media provide multi-barrier removal processes. The tables below provide the current operational and verification, monitoring and a summary of the water quality data.

OPERATIONAL MONITORING

The operational monitoring currently undertaken at Dysart is detailed in the following table. Dysart WTP has recently been upgraded to enable fully automated operation and thus has substantial online monitoring and PLC control capabilities.

TABLE 0-1: DYSART OPERATIONAL MONITORING

Process Step / Critical Control Point / Location in System	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Raw Water	pH	High or Low pH	Daily	N/A	Assess chemical dosing requirements if pH becomes high or low	N/A	N/A
Raw Water	True colour	High Colour	Daily	N/A	Assess chemical dosing requirements if colour is high		
Raw Water	Turbidity	High Turbidity	Daily	N/A	Assess chemical dosing requirements if turbidity is high	N/A	N/A
Raw Water	Total Manganese	High Manganese	Daily	N/A	Adjust potassium permanganate and/or chlorine dose rates for oxidation	N/A	N/A
Raw Water	Total Iron	High Iron	Daily	N/A	Adjust potassium permanganate and/or chlorine dose rates for oxidation	N/A	N/A
Raw Water	Alkalinity	None in raw water	Daily	N/A	Monitoring only	N/A	N/A
Settled Water	True Colour	High Colour	Daily	N/A	Assess chemical dosing requirements	N/A	N/A
Settled Water	Turbidity	Coagulation failure	Daily	<2 NTU	Assess chemical dosing requirements if turbidity is high	N/A	N/A
Settled Water	pH	Coagulation failure	Daily	N/A	Assess chemical dosing requirements if pH becomes high or low	N/A	N/A
Settled Water	Free Chlorine	N/A	Monthly	N/A	Assess chemical dosing requirements if chlorine becomes high or low	N/A	N/A
Filtered Water	Turbidity	Filter breakthrough	Online / Daily	<0.2 NTU	See Critical Control Points for Dysart		
Filtered Water	Chlorine	High manganese	Online / Daily	>0.1 mg/L	Increase pre-filter chlorine dose	N/A	N/A
Treated Water	pH	Acidic or alkaline water	Daily	7 – 8	See Critical Control Points for Dysart		
Treated Water	Turbidity Lab	High Turbidity	Daily	< 0.5 NTU	See Critical Control Points for Dysart		

TABLE 0-1: DYSART OPERATIONAL MONITORING

Process Step / Critical Control Point / Location in System	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Treated Water	Turbidity Inline	High Turbidity	Online / Daily	< 0.5 NTU	See Critical Control Points for Dysart		
Treated Water	True Colour	High Colour	Daily	< 15 HU	Adjust WTP chemical dosing	N/A	N/A
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria. High chlorine increases risk of by-products	Online / Daily	1.5 - 2.5 mg/L	See Critical Control Points for Dysart		
Treated Water	Total Iron	High Iron – taste and odour	Weekly	<0.3 mg/L	Adjust potassium permanganate and/or pre-chlorine dosing	N/A	N/A
Treated Water	Total Manganese	High Manganese	Daily	<0.05 mg/L	This level causes possible staining. Chlorine dosing should be adjusted. (ADWG Health limit 0.5 mg/L)	N/A	N/A
Treated Water	Hardness	Aesthetic and problems with lathering	Weekly	< 200 mg/L $CaCO_3$	Monitoring only (if hardness is a continuous problem, consider water softening equipment)	N/A	N/A
Treated Water	Alkalinity	Corrosion	Weekly	N/A	Monitoring only	N/A	N/A
Treated Water	Aluminium	High Aluminium	Weekly	< 0.2 mg/L	Check coagulant dose (overdosing may be occurring)	N/A	N/A
Town Water	True Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Twice Weekly	< 15 HU			
Town Water	Turbidity	High Turbidity	Twice Weekly	< 0.5 NTU			
Town Water	pH	High or low pH	Twice Weekly	6.5 – 8.5			
Town Water	Free Chlorine	Low chlorine increases the risk of bacteria. High chlorine increases risk of by-products	Twice Weekly	0.2 – 1.0 mg/L			
Town Water	Total Manganese	High Manganese	Twice Weekly	< 0.05 mg/L			
Town Water	Total Iron	High iron – taste and odour	Twice Weekly	< 0.3 mg/L			

CRITICAL CONTROL POINTS

Table 0-2 details the critical control points (CCPs), limits and rectification actions for Dysart WTP. Target limits are in line with ADWG best practice operation guidelines and critical limits are as per ADWG health limits.

TABLE 0-2: DYSART CRITICAL CONTROL POINTS

Process Step	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Filtered Water	Turbidity	Pathogens	Online (individual filters)	<0.2 NTU	Optimise coagulation, i.e. adjust coagulant dose rate and coagulation pH. Backwash filter if turbidity continues to approach critical limit.	0.5 NTU	Backwash filter immediately then continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	pH	Acidic or alkaline water	Daily	7 – 8	Monitoring only	<6.5 or >8.5	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Turbidity	High Turbidity	Daily	<0.5 NTU	Adjust WTP chemical dosing Backwash filter(s) if required	1.0 NTU	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria High chlorine increases risk of by-products	Online	1.5 - 2.5 mg/L	Target limit is set to ensure that there is sufficient residual maintained throughout reticulation. If concentration outside the target limits, adjust chlorine dose rate	< 1.0 or >3.0 mg/L	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit ADWG allows residual between 0.2 and 5.0mg/L. However, chlorine dose rate should be adjusted prior to reaching the low/high limits Action is critical if the concentration is below 1mg/L. If the concentration is too low at the exit of the plant, an adequate residual is unlikely to be maintained in the reticulation Advise W&WW manager of non-compliant water

DYSART RAW WATER QUALITY

Presented below are the results of raw water testing which is completed onsite by operators.

TABLE 0-3: DYSART RAW WATER QUALITY									
Dysart Raw Water – Raw Water Turkeys Next (from the Bingegang Weir)									
Date	Sampling Location	Units	Summary of Results (July 2014 – October 2021)						Comments
			No of Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	
pH	Inlet to WTP	pH units	2573	6.44	7.25	7.64	8.13	9.13	
Turbidity		NTU	2580	1.29	5.37	50.23	171.00	323.00	
True Colour		HU	2560	0	10	109	663	2438	True colour is highly variable
Iron		mg/L	1546	0.000	0.010	0.049	0.130	2.300	Samples taken 2-3 times per week September 2016 – July 2017, then daily August 2017 onwards
Manganese		mg/L	1978	0.000	0.000	0.083	0.420	9.300	Elevated levels of manganese occur in the raw water and require appropriate monitoring to ensure adequate removal and setting of chemical doses
Alkalinity		mg/L	1600	0	70	103	150	260	

DYSART TREATED WATER QUALITY

Daily samples of treated water are collected for onsite analysis. The results of these from available recorded data are provided in the table below.

TABLE 0-4: DYSART TREATED WATER QUALITY

Parameters	Units	Sampling Location	Summary of Results (July 2014 – October 2021)						CCP		ADWG		Comments
			No of Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	Critical Limit	Exceptions	Guideline Value [29]	Exceptions	
pH	pH units	Clear Water Tank	2548	6.38	7.02	7.35	7.79	8.94	6.5-8.5	2, 3	6.5-8.5 (A)	2, 3	0.2% of samples out of CCP/ ADWG range
Turbidity (Lab)	NTU		2583	0.01	0.07	0.25	0.76	8.01	1	71	<=1 (H)[30] <=5 (A)	71 (H) 3 (A)	2.75% of samples above CCP limit 0.12% of samples above ADWG aesthetic limit
Colour	HU		2578	0.0	0.0	1.3	6.2	53.0	N/A	-	<=15 (A)	31	1.2% of samples above ADWG aesthetic limit
Iron	mg/L		1552	0.00	0.00	0.01	0.02	0.15	N/A	-	<=0.3 (A)	0	
Manganese	mg/L		2009	0.00	0.00	0.03	0.20	1.70	N/A	-	<=0.5 (H) <=0.1 (A)	23 (H) 135 (A)	1.1% of samples above ADWG health limit. 6.7% of samples above ADWG aesthetic limit
Hardness	mg/L as $CaCO_3$		1524	5	60	87	125	220			60-200 (A)	1	1 sample above the ADWG aesthetic threshold
Alkalinity	mg/L as $CaCO_3$		1603	0	60	85.8	115	275	N/A	-	N/A	0	
Chlorine	mg/L		2579	0.00	1.32	2.36	4.13	7.81	1-3	38, 415	0.2-5.0 (H)	2, 7	415 samples (16.1%) above CCP limit including 7 samples (0.3%) above ADWG health limit. 38 samples (1.5%) below CCP limit, including 2 samples below the ADWG recommended minimum residual
Aluminium	mg/L		836	0.000	0.000	0.044	0.100	0.400	N/A	-	<=0.2 (A)	1	One sample about the ADWG aesthetic threshold

[29] A = aesthetic guideline value; H = health-based guideline value
[30] Recommended at the point of disinfection with chlorine

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The following figure shows raw and treated water data on a logarithmic scale. The turbidity in the raw water is seen to fluctuate significantly. From early 2015 a significant improvement in treated water turbidity is observed with some spikes, particularly in summer months. Improvement in treated water quality relates to the finalisation of the new filter commissioning and overall optimisation of the upgraded WTP. Spikes in treated water turbidity relate to poor water quality from significant algal blooms (2016/17 summer) and tropical cyclone and associated storms in April 2018. Raw turbidity has seen a somewhat seasonal increase in turbidity from January 2020 to present, with a corresponding effect on treated water turbidity, although this has managed to be maintained below the CCP limit.

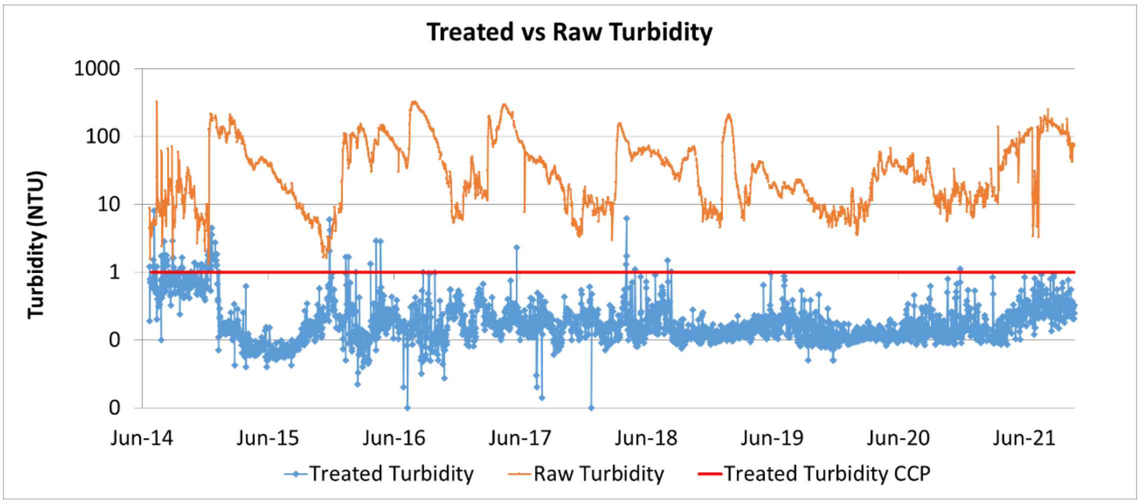

Figure 0-1: Dysart Raw and Treated Water Turbidity

Figure 0-2 shows free chlorine residual in treated water at Dysart. Historically there has been significant variation in residual level with a trend of very high chlorine residual observed from late 2015 to July 2017. However, free chlorine results in the reticulation for this period are all within acceptable limits suggesting that the increased chlorine dose at the WTP is to cope with higher losses in the network. Increased and formalised network flushing and reservoir desludging would help to reduce chlorine doses to achieve required residuals at the extremities of the network. Chlorine residuals have remained more stable and generally within CCP bounds from July 2017 onwards.

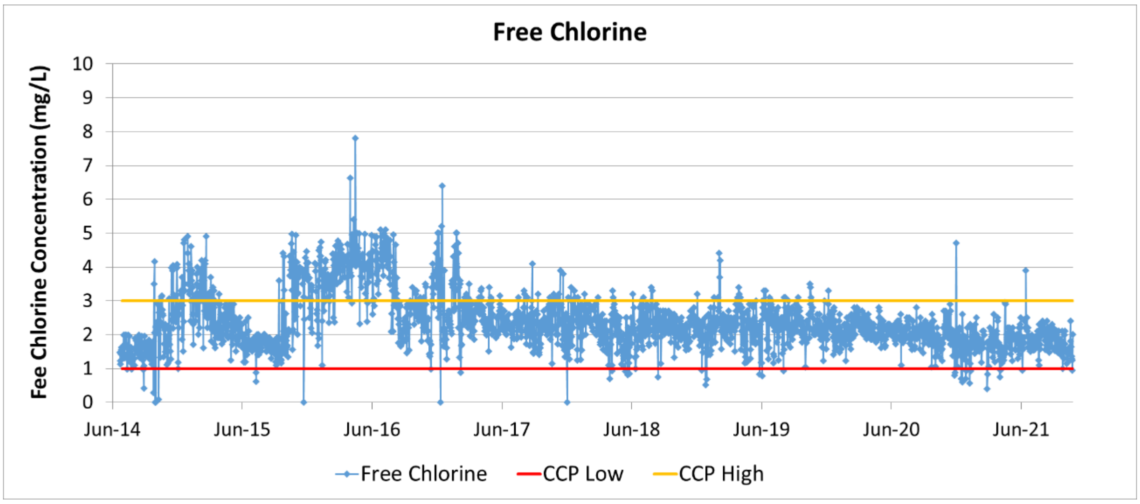

Figure 0-2: Dysart Treated Water Free Chlorine

Figure 0-3 shows raw and treated water levels for colour. Colour in the raw water is highly variable and significant peaks are observed in late 2016. Variability has also historically been observed in the treated water colour however this has improved in recent years. With some spikes well above the ADWG aesthetic limit in December 2014, 2016,April 2018 December 2020and June 2021.

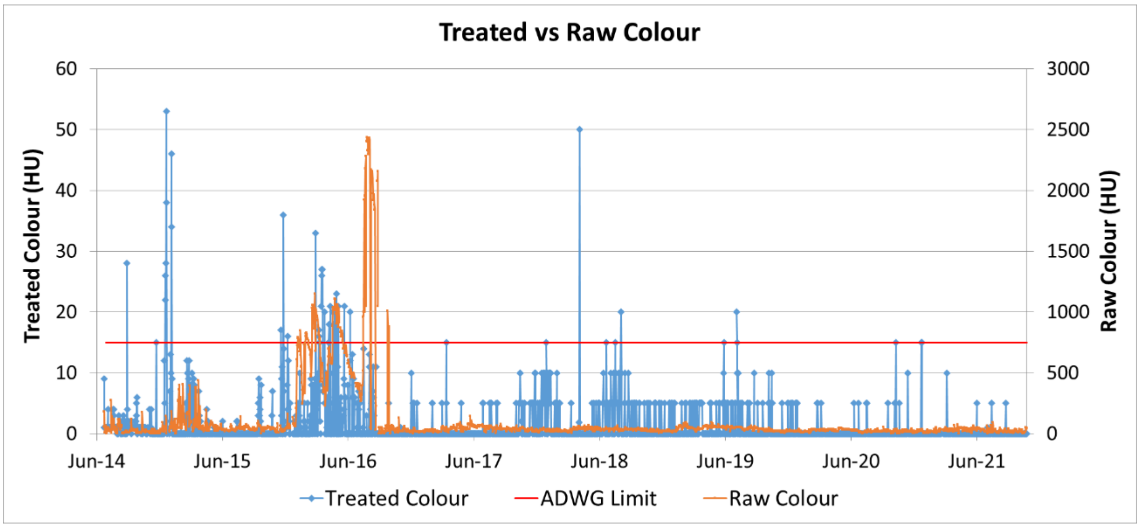

Figure 0-3: Dysart Raw and Treated Water Colour

Figure 0-4 shows manganese levels in the raw and treated water at Dysart. Significant peaks in both raw and treated water are observed in 2014. Since this time, there have been far fewer exceedances of the ADWG limit. This can be attributed to the upgrade of Dysart WTP to incorporate potassium permanganate dosing when required and a major upgrade of the filters. There was a small spike in raw water manganese in January 2020 but had no observable effect on treated water manganese concentrations.

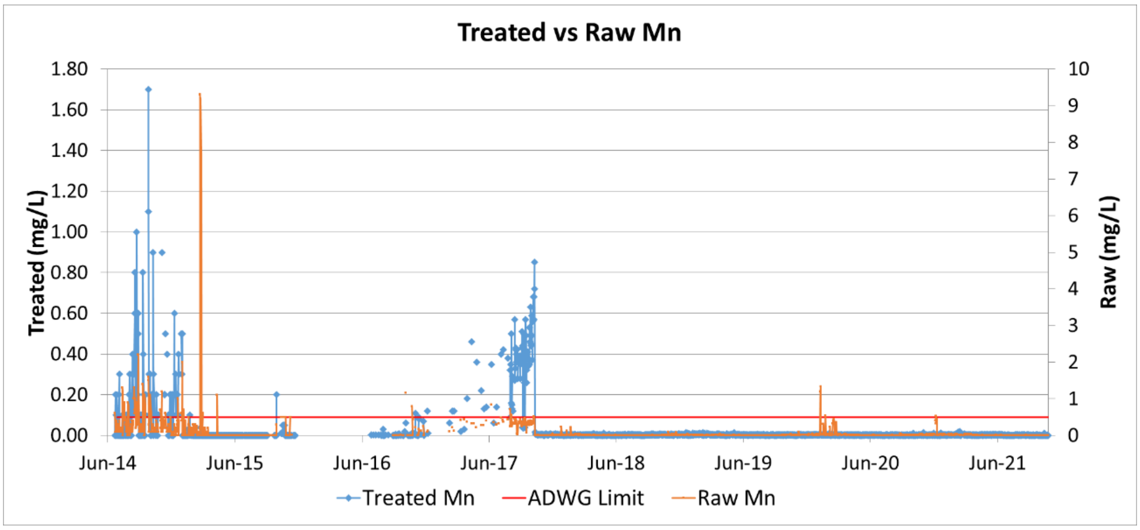

Figure 0-4: Dysart Raw and Treated Water Manganese

DYSART RETICULATED WATER QUALITY

The sample results from Dysart reticulated water quality are presented in Table 0-5: Dysart Reticulated Water Quality (January 2014 to October 2021) table below. In the past, chlorine residual was sometimes very low however *E. coli* has not been detected since December 2011. There has been significant improvement since 2015 when Stage 1 of the new Dysart WTP was completed.

TABLE 0-5: DYSART RETICULATED WATER QUALITY (JANUARY 2014 TO OCTOBER 2021)

Samples taken at: Fisher Street Sports Complex, Fox Park, Centenary Park, Lions Park, Powell St SPS

Parameter	No. of Samples	Summary of Results					ADWG Guideline Value [31]	No. of Samples Exceeding ADWG Guideline Value
		Minimum	5th Percentile	Average	95th Percentile	Maximum		
E. coli (MPN/100 mL)	359	ND	ND	ND	ND	ND	<1 (H)	0
Free Chlorine (mg/L)	356	0.02	0.06	0.90	1.94	3.87	0.2-5.0 (H)	44, 0
Total Iron	11	<0.007	<0.007	0.042	0.138	0.217	<=0.3 (A)	2
Total Manganese	11	<0.004	<0.004	0.059	0.202	0.241	<=0.5 (H) <=0.1 (A)	0 0
pH	318	6.77	7.14	7.45	7.8	8.3	6.5-8.5 (A)	0
Total Coliforms (cfu/100 mL)	291	<1	<1	1.00	<1	2		
True Colour (HU)	10	1	1	3.90	9.95	14	<=15 (A)	0
Turbidity	8	0.16	0.18	2.42	7.10	7.77	<=5 (A)	2

[31] A = aesthetic guideline value; H = health-based guideline value

DYSART WATER QUALITY COMPLAINTS

There were a number of water quality complaints recorded by IRC during 2011 and 2012. Most are related to dirty water and discoloured water. It is understood from the Supervisor that the issues have been addressed by water main flushing and temporary increase of operational monitoring. Refer to Section 0 for details.

In addition, there have been various dirty water complaints in Dysart in summer months of 2012/2013. The causes of these complaints have not been fully established and an expanded monitoring regime has been recommended to better define the water quality parameters., however it is likely that these relate to the elevated manganese levels that were being experienced at the time.

In the 2014/15 financial year 1 dirty water complaint was reported, and 6 reported in 2015/16. An additional 6 complaints were received in 2015/16 regarding odour. Six complaints were received in 2016/17 for water taste due to an outbreak of algae in the raw water source.

Four water quality complaints were recorded in 2017/18 – two for discoloured water, one for taste and the other for odour. In 2018/19 two water quality complaints were received – both for discoloured water. This was the same as for the 2019/20 reporting year. Two quality complaints were recorded in the 2020/21 reporting year, both for odour.

DYSART KEY ISSUES

No key water quality issues in the Dysart water scheme have been identified. Council will continue to monitor treated water quality to optimise treatment processes and ensure plant performance is acceptable.

MIDDLEMOUNT WATER SCHEME

Raw water for the Middlemount Water Scheme is provided from the Bingegang weir. The raw water for this weir is abstracted from the Mackenzie River, approximately 60 km away. SunWater operates the dam, pipeline and Tralee pump station which supplies raw water to the Middlemount WTP raw water turkeys nest. For further details of the raw water supply, refer to Figure 0-4 which shows the Bingegang weir water allocations.

Water from the WTP is provided to the residents of Middlemount via a gravity reticulation network. The infrastructure for the overall scheme is shown schematically in Figure 0-1. The WTP process is shown schematically in Figure 0-2. An overview of the Middlemount Water Scheme is shown in Table 0-1 with further detail in the sections following.

TABLE 0-1: MIDDLEMOUNT SYSTEM OVERVIEW

System Component	Description
Population Supplied	Total connections of approximately 969 comprising approximately 1,841 persons.
Water Sources	Surface water from the Mackenzie River via the Bingegang Weir (owned by BMA and operated by SunWater)
Water Storage (Before Treatment)	Raw water is stored in a 10 ML Turkeys Nest Dam onsite prior to treatment
Water Treatment	Surface Water from the Bingegang Weir is dosed with pre-treatment chemicals prior to entering the turkey's nest dam: • Pre-pH correction with sodium hydroxide (if required); • Oxidation with potassium permanganate. Raw Water from the Bingegang weir is treated at Middlemount WTP as follows: • Oxidation of iron and manganese with potassium permanganate (at the raw water pump station) • PAC Dosing on the discharge side of the raw water pumps (when necessary); • Pre-pH correction with caustic if required • Chlorine Gas dosing for iron and manganese oxidation (optional); • Coagulation with an ACH blend; • Polymer dosing for improved coagulation; • Flocculation; • Clarification; • PAC dosing for additional taste and odour removal (optional); • Pre-filter chlorination for residual iron and manganese removal in the filters (optional); • Sand filtration; • Post-pH correction with sodium hydroxide or acid (if required); and • Disinfection with chlorine gas. The wastewater system comprises:

TABLE 0-1: MIDDLEMOUNT SYSTEM OVERVIEW	
System Component	**Description**
	• Filter Backwash Tank (supernatant from this tank is used for onsite irrigation); • Sludge drying beds; and • Supernatant recycle to turkeys nest dam.
Water Storage (After Treatment)	• 2 x 100 kL Clearwater Tanks onsite • 8 ML Treated Water High Level Reservoir The Clearwater Tanks and Reservoir are fully enclosed and vermin proofed.
Distribution of Product	Gravity fed from the Water Tower via approximately 23 km of reticulation mains.
Any Special Controls Required	Quality of chemicals, materials, etc. used in the production and delivery of the product. Manual verification sampling of water from the distribution network. Backflow prevention and trade waste management. Operation and maintenance of all infrastructure to prevent recontamination.

Middlemount Overall Water Scheme

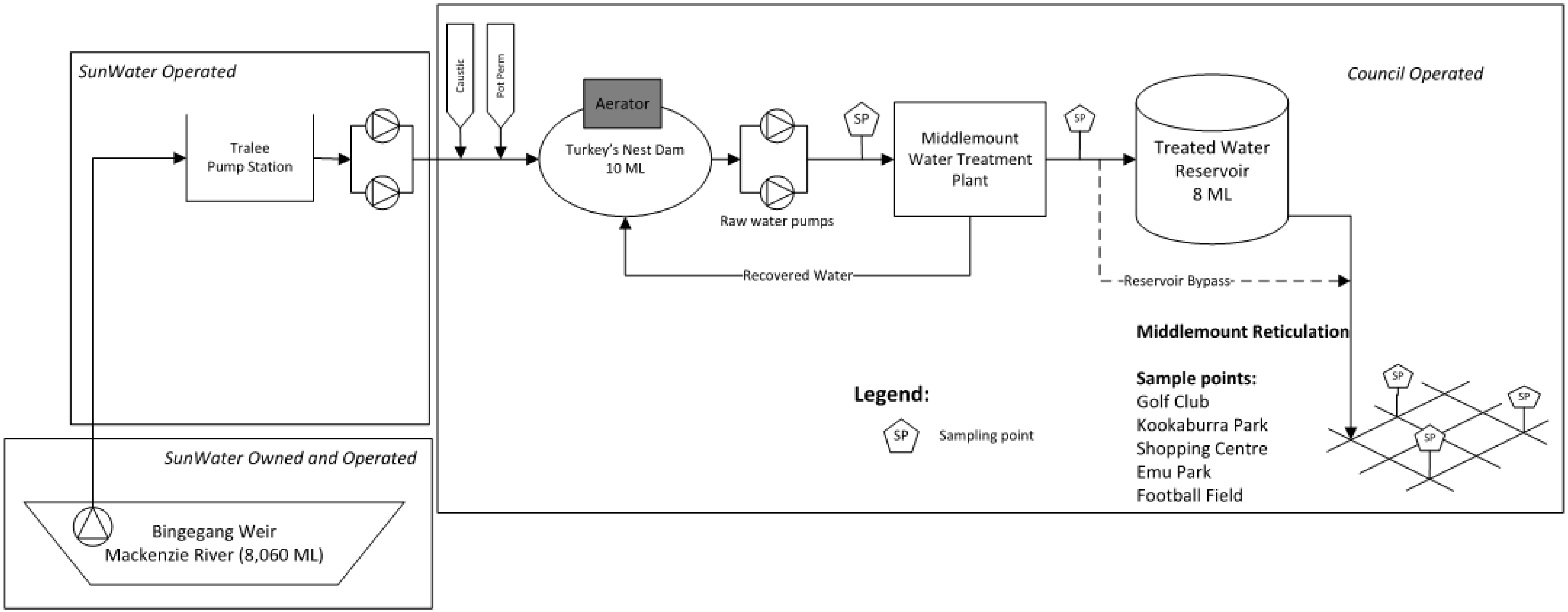

Figure 0-1: Middlemount Water Supply Scheme

Middlemount Water Treatment Plant

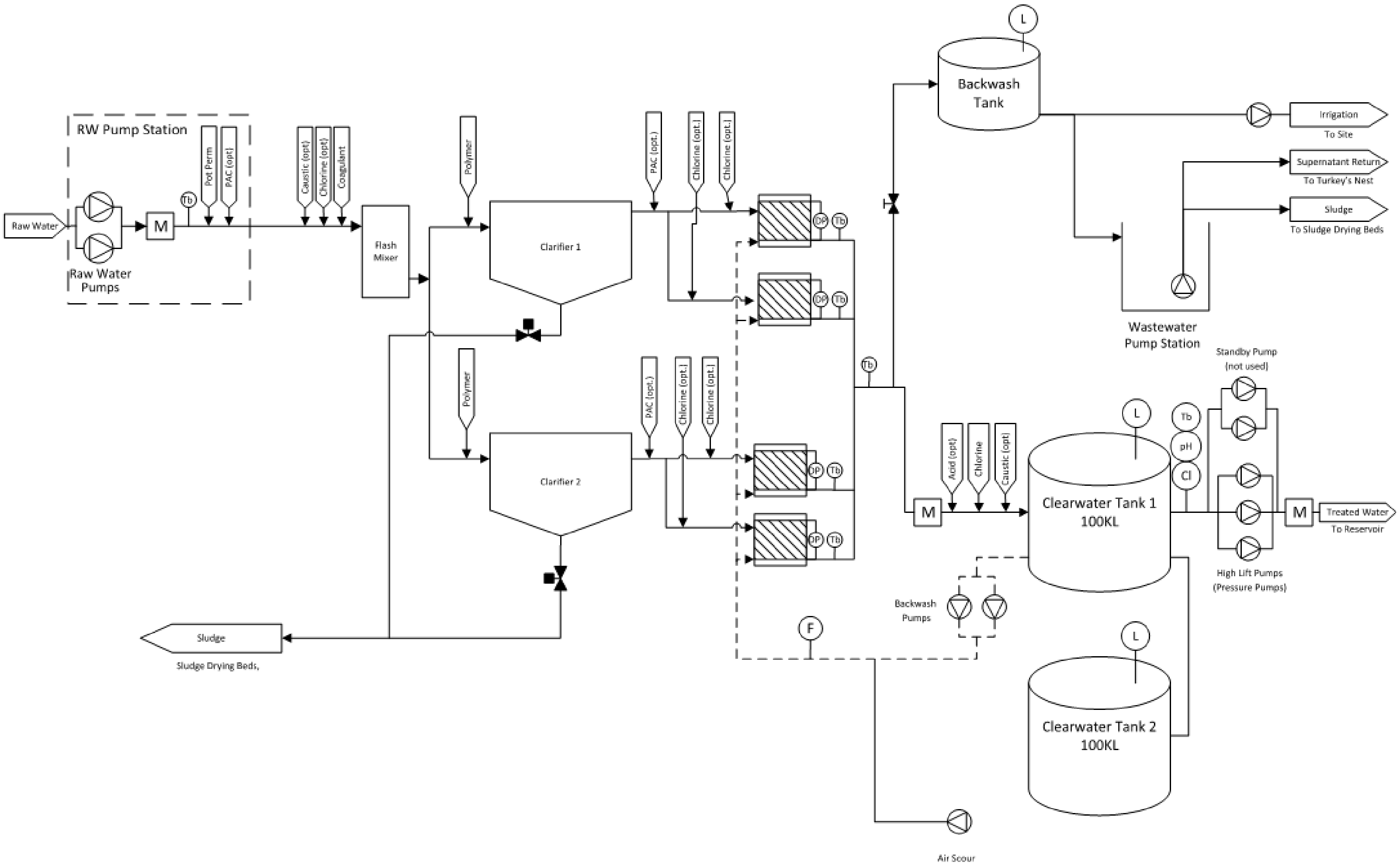

Figure 0-2: Middlemount Water Treatment Plant

MIDDLEMOUNT CATCHMENT

The Bingegang Weir is located in the Nogoa/Mackenzie system which is 79,615 km^2. The mean annual rainfall in the area is 550-650 mm[32]. Aside from being raw water supply to the Dysart WTP and Middlemount WTP; the catchment has the following uses:

- Grazing
- Contact recreation including swimming, sailing, fishing
- Supplying mining facilities
- Supplying other domestic users

Figure 0-3Figure 0-4: Bingegang Weir Water Allocations shows the location of the Bingegang Weir, Middlemount and the BMA Mine.

MIDDLEMOUNT RAW WATER

The raw water from the turkey's nest is used to feed the Middlemount WTP. The turkey's nest at Middlemount is operated by Council and because the turnover rate of water is higher, algal growth is not a major problem (unlike downstream at Dysart). However large and more frequent blooms have been experienced in recent years, leading to treatment upgrades at the WTP including an aerator in the dam and additional chemical dosing.

There is one Turkey's Nest at the WTP which stores up to 10 ML of raw water. An aeration system has been installed in the turkey's nest dam to help manage influent water quality and minimise algal blooms.

Figure 0-3: Middlemount Raw Water Turkey's Nest

[32] http://www.anra.gov.au/topics/water/overview/qld/swma-nogoa-mackenzie.html

TABLE 0-2: MIDDLEMOUNT UPSTREAM WATER INFRASTRUCTURE OWNERS

Infrastructure	Owners/Operator	Responsibility
Bingegang Weir	Sunwater	Asset Owner
	Sunwater	Operation and maintenance
Intermediate Pump Stations	BMA	Asset Owner
	Sunwater	Operation and maintenance
Turkey nest and Raw water pumps at Middlemount WTP	Isaac Regional Council	Asset owner and operator of the raw water storage and raw water supply to Middlemount WTP

MIDDLEMOUNT WATER TREATMENT PLANT

Raw Water Dosing

Raw water is pumped to the Middlemount WTP from the turkey's nest and the flow is measured by a flowmeter. The raw water pumps are arranged in a duty/standby configuration.

Chemicals are dosed after the raw water pumps and flowmeter, prior to the flash mixer, with extra dosing points available to enable trials or alternate dosing configurations. Potassium permanganate and PAC can be dosed at the pump station to provide additional contact time prior to coagulation. The coagulant used is an ACH blend and is dosed on the inlet of the flash mixer. The coagulant dose rate is set by the operator and adjusted as required. The chemical dosing stops when no WTP flow is detected at the inlet flowmeter. The coagulant dosing system has two dosing pumps which operate as duty/standby. The pump duty is automatically rotated on daily startup.. Sodium hydroxide and chlorine gas can be dosed for pH correction and as an alternate oxidant at the inlet to the flash mixer if required, but are not often used.

Flash Mixing and Flocculation

The flash mixer tank has baffles which promote turbulent mixing of the raw water and coagulant.

Water flows by gravity from the flash mixer to the flocculation chamber in the centre of one of two clarifiers. Flow to each clarifier is evenly split by a manually adjusted valve. Polymer is dosed at the inlet to each clarifier to improve coagulation.

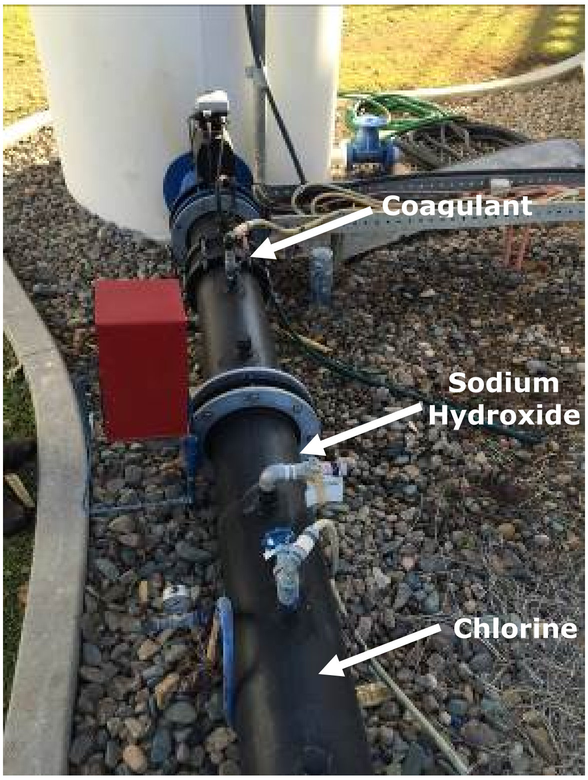

Figure 0-4: Dosing Points on Flash Mixer Inlet

Clarification

The flocs that have formed in the flocculation chamber settle to the bottom of the clarifier. Clarified water flows out via the launders and into the filters through the outlet channel.

Sludge is released by opening an air-actuated de-sludge valve at the bottom of the clarifier. The de-sludge valve opens automatically based on an operator adjustable timer setting. Blowdown is currently scheduled to occur for ~30 seconds every 10 minutes.

There are two clarifiers at Middlemount, one constructed of welded steel and the other of concrete. Based on visual inspection the internal surfaces of the clarifiers appear to be in poor condition. The internal painted surface of the steel clarifier is peeling and risks blocking the sludge outlet. Structural integrity of the clarifier is also unknown as the deterioration of the protective coating may have enabled pitting and corrosion. The internal surface of the concrete clarifier is also in poor condition with the smooth cement finish eroded in some areas. The external surfaces, structures and ancillaries appear to be in good condition with no signs of deterioration.

Figure 0-5: Middlemount Clarifiers and Sand Filters

PAC can be dosed into the outlet channels of the clarifiers for adsorption of tastes and odours if required. PAC is often required in the summer months if algae is present in the turkey's nest dam.

Filtration

The clarified water flows by gravity into four sand filters (two filters for each clarifier). Clarified water can be dosed with chlorine at the inlet to each filter for oxidation of residual taste and odour compounds and maintain a manganese oxide coating on the filter media.

Differential pressure and turbidity are continuously monitored for each individual filter. Operators manually initiate backwash approximately every 28-32 run hours, headloss, turbidity or based on flow volume through the filter. Filters are resumed to operation when the filtered water is visually clear. During backwashing, the WTP is downrated so as not to overload the remaining online filters.

Filter media in all filters has been replaced. Maintenance and repairs to damaged nozzles and filter floors were also included in this work.

Clearwater Tanks

The filtered water main from the filters to the clear water tank is dosed with chlorine for disinfection. Sodium hydroxide and hydrochloric acid can also be dosed for final pH correction of the treated water if required.

There are two Clearwater tanks which are hydraulically linked and only one of them is usually in use. From the clear water tanks, water is pumped by a set of pressure pumps to a high level reservoir. The old centrifugal pumps remain as a standby system in the event of duty pumps failure.

Figure 0-6: Middlemount WTP Lift Pumps

Clear Water Tank 1 has been refurbished to address corrosion and vermin proofing issues previously identified. All treated water tanks and reservoirs are now vermin proof and in good repair.

Sludge and Backwash Treatment

Backwash water is collected in a Backwash Recovery Tank. Filter backwash water is used for irrigation around the plant or it can flow to the sludge drying beds. The Backwash Recovery Tank is sized for one backwash volume only and requires the irrigation system to be operating if consecutive backwashes are required.

There is also a 6 kL wastewater pump station with programmed operating modes that directs wastewater to appropriate onsite uses. Supernatant can be used for irrigation directly from the Backwash Recovery Tank, settled sludge is pumped to the sludge drying beds and remaining supernatant can be recycled back into the raw water turkey's nest dam.

Figure 0-7: Sludge Drying Beds

Clarifier sludge is sent to the sludge drying beds. A decant pump located at the drying beds, recycles supernatant to the raw water turkey's nest.

Chemical Dosing

The WTP process currently employs the following chemicals:

TABLE 0-3: CHEMICAL USE IN THE MIDDLEMOUNT WATER TREATMENT PROCESS		
Chemicals	**Dosing Location**	**Use**
Potassium Permanganate	Turkey's Nest inlet Raw water pumps outlet	Iron and manganese oxidation
Sodium hydroxide	Turkey's Nest inlet Flash mixer inlet Clear water tank inlet	Pre-pH correction Post-pH correction
PAC	Raw water pumps outlet Clarifier Outlet Launder	Taste and odour removal (when required)
Coagulant (ACH blend from SNF Chemicals)	Flash Mixer Inlet	Coagulant and Flocculation
Polymer	Clarifier inlets	Coagulation aid
Chlorine Gas	Flash mixer inlet Filter inlets Filtered water main	Iron and Manganese removal Disinfection
Acid	Clear water tank inlet	Post-pH correction

All chemical dose rates are flow paced. All chemical dosing will stop if no flow is detected by the raw water inlet flow meter. All chemical dosing points are injection lances.

MIDDLEMOUNT RESERVOIR

Water from the clear water tank is pumped using a set of three high lift pumps to a high-level reservoir. Water flows by gravity from the elevated reservoir through the Middlemount reticulation network, and no additional pressure boosting is required. The reservoir site is fenced, and the reservoir roof is enclosed. Some areas of corrosion are present on the reservoir roof.

TABLE 0-4: MIDDLEMOUNT RESERVOIR	
Volume	8 ML
Materials of construction	Steel
Roof	Yes
Vermin-Proof	Yes

The Middlemount Reservoir has a common inlet/ outlet arrangement. This configuration could risk short circuiting of flow and insufficient chlorine contact time for effective disinfection.

Figure 0-8: Middlemount Treated Water Reservoir

MIDDLEMOUNT RETICULATION

Middlemount has approximately 23 km of reticulation pipelines. All of the existing pipelines on record are asbestos cement. Operators have not reported any low water pressure or flow stagnation issues.

MIDDLEMOUNT WATER SUPPLY SYSTEM CAPACITY

The recent plant audit indicated that the theoretical treatment plant capacity is approximately 90 L/s. However, the raw water pump and the final water supply pump can deliver up to 82 and 120 L/s respectively.

As compared with the treated water production figure, the WTP has sufficient capacity to meet the current and projected 2021 peak day water demand. However, Council has been monitoring the potential mine development projects in the area in order to facilitate infrastructure planning.

The combination of clearwater tank, rising main and the reservoir provides sufficient chlorine contact time before the water reaches the customers. However, given the arrangement of the reservoir pipework, an additional chlorine booster pump station on the outlet of the reservoir prior to the township may provide greater control over disinfection efficiency and chlorine residuals. To better manage this in the short term, reservoir operating levels have been tightened to reduce water age as a result of reduced network demand. If demand increases in future, options for a chlorine booster station may be considered further.

MIDDLEMOUNT STAKEHOLDERS

Stakeholders of the Middlemount water scheme are detailed in the table below.

TABLE 0-5: MIDDLEMOUNT STAKEHOLDERS			
Organisation	**Contact Name and Details**	**Relevance to management of drinking water quality**	**How the stakeholder is engaged in the DWQMP**
BMA		Owner of raw water infrastructure	Not engaged
SunWater		Contractor engaged for maintenance / operation of raw water infrastructure	Not engaged
Residential Users		Supplied with reticulated water from the Middlemount scheme	Not engaged

MIDDLEMOUNT WATER QUALITY

The quality of raw water at Middlemount WTP is generally good. The tables below provide the current operational monitoring and a summary of the water quality data.

OPERATIONAL MONITORING

The operational monitoring that is currently undertaken at Middlemount is detailed in the following table.

TABLE 0-1: MIDDLEMOUNT OPERATIONAL MONITORING

Process Step	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Operator Sampling							
Raw Water	Temperature	N/A	Daily	N/A	Monitoring only	N/A	N/A
Raw Water	pH	None in raw water	Daily	N/A	Assess chemical dosing requirements if pH becomes high or low	N/A	N/A
Raw Water	True Colour	None in raw water	Daily	N/A	Assess chemical dosing requirements if colour is high	~~N/A~~	~~N/A~~
Raw Water	Turbidity	None in raw water	Daily	N/A	Assess chemical dosing requirements if turbidity is high	N/A	N/A
Raw Water	Conductivity	Salts	Daily	N/A	Monitoring only	N/A	N/A
Raw Water	Total Manganese	None in raw water	Daily	N/A	N/A	N/A	N/A
Raw Water	Total Iron	None in raw water	Daily	N/A	N/A	N/A	N/A
Raw Water	Hardness	None in raw water	Weekly	N/A	N/A	N/A	N/A
Raw Water	Alkalinity	Coagulation failure	Weekly	N/A	Assess soda ash dosing requirements	N/A	N/A
Dosed Water	Free chlorine	Metals (in treated water)	Daily	>0.1 mg/L (maintain residual)	Adjust chlorine gas dosing	N/A	N/A
Dosed Water	pH	Poor coagulation	Daily	6.5 - 7.5	Adjust chemical dosing	N/A	N/A
Dosed Water	Temperature	N/A	Daily	N/A	Monitoring only	N/A	N/A
Dosed Water	UV254		Daily				
Settled Water (clarifier outlet)	Free chlorine	Metals (in treated water)	Daily	>0.1 mg/L (maintain residual)	Adjust chlorine gas dosing	N/A	N/A
Settled Water (clarifier outlet)	pH	Aesthetic issue (in treated water)	Daily	6.5 – 7.5	Monitoring only	N/A	N/A
Settled Water (clarifier outlet)	True Colour	Disinfection by-products	Daily	< 15 HU	Monitoring only	N/A	N/A
Settled Water (clarifier outlet)	Temperature	N/A	Daily	N/A	Monitoring only	N/A	N/A

TABLE 0-1: MIDDLEMOUNT OPERATIONAL MONITORING

Process Step	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Settled Water (clarifier outlet)	Turbidity	Pathogens	Daily	<2.0 NTU	Check coagulation pH. Adjust coagulant and/or soda ash dose rates.	N/A	N/A
Settled Water (clarifier outlet)	UV254		Daily				
Treated Water	pH	Acidic or alkaline water	Daily	7 – 7.5	See Critical Control Points for Middlemount		
Treated Water	Turbidity	High Turbidity	Daily & inline	<0.5 NTU	See Critical Control Points for Middlemount		
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria High chlorine increases risk of by-products	Daily	1.5 - 2.5 mg/L	See Critical Control Points for Middlemount		
Treated Water	True Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Daily	< 15 HU	Adjust WTP chemical dosing.	N/A	N/A
Treated Water	Total Manganese	High Manganese	Daily	<0.05 mg/L	This level causes possible staining. Chlorine dosing should be adjusted (ADWG Health limit 0.5 mg/L)	N/A	N/A
Treated Water	Total Iron	High Iron (aesthetic)	Daily	<0.3 mg/L	This level causes possible staining. Chlorine dosing should be adjusted	N/A	N/A
Treated Water	Alkalinity	N/A	Weekly	N/A	N/A	N/A	N/A
Treated Water	Hardness	Aesthetic and problems with lathering	Weekly	<200 mg/L	Monitoring only (if hardness is a continuous problem, consider water softening equipment)	N/A	N/A
Treated Water	Aluminium	High Aluminium	Weekly	< 0.2 mg/L	Check coagulant dose (overdosing may be occurring)	N/A	N/A
Treated Water	TDS	Salts (aesthetic issue)	Daily	<600 mg/L	Monitoring only (TDS removal methods not available at Middlemount WTP)	N/A	N/A
Town Water	True Colour	Formation of disinfection by-products (DBPs) from high colour and chlorine dosing	Twice Weekly	< 15 HU			
Town Water	Turbidity	High turbidity	Twice Weekly	< 0.5 NTU			
Town Water	pH	High or low pH	Twice Weekly	6.5 – 8.5			

TABLE 0-1: MIDDLEMOUNT OPERATIONAL MONITORING							
Process Step	**Parameter**	**Associated Hazard**	**Sampling Frequency**	**Target Limit**	**Action if Target Limit Exceeded**	**Critical Limit**	**Action if Critical Limit Exceeded**
Town Water	Free Chlorine	Pathogens	Twice Weekly	0.2 – 1.0 mg/L			
Town Water	Total Manganese	High manganese	Twice Weekly	< 0.05 mg/L			
Town Water	Total Iron	High Iron (aesthetic)	Twice Weekly	< 0.3 mg/L			

CRITICAL CONTROL POINTS

Table 0-2 details the critical control points (CCPs), limits and rectification actions for Middlemount WTP. Target limits are in line with ADWG best practice operation guidelines and critical limits are as per ADWG health limits.

TABLE 0-2: MIDDLEMOUNT CRITICAL CONTROL POINTS

Process Step	Parameter	Associated Hazard	Sampling Frequency	Target Limit	Action if Target Limit Exceeded	Critical Limit	Action if Critical Limit Exceeded
Filtered Water	Turbidity	Pathogens	As frequently as practicable, minimum daily. (Target online ASAP)	<0.2 NTU	Optimise coagulation, i.e. adjust coagulant dose rate and coagulation pH. Backwash filter if turbidity continues to approach critical limit.	0.5 NTU	Backwash filter immediately then continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	pH	Acidic or alkaline water	Daily	7 – 7.5	Monitoring only	<6.5 or >8.5	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Turbidity	High Turbidity	Daily	<0.5 NTU	Adjust WTP chemical dosing Backwash filter(s) if required	1.0 NTU	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit Advise W&WW Manager if critical limit exceeded
Treated Water	Free chlorine	Low chlorine increases the risk of bacteria High chlorine increases risk of by-products	As frequently as practicable, minimum daily. (Target online ASAP)	1.5 - 2.5 mg/L	Target limit is set to ensure that there is sufficient residual maintained throughout reticulation. If concentration outside the target limits, adjust chlorine dose rate	< 1.0 or >3.0 mg/L	Shutdown plant if immediate correction cannot be made Continue actions per Target Limit ADWG allows residual between 0.2 and 5.0mg/L. However, chlorine dose rate should be adjusted prior to reaching the low/high limits Action is critical if the concentration is below 1mg/L. If the concentration is too low at the exit of the plant, an adequate residual is unlikely to be maintained in the reticulation Advise W&WW manager of non-compliant water

MIDDLEMOUNT RAW WATER QUALITY

Presented below are the results of raw water testing.

TABLE 0-3: MIDDLEMOUNT RAW WATER QUALITY									
Middlemount Raw Water – Bingegang Weir									
Parameters	Units	Sampling Location	Summary of Results (July 2014 – October 2021)						Comments
			No. of Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	
Turbidity	NTU	Raw water main into WTP	2471	0.00	6.07	167.94	631.50	2242.00	Turbidity tends to be high around January each year.
True Colour	HU		2458	0	3	31	70	298	Colour also tends to increase when turbidity increases.
Iron	mg/L		1564	0.000	0.000	0.056	0.135	5.000	
Manganese	mg/L		1750	0.000	0.000	0.130	0.420	4.000	
pH	pH units		2454	4.46	7.01	7.77	8.43	9.78	
Alkalinity	mg/L		346	16	48	82	120	280	
Hardness	mg/L		168	15.0	30.0	74.7	120.0	210.0	Samples taken weekly commencing July 2017.
Conductivity	µS/cm		1316	0	159	277	437	659	Samples taken daily commencing August 2017.

MIDDLEMOUNT TREATED WATER QUALITY

Daily samples of treated water are collected for onsite analysis. The results of these from available recorded data are provided in the table below.

Table 0-4: Middlemount Treated Water Quality

Middlemount Water Treatment Plant													
Parameters	Units	Sample Location	Summary of Results (July 2014 – October 2021)						CCP		ADWG		Comments
			No. of Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	Critical Limit	Exceptions	Guideline Value [33]	Exceptions	
pH	pH Units	Treated Water to Reservoir	2468	1.90	7.03	7.37	7.68	8.76	6.5-8.5	1, 13	6.5-8.5 (A)	1, 13	0.57% of samples were outside of CCP/ADWG limits
Turbidity (Lab)	NTU		2467	0.00	0.07	0.26	0.72	4.48	1	27	<=1 (H)[34] <=5 (A)	27, 0	1.1% of sampled above CCP limit and ADWG recommendation at point of disinfection with chlorine
Turbidity (Inline)	NTU		2179	0.00	0.00	0.07	0.20	2.50	1	2	<=1 (H)[35] <=5 (A)	2	0.1% of samples above CCP limit and ADWG recommendation at point of disinfection with chlorine
Colour	HU		2453	0.0	0.0	0.4	2	30	N/A	-	<=15 (A)	5	0.2% of samples above ADWG aesthetic limit
Iron	mg/L		1715	0.000	0.000	0.006	0.020	0.100	N/A	-	<=0.3 (A)	0	
Manganese	mg/L		1900	0.000	0.000	0.067	0.200	4.500	N/A	-	<=0.5 (H) <=0.1 (A)	2 525	0.1% of samples above ADWG health limit and 27.6% of samples above ADWG aesthetic limit
Alkalinity	mg/L		364	0	53	83	120	195	N/A	-	N/A	-	
Hardness	mg/L		192	30	45	77	115	140	N/A	-	60-200 (A)	38, 0	19.8% of samples are below the best practice aesthetic threshold
Chlorine	mg/L		2469	0.01	1.68	2.49	3.28	6.30	1.0-3.0	7, 275	0.2-5.0 (A)	3, 3	275 samples (13.6%) were above CCP limit and on 3 (0.1%) occasions the ADWG health limit was exceeded. 7 (0.3%) samples were below CCP limit and 3 (0.1%) of

[33] A = aesthetic guideline value; H = health-based guideline value

[34] Recommended at the point of disinfection with chlorine

[35] Recommended at the point of disinfection with chlorine

Table 0-4: Middlemount Treated Water Quality

Middlemount Water Treatment Plant													
													samples were below the ADWG health limit
Total Dissolved Solids	mg/L		1250	0	84	189	334	478	N/A	-	<=600 (A)	0	

Figure 0-1 shows raw and treated water turbidity for Middlemount WTP on a logarithmic scale. Raw water turbidity is seen to be highly variable, however treated water turbidity generally remains below the CCP limit. Slightly improved turbidity removal is observed from late 2015 onwards. There was recently a single treated water turbidity exceedance of >1 NTU in July 2021.

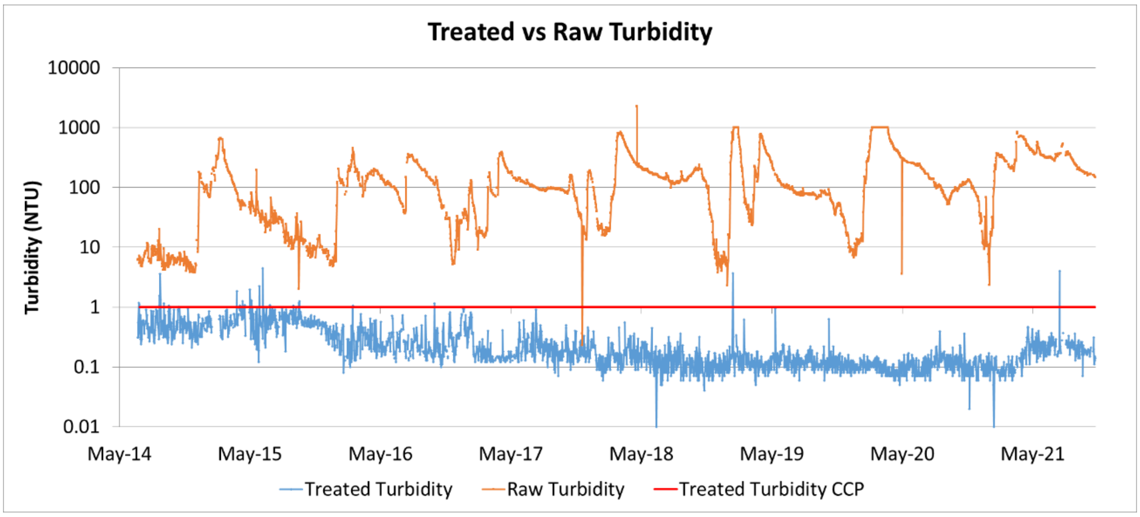

Figure 0-1: Middlemount Treated and Raw Water Turbidity

The figure below shows raw and treated water colour for Middlemount. True colour in the raw water is seen to vary, however does not show extreme peaks. Few exceedances of the treated water colour are observed over the last five years.

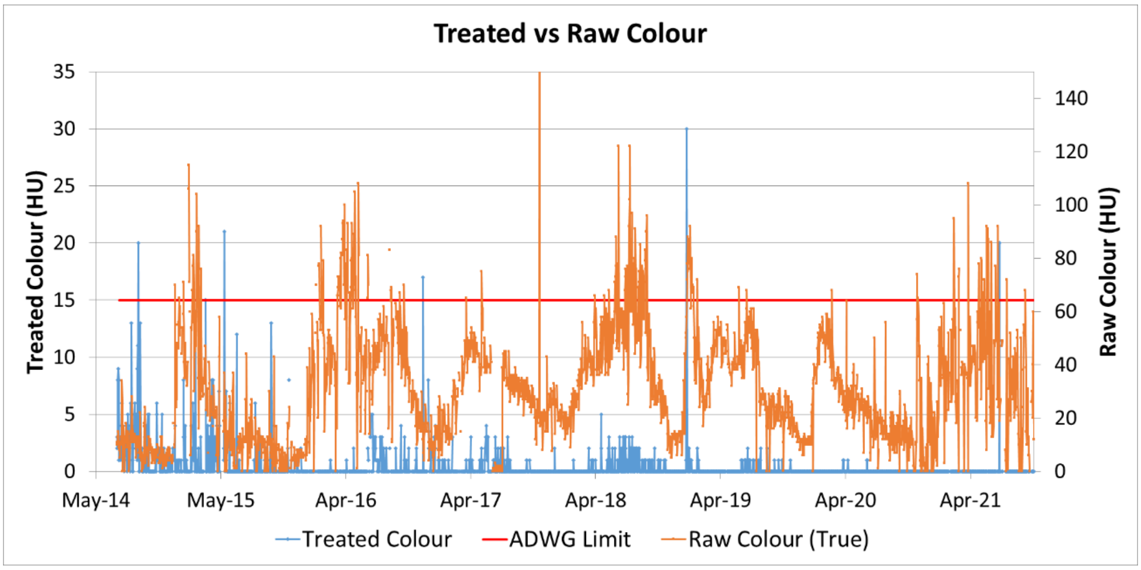

Figure 0-2: Middlemount Treated and Raw Water Colour

Figure 0-3 below shows free chlorine residual in the treated water for Middlemount. The residual is frequently observed to exceed the CCP limit of 3 mg/L. It is important to maintain a chlorine residual to all extremities of the reticulation; therefore it is usually preferable to maintain a slightly higher residual than to fall below the lower limit of the CCP. A review of the CCP limits for Middlemount has been included on the Improvement Plan and reservoir operating levels have been adjusted to minimise issues of residual maintenance in the short term.

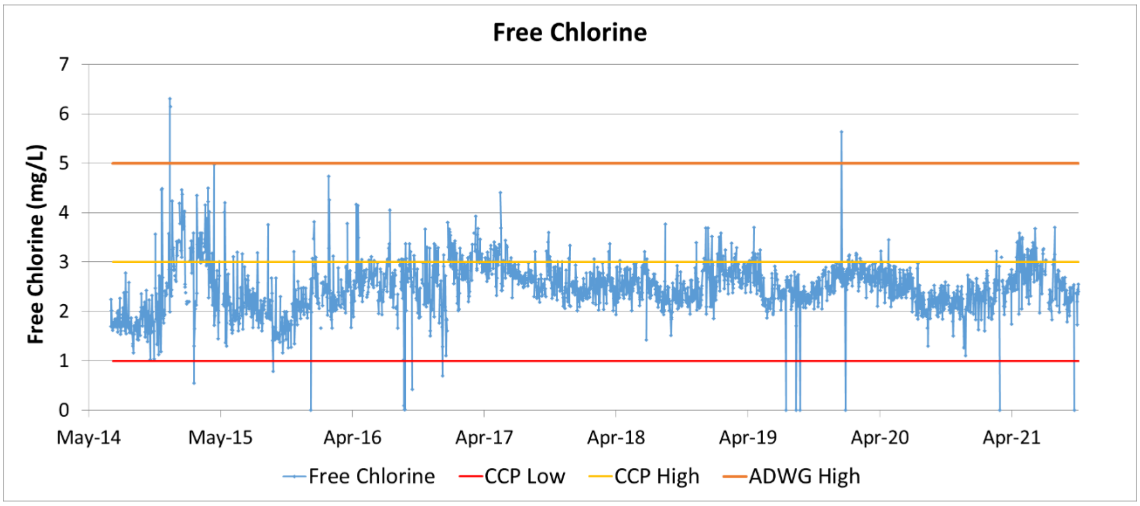

Figure 0-3: Middlemount Treated Water Free Chlorine

Figure 0-4 and Figure 0-5 show iron and manganese levels for the raw and treated water at Middlemount. The ADWG Limit is not shown on the iron graph as treated water levels were always well below the limit of 0.3 mg/L. There are a few significant spikes in the treated water manganese levels, however manganese has remained well below the ADWG health limit since 2015, despite some large spikes in raw water concentrations. Treated manganese levels have further dropped since June 2015 due to better management of the raw water and additional treatment processes being available at the WTP.

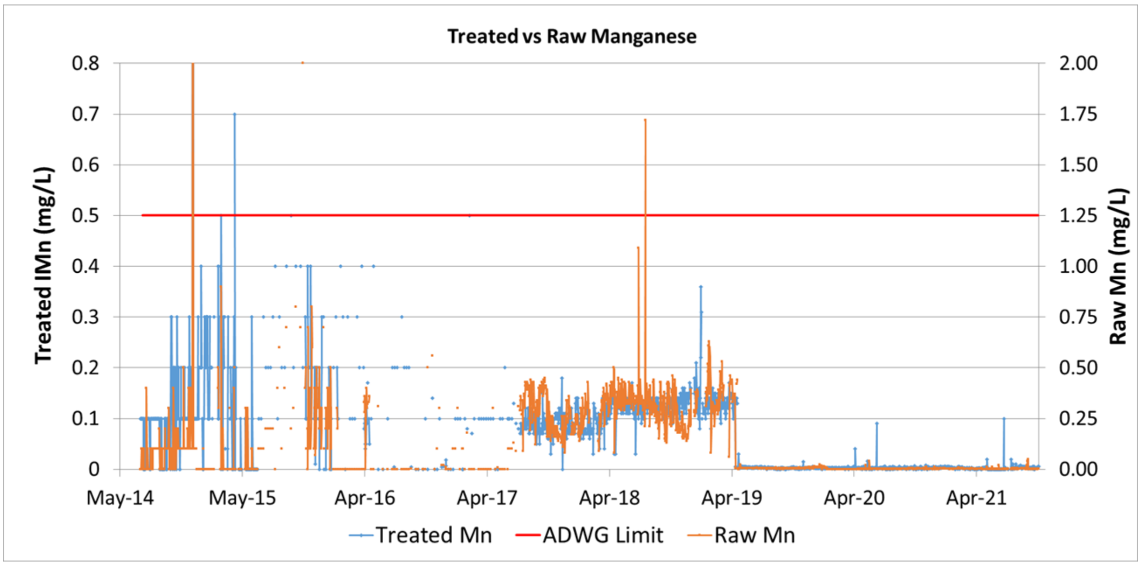

Figure 0-4: Raw and Treated Water Manganese Content

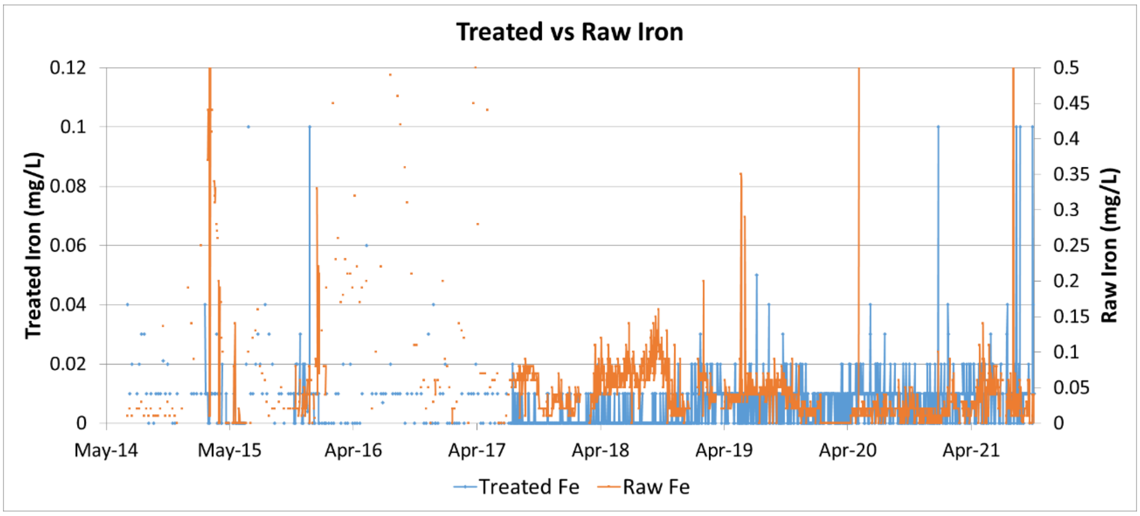

Figure 0-5: Middlemount Raw and Treated Water Iron

MIDDLEMOUNT RETICULATED WATER QUALITY

The sample results from Middlemount reticulated water quality are presented in Table 0-5: Middlemount Reticulated Water Quality (January 2014 to October 2021) table below. In the past, chlorine residual was sometimes low however this has improved in recent years.

TABLE 0-5: MIDDLEMOUNT RETICULATED WATER QUALITY (JANUARY 2014 TO OCTOBER 2021)

Sampling Locations: Footy Fields, Emu Park, Shopping Centre, Kookaburra Park, Middlemount Golf Course, Reservoir, Centenary Drive, Clarence Baker Drive

Parameter	No. of Samples	Summary of Results					ADWG Guideline Value [36]	No. of Samples Exceeding ADWG Guideline Value
		Minimum	5th Percentile	Average	95th Percentile	Maximum		
E. coli (MPN/100 mL)	356	<1	<1	<1	<1	<1	<1 (H)	0
Free Chlorine (mg/L)	357	0.02	0.06	0.73	1.72	2.74	0.2-5.0 (H)	47, 0
pH	311	6.88	7.12	7.49	7.81	8.42	6.5-8.5 (A)	0
Total Coliforms (cfu/100 mL)	288	<1	<1	<1	<1	9		

[36] A = aesthetic guideline value; H = health-based guideline value

MIDDLEMOUNT WATER QUALITY COMPLAINTS

Two water quality complaints were received by IRC between 2011 and 2012. They are related to dirty water complaints, and it is understood that the investigation did not identify the cause of the complaint. Similarly, there were a number of complaints during early 2013, and the causes of these water complaints were not established due to lack of information.

In 2014/15 there were 2 dirty water complaints recorded by IRC, and 1 additional complaint recorded in 2015/16. In the 2016/17 financial year there were 28 complaints received regarding dirty water and tastes. Significant algal blooms were experienced in the raw water sources and storages over the summer months which contributed to this.

In 2017/18 one complaint was received (unknown cause) and in 2018/19 one additional complaint of discoloured water was received. In 2019/20, two complaints were received, 1 for taste and 1 for odour. In 2020/21, one water quality complaint was received from a customer who developed a rash after showering and was therefore reported as a health concern. Additional testing was conducted and the results found to be within the acceptable water quality limits.

MIDDLEMOUNT KEY ISSUES

No key water quality issues in the Middlemount water scheme have been identified. Council will continue to monitor treated water quality to optimise treatment processes and ensure plant performance is acceptable.

INFORMATION DISTRIBUTION

This section describes the information distribution processes applicable to all of the water schemes.

- Operational documentation – Section 19.1;
- Procedure for water main flushing – Section 19.2;
- Water quality testing report data – Section 19.3;
- Incidents and Emergencies Management – Section 19.4;
- Complaints Procedures – Section 19.5;

Council has its own customised information management system, Enterprise Content Management (ECM), which records all water analysis reports received from external laboratories, water complaints, customer service request and response actions. It also stores the previous water complaint investigations, planning and engineering studies and reports.

In addition, IRC staff uses TechOne to record the tasks and response actions undertaken for the purpose of statistical, financial and maintenance information applied to IRC assets. TechOne has a Water Management Module which records water meter assets and information with regards to water billing.

OPERATIONAL DOCUMENTATION

The existing operation and maintenance documentation are detailed in Table 19-1 (Appendix 4 Documentation Register).

IRC has worked to update all Operating Procedures and documentation (including operation and maintenance manuals) for WTP and schemes, with the first focus being on the health and safety manuals.

Work instructions (formerly referred to as Standard Operating Procedures (SOPs)) are standardised documents which are issued to all WTPs and are also available via the IRC intranet (https://iris.isaac.qld.gov.au/cgfs/organisational-safety/whs-resources/work-instructions). The work instructions and site based management plans contain the following elements:

- WTP Process Description and Overview.
- Process Drawings and Site General Arrangement Drawings.
- Functional Description.
- Operational and Verification monitoring/testing regimes.
- Routine operational and maintenance tasks.
- Alarm list and process responses.
- Workplace Health and Safety issues and procedures.
- Equipment manuals from manufacturers.
- Communication protocols with other entities e.g. Sunwater, Bloomfield, BMA and Glencore in relation to response to changes in raw water quality.
- Emergency procedure.
- Water quality data management.
- Incident reporting procedures.
- Water main flushing program and procedures.

Other key water and wastewater documentation are also available via the IRC intranet:

- Water and wastewater site specific documentation: https://iris.isaac.qld.gov.au/w-w/home.
- Water and wastewater site checklists: https://iris.isaac.qld.gov.au/w-w/checklists.

Water and wastewater guidelines: https://iris.isaac.qld.gov.au/w-w/guidelines-and-procedures. The current practice for information distribution to the operators via regular toolbox meetings will continue.

WATER MAIN FLUSHING PROCEDURE

The network maintenance crew assess the water network condition and determine whether water main flushing is necessary. Flushing is also completed when complaints are received from customers. A formalised mains flushing procedure is in place that documents the procedure, frequency and trigger conditions.

DATA FLOW FOR WATER QUALITY TESTING REPORTS

Operational Monitoring Test Results

The Treatment Plant Team Leaders and operators enter their operational monitoring test results and plant records into the respective monthly spreadsheet records. The records are located on the share drive which can be accessed by the IRC operational staff. Integration of electronic devices to automate the data input into TechOne is underway.

Verification Monitoring Test Results

The operational staff regularly collect samples for verification testing. These samples are tested and analysed by an external laboratory (Mackay Regional Council). The test reports are in PDF format and are sent to:

- the relevant WTP operators and Team Leaders;
- Assets and Compliance Officer;
- Water and Wastewater Engineer
- Operations Manager, Water and Wastewater and
- IRC Records staff for record keeping (in ECM).

The flow of information for the current verification procedure for water quality test reports is presented schematically in Figure 0-1.

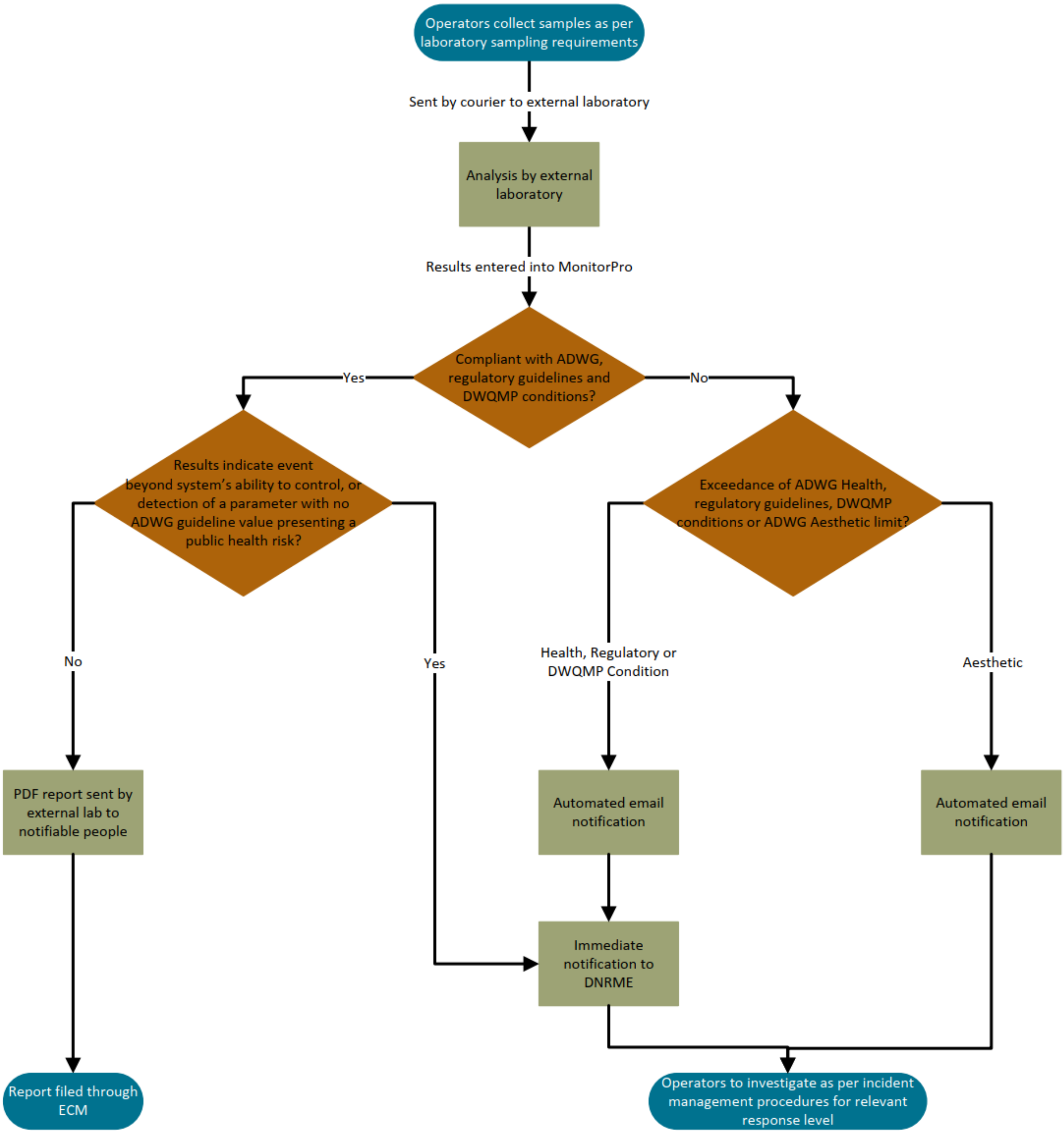

Figure 0-1: Current Verification Water Quality Test Reports Information Flow

In addition to the above flowchart, an additional procedure providing more details around the requirements for actioning complaints and investigating non-compliant water quality results has been developed. A summary of this procedure is presented as a flow chart in Figure 0-2.

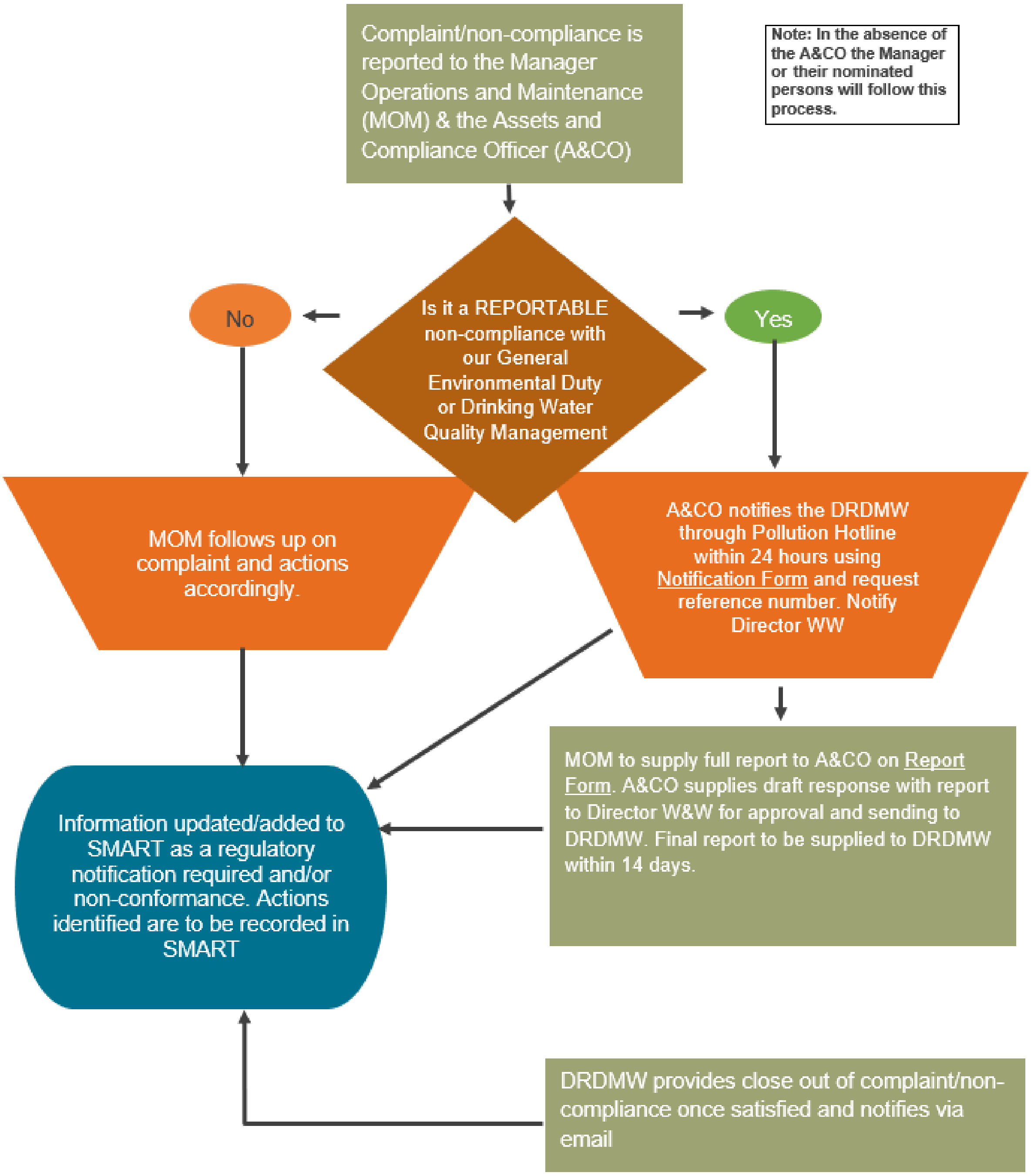

Figure 0-2: Non-Compliance Water and Effluent Water Reporting Process

As part of the initial development of the DWQMP, Harrison Grierson found that some historical data records were missing. Monitoring records have since been centralised as per the action identified in the Improvement Program, with operational records being stored on the Council share drive and verification results being stored online by the external lab (Mackay Regional Council) records system, Monitor Pro, and reports filed by records staff through ECM.

INCIDENT AND EMERGENCY MANAGEMENT

Council has developed procedures for operators to follow in specific emergency situations. IRC Emergency Management documentation are available via IRC's intranet: https://iris.isaac.qld.gov.au/cgfs/organisational-safety/whs-resources/emergency-management.

Emergency management and emergency response procedures, specific to drinking water quality management, include response to power failure and PLC failure. These procedures are also available via IRC's intranet:

- Power failure: https://iris.isaac.qld.gov.au/downloads/file/2882/power-failure-response-guideline-all-water-and-wastewater-sites-corp-gds-090
- PLC failure: https://iris.isaac.qld.gov.au/downloads/file/503/programmable-logic-controller-plc-failure-response-guide-corp-gds-089-docx

Council intend to adopt emergency response levels as per the table below.

TABLE 0-1: DESCRIPTION OF LEVEL

Incident / Emergency Level	Description of Level
Level 5	• Widespread outbreak of waterborne disease • Declared disaster during which water supply is unable to be maintained • Gross exceedances of ADWG health guideline values for a chemical parameter (e.g. more than five times the ADWG health guideline limit) • Significant elevation or gross exceedance of regulator guidelines, DWQMP conditions or parameter with no water quality criteria. • Water quality event which has escalated beyond ability to control, with risk to public health.
Level 4	• High level of E. coli (e.g. > 5 CFU/ 100 mL) or any pathogens detected in reticulation • Failure of infrastructure (severe or emergency level supply restrictions required to ensure continuity of supply) • High level of parameter with no water quality criteria presenting health risk.
Level 3	• Detection of 1-5 CFU/100 mL E. coli in reticulation • Failure of infrastructure (ability to supply water compromised – short term water restrictions may be required) • Minor exceedances of ADWG health guideline value for chemical parameter (determined value is close to guideline value). • Minor elevation or exceedances of regulator guidelines, DWQMP conditions or parameter with no water quality criteria.

TABLE 0-1: DESCRIPTION OF LEVEL	
Incident / Emergency Level	**Description of Level**
Level 2	• Failure of infrastructure or source supply (water quality or supply unlikely to be compromised or alternate process available to provide drinking water) • Exceedances of ADWG aesthetic guideline (customer complaints possible)
Level 1	• Exceedances of operational limit managed through operational and maintenance procedures

Management of incidents and emergencies will be as per Table 0-2.

TABLE 0-2: MANAGEMENT OF INCIDENTS AND EMERGENCIES			
Level	**Incident or Emergency**	**Summary of Actions to be Taken (with Documented Procedure Listed)**	**Positions Responsible for Actions**
5	Treated water contamination causing gross exceedance or elevation of ADWG health limits, regulator guidelines, DWQMP conditions or parameter with no water quality parameter OR Water borne disease OR Infrastructure failure resulting in inability to supply water OR Water quality event beyond ability to control	Operator to immediately notify Treatment Plant Coordinator. Treatment Plant Coordinator and O&M Manager Water and Wastewater by phone and follow up with a written description of the incident. If these people are not available, the Director of Water and Wastewater shall be notified O&M Manager Water and Wastewater to communicate with Director of Water and Wastewater to arrange for details of the incident to be communicated to the community as required	O&M Manager Water and Wastewater Reviewed by Director Water and Wastewater
4	Treated water contamination causing exceedance of ADWG health limits OR Severe failure of infrastructure resulting in severe reduction in water supply OR High level of parameter with no water quality criteria	Operator to immediately notify Treatment Plant Coordinator by phone and follow up with a written description of the incident O&M Manager Water and Wastewater also to be notified as soon as possible or within 24 hours by phone or email O&M Manager Water and Wastewater to arrange for details of the incident to be communicated to the community as required	Water and Wastewater Engineer Reviewed by O&M Manager Water and Wastewater

TABLE 0-2: MANAGEMENT OF INCIDENTS AND EMERGENCIES			
Level	**Incident or Emergency**	**Summary of Actions to be Taken (with Documented Procedure Listed)**	**Positions Responsible for Actions**
3	Detection of E coli in reticulation OR Minor exceedance or elevation of ADWG chemical parameters, regulator guidelines, DWQMP conditions or parameter with no water quality parameter OR Infrastructure failure causing Short term reduction in water supply	Operator to provide a report to the Treatment Plant Coordinator within 24 hours by email Treatment Plant Coordinator to communicate details of the incident internally as required Plant operator to advise Treatment Plant Coordinator, O&M Manager Water and Wastewater of any complaints relating to the incident	Treatment Plant Coordinator Reviewed by Water and Wastewater Engineer
2	Failure of infrastructure that is unlikely to cause compromise to supply OR Exceedance of aesthetic limits in ADWG	Operator to provide a report to the Treatment Plant Coordinator, O&M Manager Water and Wastewater and data analyst within 48 hours by email Plant operator to advise Treatment Plant Coordinator, O&M Manager Water and Wastewater of any complaints relating to the incident	Plant Operator Reviewed by Treatment Plant Coordinator
1	Exceedances of operational limits managed through O&M procedures	Operator to complete O&M procedures or raise maintenance request Operators to advise Treatment Plant Coordinator if assistance is required	Plant Operator Reviewed by Treatment Plant Coordinator

The Water and Wastewater Engineer liaises with the Treatment Plant Coordinators and Operators while they conduct the investigations. Investigation reports (generally email reports) are submitted to the Water and Wastewater Engineer for review, and then stored in ECM, Council's information management system. O&M Manager Water and Wastewater also oversees the investigation as applicable.

The emergency contactsand protocols for contact are in Table 0-3. The Water and Wastewater contact list (ECM ID 4571029) is updated on a monthly basis and issued to operators for display in the control rooms.

TABLE 0-3: EMERGENCY CONTACT DETAILS AND PROTOCOLS				
Description of Incident / Emergency	**Level**	**Business Unit / Organisation**	**Contact Person(s) Details**	**Communication Protocols**
Contamination of treated water from either treatment plant failure, mains break, raw water contamination or other requiring boiled water notice	5	Water and Wastewater	O&M Manager Water and Wastewater Director of Water and Wastewater	Council website, social media, local paper, or mail drop as required
Water Restrictions due to drought / infrastructure failure	4	Water and Wastewater	O&M Manager Water and Wastewater Water and Wastewater Engineer	Council website, social media, local paper, or mail drop as required
Contamination of treated water resulting in only minor exceedance of ADWG guidelines	3	Water and Wastewater	Water and Wastewater Engineer Treatment Plant Coordinator	Internal communication by phone/email
Water main break repair	3 or 2	Water and Wastewater	Water and Wastewater Network Coordinator Admin staff After Hours Call Centre	Internal communication by phone/email
ADWG non-compliance with aesthetic parameters	2	Water and Wastewater	Treatment Plant Coordinator Plant Operator	Internal communication by phone/email

IRC's corporate organisational safety procedures can be found via IRC's intranet (https://iris.isaac.qld.gov.au/cgfs/organisational-safety/whs-documents/safety-procedures).

COMPLAINT PROCEDURES

Customer complaints are received at Council's offices during working hours. Afterhours enquiries and service complaints are diverted to after-hours duty officers. Figure 0-3 details the Council's complaints processing procedure.

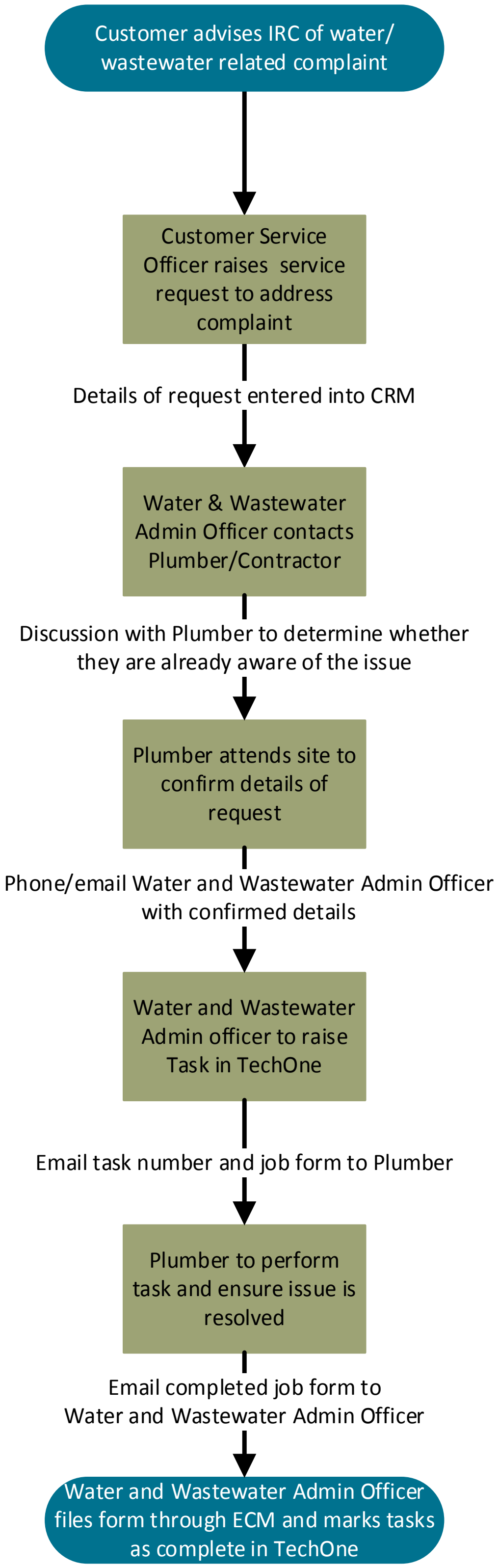

Figure 0-3 Complaint Processing Flow Diagram

Complaints record was recently migrated to TechOne, which provides easier access to previous complaint records. The following two tables present the historical water complaints at Clermont and the water complaints captured in TechOne between 2011 and 2012 and State-wide Water Information Management (SWIM) and TechOne for 2014-2020.

TABLE 0-4: HISTORICAL WATER QUALITY COMPLAINTS FOR CLERMONT SCHEME					
Year	**No of Water Quality Complaints**	**Water Quality Complaints per 1000 Connections**	**Main Reasons for Complaints**	**Likely Sources / Causes of Problems**	**Resolution of Problem**
1997	6	<6	Specific details of complaints were not recorded	Problems with filtration were noted during September and December 1997 which were the months where four complaints were recorded. These included corrosion issues in Filter 3 and level control issues in filters 1 and 2	Filter 3 was taken out of service Problems with the level controllers on filters 1 and 2 were fixed and the turbidity and colour returned to normal
2003	3	<3	Specific details of complaints were not recorded	During the early part of 2003, the Theresa Creek dam level was rapidly filled by high rainfall after a period of drought. The raw water turbidity rose very rapidly. This would have affected treated water quality. It was during this time that the complaints were recorded.	
2004	1	<1	Specific details of complaints were not recorded	No information recorded to indicate the cause of complaint. The water quality information for the month is in line with the ADWG.	
2006	1	<1	Specific details of complaints were not recorded	There were a number of mains fixed during the month when the complaint was placed. The complaint may have been due to this work taking place. The water quality information for the month is in line with the ADWG.	
2007	1	<1	Specific details of complaints were not recorded	There were a number of mains fixed during the month when the complaint was placed. The complaint may have been due to this work taking place. The water quality information for the month is in line with the ADWG.	
2009	1	<1	Specific details of complaints were not recorded	One main was fixed during the month when the complaint was placed. The complaint may have been due to this work taking place. The water quality information for the month is in line with the ADWG.	

TABLE 19.6: WATER QUALITY COMPLAINTS REGISTERED IN TECHONE (2011 TO PRESENT)					
Year	**No of Water Quality Complaints**	**Water Quality Complaints per 1000 Connections**	**Main Reasons for Complaints**	**Likely Sources / Causes of Problems**	**Resolution of Problem**
Clermont					
2011	1	<1	Colour in water	No information recorded to indicate the cause of complaint. The water quality information for the month is in line with the ADWG.	
2012	6	6	Understood to relate to colour	No information recorded to indicate the cause of complaint. The water quality data are generally in line with the ADWG.	Water main flushing was undertaken
2013-14	2	-	Unknown	No information recorded to indicate the cause of complaint.	
2014-15	6	5	Unknown	No information recorded to indicate the cause of complaint. The water quality data are generally in line with the ADWG.	
2015-16	26	19.7	Discoloured water	No information recorded to indicate the cause of complaint. The water quality data are generally in line with the ADWG.	Localised and mains flushing performed. WTP processes reviewed.
2016-17	31	23.7	Discoloured water	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. WTP processes reviewed.
2017-18	39	29.82	Discoloured water	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. WTP processes reviewed.
2018-19	91	63.4	Discoloured water	Failure of alum dosing pump, with lack of interlock.	Localised and mains flushing performed. Interlock added to all alum dosing pumps.
2019-20	203	142.1	Discoloured water	Samples taken within ADWG	Localised and mains flushing performed. WTP processes reviewed.
2020-21	28	9.2	Discoloured water	Samples taken within ADWG	Localised and mains flushing performed.
Moranbah					

TABLE 19.6: WATER QUALITY COMPLAINTS REGISTERED IN TECHONE (2011 TO PRESENT)					
Year	**No of Water Quality Complaints**	**Water Quality Complaints per 1000 Connections**	**Main Reasons for Complaints**	**Likely Sources / Causes of Problems**	**Resolution of Problem**
2011	2	<1	Specific details of complaints were not recorded	The complaints coincide with turbidity spikes observed during the period.	Sand filter refurbishment was undertaken
2012	2	<1	Specific details of complaints were not recorded	No information recorded to indicate the cause of complaint. The water quality data are generally in line with the ADWG	
2013-14	21	-	Unknown	No information recorded to indicate the cause of complaint.	
2014-15	8	2	Unknown	No information recorded to indicate the cause of complaint.	
2015-16	21	5.8	Water taste	No information recorded to indicate the cause of complaint. The water quality data are generally in line with the ADWG.	Localised and mains flushing performed. Raw water quality and WTP processes reviewed and adjusted.
2016-17	90	25.1	Discoloured water	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. WTP processes reviewed.
2017-18	67	13.97	Unknown/ Discoloured water	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. WTP processes reviewed.
2018-19	8	2.2	Discoloured water and water odour	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. WTP processes reviewed.
2019-20	15	3.6	Discoloured water	Cause of the complaint not known	Localised and mains flushing performed.
2020-21	4	0.95	Discoloured water	Cause of the complaint not known. Samples taken within ADWG	Localised and mains flushing performed.
Dysart					
2011	2	<1	Taste of tap water	No information recorded to indicate the cause of complaint. The water quality data are generally in line with the ADWG	

TABLE 19.6: WATER QUALITY COMPLAINTS REGISTERED IN TECHONE (2011 TO PRESENT)					
Year	**No of Water Quality Complaints**	**Water Quality Complaints per 1000 Connections**	**Main Reasons for Complaints**	**Likely Sources / Causes of Problems**	**Resolution of Problem**
2012	7	3.5	Understood to be related to colour and taste	No information recorded to indicate the cause of complaint.	Water main flushing was undertaken
2013-14	77	-	Understood to be related to colour and taste	Raw water source bypassed in November 2013 due to poor quality. Major WTP failure occurred in December 2013.	Calvert's Dam bypassed. Filter media replaced and WTP upgraded. Reservoirs emptied and network flushed
2014-15	1	1	Dirty water	Related to mains flushing	
2015-16	13	9.1	Discoloured water and water odour	The water quality data are generally in line with the ADWG.	Localised and mains flushing performed. Raw water quality and WTP processes reviewed and adjusted.
2016-17	6	4.3	Water taste	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. Raw water quality and WTP processes reviewed and adjusted.
2017-18	4	2.84	Discoloured water	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. WTP processes reviewed.
2018-19	2	1.4	Discoloured water	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. WTP processes reviewed.
2019-20	2	1.3	Discoloured water	Cause of the complaint not known	Localised and mains flushing performed.
2020-21	2	1.3	Odour	Samples taken within ADWG	Supervisor unable to determine the cause
Middlemount					
2011	1	<1	Dirty water	No information recorded to indicate the cause of complaint.	
2012	1	<1	Understood to be related to colour	No information recorded to indicate the cause of complaint.	
2013-14	19	-	Unknown	No information recorded to indicate the cause of complaint.	
2014-15	2	2	Unknown	Possibly related to mains flushing	

TABLE 19.6: WATER QUALITY COMPLAINTS REGISTERED IN TECHONE (2011 TO PRESENT)					
Year	**No of Water Quality Complaints**	**Water Quality Complaints per 1000 Connections**	**Main Reasons for Complaints**	**Likely Sources / Causes of Problems**	**Resolution of Problem**
2015-16	1	<1	Discoloured water	No information recorded to indicate the cause of complaint. The water quality data are generally in line with the ADWG.	Localised and mains flushing performed. WTP processes reviewed.
2016-17	28	29.9	Discoloured water and water taste	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. Raw water quality and WTP processes reviewed and adjusted.
2017-18	1	1.07	Unknown	No information recorded to indicate the cause of complaint.	
2018-19	1	1.0	Discoloured water	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. WTP processes reviewed.
2019-20	2	2.1	Taste and odour	Cause of the complaint not known. Samples taken within ADWG	WTP processes reviewed.
2020.21	1	1	Health Concern	Complaint investigated; no known cause could be found.	Customer advised no reoccurring issue.
Glenden					
2015-16	2	6.0	Discoloured water	No information recorded to indicate the cause of complaint. The water quality data are generally in line with the ADWG.	Localised and mains flushing performed. WTP processes reviewed.
2017-18	0	0	N/A	N/A	N/A
2018-19	0	0	N/A	N/A	
2019-20	3	5.1	Discoloured water	Cause of the complaint not known. Samples taken within ADWG	Localised and mains flushing performed
2020-21	0	0	N/A	N/A	N/A
Nebo					
2013-14	1	-	Unknown	No information recorded to indicate the cause of complaint.	
2017-18	3	9.26	Unknown/ Odour	No information recorded to indicate the cause of complaint.	
2018-19	1	2.8	Unknown	No information recorded to indicate the cause of complaint.	

TABLE 19.6: WATER QUALITY COMPLAINTS REGISTERED IN TECHONE (2011 TO PRESENT)					
Year	**No of Water Quality Complaints**	**Water Quality Complaints per 1000 Connections**	**Main Reasons for Complaints**	**Likely Sources / Causes of Problems**	**Resolution of Problem**
2019-20	4	10.0	Taste	Cause of the complaint not known. Samples taken within ADWG	WTP processes reviewed.
2020-21	1	2.5	Other	Water hardness deposits on vehicle after washing	Dry vehicle with chamois rather than air-dry. Customer satisfied.
Carmila					
2016-17	2	31.7	Dirty water	No information recorded to indicate the cause of complaint. The water quality data are generally in line with the ADWG.	Localised and mains flushing performed. WTP processes reviewed.
2017-18	0	0	N/A	N/A	N/A
2018-19	0	0	N/A	N/A	N/A
2019-20	0	0	N/A	N/A	N/A
2020-21	0	0	N/A	N/A	N/A
St. Lawrence					
2012	1	5	Dirty water	No information recorded to indicate the cause of complaint.	
2017-18	2	16.95	Discoloured water	No information recorded to indicate the cause of complaint.	Localised and mains flushing performed. WTP processes reviewed.
2018-19	0	0	N/A	N/A	N/A
2019-20	1	7.3	Discoloured water	Cause of the complaint not known. Samples taken within ADWG	Localised and mains flushing performed.
2020-21	0	0	N/A	N/A	N/A

The above complaint record summary shows that there has been some improvement made by IRC staff to facilitate better capture of water complaints. Nevertheless improvement is still required to capture more specific details of the complaints, this provides better documentation record and reduces the likelihood of repeating complaints.

DOCUMENT CONTROL AND ARCHIVING

The operational monitoring results are entered into spreadsheet records and the files on the share drive are accessible to all IRC operational staff. The spreadsheets will be transferred into IRC's Information Management System at the end of the monitoring period where they are locked and archived. The files can still be accessed by IRC staff for future reference. PDF copies of external test reports are sent directly to the relevant WTP, Treatment Plant Coordinator, Water and Wastewater Engineer and IRC Records staff for filing through ECM.

IRC documents generally have a publish date on the cover to distinguish the document from the previous issues, if applicable. The IRC Electronic Data Management System (EDMS) application has version control. Documents are filed by subject and are made available to all IRC staff. Archiving is carried out by IRC Records staff in accordance with the State Archives Retention and Disposal Scheme.

IRC's document control procedure is available via Council's intranet. (https://iris.isaac.qld.gov.au/edrms/download/Zm9sZGVyLTM1NTEzNjd8fGZvbGRlci0zNTUxMzY3). All other IRC procedures can be found on Council's intranet (https://iris.isaac.qld.gov.au/procedure-guidelines).

ASSESSMENT OF RISKS

Risk assessments were completed on all of the hazards identified. The original assessments for each scheme were completed on the following dates:

- Clermont: 29 February 2012
- Moranbah: 9 July 2012
- Glenden: 9 July 2012
- Nebo: 9 July 2012
- St Lawrence: 9 July 2012
- Carmila: 11 July 2012
- Dysart: 10 July 2012
- Middlemount: 10 July 2012

A risk review was conducted on 12-13 November 2019 for all schemes, except Nebo which requires a risk assessment for its new water treatment plant.

The Risk Review workshop was attended by the people as indicated in Table 0-1: Risk Workshop Attendees table.

TABLE 0-1: RISK WORKSHOP ATTENDEES

Name	Position	Relevance to Water Supply Scheme
Tom Dippel	Manager Operations & Maintenance (Water & Wastewater)	Responsibilities include Operations and Maintenance of the water supply schemes for IRC
Gopi Palayam	Process Engineer (Water & Wastewater)	Process Engineer for the IRC water supply schemes
Neville Bell	Assets and Compliance Officer	Assets and compliance for the IRC water supply schemes
Craig Bindoff	Treatment Supervisor North	Supervisor for the Clermont, Dysart and Middlemount operators
Rohan Phillips	Treatment Supervisor South	Supervisor for the Carmila, Glenden, Moranbah, Nebo and St Lawrence operators
Peter Fentiman	Network Supervisor	Supervisor for all Networks
Jacquelyn Osborne	Senior Process Engineer	Consultant from City Water Technology Pty Ltd assisting in completion of DWQMP and Risk Review workshop process
Sarah Loder	Senior Risk Analyst	Consultant from Praktik (for City Water Technology Pty Ltd) assisting in completion of DWQMP and Risk Review workshop process
Tom Dippel	Manager Operations & Maintenance (Water & Wastewater)	Responsibilities include Operations and Maintenance of the water supply schemes for IRC

The risk assessment methodology was as per IRC's standard risk matrix, with consequence and likelihood descriptors tailored for water quality risks. The risk matrix and definitions used for the risk workshop are provided below in Figure 0-1.

	Consequence				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	High	High	Extreme	Extreme
Likely	Medium	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

Figure 0-1: Risk Matrix

Table 0-2: Definitions table details the definitions used in the risk workshop for likelihood, consequence and uncertainty.

TABLE 0-2: DEFINITIONS	
Likelihood	**Description**
Almost Certain	Occurs more than once per week
Likely	Occurs more than once per month and up to once per week
Possible	Occurs more than once per year and up to once per month
Unlikely	Occurs more than once every five years and up to once per year
Rare	Occurs less than or equal to once every five years
Consequence	**Description**
Catastrophic	Potential acute health impact, declared outbreak expected
Major	Potential acute health impact, no declared outbreak expected
Moderate	Potential widespread aesthetic impact or repeated breach of chronic health parameter
Minor	Potential local aesthetic, isolated exceedance of chronic health parameter
Insignificant	Isolated exceedance of aesthetic parameter with little or no disruption to normal operation
Uncertainty	**Description**
Certain	There is five years of continuous monitoring data, which has been trended and assessed, with at least daily monitoring. The processes involved are thoroughly understood.
Confident	There is five years of continuous monitoring data, which has been collated and assessed, with at least weekly monitoring for the duration of seasonal events. There is a good understanding of the processes involved
Reliable	There is at least a year of continuous monitoring data available, which has been assessed and there is a good understanding of the processes involved
Estimate	There is limited monitoring data available and there is a reasonable understanding of the processes involved
Uncertain	There is limited or no monitoring data available and the processes are not well understood

The full results of the risk assessment are provided in the following table. The acceptable residual risk level selected is “Low” because this generally means that all possible actions have been taken to eliminate, isolate, or minimise the risk. However, where there are further possible actions to mitigate the risk, these have been included in the improvement programme.

In addition, “Medium” has sometimes been considered an acceptable residual risk. The residual risk can be “Medium” even when the Likelihood is “Rare” because the preventative measures for some hazards reduce the likelihood of the event occurring but do not change the consequence when they are “Major” or “Catastrophic”. This implies that the risk is being managed to a level that is “as low as practicable”. The improvement programme details when a particular risk is considered to be minimised or as low as reasonably practicable.

RISK ASSESSMENT

The risk assessment is presented in Table 20.3 which is attached as Appendix 1. The original risk assessment was conducted by Harrison Grierson in 2012. A risk review was facilitated by City Water Technology in November 2019. The risk register should be reviewed annually or for any significant process change with relevant stakeholders to ensure it remains relevant.

Major changes to the treatment process (such as the new WTP currently being commissioned at Nebo) will require a new risk assessment to be conducted to capture new processes, applicable risks, and updated preventive measures.

MANAGING RISK

EXISTING AND PROPOSED PREVENTATIVE MEASURES

The existing and proposed preventative measures are presented in Table 20.3, combined with the existing risk register which is attached as Appendix 1.

The existing and proposed preventive measures listed in this table updated based on discussions during the November 2019 risk review workshop. It is recommended that Council conduct an annual review of the risks, risk scores and proposed preventive measures with relevant stakeholders to keep the risk management improvement actions relevant and risk scores as low as practicably possible.

The risk management improvement programme (see Table 22.1 in Appendix 2) lists the updated status of each improvement action and recommendations as a result of the November 2019 risk review. The status of each improvement action has been updated again in November 2021.

RISK MANAGEMENT IMPROVEMENT PROGRAMME

The risk management improvement programme is intended to further reduce residual risks which were identified in the risk workshop. The preventative measures and programme for implementation is provided in Table 22.1 (Appendix 2).

GENERAL IMPROVEMENT

As discussed in earlier sections, improvements will continue to be made in the following general areas:

1. Continuing to improve and update operational documentation including Work Instructions via the IMS.
2. Continue to work through dead end replacements in the reticulation network.
3. Continue water system network modelling which allows for the identification of low pressure/flow areas. Pressure monitoring will also be implemented during the same period.
4. Continuing to work towards a formalised communication protocol with Xstrata/Bloomfield in relation to water availability and quality, to alerts for rapid change of raw water quality (e.g. algal bloom), as far as practical.
5. Continue to improve and streamline recording of water quality complaints and utilisation of this information to address issues within the network.
6. Continue to improve data utilisation and trending of external water quality testing results.
7. Develop succession planning, continue training programs and maintain Preferred Supplier Agreements (PSAs) for labour hire (relief staff) to address resourcing issues.
8. Continue to hold regular meetings between the Operations and Capital Works teams.
9. Conduct process audits on all WTPs to identify areas for further improvements to the treatment performance and process control in line with upcoming implementation of the health-based targets.

Given the significant process and operational upgrades to Nebo water supply system, it is recommended that a new risk assessment be conducted to incorporate these changes and reassess the capabilities of the plant as well as both new and mitigated risks to water quality and supply. New/updated risk assessments are recommended for any major process upgrade or system change.

These general improvement items (GEN01 to GEN19) are described in the first section of the improvement spreadsheet (Table 22.1).

IMPROVEMENT PROGRAMME

The improvement programme is presented in Table 22.1 which is attached as Appendix 2.

VERIFICATION MONITORING

The verification monitoring that is currently undertaken at all sites considered in this plan are detailed in the following table. Results of verification modelling are detailed in the sections below.

	Middlemount Water Treatment Plant	Dysart Water Treatment Plant	St Lawrence Water Treatment Plant	Carmila Water Treatment Plant	Glenden Water Treatment Plant	Nebo Water Treatment Plant	Clermont Water Treatment Plant	Moranbah Water Treatment Plant
Test	Frequency	Frequency	Frequency	Frequency	Frequency	Frequency	Frequency	Frequency
pH	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Residual Chlorine	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
E Coli	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Turbidity	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Aluminium	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Iron	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Manganese	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Conductivity	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Total Dissolved Solids	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Fluoride	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Weekly
True Colour	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
DO	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Calcium (Ca) & Magnesium (Mg)	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Total Hardness	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Temporary Hardness	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Alkalinity & Residual Alkalinity	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Nitrite	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Nitrate	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
THMs	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Bromate	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Chlorite	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Chlorate	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly

Total Algae	Monthly	Monthly	Monthly	N/A	Monthly	N/A	Monthly	Monthly
Formaldehyde	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Arsenic	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Selenium	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Mercury	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Lead	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Zinc	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Copper	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Cadmium	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Chromium	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Nickel	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Ammonia	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Hydrogen Sulphide	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Pesticides	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Molybdenum	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually
Boron	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually
Tin	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually
Silver	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually
Beryllium	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually
Uranium	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually
Iodide	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually
Barium	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually
Radionuclides	Annually	Annually	Annually	Annually	Annually	Annually	Annually	Annually

Isaac Regional Council Verification Monitoring - Water Reticulation System								
	Potable water samples in water network							
	Middlemount Water Treatment Plant	Dysart Water Treatment Plant	St Lawrence Water Treatment Plant	Carmila Water Treatment Plant	Glenden Water Treatment Plant	Nebo Water Treatment Plant	Clermont Water Treatment Plant	Moranbah Water Treatment Plant
pH	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Residual Chlorine	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
E coli	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Fluoride	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Monthly

Current Event Sampling								
Isaac Regional Council Verification Monitoring - Raw Water								
	Raw water samples from water dams							
	Middlemount Water Treatment Plant	Dysart Water Treatment Plant	St Lawrence Water Treatment Plant	Carmila Water Treatment Plant	Glenden Water Treatment Plant	Nebo Water Treatment Plant	Clermont Water Treatment Plant	Moranbah Water Treatment Plant
Total Algae	Weekly	Weekly	Weekly	N/A	Weekly	N/A	Weekly	Weekly
Algae - Toxin Analysis	Weekly	Weekly	Weekly	N/A	Weekly	N/A	Weekly	Weekly
Geosmin / MIB	Monthly	Monthly	Monthly	N/A	Monthly	N/A	Monthly	Monthly
Isaac Regional Council Verification Monitoring - Treated Water								
	Treated water samples from water treatment plants							
	Middlemount Water Treatment Plant	Dysart Water Treatment Plant	St Lawrence Water Treatment Plant	Carmila Water Treatment Plant	Glenden Water Treatment Plant	Nebo Water Treatment Plant	Clermont Water Treatment Plant	Moranbah Water Treatment Plant
Geosmin / MIB	Monthly	Monthly	Monthly	N/A	Monthly	N/A	Monthly	Monthly

CLERMONT VERIFICATION RESULTS

TABLE 0-1: CLERMONT VERIFICATION DATA RESULTS

Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
pH	pH Unit	Weekly	470	6.5	7.0	7.2	7.5	8.64			6.5-8.5	1
Free Residual Chlorine	mg/L		461	0.02	1.00	1.78	2.80	3.9		5		0
E Coli	MPN/100mL		375	<1	<1	<1	<1	<1	<1	1		0
Turbidity	NTU		353	<0.1	<0.1	0.4	1.4	3.95	<0.1		5	0
Aluminium	mg/L		353	<0.005	0.011	0.053	0.102	2.156	<0.005		0.2	5
Iron	mg/L		363	<0.001	0.001	0.005	0.012	0.080	<0.001		0.3	0
Manganese	mg/L		366	<0.001	<0.001	0.009	0.033	0.254	<0.001	0.5	0.1	8
Conductivity	μS/cm		287	113	234	372	643	894				0
Total Dissolved Solids	mg/L		287	68	140	223	385	536		600		0
Fluoride	mg/L	Monthly	63	<0.01	0.03	0.09	0.19	0.23	<0.01		1.5	0
Colour - True	TCU		81	<1	<1	2	4	9	<1		15	0
DO	% Sat		71	70.7	77.6	89.5	98.8	102.6			85	19
Calcium (Ca)	mg/L		81	10.064	11.367	22.230	36.590	46.670				0
Magnesium (Mg)	mg/L		81	2.868	3.638	8.026	15.890	21.670				0
Hardness	mg/L		80	36.94	43.93	88.99	157.86	205.77			200	1
Hardness - Temporary	mg/L		80	23.30	38.90	87.30	150.42	197.40				0
Alkalinity	mg/L		81	23.26	39.00	87.80	150.44	197.44				0
Residual Alkalinity	mg/L		51	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0
Nitrite	mg/L		81	<0.004	<0.004	0.064	0.283	<0.4	<0.004	3		0
Nitrate	mg/L		81	<0.015	<0.015	0.652	1.732	3.605	<0.015	50		0
THMs	mg/L		111	0.0480	0.0745	0.1177	0.1815	0.2540		0.25		1
Bromate	mg/L		72	<0.005	0.007	0.012	<0.05	<0.05	<0.005	0.02		0
Chlorite	mg/L		71	<0.005	0.007	0.012	0.035	<0.05	<0.005	0.8		0
Chlorate	mg/L		71	<0.01	0.01	0.04	0.04	0.40	<0.01			0
Total Algae	cells/mL		129	0	0.0	3.6	26.0	100				0
Formaldehyde	mg/L	Quarterly	37	<0.1	<0.1	<0.1	<0.1	0.2	<0.1			0

TABLE 0-1: CLERMONT VERIFICATION DATA RESULTS

Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
Arsenic	mg/L		23	<0.0005	<0.0005	0.0	0.0007	0.0008	<0.0005	0.01		0
Selenium	mg/L		23	<0.001	<0.001	0.003	0.004	<0.005	<0.001	0.01		0
Mercury	mg/L		23	<0.00005	<0.00005	0.00025	0.00035	<0.0005	<0.00005	0.001		0
Lead	mg/L		23	<0.0005	<0.0005	<0.0005	0.0007	<0.001	<0.0005	0.01		0
Zinc	mg/L		24	<0.001	<0.001	0.003	0.007	0.008	<0.001		3	0
Copper	mg/L		24	<0.001	<0.001	0.005	0.011	0.012	<0.001	2		0
Cadmium	mg/L		24	<0.0001	<0.0001	0.0004	0.0014	<0.002	<0.0001	0.002		0
Chromium	mg/L		24	<0.0001	<0.0001	0.0018	0.0071	<0.01	<0.0001	0.05		0
Nickel	mg/L		24	<0.0005	<0.0005	0.0056	<0.03	<0.03	<0.0005	0.02		0
Ammonia	mg/L		35	<0.01	<0.01	<0.01	0.0	0.02	<0.01		0.5	0
Hydrogen Sulphide	mg/L		23	<0.005	<0.005	<0.005	<0.005	0.030	<0.005		0.05	0
Pesticides*	µg/L		22	<0.0001	<0.0001	<0.0001	<0.0001	0.19544	<0.0001			0
Molybdenum	mg/L	Annually	7	<0.001	<0.001	0.007	0.027	<0.05	<0.001	0.05		0
Boron	mg/L		7	0.0231	0.0235	0.0333	0.0513	0.0560		4		0
Tin	mg/L		6	<0.001	<0.001	0.0	0.007	0.009	<0.001			0
Silver	mg/L		6	<0.0001	<0.0001	0.0002	0.0006	<0.001	<0.0001	0.1		0
Beryllium	mg/L		6	<0.0005	<0.0005	<0.0005	0.0006	<0.001	<0.0005	0.06		0
Uranium	mg/L		6	<0.0005	<0.0005	0.0	0.0027	0.0034	<0.0005	0.017		0
Iodide	mg/L		9	<0.02	<0.02	<20	<20	<20	<0.02	0.5		0
Barium	mg/L		6	0.033	0.033	0.040	0.047	0.048		2		0
Gross Alpha (Radionuclides)	Bq/L		9	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	≤0.5		0
Gross Beta (Radionuclides)	Bq/L		9	<0.1	<0.1	<0.1	0.11	0.13	<0.1	≤0.5		0

MORANBAH VERIFICATION RESULTS

TABLE 0-2: MORANBAH VERIFICATION DATA RESULTS

Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
pH	pH Unit	Weekly	452	6.5	7.1	7.4	7.9	8.13		6.5-8.5		0
Free Residual Chlorine	mg/L		449	0.31	1.18	1.66	2.19	3.72		5		0
E Coli	MPN/100mL		369	<1	<1	<1	<1	<1	<1	1		0
Turbidity	NTU		314	<0.1	<0.1	0.4	1.1	9.86	<0.1		5	2
Aluminium	mg/L		222	<0.005	<0.005	0.020	0.083	0.247	<0.005		0.2	1
Iron	mg/L		366	<0.001	0.001	0.005	0.011	0.150	<0.001		0.3	0
Manganese	mg/L		371	<0.001	<0.001	0.002	0.003	0.060	<0.001	0.5	0.1	0
Conductivity	µS/cm		289	112	146	217	272	3031				0
Total Dissolved Solids	mg/L		288	16	88	130	163	1819			600	2
Fluoride	mg/L	Monthly	316	0.02	0.29	0.63	0.84	1.01			1.5	0
Colour - True	TCU		86	<1	<1	1	3	10	<1		15	0
DO	% Sat		74	84.8	88.0	96.4	103.8	106.0			85	1
Calcium (Ca)	mg/L		86	8.423	9.189	13.606	18.309	21.003				0
Magnesium (Mg)	mg/L		86	3.603	3.939	6.290	9.235	11.140				0
Hardness	mg/L		85	36.39	39.04	59.64	80.77	92.69			200	0
Hardness - Temporary	mg/L		85	0.02	32.30	56.89	86.76	100.80				0
Alkalinity	mg/L		86	28.28	32.76	58.07	86.78	100.8				0
Residual Alkalinity	mg/L		51	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0
Nitrite	mg/L		86	<0.004	<0.004	0.060	0.283	<0.4	<0.004	3		0
Nitrate	mg/L		86	<0.015	<0.015	0.278	0.598	1.559	<0.015	50		0
THMs	mg/L		111	0.0140	0.0170	0.0455	0.0780	0.1060		0.25		0
Bromate	mg/L		60	<0.005	0.007	0.012	<0.5	<0.5	<0.005	0.02		0
Chlorite	mg/L		59	<0.005	0.007	0.012	0.035	<0.5	<0.005	0.8		0
Chlorate	mg/L		58	<0.01	0.01	0.05	0.09	0.84	<0.01			0
Total Algae	cells/mL		99	0	0.0	2.0	0.0	200				0
Formaldehyde	mg/L	Quarterly	29	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0

TABLE 0-2: MORANBAH VERIFICATION DATA RESULTS

Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No.	Minimum	5th Percentile	Averag	95th Percentile	Maximum	LOR	Limit		Exceedanc
Arsenic	mg/L		25	<0.0005	<0.0005	0.0	0.0007	0.0012	<0.0005	0.01		0
Selenium	mg/L		25	<0.001	<0.001	0.003	0.004	<0.005	<0.001	0.01		0
Mercury	mg/L		25	<0.00005	<0.00005	0.00026	0.00035	<0.001	<0.00005	0.001		0
Lead	mg/L		26	<0.0005	<0.0005	0.0005	0.0007	<0.003	<0.0005	0.01		0
Zinc	mg/L		27	<0.001	0.004	0.009	0.015	0.017	<0.001		3	0
Copper	mg/L		27	<0.001	<0.001	0.004	0.011	<0.015	<0.001	2		0
Cadmium	mg/L		26	<0.0001	<0.0001	0.0005	0.0014	<0.002	<0.0001	0.002		0
Chromium	mg/L		26	<0.0001	<0.0001	0.0022	0.0071	<0.01	<0.0001	0.05		0
Nickel	mg/L		26	<0.0005	<0.0005	0.0068	<0.03	<0.03	<0.0005	0.02		0
Ammonia	mg/L		35	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		0.5	0
Hydrogen Sulphide	mg/L		25	<0.005	<0.005	<0.005	0.006	0.013	<0.005		0.05	0
Pesticides*	µg/L		22	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001			0
Molybdenum	mg/L	Annually	7	<0.001	<0.001	0.006	0.025	<0.05	<0.001	0.05		0
Boron	mg/L		7	0.0177	0.0199	0.0286	0.0369	0.0385		4		0
Tin	mg/L		6	<0.001	<0.001	0.0	0.005	0.007	<0.001			0
Silver	mg/L		6	<0.0001	<0.0001	0.0002	0.0005	<0.001	<0.0001	0.1		0
Beryllium	mg/L		6	<0.0005	<0.0005	<0.0005	0.0006	<0.001	<0.0005	0.06		0
Uranium	mg/L		6	<0.0005	<0.0005	<0.0005	0.0006	<0.001	<0.0005	0.017		0
Iodide	mg/L		7	<0.02	<0.02	<20	<20	<20	<0.02	0.5		0
Barium	mg/L		6	0.020	0.022	0.032	0.041	0.042		2		0
Gross Alpha (Radionuclides)	Bq/L		10	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	≤0.5		0
Gross Beta (Radionuclides)	Bq/L		10	<0.1	<0.1	<0.1	0.15	0.15	<0.1	≤0.5		0

NEBO VERIFICATION RESULTS

TABLE 0-3: NEBO VERIFICATION DATA RESULTS													
Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)										
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
pH	pH Unit	Weekly	456	6.55	6.8	7.1	7.7	7.9		6.5-8.5		0
Free Residual Chlorine	mg/L		433	<0.02	0.32	0.99	1.65	2.68	<0.02	5		0
E Coli	MPN/100mL		385	<1	<1	<1	<1	<1	<1	1		0
Turbidity	NTU		388	<0.1	<0.1	0.2	0.4	2.58	<0.1		5	0
Aluminium	mg/L		230	<0.001	0.004	0.004	0.005	0.049	<0.001		0.2	0
Iron	mg/L		278	<0.001	<0.001	0.003	0.009	0.090	<0.001		0.3	0
Manganese	mg/L		280	<0.001	<0.001	<0.001	0.003	0.004	<0.001	0.5	0.1	0
Conductivity	µS/cm		391	182	449	886	1307	1846				0
Total Dissolved Solids	mg/L		386	123	272	527	773	1108			600	124
Fluoride	mg/L	Monthly	69	0.03	0.07	0.11	0.16	0.18			1.5	0
Colour - True	TCU		120	<1	<1	1	3	7	<1		15	0
DO	% Sat		72	51.3	57.4	77.9	95.6	98.2			85	42
Calcium (Ca)	mg/L		167	12.159	31.229	44.023	74.485	95.520				0
Magnesium (Mg)	mg/L		167	5.052	15.258	25.228	45.152	60.480				0
Hardness	mg/L		163	51.97	141.91	213.90	369.22	487.57			200	72
Hardness - Temporary	mg/L		116	103.50	115.58	176.69	224.73	257.50				0
Alkalinity	mg/L		120	45.92	113.91	175.61	222.53	257.52				0
Residual Alkalinity	mg/L		58	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0
Nitrite	mg/L		120	<0.004	<0.004	0.082	0.283	<0.4	<0.004	3		0
Nitrate	mg/L		120	0.0960	0.5272	2.382	5.329	6.344		50		0
THMs	mg/L		132	<0.001	0.0035	0.0150	0.0275	0.2070	<0.001	0.25		0
Bromate	mg/L		93	<0.005	0.007	0.011	<0.05	<0.05	<0.005	0.02		0
Chlorite	mg/L		92	<0.005	0.007	0.011	0.035	<0.05	<0.005	0.8		0
Chlorate	mg/L		92	<0.02	<0.02	0.10	0.26	0.70	<0.02			0
Formaldehyde	mg/L	Quarterly	29	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0
Arsenic	mg/L		26	<0.0005	<0.0005	0.0	0.0007	<0.001	<0.0005	0.01		0

TABLE 0-3: NEBO VERIFICATION DATA RESULTS

Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
Selenium	mg/L		26	<0.001	<0.001	0.003	0.004	<0.005	<0.001	0.01		0
Mercury	mg/L		24	<0.00005	<0.00005	0.00023	0.00035	<0.0005	<0.00005	0.001		0
Lead	mg/L		26	<0.0005	<0.0005	0.0005	0.0007	0.0011	<0.0005	0.01		0
Zinc	mg/L		28	<0.001	0.002	0.007	0.015	0.016	<0.001		3	0
Copper	mg/L		28	<0.001	0.002	0.010	0.019	0.026	<0.001	2		0
Cadmium	mg/L		28	<0.0001	<0.0001	0.0005	0.0014	<0.002	<0.0001	0.002		0
Chromium	mg/L		27	<0.0001	<0.0001	0.0020	0.0071	<0.01	<0.0001	0.05		0
Nickel	mg/L		28	<0.0005	<0.0005	0.0057	<0.03	<0.03	<0.0005	0.02		0
Ammonia	mg/L		34	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		0.5	0
Hydrogen Sulphide	mg/L		25	<0.005	<0.005	<0.005	<0.005	0.006	<0.005		0.05	0
Pesticides*	µg/L		12	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001			0
Molybdenum	mg/L	Annually	10	<0.001	<0.001	0.008	0.035	<0.05	<0.001	0.05		0
Boron	mg/L		10	0.0171	0.0177	0.0212	0.0257	0.0279		4		0
Tin	mg/L		9	<0.001	<0.001	0.0	0.004	0.005	<0.001			0
Silver	mg/L		9	<0.0001	<0.0001	0.0003	0.0007	<0.001	<0.0001	0.1		0
Beryllium	mg/L		8	<0.0005	<0.0005	<0.0005	0.0006	<0.001	<0.0005	0.06		0
Uranium	mg/L		9	<0.0005	<0.0005	0.0	0.0008	0.0008	<0.0005	0.017		0
Iodide	mg/L		9	<0.02	<0.02	<20	<20	<20	<0.02	0.5		0
Barium	mg/L		9	0.010	0.011	0.016	0.023	0.025		2		0
Gross Alpha (Radionuclides)	Bq/L		11	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	≤0.5		0
Gross Beta (Radionuclides)	Bq/L		11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	≤0.5		0

GLENDEN VERIFICATION RESULTS

TABLE 0-4: GLENDEN VERIFICATION DATA RESULTS												
Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
pH	pH Unit	Weekly	500	6.75	7.0	7.2	7.5	7.96		6.5-8.5		0
Free Residual Chlorine	mg/L		487	0.28	0.71	1.33	2.00	3		5		0
E Coli	MPN/100mL		369	<1	<1	<1	<1	<1	<1	1		0
Turbidity	NTU		338	<0.1	<0.1	0.2	0.6	1.57	<0.1		5	0
Aluminium	mg/L		351	<0.005	0.013	0.035	0.053	0.176	<0.005		0.2	0
Iron	mg/L		365	<0.001	0.001	0.005	0.015	0.163	<0.001		0.3	0
Manganese	mg/L		370	<0.001	<0.001	0.002	0.005	0.029	<0.001	0.5	0.1	0
Conductivity	μS/cm		292	109	167	246	344	465				0
Total Dissolved Solids	mg/L		293	<1	99	146	207	279	<1		600	0
Fluoride	mg/L	Monthly	68	<0.01	0.02	0.06	0.09	0.17	<0.01		1.5	0
Colour - True	TCU		84	<1	<1	1	4	13	<1		15	0
DO	% Sat		73	9.56	88.4	95.6	105.1	109.4			85	1
Calcium (Ca)	mg/L		84	13.981	14.451	20.821	28.186	30.425				0
Magnesium (Mg)	mg/L		84	2.313	2.497	5.674	9.994	11.720				0
Hardness	mg/L		82	44.79	45.98	74.93	112.07	120.09			200	0
Hardness - Temporary	mg/L		84	3.29	34.15	59.99	96.62	107.80				0
Alkalinity	mg/L		84	30.68	34.79	60.74	96.65	107.78				0
Residual Alkalinity	mg/L		51	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0
Nitrite	mg/L		84	<0.004	<0.004	0.060	0.283	<0.04	<0.004	3		0
Nitrate	mg/L		84	<0.015	<0.015	0.265	0.845	0.964	<0.015	50		0
THMs	mg/L		140	<0.005	0.0141	0.0424	0.0821	0.1780	<0.005	0.25		0
Bromate	mg/L		92	<0.005	0.007	0.010	<0.05	<0.05	<0.005	0.02		0
Chlorite	mg/L		91	<0.005	0.007	0.010	0.035	<0.05	<0.005	0.8		0
Chlorate	mg/L		91	<0.02	0.04	0.26	0.60	0.76	<0.02			0
Total Algae	cells/mL		175	0	0.0	26.1	0.0	4310				0
Formaldehyde	mg/L	Quarterly	34	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0

TABLE 0-4: GLENDEN VERIFICATION DATA RESULTS

Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
Arsenic	mg/L		23	<0.0005	<0.0005	<0.0005	0.0007	<0.001	<0.0005	0.01		0
Selenium	mg/L		23	<0.001	<0.001	0.003	0.004	<0.005	<0.001	0.01		0
Mercury	mg/L		23	<0.00005	<0.00005	0.00024	0.00035	<0.0005	<0.00005	0.001		0
Lead	mg/L		23	<0.0005	<0.0005	<0.0005	0.0007	<0.001	<0.0005	0.01		0
Zinc	mg/L		24	<0.001	0.002	0.003	0.004	0.008	<0.001		3	0
Copper	mg/L		24	0.002	0.002	0.006	0.011	<0.015		2		0
Cadmium	mg/L		24	<0.0001	<0.0001	0.0004	0.0014	<0.002	<0.0001	0.002		0
Chromium	mg/L		23	<0.0001	<0.0001	0.0016	0.0071	<0.01	<0.0001	0.05		0
Nickel	mg/L		24	<0.0005	<0.0005	0.0047	<0.03	<0.03	<0.0005	0.02		0
Ammonia	mg/L		33	<0.01	<0.01	<0.01	<0.01	0.04	<0.01		0.5	0
Hydrogen Sulphide	mg/L		24	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		0.05	0
Pesticides*	µg/L		24	<0.0001	<0.0001	<0.0001	<0.0001	2.1182	<0.0001			0
Molybdenum	mg/L	Annually	7	<0.001	<0.001	0.006	0.025	<0.05	<0.001	0.05		0
Boron	mg/L		7	0.0055	0.0079	0.0132	0.0163	0.0170		4		0
Tin	mg/L		6	<0.001	<0.001	0.0	0.007	0.008	<0.001			0
Silver	mg/L		6	<0.0001	<0.0001	0.0002	0.0005	<0.001	<0.0001	0.1		0
Beryllium	mg/L		6	<0.0005	<0.0005	<0.0005	0.0006	<0.001	<0.0005	0.06		0
Uranium	mg/L		6	<0.0005	<0.0005	<0.0005	0.0007	<0.001	<0.0005	0.017		0
Iodide	mg/L		8	<0.02	<0.02	<20	<20	<20	<0.02	0.5		0
Barium	mg/L		6	0.014	0.015	0.017	0.022	0.023		2		0
Gross Alpha (Radionuclides)	Bq/L		12	<0.04	<0.04	<0.04	0.06	0.08	<0.04	≤0.5		0
Gross Beta (Radionuclides)	Bq/L		12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	≤0.5		0

ST LAWRENCE VERIFICATION RESULTS

TABLE 0-5: ST LAWRENCE VERIFICATION DATA RESULTS												
Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
pH	pH Unit	Weekly	494	6.63	7.1	7.4	7.8	8		6.5-8.5		0
Free Residual Chlorine	mg/L		493	0.05	0.87	1.77	2.50	8.75		5		2
E Coli	MPN/100mL		369	<1	<1	<1	<1	<1	<1	1		0
Turbidity	NTU		333	<0.1	<0.1	0.2	0.7	2.14	<0.1		5	0
Aluminium	mg/L		359	<0.005	0.014	0.065	0.170	0.589	<0.005		0.2	11
Iron	mg/L		365	<0.001	0.001	0.009	0.036	0.134	<0.001		0.3	0
Manganese	mg/L		371	<0.001	<0.001	0.024	0.120	0.496	<0.001	0.5	0.1	23
Conductivity	µS/cm		362	97	185	256	361	917				0
Total Dissolved Solids	mg/L		362	58	111	154	217	550			600	0
Fluoride	mg/L	Monthly	67	<0.01	0.02	0.05	0.07	0.11	<0.01		1.5	0
Colour - True	TCU		83	<1	<1	1	4	10	<1		15	0
DO	% Sat		71	67.1	80.8	91.7	105.6	116.0			85	16
Calcium (Ca)	mg/L		82	5.474	6.737	10.050	17.901	21.306				0
Magnesium (Mg)	mg/L		82	2.176	2.500	3.979	7.245	7.888				0
Hardness	mg/L		81	23.97	30.20	41.39	72.58	80.25			200	0
Hardness - Temporary	mg/L		81	28.00	35.60	57.77	84.30	141.70				0
Alkalinity	mg/L		82	28.02	35.64	57.84	84.15	141.68				0
Residual Alkalinity	mg/L		50	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0
Nitrite	mg/L		82	<0.004	<0.004	0.061	0.283	<0.4	<0.004	3		0
Nitrate	mg/L		82	<0.015	<0.015	0.328	0.839	2.671	<0.015	50		0
THMs	mg/L		143	<0.005	0.0338	0.1083	0.2191	0.3410	<0.005	0.25		3
Bromate	mg/L		90	<0.005	0.007	0.010	<0.05	<0.05	<0.005	0.02		0
Chlorite	mg/L		89	<0.005	0.007	0.011	0.035	<0.05	<0.005	0.8		0
Chlorate	mg/L		89	<0.02	0.08	0.65	2.23	4.76	<0.02			0
Total Algae	cells/mL		112	0	0.0	30.5	0.0	2570				0
Formaldehyde	mg/L	Quarterly	36	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0

TABLE 0-5: ST LAWRENCE VERIFICATION DATA RESULTS

Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No.	Minimum	5th	Average	95th	Maximum	LOR	Limit		Exceedance
Arsenic	mg/L		22	<0.0005	<0.0005	<0.0005	0.0007	<0.001	<0.0005	0.01		0
Selenium	mg/L		22	<0.001	<0.001	0.003	0.004	<0.005	<0.001	0.01		0
Mercury	mg/L		22	<0.00005	<0.00005	0.00025	0.00035	<0.0005	<0.00005	0.001		0
Lead	mg/L		22	<0.0005	<0.0005	<0.0005	0.0007	<0.001	<0.0005	0.01		0
Zinc	mg/L		23	<0.001	<0.001	0.004	0.013	0.014	<0.001		3	0
Copper	mg/L		23	<0.001	<0.001	0.007	0.011	0.078	<0.001	2		0
Cadmium	mg/L		23	<0.0001	<0.0001	0.0005	0.0014	<0.002	<0.0001	0.002		0
Chromium	mg/L		23	<0.0001	<0.0001	0.0019	0.0071	<0.01	<0.0001	0.05		0
Nickel	mg/L		23	<0.0005	<0.0005	0.0058	<0.03	<0.03	<0.0005	0.02		0
Ammonia	mg/L		32	<0.01	<0.01	<0.01	<0.01	0.03	<0.01		0.5	0
Hydrogen Sulphide	mg/L		22	<0.005	<0.005	0.050	0.014	1.000	<0.005		0.05	1
Pesticides*	µg/L		19	<0.0001	<0.0001	<0.0001	<0.0001	0.2922	<0.0001			0
Molybdenum	mg/L	Annually	7	<0.001	<0.001	0.006	0.025	<0.05	<0.001	0.05		0
Boron	mg/L		7	0.0201	0.0205	0.0235	0.0265	0.0272		4		0
Tin	mg/L		6	<0.001	<0.001	0.0	0.005	0.006	<0.001			0
Silver	mg/L		6	<0.0001	<0.0001	0.0002	0.0005	<0.001	<0.0001	0.1		0
Beryllium	mg/L		6	<0.0005	<0.0005	<0.0005	0.0006	<0.001	<0.0005	0.06		0
Uranium	mg/L		6	<0.0005	<0.0005	<0.0005	0.0006	<0.001	<0.0005	0.017		0
Iodide	mg/L		8	<0.02	<0.02	<20	<20	<20	<0.02	0.5		0
Barium	mg/L		6	0.009	0.010	0.013	0.015	0.015		2		0
Gross Alpha (Radionuclides)	Bq/L		10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	≤0.5		0
Gross Beta (Radionuclides)	Bq/L		10	<0.1	<0.1	<0.1	0.11	0.14	<0.1	≤0.5		0

CARMILA VERIFICATION RESULTS

TABLE 0-6: CARMILA VERIFICATION RESULTS												
Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
pH	pH Unit	Weekly	431	6.95	7.20	7.70	8.02	8.17		6.5-8.5		0
Free Residual Chlorine	mg/L		431	<0.02	0.64	1.54	2.50	3.08	<0.02	5		0
E Coli	MPN/100mL		369	<1	<1	<1	<1	8	<1	1		1
Turbidity	NTU		343	<0.1	<0.1	0.2	0.5	1.21	<0.1		5	0
Aluminium	mg/L		364	<0.005	0.026	0.057	0.117	0.775	<0.005		0.2	2
Iron	mg/L		363	<0.002	<0.002	0.016	0.085	0.599	<0.002		0.3	1
Manganese	mg/L		368	<0.001	<0.001	0.005	0.016	0.129	<0.001	0.5	0.1	2
Conductivity	µS/cm		361	161	261	332	419	721				0
Total Dissolved Solids	mg/L		360	97	155	199	250	433			600	0
Fluoride	mg/L	Monthly	68	<0.01	0.06	0.10	0.14	0.15	<0.01		1.5	0
Colour - True	TCU		88	<1	<1	1	3	5	<1		15	0
DO	% Sat		76	50.1	69.1	86.7	100.1	104.5			85	29
Calcium (Ca)	mg/L		87	6.720	18.186	23.538	29.349	34.109				0
Magnesium (Mg)	mg/L		87	2.381	7.608	9.982	12.524	13.990				0
Hardness	mg/L		86	29.18	79.54	100.01	126.07	136.87			200	0
Hardness - Temporary	mg/L		86	54.20	70.65	90.57	105.23	115.70				0
Alkalinity	mg/L		87	54.16	70.93	90.81	106.67	115.7				0
Residual Alkalinity	mg/L		51	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0
Nitrite	mg/L		87	<0.004	<0.004	0.061	0.283	<0.4	<0.004	3		0
Nitrate	mg/L		87	<0.015	<0.015	0.234	0.578	1.188	<0.015	50		0
THMs	mg/L		148	0.0130	0.0230	0.0686	0.1296	0.2010		0.25		0
Bromate	mg/L		100	<0.005	0.007	0.011	<0.05	<0.05	<0.005	0.02		0
Chlorite	mg/L		99	<0.005	0.007	0.011	0.035	<0.05	<0.005	0.8		0
Chlorate	mg/L		98	<0.02	0.04	0.37	1.32	2.29	<0.02			0
Formaldehyde	mg/L	Quarterly	37	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0
Arsenic	mg/L		23	<0.0005	<0.0005	0.0	0.0009	0.0010	<0.0005	0.01		0

TABLE 0-6: CARMILA VERIFICATION RESULTS

Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No.	Minimum	5th	Average	95th	Maximum	LOR	Limit		Exceedance
Selenium	mg/L		23	<0.001	<0.001	0.003	0.004	<0.005	<0.001	0.01		0
Mercury	mg/L		23	<0.00005	<0.00005	0.00026	0.00035	<0.0005	<0.00005	0.001		0
Lead	mg/L		23	<0.0005	<0.0005	<0.0005	0.0007	<0.001	<0.0005	0.01		0
Zinc	mg/L		24	<0.001	<0.001	0.005	0.010	0.012	<0.001		3	0
Copper	mg/L		24	<0.001	<0.001	0.005	0.011	0.011	<0.001	2		0
Cadmium	mg/L		24	<0.0001	<0.0001	0.0004	0.0014	<0.002	<0.0001	0.002		0
Chromium	mg/L		24	<0.0001	<0.0001	0.0019	0.0071	<0.01	<0.0001	0.05		0
Nickel	mg/L		24	<0.0005	<0.0005	0.0056	<0.03	<0.03	<0.0005	0.02		0
Ammonia	mg/L		41	<0.01	<0.01	<0.01	<0.01	0.03	<0.01		0.5	0
Hydrogen Sulphide	mg/L		23	<0.005	<0.005	0.006	0.011	0.040	<0.005		0.05	0
Pesticides*	μg/L		17	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001			0
Molybdenum	mg/L	Annually	7	<0.001	<0.001	0.006	0.026	<0.05	<0.001	0.05		0
Boron	mg/L		7	0.0100	0.0115	0.0153	0.0177	0.0181		4		0
Tin	mg/L		6	<0.001	<0.001	0.0	0.009	0.011	<0.001			0
Silver	mg/L		6	<0.0001	<0.0001	0.0002	0.0006	<0.001	<0.0001	0.1		0
Beryllium	mg/L		6	<0.0005	<0.0005	<0.0005	0.0006	<0.001	<0.0005	0.06		0
Uranium	mg/L		6	<0.0005	<0.0005	0.0	0.0015	0.0018	<0.0005	0.017		0
Iodide	mg/L		8	<0.02	<0.02	<20	<20	<20	<0.02	0.5		0
Barium	mg/L		6	0.018	0.019	0.024	0.030	0.031		2		0
Gross Alpha (Radionuclides)	Bq/L		10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	≤0.5		0
Gross Beta (Radionuclides)	Bq/L		10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	≤0.5		0

DYSART VERIFICATION RESULTS

TABLE 0-7: DYSART VERIFICATION RESULTS												
Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
pH	pH Unit	Weekly	445	4.8	7.0	7.3	7.8	8.67		6.5-8.5		3
Free Residual Chlorine	mg/L		441	<0.02	0.69	2.15	3.79	4.98	<0.02	5		0
E Coli	MPN/100mL		373	<1	<1	<1	<1	<1	<1	1		0
Turbidity	NTU		343	<0.1	<0.1	0.6	1.1	92	<0.1		5	3
Aluminium	mg/L		303	0.002	0.006	0.039	0.091	0.626			0.2	8
Iron	mg/L		369	<0.001	0.001	0.006	0.016	0.338	<0.001		0.3	1
Manganese	mg/L		374	<0.001	<0.001	0.003	0.005	0.235	<0.001	0.5	0.1	2
Conductivity	µS/cm		287	117	205	330	573	703				0
Total Dissolved Solids	mg/L		287	<1	122	197	323	422	<1		600	0
Fluoride	mg/L	Monthly	67	<0.01	0.06	0.12	0.20	0.22	<0.01		1.5	0
Colour - True	TCU		87	<1	<1	2	7	29	<1		15	1
DO	% Sat		71	67.5	79.5	90.7	101.6	105.0			85	12
Calcium (Ca)	mg/L		86	12.987	14.205	20.963	29.208	33.120				0
Magnesium (Mg)	mg/L		86	4.775	5.485	8.953	15.730	19.000				0
Hardness	mg/L		83	52.26	58.25	89.03	136.90	157.77			200	0
Hardness - Temporary	mg/L		84	29.64	52.36	78.32	109.27	126.90				0
Alkalinity	mg/L		85	50.98	56.10	79.22	109.30	126.9				0
Residual Alkalinity	mg/L		51	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0
Nitrite	mg/L		85	<0.004	<0.004	0.066	0.283	0.435	<0.004	3		0
Nitrate	mg/L		85	<0.015	<0.015	0.679	1.694	12.206	<0.015	50		0
THMs	mg/L		117	0.0133	0.0207	0.0709	0.1680	0.2470		0.25		0
Bromate	mg/L		68	<0.005	<0.05	<0.05	<0.05	<0.05	<0.005	0.02		0
Chlorite	mg/L		67	<0.005	0.007	0.011	0.035	<0.05	<0.005	0.8		0
Chlorate	mg/L		66	<0.01	0.01	0.03	0.04	0.16	<0.01			0
Total Algae	cells/mL		117	0	0.0	62.6	78.0	5760				0
Formaldehyde	mg/L	Quarterly	35	<0.1	<0.1	<0.1	<0.1	0.2	<0.1			0

TABLE 0-7: DYSART VERIFICATION RESULTS

Parameter	Unit	Frequency	Summary of Results (Jan 2014 – Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
Arsenic	mg/L		24	<0.0005	<0.0005	0.0	0.0007	0.0009	<0.0005	0.01		0
Selenium	mg/L		24	<0.001	<0.001	0.003	0.004	<0.005	<0.001	0.01		0
Mercury	mg/L		24	<0.00005	<0.00005	0.00025	0.00035	<0.0005	<0.00005	0.001		0
Lead	mg/L		24	<0.0005	<0.0005	0.0006	0.0008	0.0040	<0.0005	0.01		0
Zinc	mg/L		25	<0.001	0.004	0.011	0.024	0.027	<0.001		3	0
Copper	mg/L		25	0.003	0.009	0.037	0.063	0.366		2		0
Cadmium	mg/L		25	<0.0001	<0.0001	0.0004	0.0014	<0.002	<0.0001	0.002		0
Chromium	mg/L		24	<0.0001	<0.0001	0.0019	0.0071	<0.01	<0.0001	0.05		0
Nickel	mg/L		25	<0.0005	<0.0005	0.0058	<0.03	<0.03	<0.0005	0.02		0
Ammonia	mg/L		35	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		0.5	0
Hydrogen Sulphide	mg/L		23	<0.005	<0.005	0.005	<0.005	0.040	<0.005		0.05	0
Pesticides*	µg/L		23	<0.0001	<0.0001	<0.0001	<0.0001	1.2393	<0.0001			0
Molybdenum	mg/L	Annually	8	<0.001	<0.001	0.005	0.024	<0.05	<0.001	0.05		0
Boron	mg/L		8	0.0354	0.0364	0.0463	0.0582	0.0604		4		0
Tin	mg/L		7	<0.001	<0.001	0.002	0.006	0.008	<0.001			0
Silver	mg/L		7	<0.0001	<0.0001	0.0003	0.0007	<0.001	<0.0001	0.1		0
Beryllium	mg/L		6	<0.0005	<0.0005	<0.0005	0.0006	<0.001	<0.0005	0.06		0
Uranium	mg/L		7	<0.0005	<0.0005	0.0005	0.0008	0.0009	<0.0005	0.017		0
Iodide	mg/L		8	<0.02	<0.02	<20	<20	<20	<0.02	0.5		0
Barium	mg/L		7	0.031	0.032	0.039	0.048	0.048		2		0
Gross Alpha (Radionuclides)	Bq/L		10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	≤0.5		0
Gross Beta (Radionuclides)	Bq/L		10	<0.1	<0.1	<0.1	0.14	0.16	<0.1	≤0.5		0

MIDDLEMOUNT VERIFICATION RESULTS

TABLE 0-8: MIDDLEMOUNT VERIFICATION RESULTS												
Parameter	Unit	Frequency	Summary of Results (Jan 2014 -Oct 2021)									
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Limit		Exceedance
										Health	Aesthetic	
pH	pH Unit	Weekly	449	6.97	7.1	7.5	7.9	8.53		6.5-8.5		1
Free Residual Chlorine	mg/L		447	<0.02	1.03	2.33	3.11	3.75	<0.02	5		0
E Coli	MPN/100mL		373	<1	<1	<1	<1	<1	<1	1		0
Turbidity	NTU		316	<0.1	<0.1	0.4	1.4	10.2	<0.1		5	3
Aluminium	mg/L		215	0.002	0.004	0.005	0.012	0.038			0.2	0
Iron	mg/L		369	<0.001	0.001	0.004	0.009	0.076	<0.001		0.3	0
Manganese	mg/L		374	<0.001	<0.001	0.002	0.005	0.040	<0.001	0.5	0.1	0
Conductivity	µS/cm		292	114	185	324	558	673				0
Total Dissolved Solids	mg/L		292	68	111	194	334	404			600	0
Fluoride	mg/L	Monthly	69	<0.01	0.03	0.13	0.19	0.22	<0.01		1.5	0
Colour - True	TCU		87	<1	<1	2	5	13	<1		15	0
DO	% Sat		70	80.4	84.9	94.8	103.1	107.1			85	4
Calcium (Ca)	mg/L		88	9.826	11.341	18.953	27.281	34.610				0
Magnesium (Mg)	mg/L		88	4.045	4.606	8.882	15.767	18.950				0
Hardness	mg/L		86	41.98	46.91	83.99	132.49	157.77			200	0
Hardness - Temporary	mg/L		86	37.90	47.05	79.80	115.30	131.40				0
Alkalinity	mg/L		87	37.9	47.07	79.70	115.13	131.42				0
Residual Alkalinity	mg/L		50	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0
Nitrite	mg/L		87	<0.004	<0.004	0.060	0.283	0.496	<0.004	3		0
Nitrate	mg/L		87	<0.015	0.0806	0.820	1.935	2.772	<0.015	50		0
THMs	mg/L		122	<0.005	0.0291	0.1281	0.2100	0.2430	<0.005	0.25		0
Bromate	mg/L		68	<0.005	<0.05	<0.05	<0.05	<0.05	<0.005	0.02		0
Chlorite	mg/L		67	<0.005	0.007	0.011	0.035	<0.05	<0.005	0.8		0
Chlorate	mg/L		66	<0.01	0.01	0.04	0.04	0.73	<0.01			0
Total Algae	cells/mL		127	0	0.0	1.9	0.0	140				0
Formaldehyde	mg/L	Quarterly	42	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0

TABLE 0-8: MIDDLEMOUNT VERIFICATION RESULTS

Parameter	Unit	Frequency	Summary of Results (Jan 2014 -Oct 2021)							Limit		
			No. Samples	Minimum	5th Percentile	Average	95th Percentile	Maximum	LOR	Health	Aesthetic	Exceedance
Arsenic	mg/L		25	0.00052	0.0	0.0	0.0011	0.0012		0.01		0
Selenium	mg/L		25	<0.001	<0.001	0.003	0.004	<0.005	<0.001	0.01		0
Mercury	mg/L		25	<0.00005	<0.00005	0.00028	0.00051	<0.001	<0.00005	0.001		0
Lead	mg/L		25	<0.0005	<0.0005	<0.0005	0.0007	<0.001	<0.0005	0.01		0
Zinc	#N/A		26	<0.001	0.004	0.006	0.010	0.012	<0.001		3	0
Copper	mg/L		26	0.009	0.009	0.015	0.026	0.038		2		0
Cadmium	mg/L		26	<0.0001	<0.0001	0.0005	0.0014	<0.002	<0.0001	0.002		0
Chromium	mg/L		26	<0.0001	<0.0001	0.0020	0.0071	<0.01	<0.0001	0.05		0
Nickel	mg/L		26	0.000597	0.001	0.0066	<0.03	<0.03		0.02		0
Ammonia	#N/A		35	<0.01	<0.01	<0.01	0.0	0.05	<0.01		0.5	0
Hydrogen Sulphide	mg/L		23	<0.005	<0.005	<0.005	0.006	0.006	<0.005		0.05	0
Pesticides*	µg/L		23	<0.0001	<0.0001	<0.0001	<0.0001	0.5881	<0.0001			0
Molybdenum	mg/L		9	<0.001	<0.001	0.009	0.035	<0.05	<0.001	0.05		0
Boron	mg/L		9	0.0340	0.0348	0.0436	0.0528	0.0530		4		0
Tin	mg/L		7	<0.001	<0.001	0.0	0.005	0.007	<0.001			0
Silver	mg/L		7	<0.0001	<0.0001	0.0003	0.0007	<0.001	<0.0001	0.1		0
Beryllium	mg/L		6	<0.0005	<0.0005	<0.0005	0.0006	<0.001	<0.0005	0.06		0
Uranium	mg/L	Annually	6	<0.0005	<0.0005	<0.0005	0.0007	<0.001	<0.0005	0.017		0
Iodide	mg/L		9	<0.02	<0.02	<20	<20	<20	<0.02	0.5		0
Barium	mg/L		7	0.027	0.027	0.038	0.046	0.049		2		0
Gross Alpha (Radionuclides)	Bq/L		12	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	≤0.5		0
Gross Beta (Radionuclides)	Bq/L		12	<0.1	<0.1	<0.1	0.17	0.20	<0.1	≤0.5		0

LIMITATIONS

GENERAL

This report is for the use of Isaac Regional Council only and should not be used or relied upon by any other person or entity or for any other project.

APPENDIX 1

Risk Register
Table 20.3

APPENDIX 2

Risk Management Improvement Program Table 22.1

APPENDIX 3

DWQMP Amendments Record for DNRME Approval

APPENDIX 4

IRC Documentation Register