Ballina Shire Council Drinking Water Management System

Risk Assessment Workshop Report

December 2012

Ballina Shire Council Drinking Water Management System

Risk Assessment Workshop Report

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1 Introduction

This is the risk assessment report for the Ballina Shire Council Drinking Water Management System (DWMS). The *Public Health Act 2010* and the *Public Health Regulation 2012* require all water suppliers to prepare a quality assurance program in the form of a DWMS. The DWMS must prepared in accordance with the *NSW Guidelines for Drinking Water Management Systems* (2012) (the DWMS Guidelines) and address the elements of the national framework for drinking water quality, the *Australian Drinking Water Guidelines* (ADWG) (NHMRC & NRMMC 2011). An assessment of the drinking water supply system is required under Element 2. The DWMS guidelines state that:

A risk assessment of the drinking water system must be undertaken:

- *assemble a team to undertake the risk assessment*
- *draw a flow diagram of the system from catchment to consumer*
- *review and analyse water quality data*
- *develop a workshop briefing paper*
- *hold a hazard identification, preventive measure identification and risk assessment workshop*
- *record the workshop outcomes in a Risk Assessment Report*

The risk assessment workshop briefing paper was prepared prior to the Ballina Shire Council risk assessment workshop and includes scheme descriptions, flow diagrams, scheme layout plans and the water quality analysis. The briefing paper is provided in Appendix A.

The risk assessment workshop was also used to identify critical control points (CCPs) to meet the requirements of Element 3, the results of the CPP identification are presented in the DWMS (Appendix D, DWMS).

2 Risk Assessment Team

A team was assembled to undertake the risk assessment that was judged to have appropriate knowledge and expertise to assess the risk for this system. This team included the operators and managers of the water supply system, catchment managers, a representative of the bulk water supplier (Rous Water) and officers from NSW Health and NSW Office of Water (NOW).

In addition, James Howey for Viridis Consultants P/L (Viridis), an expert in the area of water quality risk assessment, directed and facilitated the risk assessment.

James is an Applied Chemist with a background in water and wastewater, specialising in risk assessment. His formal qualifications relevant to this task are as follows:

- BSc (Hons) Applied Chemistry
- MSc (Hons) Environmental Management
- RABQSA - Lead Drinking Water QMS Auditor
- RABQSA – Drinking Water Quality Management Systems
- RABQSA – Recycled Water Quality Management Systems

Relevant experience prior to this risk assessment:

- water quality risk assessments of 40 SEQ WTPs
- preparation of 3 drinking water quality management plans
- preparation of 6 HACCP plans for WTPs
- risk assessment and HACCP plan preparation for a wastewater catchment
- preparation of recycled water management plans for 4 WWTPs
- water quality risk assessment for the SEQ Water Grid, bulk water transport
- water quality risk assessment of a retail water business.

Viridis had previously developed the methodology and a template in consultation with Ballina Shire Council. This was the starting point for the risk assessment workshops where expert opinion from the risk assessment team was used to review information in the briefing paper and add detail.

The workshop for the risk assessment was undertaken on 6 and 7 September 2012. Details of the workshop participants and the risk assessment team are in Table 1. Following completion of the draft risk register, the risk assessment team was invited to review the risk register and provide comment before finalisation.

Table 1 Risk Assessment Team

Name	Company	Position	Experience
Tony Partridge	Ballina Shire Council	Operations Engineer	5+ years
Simon Smith	Ballina Shire Council	Environmental Engineer	15 years
Matt Collins	Ballina Shire Council	Water Foreman	18 months
Garry Meredith	Ballina Shire Council	Team Leader	27 years
Andrew Swan	Ballina Shire Council	W&S Engineer	5+ years
Gavin Spring	Ballina Shire Council	Water Quality Trade Waste	10+ years
Jenny Ryan	Ballina Shire Council	Environmental Health Officer	10 years
Besim Sinanovski	Ballina Shire Council	Water Operator	6+ years

Name	Company	Position	Experience
Graham Plumb	Ballina Shire Council	Environmental Health Officer	35 years
Belinda Fayle	Rous Water	Dams and Treatment Manager	Source, treatment management, bulk supply
Terry Call	NSW Office of Water	Regional Inspector	Numerous
Geoff Sullivan	NSW Health	Environmental Health Officer	Public Health
Tony Kohlenberg	NSW Health	Environmental Health Officer	Public Health
James Howey	Viridis	Facilitator	Chemist, RABQSA DW-QMS
Karen Pither	Viridis	Facilitator	Water regulation, risk assessment

3 Process

3.1 Methodology

The methodology used for the risk assessment is described in the DWMS. This includes a definition of the likelihood, consequence and risk level, an explanation of the acceptable risk level and the rationale for this selection.

The methodology is based on the premise that risk is defined as the likelihood of identified hazards causing harm in exposed populations in a specified timeframe, with consideration for the severity of the consequences (i.e. risk = likelihood x consequence) (NHMRC & NRMMC 2011). The risk matrix that was used to calculate risk is presented in Table 2, the consequence and likelihood descriptors are presented in Table 3 and Table 4. The descriptors for uncertainty are presented in Table 5.

Table 2 Risk Matrix

Likelihood	**Consequence**				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium (6)	High (10)	High (15)	Extreme (20)	Extreme (25)
Likely	Medium (5)	Medium (8)	High (12)	High (16)	Extreme (20)
Possible	Low (3)	Medium (6)	Medium (9)	High (12)	High (15)
Unlikely	Low (2)	Low (4)	Medium (6)	Medium (8)	High (10)
Rare	Low (1)	Low (2)	Low (3)	Medium (5)	Medium (6)

Table 3 Consequence Descriptors

Consequence	**Descriptor**	**Definition**
1	Insignificant	Isolated exceedence of aesthetic parameter with little or no disruption to normal operation
2	Minor	Potential local aesthetic, isolated exceedence of chronic health parameter
3	Moderate	Potential widespread aesthetic impact or repeated breach of chronic health parameter
4	Major	Potential acute health impact, no declared outbreak expected
5	Catastrophic	Potential acute health impact, declared outbreak expected

Table 4 Likelihood Descriptors

Likelihood	Descriptor	Definition
1	Rare	Occurs less than or equal to once every 5 years
2	Unlikely	Occurs more often than once every 5 years and up to once per year
3	Possible	Occurs more often than once per year and up to once a month (12/yr)
4	Likely	Occurs more often than once per month (12/yr) and up to once per week (52/yr)
5	Almost Certain	Occurs more often than once per week (52/yr)

Table 5 Uncertainty Descriptors

Level of Uncertainty	Descriptor	Definition
1	Certain	• there is 5 years of continuous monitoring data, which has been trended and assessed, with at least daily monitoring • the processes involved are thoroughly understood
2	Confident	• there is 5 years of continuous monitoring data, which has been collated and assessed, with at least weekly monitoring or for the duration of seasonal events • there is a considerable understanding of the processes involved
3	Reliable	• there is at least a year of continuous monitoring data available, which has been assessed • there is a good understanding of the processes involved
4	Estimate	• there is limited monitoring data available • There is a reasonable understanding of the processes involved
5	Uncertain	• there is limited or no monitoring data available • the processes are not well understood

3.2 Information used to inform the risk assessment

To assess the water supply system a range of background information was used to inform the risk assessment, including:

- catchment characteristics and known land uses in the catchments (including aerial photography)
- process flow diagrams and scheme descriptions for each water supply scheme (Wardell and distribution of supplied bulk water)
- supply system layout plans
- water quality data analysis for the raw water, filtered water, finished water (and distribution. The water quality analysis provided information on:
  - trends
  - exceedences
  - major variations
  - abnormal results
  - low number of results or no results for some relevant characteristics

  - potential water quality issues
- anecdotal information was gathered during the workshop from managers, operators and stakeholders based on experience and historical performance of the Ballina Shire supply system.

The background information is summarised in the Risk Assessment Briefing Paper (Appendix A).

The water quality data analysis included calculation of descriptive statistics presented in summary tables and trending of relevant parameters over time. The results of the water quality data analysis are presented the risk assessment briefing paper.

The risk assessment workshop was also used to validate the process flow diagrams and scheme descriptions with operators of the system.

3.3 Undertaking the Risk Assessment

The risk register template was designed in order to provide a structure to assess the risk of hazards and hazardous events. There are three levels of risk as depicted in Figure 1, which includes a representation of the process that was undertaken to determine residual risk.

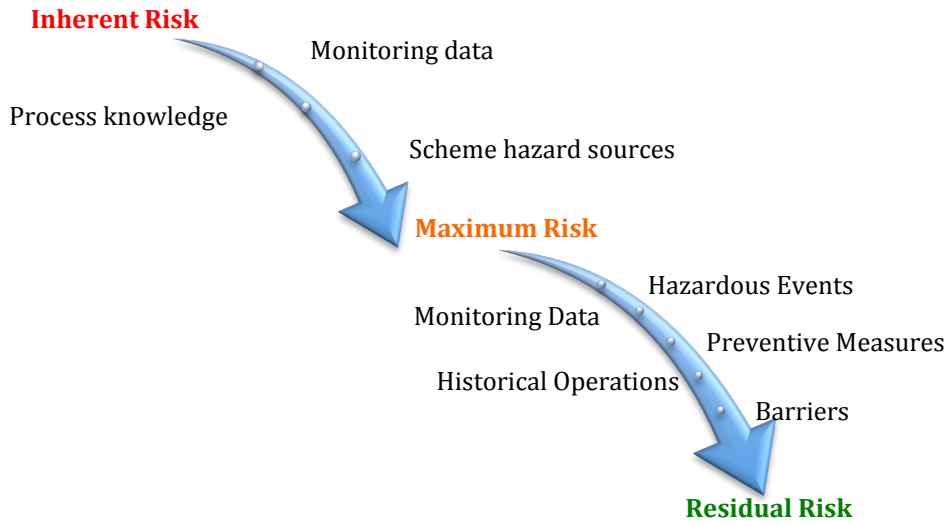

Figure 1 Risk Relationship

The three levels of risk for the Ballina Shire DWMS are summarised as follows:

- inherent risk
  - Marom Creek Dam
  - Ellis Road and LIndendale Road bores
  - significant residual risk passed on by Rous Water
- maximum risk
  - inherent risk and the risk of hazards introduced through the treatment process, distribution and scheme management
- residual risk
  - maximum risk after the preventive measures have been applied.

3.3.1 Inherent Risk

Inherent risk is the risk in the source water without treatment barriers in place. The inherent risk for the Wardell Scheme was determined based on the water quality analysis and catchment characteristics described in the risk assessment briefing paper and anecdotal information provided and discussed at the workshop. Risk was calculated for both water sources, Maron Creek Dam and bore sites.

The inherent risk register is provided in Appendix B. The inherent risk was calculated for each hazard, depicted in the left-most column in Figure 2. Sources for each hazard were identified and recorded. Based on the water quality analysis and anecdotal information, consequence and likelihood values were determined and a risk score calculated using the risk matrix for all of the raw water sources. Notes in relation to this risk assessment were also captured.

The inherent risks for the Ballina Shire distribution system (excluding Wardell) were sourced from the Rous Water Risk Assessment as identified in the Ballina Shire Risk Assessment Workshop Briefing Paper.

Impact	Source	Marom Creek			Bores		
		Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
H	**Wardell supply** - Wildlife - Dairies - Rural septic systems - Agriculture	Catastrophic	Likely	**Extreme (20)**	Major	Unlikely	**Medium (8)**

Figure 2 Inherent Risk Calculation

3.3.2 Maximum Risk

Maximum risk is defined as the risk in the absence of preventative measures (NHMRC & NRMMC 2011). Maximum risk represents the inherent risk plus the risk associated with additional sources of hazards introduced in the treatement and distribution processes. Maximum risk was calculated using the following process.

- Hazardous events were identified within the water supply system from raw water extraction to finished water supply points.
- All potential hazards were identified for each hazardous event.
- The limiting hazard for each hazardous event was identified and the inherent risk for the limiting hazard was used to determine the risk as well as any process introduced sources of the hazard.

Figure 3 demonstrates the process for determining the maximum risk or each hazardous event. As shown in Figure 3, hazardous events were identified at each step of the water supply system. Hazards and limiting hazards were identified to determine the maximum risk.

Ref	Component	Hazardous Event	Potential Hazard		Limiting Hazard/s	Maximum Consequence	Maximum Likelihood	Maximum Risk
Risk T-1	Source Water	**Algal bloom in Marom Creek**	Environmental conditions lead to algal bloom (e.g. low flows, high nutrients). Discharge from upstream dams	- Cyanotoxins	Cyanotoxins	Insignificant	Rare	**Low (1)**
Risk T-2	Source Water	**Out of Specification Source Water**	Source water exceeds treatment capacity due to: - storm event - nursery dam discharge - other	- T&O - Turbidity - Bacteria - Viruses - Protozoa - pH - Iron - Cyanotoxins	Protozoa	Catastrophic	Possible	**High (15)**

Figure 3 Maximum Risk Calculation

The risk registers for maximum and residual risk for treatment, distribution and whole of system are provided in Appendices C, D and E.

3.3.3 Residual Risk

Residual risk is defined as the risk remaining after consideration of existing preventative measures (NHMRC & NRMMC 2004). Residual risk was calculated using the following process.

- Preventive measures were identified for each previously recorded hazardous event. Monitoring that may identify the hazardous event was also identified at this stage.
- Taking into consideration available information such as historical performance and monitoring data the adequacy of the preventative measures was discussed and the residual risk was calculated using the risk methodology.
- The level of uncertainty of the risk assessment was determined using the risk assessment methodology.
- All comments were captured in the risk register.

Figure 4 demonstrates how the preventative measures were assessed to determine the residual risk.

Maximum Risk	Preventive Measures	Monitoring	Residual Consequence	Residual Likelihood	Hazardous Event Risk
Low (1)	- Selective abstraction. - Continuous flow at Marom Creek. - In low flow conditions water is pumped over weir to maintain flows. - Alternate sources (bores once operational).	- Catchment monitoring. - Monthly monitoring at Marom Creek.	Insignificant	Rare	Low (1)
High (15)	- Selective abstraction - Alternate source - Up to 7 days storage in system	- Daily visual inspection - Daily turbidity at Marom Creek - Review of weather	Major	Unlikely	Medium (8)

Preventative measures identified for all hazardous events

Risk is reduced by the application of the preventative measures

Figure 4 Residual Risk Calculation

3.3.4 Risk Treatment

The risk assessment methodology includes a level of acceptable risk, above this value risks are deemed to be significant. The cut-off value for significant risk was determined to be any risk that was found to be Medium (8) or above. All remaining significant risks must have risk treatments applied to ensure that these risks are managed to an acceptable level. Following the calculation of residual risk, additional risk treatments were discussed and identified for each residual risk that was found to be above the cut off value. The additional risk treatments will be addressed in the Ballina Shire Council DWMS Improvement Plan.

4 Inherent, Maximum and Residual Risks

4.1 Wardell Supply System

The Wardell supply system draws raw water from Marom Creek and two bores that are currently non operational, the Lindendale Road and Ellis Road bores. The risk asssessent assessed the inherent risks separately for the Marom Creek source and the bores. Raw water data analysis and catchment characteristics, including upstream land uses were used to identify the inherent risks for Marom Creek and the bores. Figure 5 depicts the inherent risk for the Wardell supply scheme.

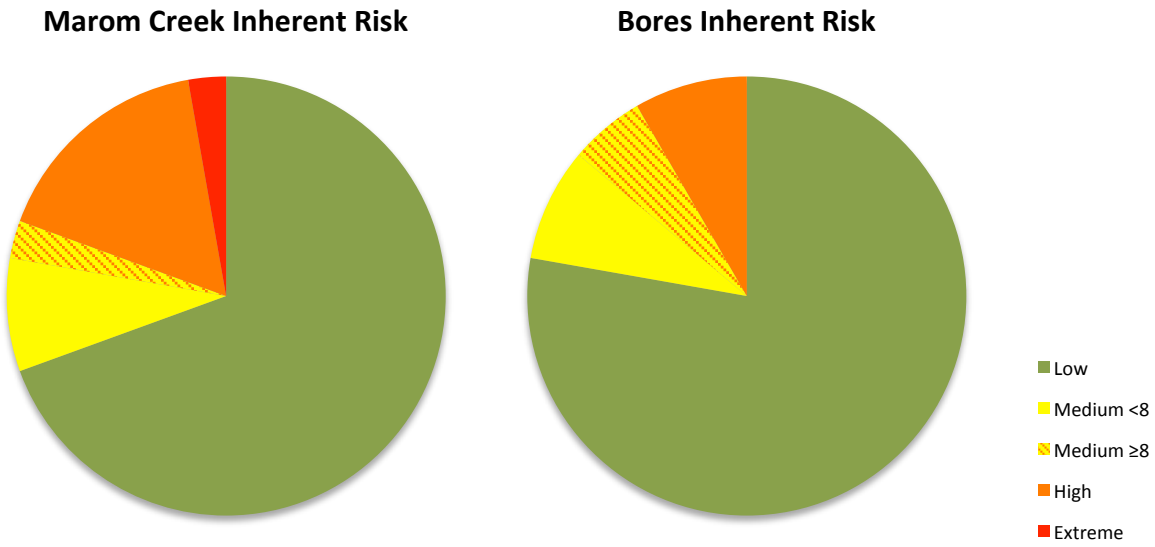

Figure 5 Wardell Supply Scheme Inherent Risks

Table 6 summarises the inherent risks for each hazard identified for the Marom Creek and the bore raw water sources that were found to be outside the acceptable risk range. (refer to Inherent Risk Register, Appendix B).

Table 6 Wardell Supply Scheme Inherent Risk Assessment Outcomes

Hazard	Inherent Risk
Marom Creek	
Bacteria	Extreme (20)
Protozoa	High (15)
Viruses	High (12)
Aluminium	Medium (8)
Iron	High (15)
Colour	High (15)
pH	High (15)
Turbidity	High (12)
Lindendale Road and Ellis Road Bores	
Bacteria	Medium (8)
Viruses	Medium (8)
Hydrogen sulphide/ sulphide	High (15)
Iron	High (15)

Hazard	Inherent Risk
Taste and odour	High (15)

Figure 6 indicates the proportion of maximum and residual risks determined for the Wardell supply scheme. It can be seen that prior to the application of preventative measures, the maximum risk was outside the acceptable range for a high proportion of hazardous events. The residual risk pie chart demonstrates that the majority of risks are within the acceptable range.

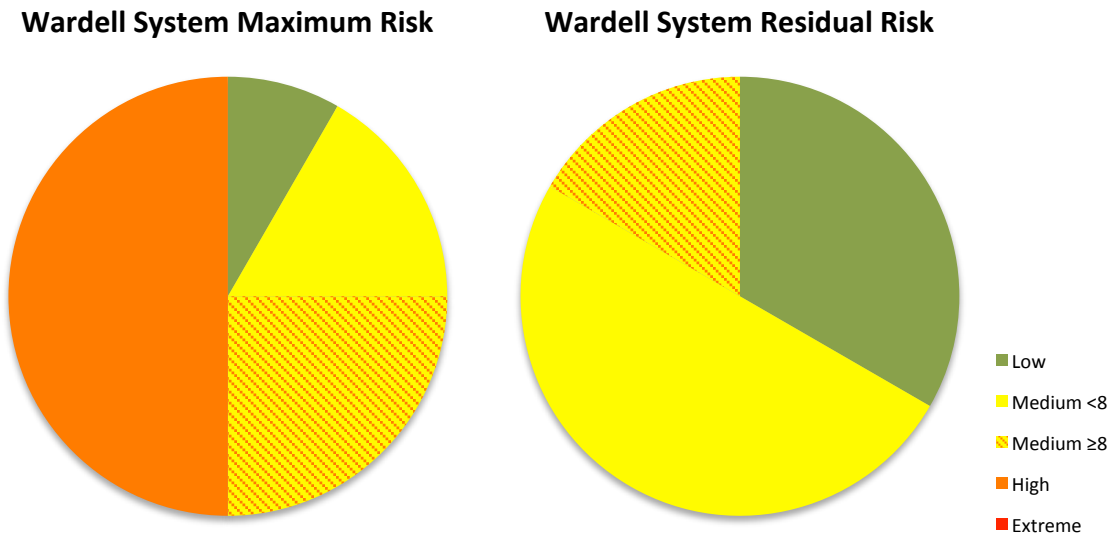

Figure 6 Wardell Supply Scheme Maximum and Residual Risk

Table 7 identifies the hazardous events that were found to have a maximum risk that was outside the acceptable range and the preventative measures that are applied to reduce the residual risk to an acceptable level. Four residual risks remain outside the acceptable risk range and will require additional risk treatment. The additional risk treatment will be addressed in the *Improvement Plan* (DWMS Appendix F).

Table 7 Wardell Supply Scheme Maximum and Residual Risk Assessment Outcomes

Hazardous Event	Maximum Risk	Preventive Measures	Residual Risk
Out of Specification Source Water	High (15)	Selective abstraction Alternate source Up to 7 days storage in system	Medium (8)
Infiltration of surface water	High (10)	Ellis Road bore covered Lindendale Road bore covered and locked Freeboard Regular maintenance	Medium (5)
Underdosing or overdosing alum	High (10)	Dose pumps linked to raw water pumps Alarm if pumps fail Spare pumps available onsite Monthly maintenance Plant is manned 7 days per week Ability to drain flocculation pond to infiltration pond if required	Medium (5)

Hazardous Event	Maximum Risk	Preventive Measures	Residual Risk
Underdosing or overdosing caustic	High (10)	Dose pumps linked to raw water pumps Alarm if pumps fail Spare pumps available onsite Monthly maintenance Plant is manned 7 days per week Ability to drain flocculation pond to infiltration pond if required	Medium (5)
Carry over of solids	Medium (8)	Cleaning of flocculation pond yearly Coarse screens at overflow to filter Maintenance program	Medium (5)
Wildlife in flocculation pond	Medium (8)	Flocculation pond completely netted	Low (1)
Filter breakthrough	High (16)	Backwash triggered on headloss Manual backwash every 2-3 weeks Plant is manned 7 days per week	Medium (8)
Insufficient chlorine Ct (concentration x time)	High (15)	Spare pumps on site Chlorine pump linked to raw water pumps Plant is manned 7 days per week	Medium (5)
Insufficient chlorine Ct (concentration x time) in bores	Medium (8)	Daily visual inspection	Medium (5)

4.2 Bulk Water Distribution

Rous Water conducted a risk assessment for their drinking water supply that used the same methodlogy as identified in this risk assessment report. Rous Water communicated the significant residual risks to Ballina Shire, which are identified in the risk assessment and were assessed by Ballina Shire in accordance with the risk assessment methodology. The distribution risk assessment process included identification and assessment of the significant residual risks that are passed onto Ballina Shire by Rous Water. Significant residual risks passed down by Rous Water are:

- Ingress of contaminants – non potable water – Medium (8) residual risk
- Backflow – backflow from a third party asset – High (10) residual risk

The signifincant risks passed on by Rous Water were captured in the Ballina Risk Assesssment as 'receipt of out of specification water' and were also included as risks that had the potential to occur in the Ballina system as identified in Table 8.

4.3 Distribution System

Figure 7 summarises the risk calculations for the Ballina Shire distribution system, Ballina and Wardell. It indicates that whilst the proportion of significant risks was reduced, there are still unacceptable residual risks in the distribution system that will require additional risk treatment.

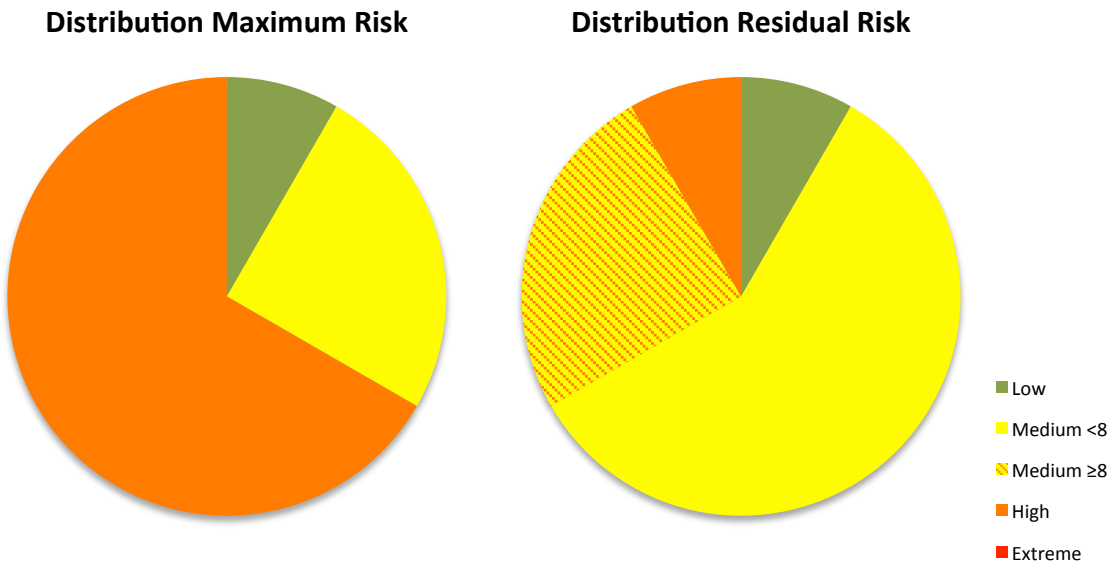

Figure 7 Distribution System Maximum and Residual Risks

Table 8 provides a summary of the risk assessment outcomes and indicates that there are four unacceptable risks remaining in the distribution system that will require additional risk treatments to manage the risk and bring the residual risk down to an acceptable level. Risk treatments will be addressed and identified in the Improvement Plan (Appendix F, DWMS).

Table 8 Distribution System Risk Maximum and Residual Risk Assessment Outcomes

Hazardous Event	Maximum Risk	Preventive Measures	Residual Risk
Receipt of out of specification water	High (10)	Service Level Agreement	High (10)
Receipt of water with low chlorine	Medium (8)	Informal notification of low chlorine between BSC and Rous Water	Medium (8)
Contamination of reservoirs due to access by third parties	High (10)	Pine Ave is fitted with a surveillance camera Some operational reservoirs are fenced (Basalt Court, Pine Ave, North Creek Rd) All access ladders and hatches are locked Chlorine residual	Medium (5)
Poor mixing within a reservoir	High (12)	Chlorine residual Design of inlets and outlets at some reservoirs (top fill) Operational range to ensure turnover	Medium (5)
Stagnation in reserviors	Medium (8)	Management of reservoir levels in Wollongbar (controlled by Rous Water SCADA)	Medium (5)
Contamination by vermin	High (10)	Chlorine residual Vermin protection on reservoirs Reservoirs are roofed	Medium (5)
Ingress of contaminants non-potable water	High (10)	Flushing of lines after maintenance works Chlorine residual	Medium (8)
Ingress of contaminants non-potable water	High (15)	HACCP Plan for dual reticulation scheme Recycled water 'fit for use' for dual reticulation Preventative measures from RWMP HACCP Plan	Medium (5)

Hazardous Event	Maximum Risk	Preventive Measures	Residual Risk
Backflow	High (15)	Positive pressure in system Plumbing Code Plumbing inspections Installation of testable devices All new high risk connections are required to have backflow prevention (Metering Policy) Backflow prevention policy ASNZS:3500 Dedicated filling stations Licensed water carters	Medium (6)
Stagnant water in pipelines	Medium (8)	Weekly flushing program	Medium (5)
New asset installation	High (10)	Northern Rivers Local Government Development Design and Construction Manuals Internal procedure for chlorination and flushing of new assets	Medium (8)

4.4 Whole of System

Whole of system hazardous events were identified and analysed to determine where organisational issues may result in a water quality risk. Figure 8 indicates that the maximum risk is high for a number of hazardous events in the Ballina Shire Council organisation. The residual risk pie chart demonstrates that two residual risks remain outside the acceptable risk range and additional risk treatments are required to reduce the risk to an acceptable level.

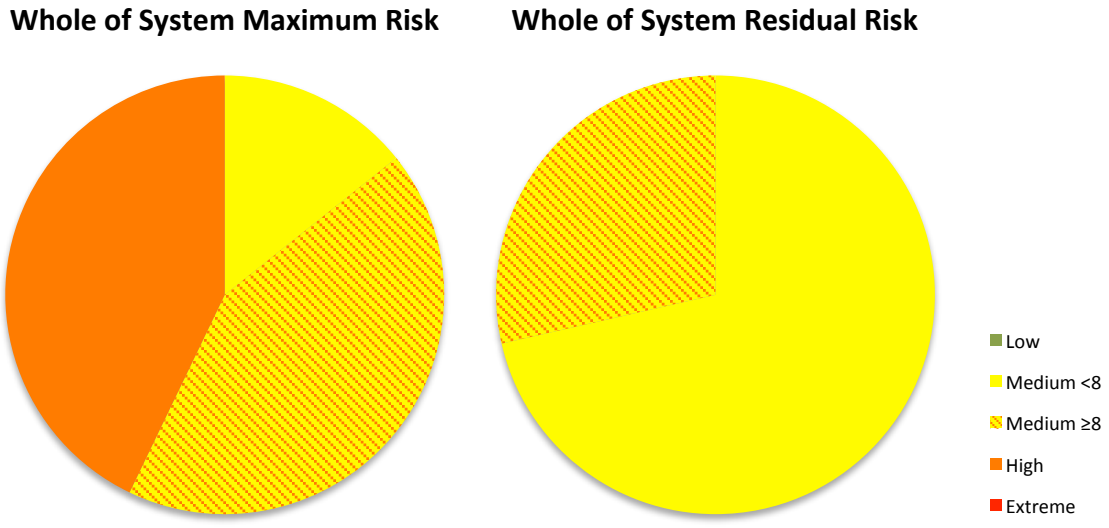

Figure 8 Whole of System Maximum and Residual Risk

Table 9 identifies the outcomes of the risk maximum and residual risk assessment and the preventative measures that are in place to reduce the risk to an acceptable level.

Table 9 Whole of System Maximum and Residual Risk Assessment Outcomes

Hazardous Event	Maximum Risk	Preventive Measures	Residual Risk
The use of unsuitable chemicals or materials	Medium (9)	Informal processes Plumbing code Australian Standards Construction specifications	Medium (6)
Telemetry or control system failure	High (12)	Master and Slave set up UPS on each system Back up CPU for SCADA	Medium (5)
Lack of training or experience	High (15)	Training register Position Descriptions and competency based skills assessment Operators - Cert III (& IV) and NOW course	Medium (5)
Loss of corporate knowledge	Medium (9)	Procedure development Informal mentoring Action plan when staff go on leave Onsite diaries	Medium (9)
Lack of resources	Medium (8)	Implementation of gap analysis Resource sharing within NRWG	Medium (8)
Lack of hygiene during operation and maintenance	High (12)	Separate crews working on sewer and water (or separate equipment) Recycled water treated as sewage Competency Procedures	Medium (5)

5 Discussion

The risk assessment process that has been adopted allows the risk for each hazard to be tracked through the treatment process, this has been visualised in Figure 9.

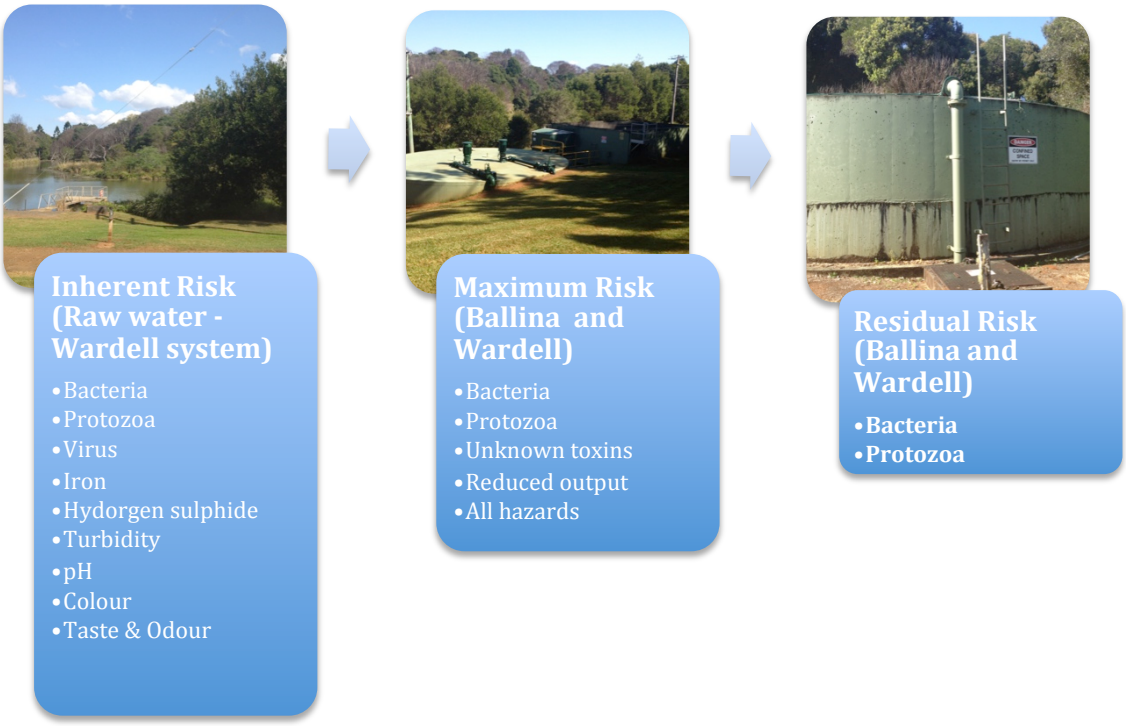

Figure 9 Unacceptable Risks in the Ballina Shire Council Water Supply System

The first principle of the ADWG is: ***The greatest risks to consumers of drinking water are pathogenic microorganisms****. Protection of water sources and treatment are of paramount importance and must never be compromised.*

The risk assessment process identified a number of residual risks that are above the acceptable range for the Ballina Shire Council water supply. These risks are related out of specification source water, absence of online monitoring, alarms and auto shut down, backflow and deterioration or contamination of water in the distribution. The identified hazardous events can be addressed through presecribed preventative measures. A number of the unacceptable risks will be managed with the upgrade of the online monitoring system in Marom Creek WTP which will include preventative measures such as online monitoring and alarms that will trigger auto shuts downs. The additional risk treatments required will be detailed the *Improvement Plan* (DWMS - Appendix F).

6 References

National Health & Medical Research Council and Natural Resource Management Ministerial Council. 2011. *National Water Quality Management Strategy: Australian Drinking Water Guidelines*. 6th Ed. Australia: NHMRC.

New South Wales Government 2012, *NSW Guidelines for Drinking Water Management Systems,* New South Wales Health, New South Wales Department of Primary Industries – Office of Water, New South Wales.

Public Health Act 2010 (NSW), s. 15 (Austl.)

Public Health Regulation 2012 (NSW), p. 5 (Austl.)

Glossary

ADWG	Australian Drinking Water Guidelines, published by the National Health and Medical Research Council (NHMRC).
Catchment	Area of land that collects rainfall and contributes to surface water (streams, rivers, wetlands) or to groundwater.
Critical control point	A point, step or procedure at which control can be applied and which is essential to prevent or eliminate a hazard or reduce it to an acceptable level.
Disinfection	The process designed to kill most microorganisms in water, including essentially all pathogenic (disease-causing) bacteria. There are several ways to disinfect, with chlorine being most frequently used in water treatment.
DWMS	Drinking Water Management System
Hazard	A biological, chemical, physical or radiological agent that has the potential to cause harm.
Hazardous event	An incident or situation that can lead to the presence of a hazard (what can happen and how).
Inherent risk	The risk in the source water without treatment barriers in place.
Maximum risk	Risk without existing barriers in place for example, treatment and/or disinfection. This is the maximum level of risk and in most instances it is the same as the inherent risk. However, there are a number of parameters whereby the treatment process adds to the risk, these include hazards such as trihalomethanes and chlorine. Therefore maximum risk is the total of the inherent risk and the additional risks added during treatment.
Preventive measure	Any planned action, activity or process that is used to prevent hazards from occurring or reduce them to acceptable levels.
Residual risk	The risk remaining after consideration of existing preventive measures.
Risk	The likelihood of a hazard causing harm in exposed populations in a specified time frame, including the magnitude of that harm.
Source water	Water in its natural state, before any treatment to make it suitable for drinking.

Appendix A

Ballina Shire Council Risk Assessment Workshop - Briefing Paper

August 12

Ballina Shire
Risk Assessment Briefing Paper

GPO Box 135, Brisbane QLD 4001, Australia

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1 Introduction

This is the risk assessment briefing paper for the Ballina Shire Council (Ballina Water) drinking water supply schemes. The briefing paper will be used during the risk assessment workshop for Ballina Water and is presented in line with the requirements under the *NSW Guidelines for Drinking Water Management Systems* (Draft 2012).

Ballina Shire Council is located in the Northern Rivers region of the Far North Coast of New South Wales. It covers an area of 687 km^2 with a shire population of 42,708 (2010) and makes up approximately 10% of the Richmond River catchment area of 6864 km^2. Some of the main localities within the council area include Lennox Head in the north, Wollongbar and Alstonville in the west, Ballina in the east and Wardell in the south (Figure 1).

Ballina shire has an urban water use of approximately 3,200 ML/year.

At present, drinking water within the Ballina Shire is supplied by Rous Water and Ballina Shire Council. Rous Water provides bulk potable water to Ballina Shire Council, Byron Shire Council, Richmond Valley Council as well as Lismore City Council. Rous Water sources its water from two on-stream storage dams, a river abstraction site and three groundwater bores.

Ballina Shire Council distributes the bulk water supplied by Rous Water to Ballina, Lennox Head, Alstonville and Wollongbar. Service reservoirs are located at Basalt Court and Lennox Reservoir at Lennox Head, Pine Avenue and East Ballina Reservoirs at Ballina, Ballina Heights Temporary Reservoir at Ballina Heights and Woolongbar Reservoir at Woolongbar.

Ballina Shire Council operates the Marom Creek WTP which supplies water to the township of Wardell. The infrastructure and system descriptions are discussed in more detail in Section 4.

A Water Supply Agreement between Ballina Shire Council and Rous Water exists for the purpose of defining the roles and responsibilities for the management of water supply within the area of operations of the parties.

Figure 1 Ballina Shire Council Map

2 Ballina Area Characteristics

Ballina Shire comprises a land area of 487 km^2, with four distinct landforms: the coastline, escarpment, lowlands and plateau. The population of the Ballina Shire is estimated at 42,708 (2010) with an average annual population growth rate in the order of 1.5%. The township of Ballina is situated on the mouth of the Richmond River. Among facilities in Ballina are four high schools, five primary schools a hospital and aged care facilities. Only ~0.4 % of the total Shire is used for industrial and business purposes (2004)

2.1.1 Climate

Ballina experiences a humid subtropical climate, typical of the central part of Australia's eastern coast. Approximately 40% of the town's total annual precipitation occurs from December to March, with March being the wettest month of the year receiving an average of 215.4 mm of precipitation. Ballina's annual precipitation total is 1808.2 mm, which is one of the highest annual precipitation levels along the eastern coast of Australia, south of the tropical coast of northern Queensland. Ballina's wetness is due to the town's coastal location and exposure to frontal systems that develop in the Tasman Sea. Rainfall data is collected at the Bureau of Meteorology's recording station at Ballina Airport.

2.1.2 Geology and Soils

The geology of the Ballina Shire is dominated by the volcanic history of the region, the Richmond River system and the proximity to the coastal zone. Areas include: the Alstonville Plateau which consists of rolling low hills and hills predominantly on the Lismore Basalts, the Wollongbar Soil Landscape which is good quality agricultural land, the Richmond River Alluvial Plain to the west and north-west of Wardell with soils consisting of clays and earthy sands, the Richmond River estuary with a deltaic floodplain with moderately fertile, potential acid sulfate soils, and coastal zone North of the Richmond River consisting of sedimentary soils, sand dunes and outlying basalt remnants.

2.1.3 Flooding

The Wardell and Cabbage Tree Island Flood Plain Risk Management Study was conducted in 2004 in order to address the existing flood problems at both Wardell and Cabbage Tree Island. The report prepared in 2007 assesses the impacts of predicted major floods, and also looks at mitigation options to minimise impacts. The mitigation options comprise engineering options as well as planning/building options.

2.1.4 Land Use

Land use within the Ballina Shire is 61.6% rural agricultural land (includes plateau, coastal and secondary agricultural land) 26.3% environmentally protected land, 2.4% national parks and nature reserves. Less than 5% of the land is used for 4% urban purposes. Agricultural uses include macadamia and avocado plantations, vegetable cropping (e.g. potato), cattle and dairy production.

2.1.5 Major Transport Corridors

The Buxner Highway situated north of the Marom Creek weir, connects Ballina with Lismore in the west and dissects the shire from east to west. The Pacific Highway dissects the shire from north to south and is located west of Ballina township. The Pacific Highway has been the subject of a major upgrade from Woolgoolga to just south of Ballina.

3 Ballina Shire Water Supply

Ballina has two main water supplies, the bulk supply from Rous Water and the Marom Creek Water Treatment Plant operated by Ballina Shire. The Marom Creek supply has in the past been supplemented with ground water from Ellis Road and Lindendale Road Bores near Alstonville.

The Ballina and Lennox Head drinking water supply is distributed from the bulk water supplied by Rous Water's Nightcap WTP via the Knockrow Reservoir. Rous Water also supplies drinking water from Emigrant Creek WTP to the Knockrow Reservoir, which is a contingency supply. Ballina Shire Council operate a number of reservoirs at Basalt Court and Lennox Reservoir at Lennox Head, Pine Avenue and East Ballina Reservoir at Ballina and the Ballina Heights Temporary reservoir at Ballina Heights.

The Alstonville and Wollongbar water supply is sourced from the Rous Water bulk supply system at Lismore. A pipeline transfers water from the Holland Street reservoir at Goonellabah to the Wollongbar Reservoir. Rous Water has in the past operated bores at Convery's Lane and Lumley Park to supplement the supply to Wollongbar and Alstonville however these are not currently operational.

The Wardell water supply is operated entirely by Ballina Shire Council. Wardell water is supplied from the Marom Creek Weir and has the ability to utilise the Ellis Road and Lindendale bores. Drinking water is pumped to the Whites lane reservoir and then gravitates to the Meerschaum Vale and Wardell Reservoirs before being distributed to Wardell and Cabbage Tree Island. A schematic overview of the system is provided in Appendix A.

The Wardell system, has in the past supplied water back into the Rous system.

Rous water is developing their Drinking Water Management System document and have defined their respective catchment characteristics and conducted their risk assessment. The residual risks from Rous Water to the Ballina Shire Council bulk distribution system are explained in Section 6.

3.1 Wardell Supply System

The Marom Creek is the water source for the Wardell water supply. The Marom Creek Water Treatment Plant is located on Marom Creek, adjacent to the weir. The weir is partially fed by groundwater. The Marom Creek catchment is characterised by intensive agriculture including cropping of macadamia and avocado, and dairy and cattle production.

BSC have identified approximately 4000 septic tanks across the shire. Initial investigations concluded that approximately 50% of the septic tanks were failing. An inspection program has been successfully implemented to manage the risks from septic tanks, comprising of approximately 250 inspections per year targeting environmentally sensitive areas. BSC implemented a program to identify and cap all cattle dips across the region and create a 200-meter exclusion zone around previous bore sites.

The Marom Creek Water Treatment Plant (WTP) is manned 7 days per week and operates 3 to 4 hours per day to meet the demand of the Wardell supply system. Raw water is extracted from the Marom Creek weir when the raw water turbidity is less than 35 NTU. The Wardell system has 4 to 5 days of storage, therefore selective extraction can be used to manage water quality. Daily grab sampling in the raw water indicates turbidity and pH levels in the raw water. Raw water extraction is via two duty pumps that operate at a flow rate of 45 L/second with a coarse screen at the intake. Water treatment plant operators report that there are no issues with algal blooms, due to

the need to maintain flows for downstream users and environmental values. The intake point is visually inspected daily. The WTP does not currently have flow meters on the raw water pumps.

Alum and caustic are dosed inline following the raw water pumps, prior to discharge into the flocculation pond. The flocculation pond is filled manually and the settling of floc takes place over a period of about 2 days. The flocculation pond is fully enclosed with nets to exclude ducks and other birds from the pond. The sludge from the flocculation pond is removed and treated onsite every 12 months.

Settled water overtops a weir at the end of the flocculation pond and is gravity fed to the sand filter. The sand filter comprises of layers of sand, anthracite and rock. The filters are backwashed weekly, wastewater is directed to the sludge drying beds and infiltrates through the stream bed into Marom Creek. The target filtered turbidity is less than 1 NTU with a shutdown on >2 NTU.

Filtered water is dosed with sodium hypochlorite inline prior to discharge into the clear water tank. Treated water is pumped to the Whites lane reservoir and then gravitates to the Meerschaum Vale and Wardell Reservoirs before being distributed to Wardell and Cabbage Tree Island. The treatment process is depicted in Figure 2

3.2 Gum Creek

Ballina Shire Council have in the past drawn raw water from the Gum Creek Weir to supplement the Wardell supply, however this source is not currently used.

3.3 Lindendale and Ellis Road Bores

The Wardell water supply includes groundwater bores at Lindendale Road and Ellis Road. These bores are currently not in operation, ceasing supply from Ellis Road in 2008. Both bore sites have re-chlorination facilities. The Lindendale Road bore is located adjacent to Marom Creek.

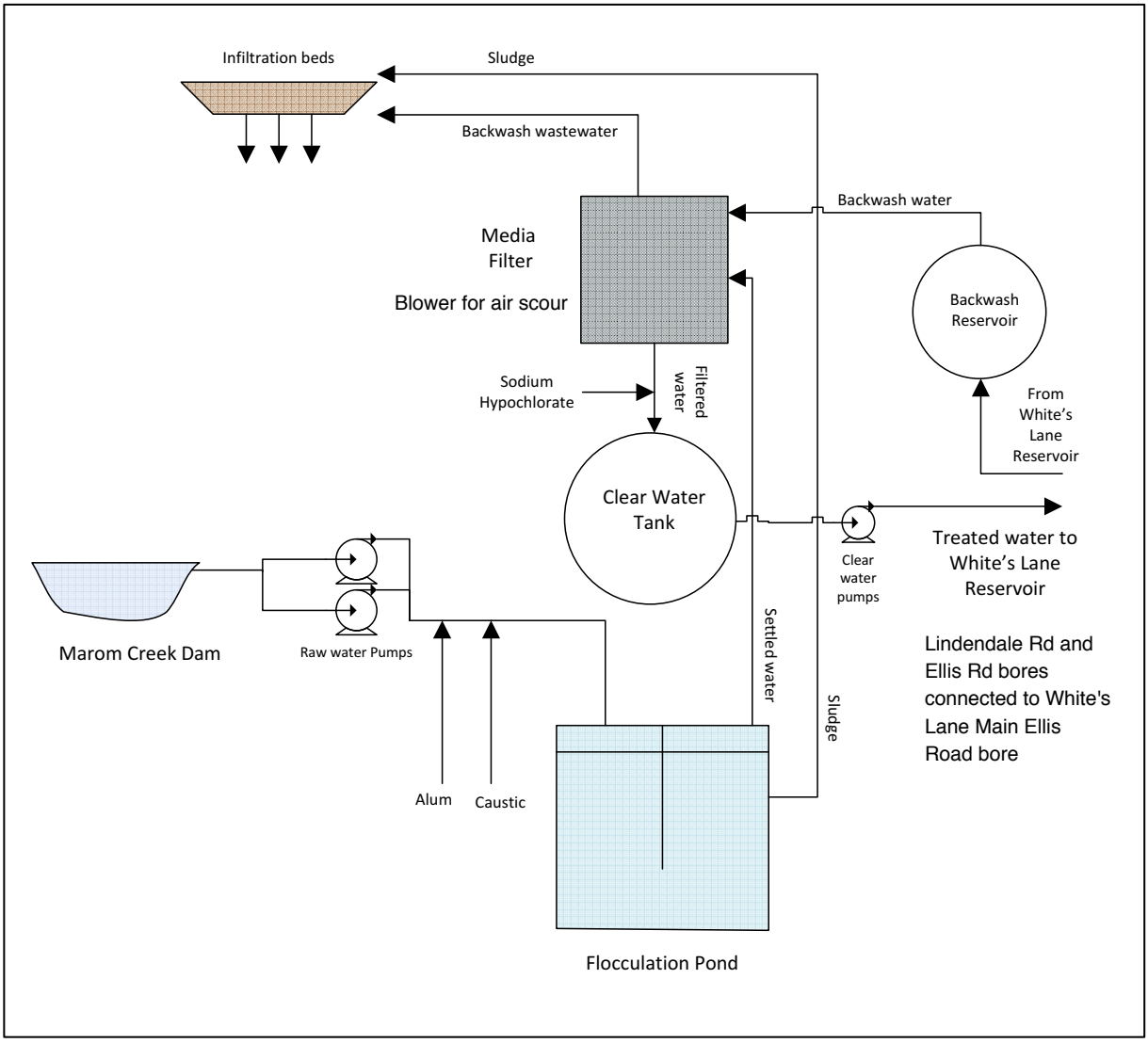


Figure 2 Process Flow Diagram - Marom Creek WTP

4 Water Supply System Schematics and Description

4.1 Bulk Water Distribution

Ballina and Lennox Head are supplied from Rous Water's bulk supply pipelines to a reservoir at Knockrow. Water gravitates to the service reservoirs at Basalt Court and Lennox Reservoir at Lennox Head, Pine Avenue and East Ballina Reservoirs at Ballina and the Ballina Heights Temp Reservoir at Ballina Heights.

Alstonville and Wollongbar are supplied from the Rous Water bulk supply system at Lismore. A pipeline transfers water from the Holland Street reservoir at Goonellabah to the Wollongbar Reservoir.

4.1.1 Communication Protocols with Rous Water

There is a water supply agreement between Rous Water and Ballina (also includes Richmond Valley Council, Byron Shire Council and Lismore Shire Council). The agreement details the communication protocols, levels of service and accountability.

It states that Rous Water will supply the Retailers water of quality that meets the Rous Water Quality Management Plan and the Australian Drinking Water Guidelines.

In terms of water quality and quantity, Rous water is required to notify the Retailers of any departure from the target water quality or quantity as soon as possible and within:

- Minimum 7 days (for planned activities)
- Maximum 1 hour after the incident is observed by Rous water (for unplanned events).

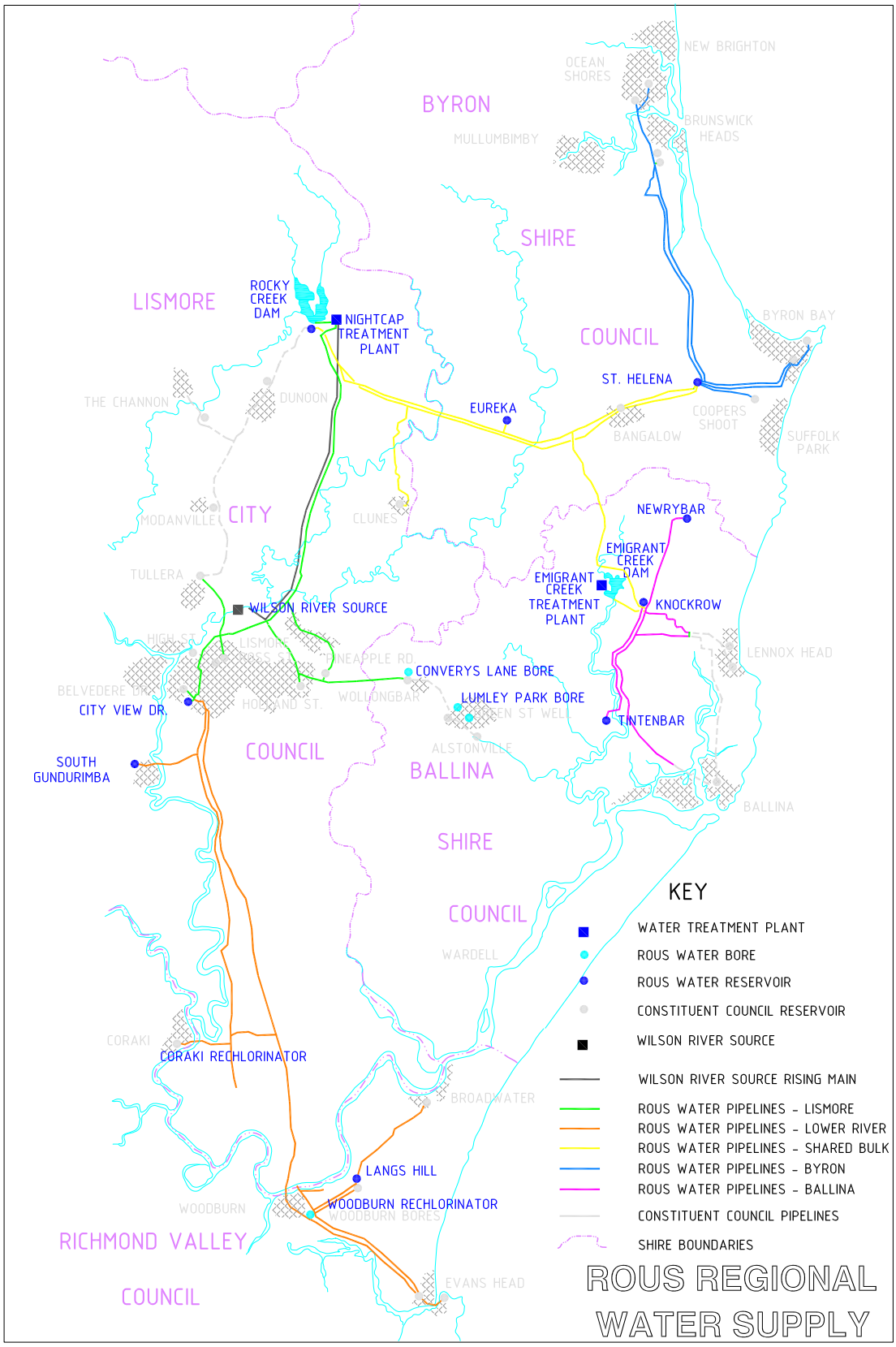


Figure 3 Rous Regional Water Supply

5 Water Quality Information and Analysis

5.1 Marom Scheme - Data and Interpretation

Water quality test data are presented for the period March 2007 to early 2012, where available.

5.1.1 Marom Creek Weir

Table 1 shows the water quality data collected by Ballina water for the Marom Creek weir.

Table 1 Marom Creek weir water quality data

Parameter	Mean	StDev	Minimum	Maximum	Range	Count	<LOR
pH	6.6	0.2	6.2	6.9	0.7	34	
Colour	49	18	20	100	80	34	
Turbidity (NTU)	5.6	3.2	1.5	14.0	12.5	34	
Conductivity (µS/cm)	95.8	21.0	0.1	123.0	122.9	34	
Nitrates (mg/L)	0.2	0.1	0.0	0.4	0.4	34	10
Total phosphorus (mg/L)	0.1	0.1	0.0	0.6	0.6	34	24
Total solids (mg/L)	73	22	27	123	96	34	
Iron soluble (mg/L)	0.6	0.5	0.0	2.2	2.2	32	2
Manganese soluble (mg/L)	0.0	0.0	0.0	0.1	0.1	32	15
Faeal coliforms (mg/L)	190	190	5	720	715	34	3

Figures 4-7 show the raw water charts for *E. coli*, pH, turbidity, iron and manganese.

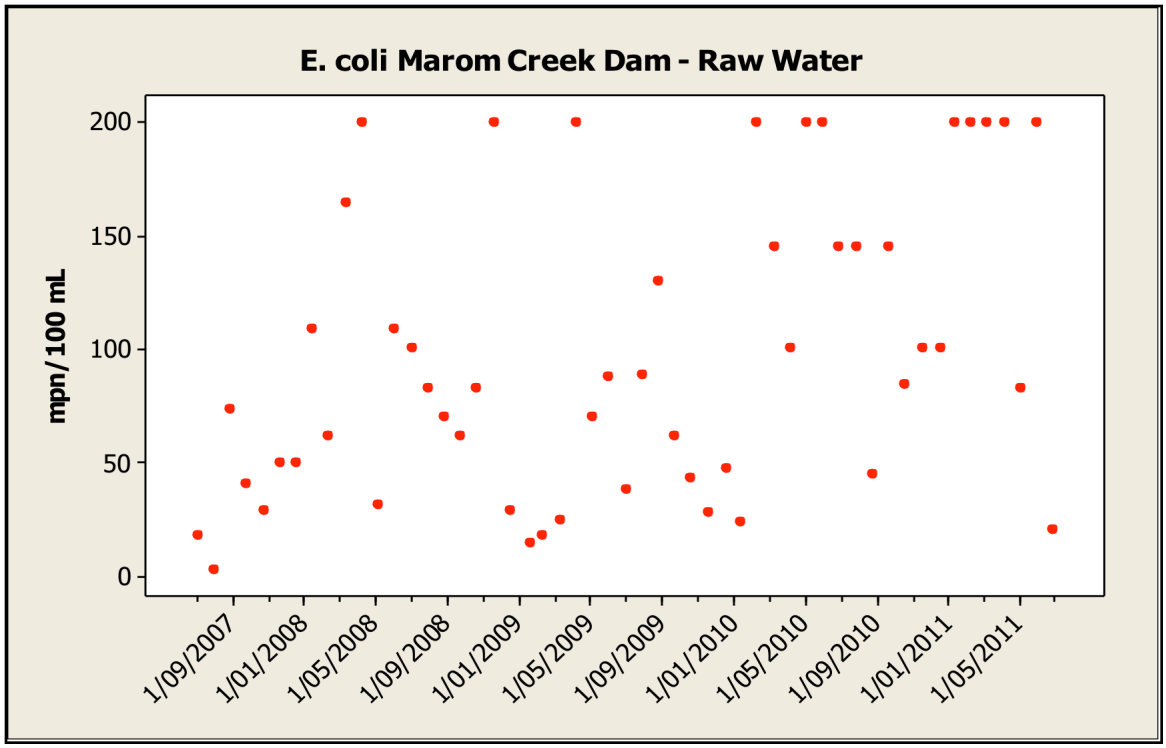


Figure 4 Raw Water – *E. coli*

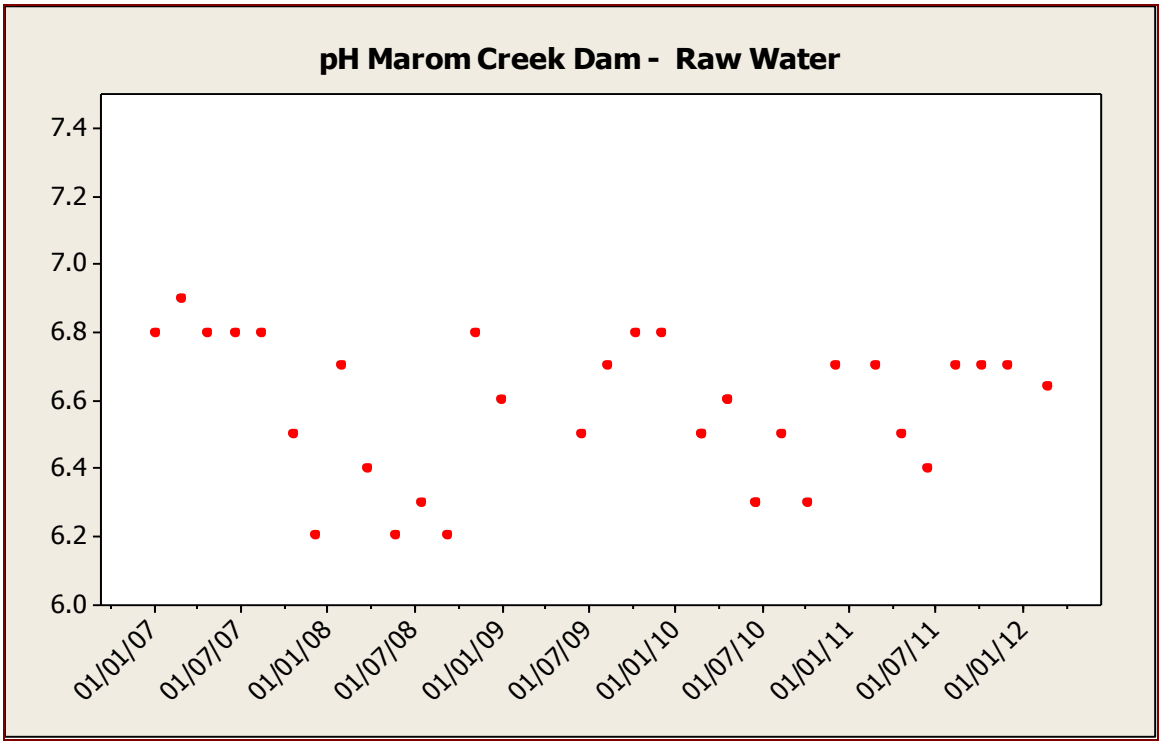


Figure 5 Raw Water – pH

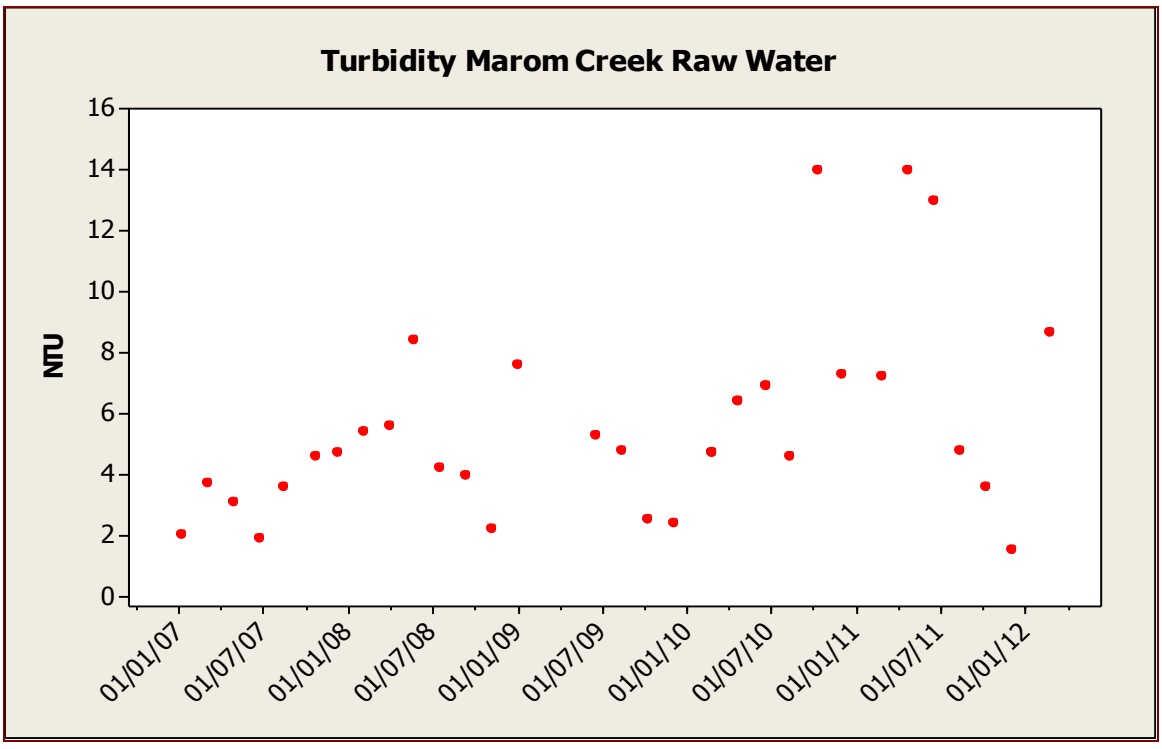


Figure 6 Raw Water – Turbidity

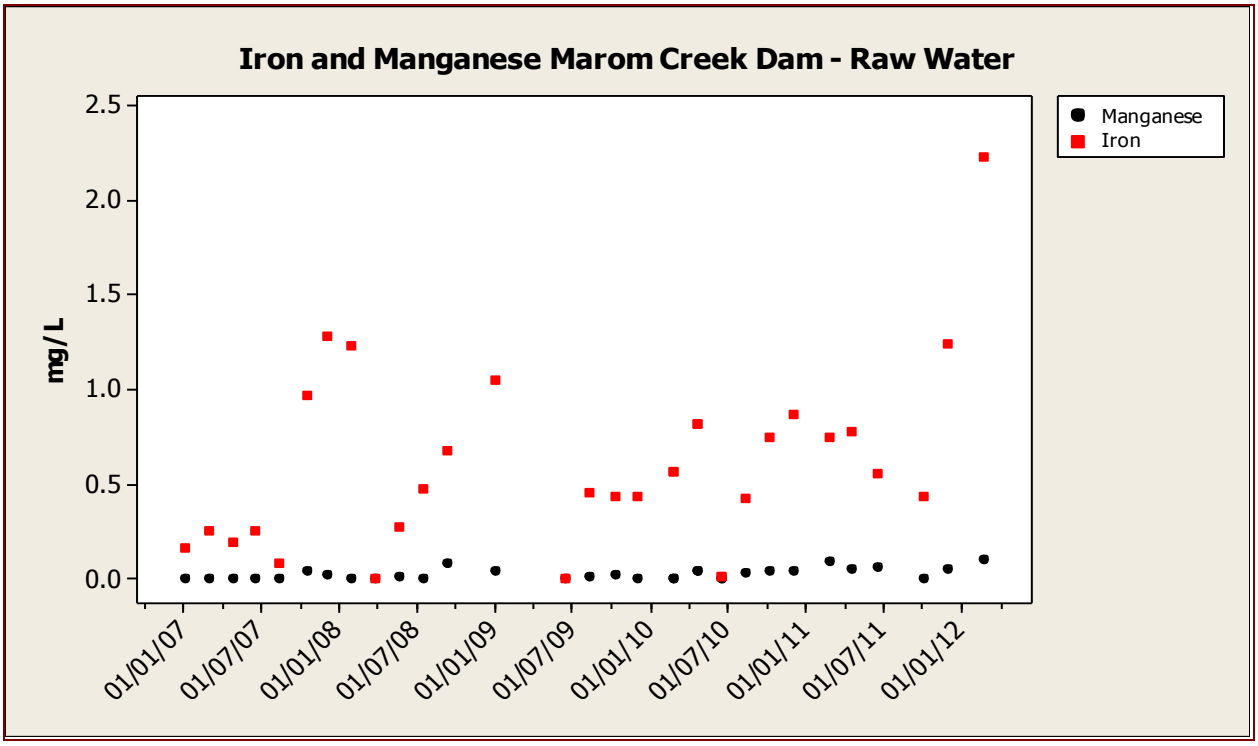


Figure 7 Raw Water – Iron and Manganese

Table 2 shows the summary for algal identification at Marom Creek Dam for the period 2005-2009.

Table 2 Marom Creek Dam – Algal identification summary

Algal Identification	Value	Count	Dates
Mixed Algae - No Cyanophyta	<100	42	Apr -05 - Jul-09
Pseudanabaena (Cyanophyta)	90, 800	2	Jul-05 & Apr-09
Diatoms	45	1	Apr-09
Chlorophyta	1930, 8500, 460	3	Aug-06, Mar & Apr-09
Aphanocapsa (Cyanophyta)	300	1	Aug-08
Chlamydomonas (Chlorophyta) No Cyanophyta	34000	1	Mar-08
Dinobryon (Dinophyta)	195	1	Aug-06
Synura (Chrysophyta)	300	1	Sep-07

5.1.2 Marom Creek Treated Water

Table 3 shows the water quality data collected by Ballina water for treated water at Marom Creek WTP.

Table 3 Marom Creek WTP – Treated Water Quality Summary

Parameter	Mean	StDev	Minimum	Maximum	Range	N	< LOR	Guide-line Health	Exceed-ences Health	Guide-line (Aes)	Exceed-ences (Aes)
pH	7.3	0.3	6.7	8.0	1.3	34				6.5-8.5	0
Colour	1.9	1.9	0.5	10.0	9.5	34	14				
Turbidity (NTU)	0	1	0	3	3	34	1			5	0
Conductivity (µS/cm)	163.95	45.62	0.18	240.00	239.82	34					
Nitrates (mg/L)	0.17	0.12	0.01	0.38	0.38	34	9	50	0		
Total phosphorus (mg/L)	0.03	0.02	0.01	0.12	0.12	34	32				
Total solids (mg/L)	102	28	54	164	110	34		500	0	250	0
Iron soluble (mg/L)	0.05	0.14	0.01	0.55	0.55	32	17			0.3	1
Manganese soluble (mg/L)	0.01	0.02	0.00	0.08	0.08	32	26	0.5	0	0.1	0
Faecal coliforms (org/100 mL)	8.4	46.2	0.5	270.0	269.5	34	32	0	2		

Figures 8-13 show the charts for *E. coli*, pH, turbidity, iron and manganese and faecal coliforms in the treated water sampled at Marom Creek WTP.

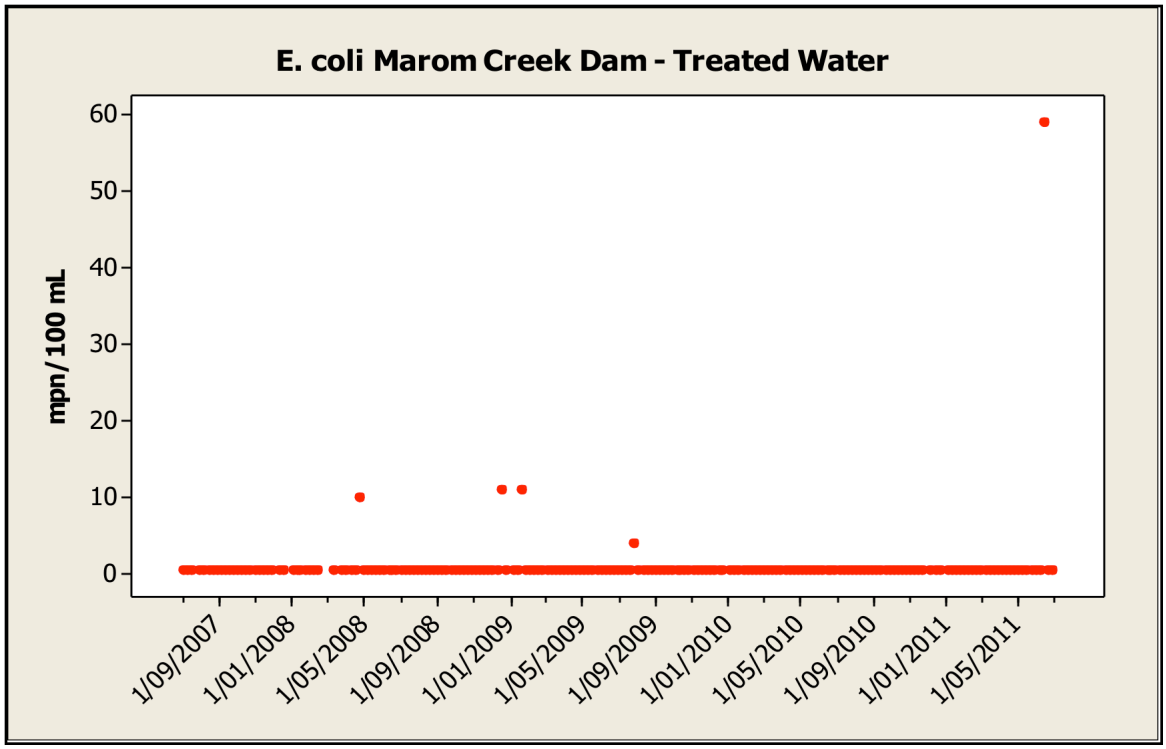


Figure 8 Treated Water – *E. coli*

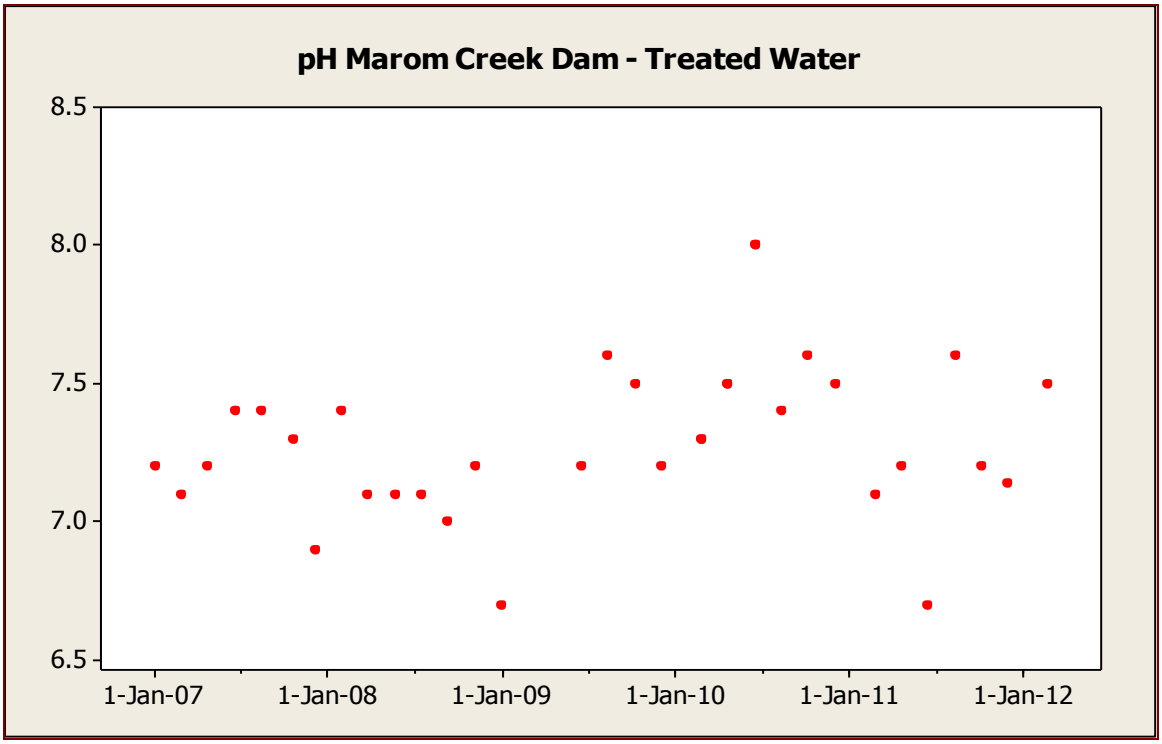


Figure 9 Treated Water – pH

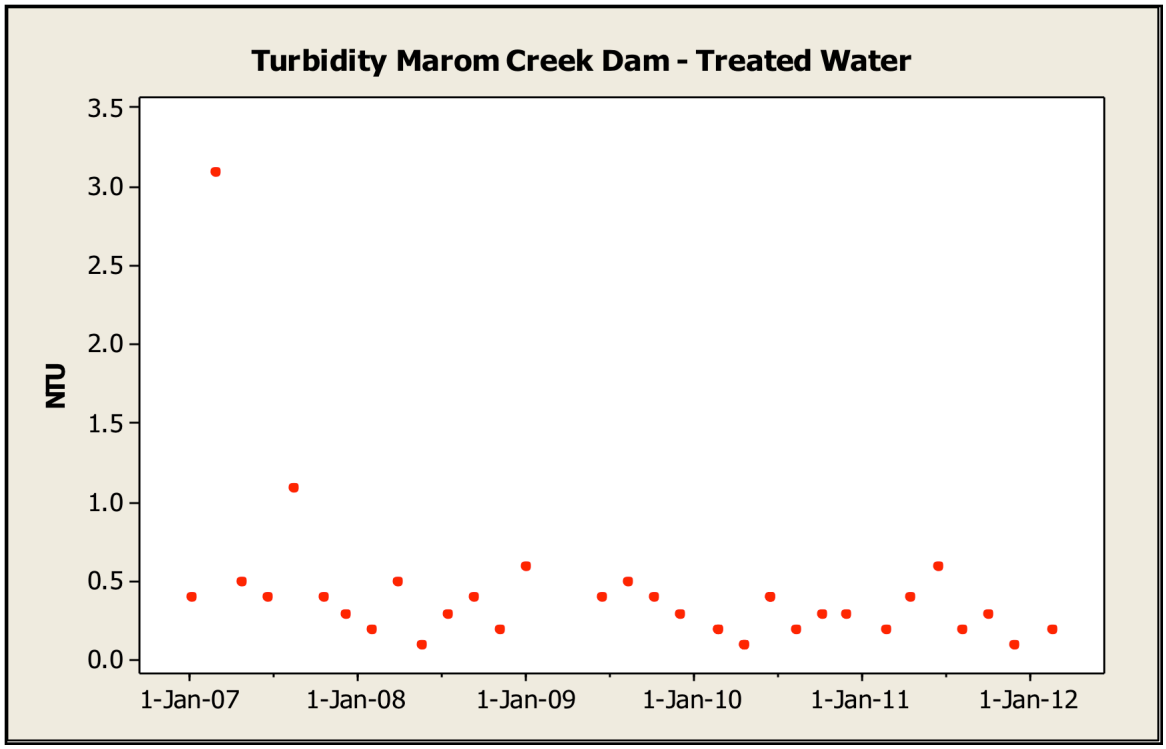


Figure 10 Treated Water – Turbidity

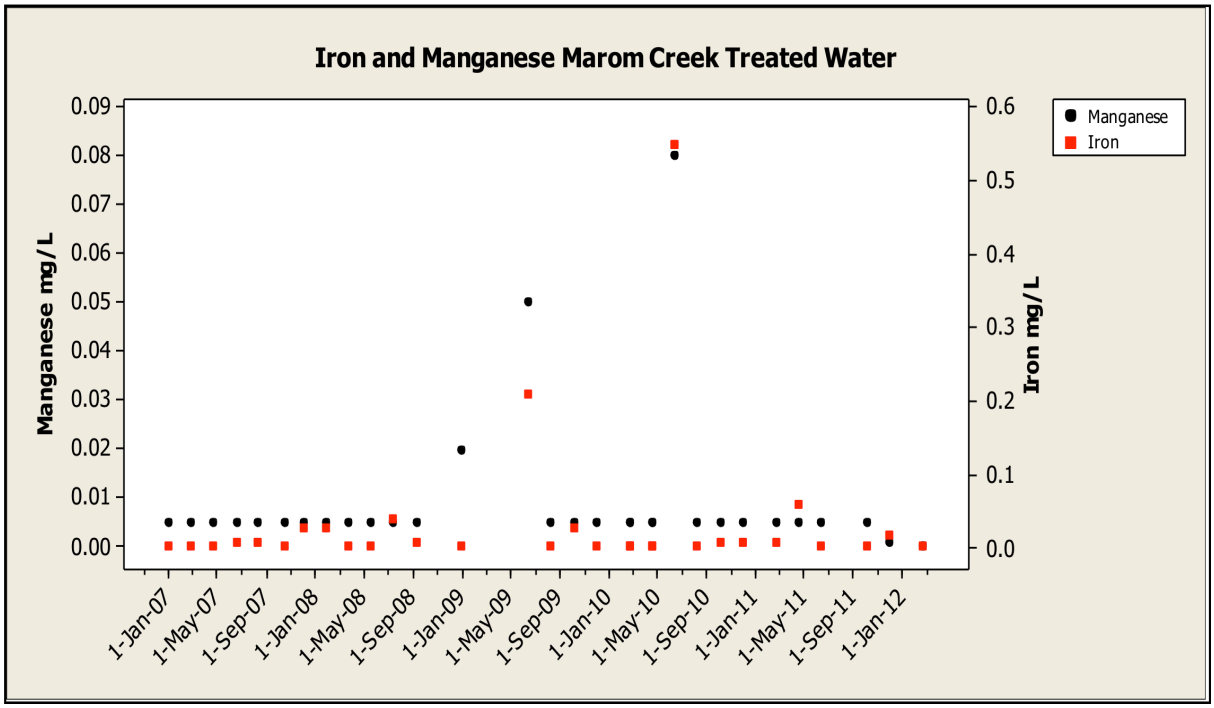


Figure 11 Treated Water – Iron and Manganese

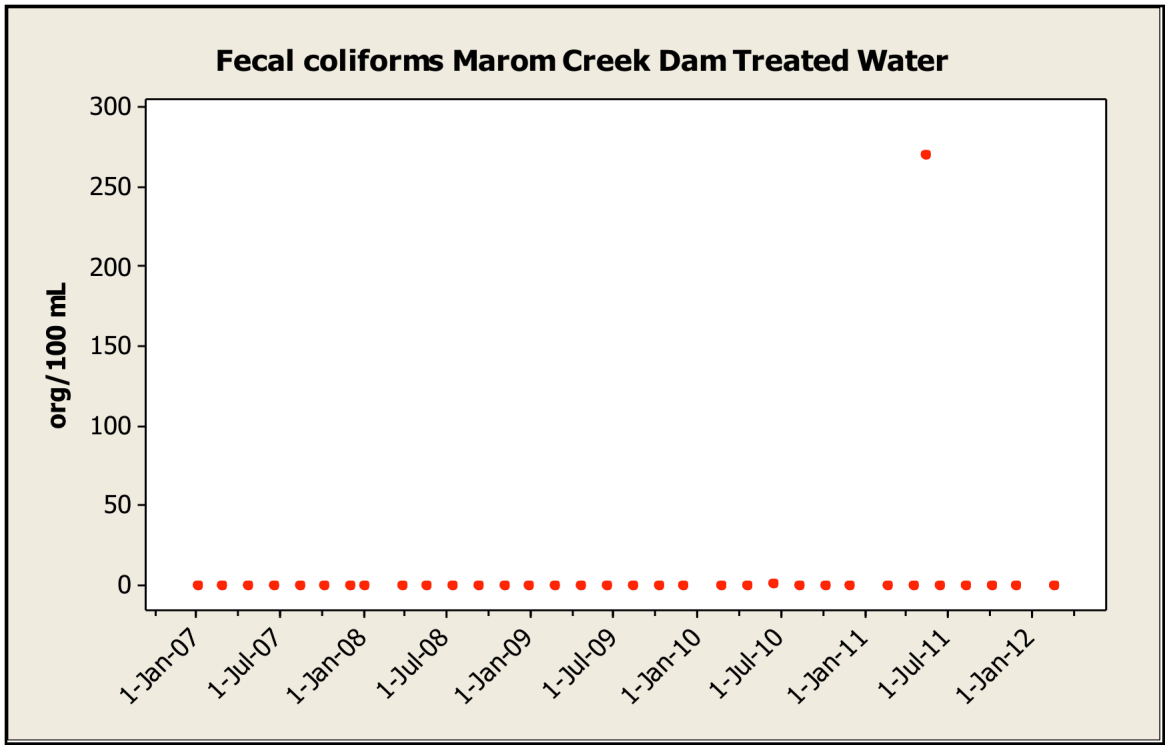


Figure 12 Treated Water - Faecal coliforms

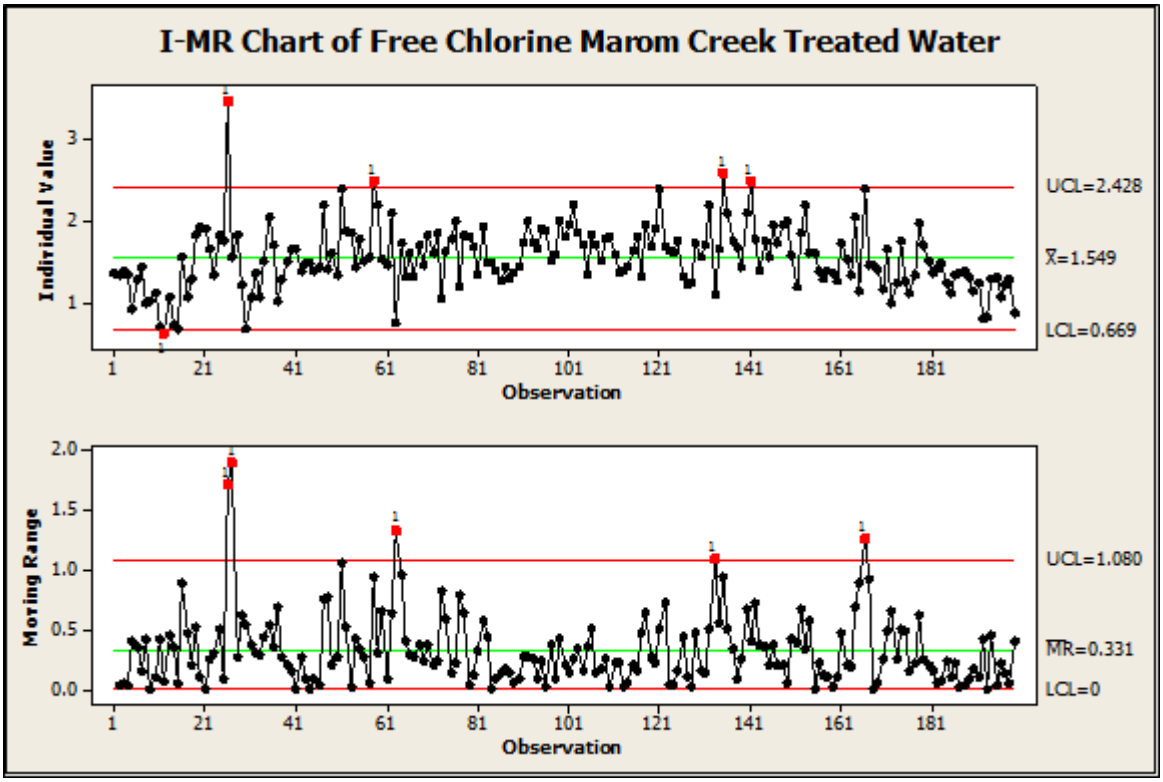


Figure 13 IMR Chart - Free chlorine

5.1.3 Ellis Road Bore

Figures 14-19 show the bacteriological data analysis for Ellis Road Bore raw and treated water from 2001-2008.

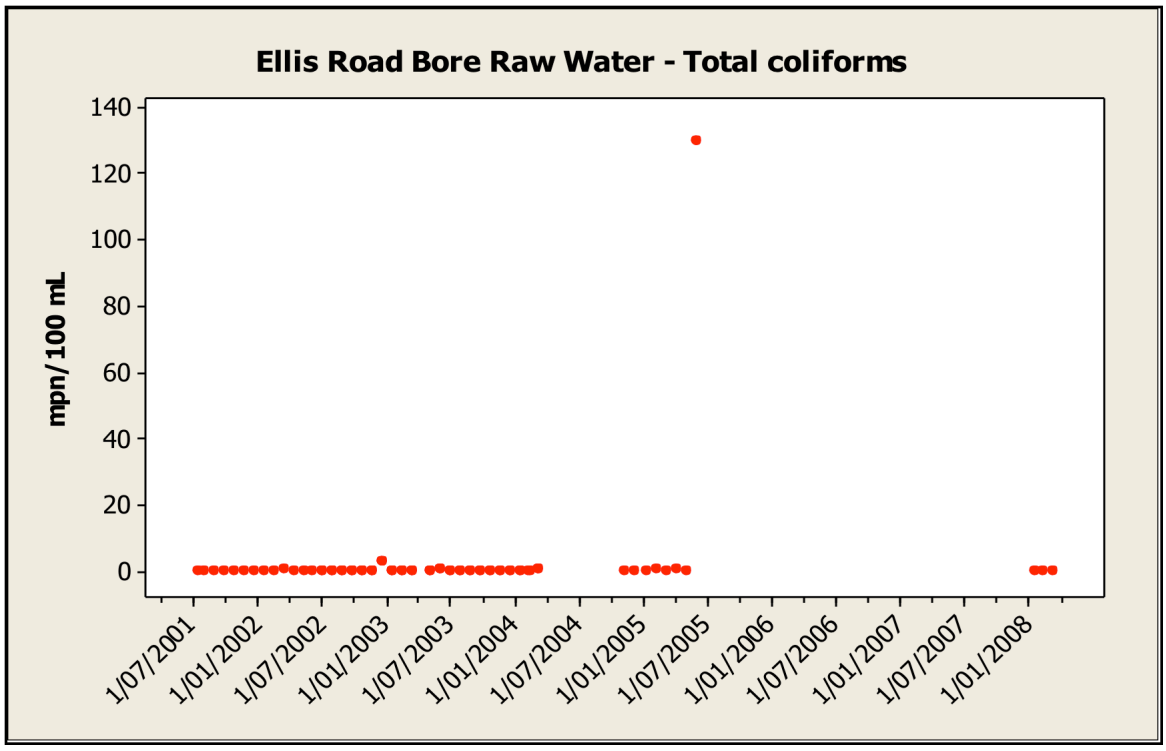


Figure 14 Raw Water – Total coliforms

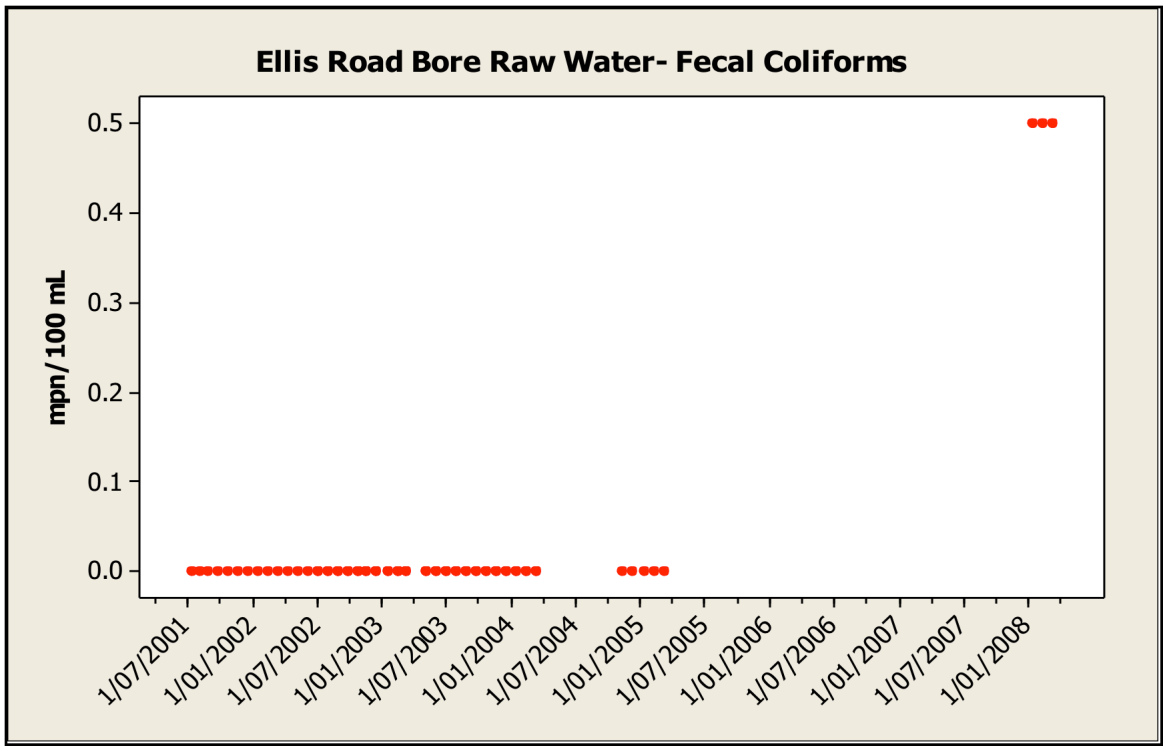


Figure 15 Raw Water – Total coliforms

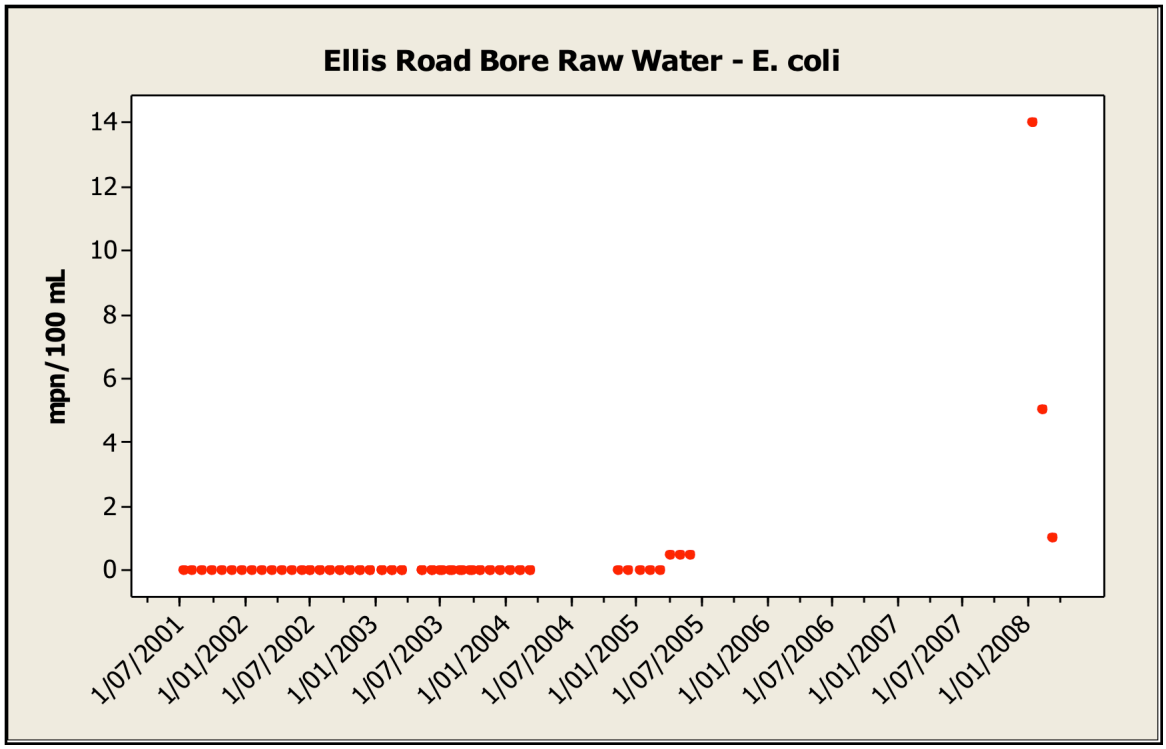


Figure 16 Raw Water – *E. coli*

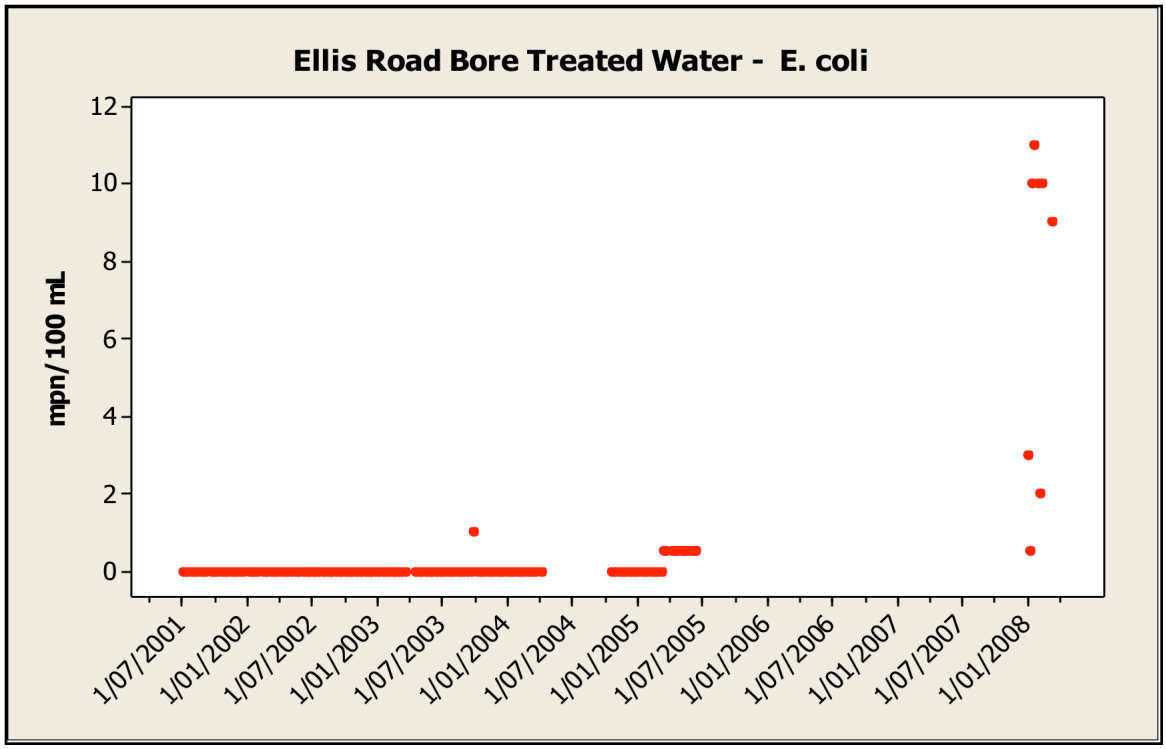


Figure 17 Treated Water – *E. coli*

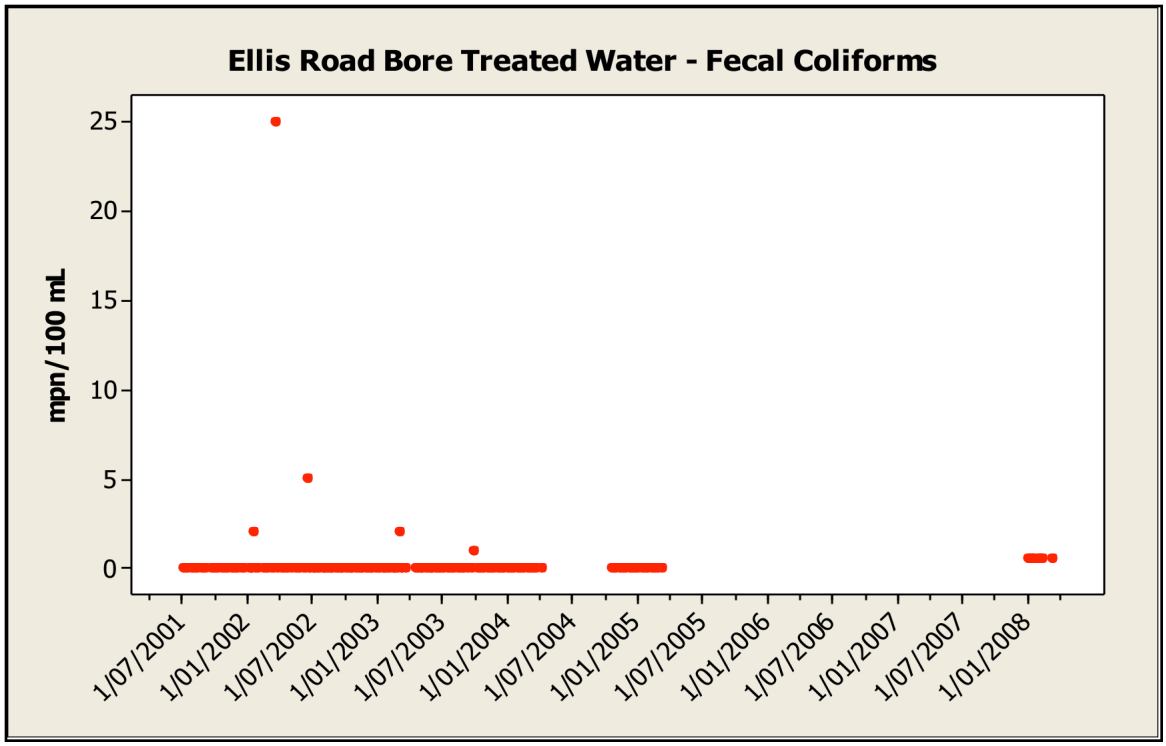


Figure 18 Treated Water – Faecal coliforms

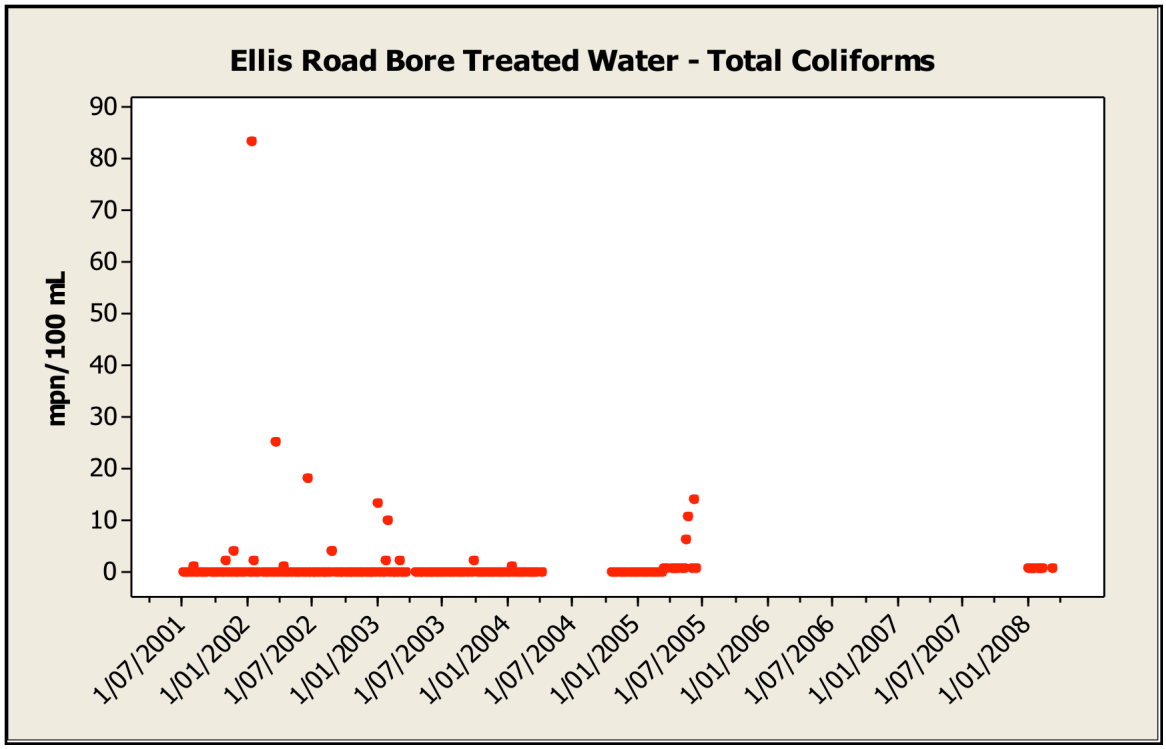


Figure 19 Treated water – Total coliforms

5.1.4 Lindendale Road Bore

Table 4 shows the bacteriological data collected by Ballina water at Lindendale Road Bore from 2002-2003.

Table 4 Lindendale Road Bore Bacteriological Data

DATE	Water type	Total Coliforms mpn/100ml	Faecal Coliforms	*E. coli* mpn/100ml
30/09/02	raw	0	0	0
21/10/02	raw	0	0	0
18/11/02	raw	1	0	0
16/12/02	raw	0	0	0
14/01/03	raw	0	0	0
11/02/03	raw	0	0	0
30/09/02	treated	0	0	0
21/10/02	treated	0	0	0
18/11/02	treated	0	0	0
16/12/02	treated	0	0	0
14/01/03	treated	0	0	0
11/02/03	treated	0	0	0

5.1.5 Whites Lane Reservoir

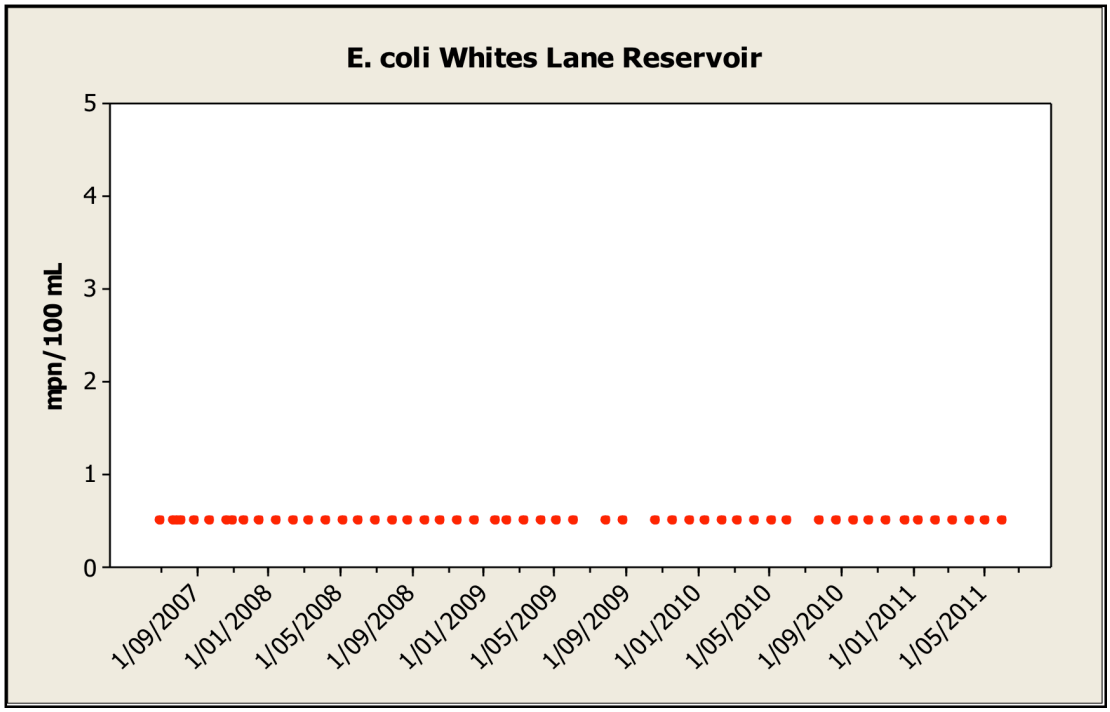


Figure 20 Whites Lane Reservoir - *E. coli*

5.1.6 Wardell Reservoir

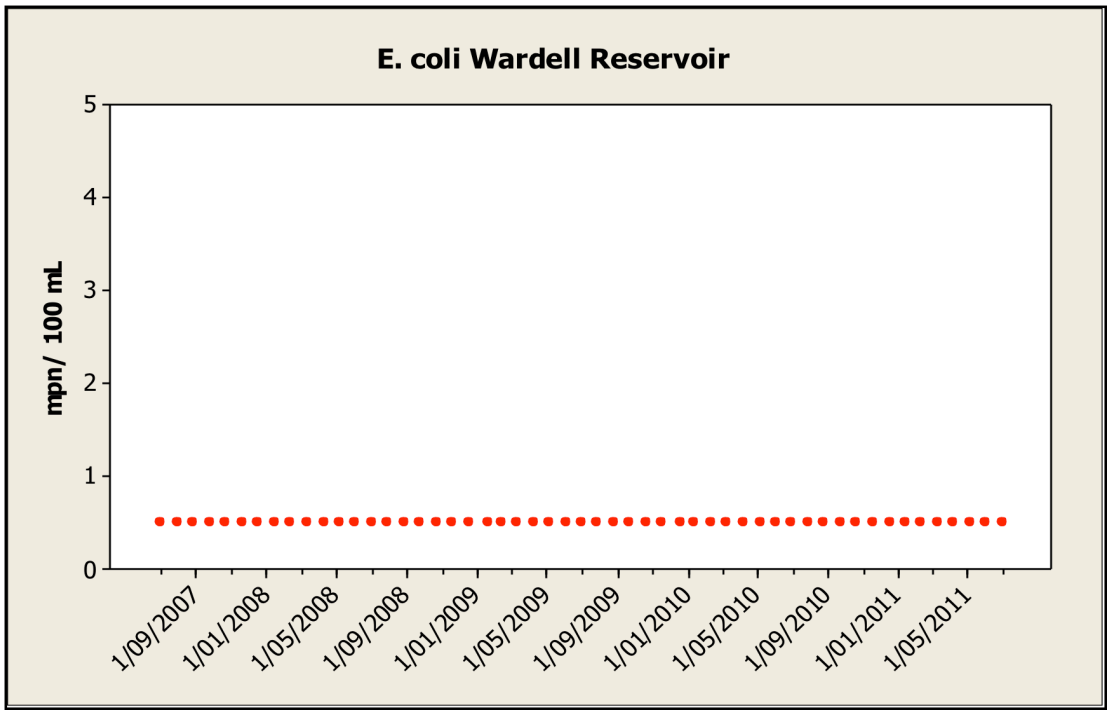


Figure 21 Wardell Reservoir – *E. coli*

5.1.7 Meerschaum Vale Balance Tank

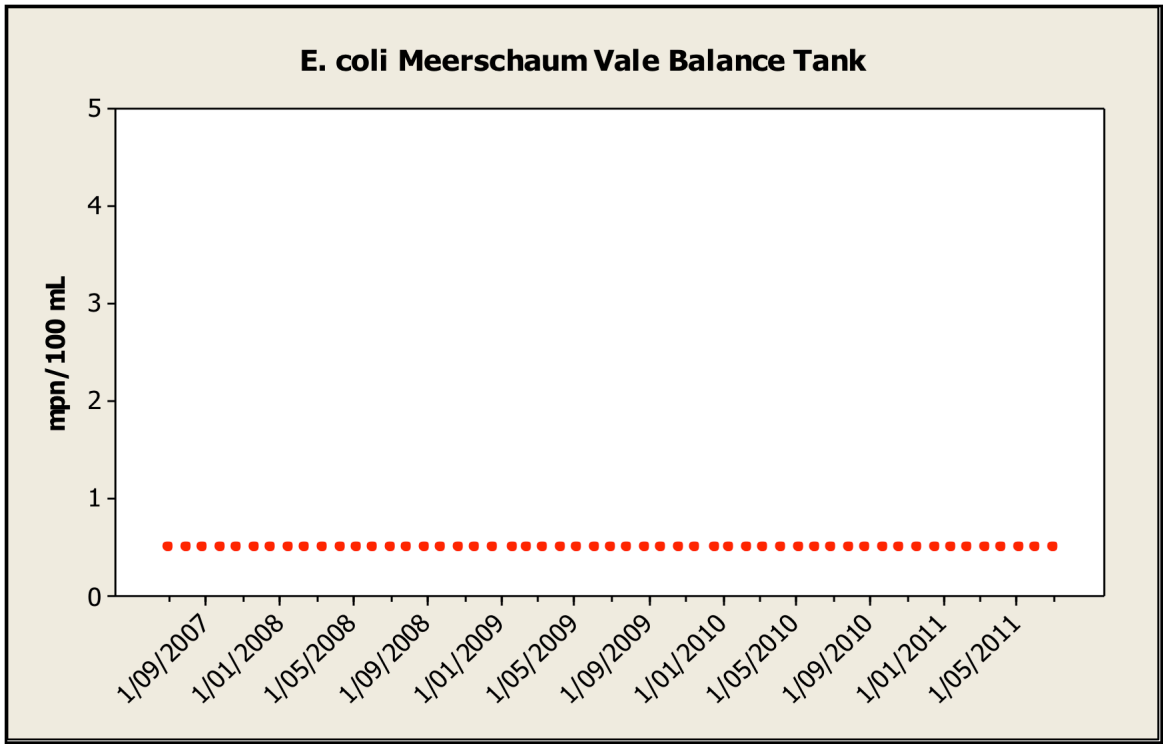


Figure 22 Meerschaum Vale Balance Tank – *E. coli*

5.1.8 Wardell (reticulation)

Table 5 contains a summary report from the NSW health database for the Wardell reticulation. The sampling points include: Corner of Wardell and Marom Creek Roads, Meerschaum Vale and Richmond Street, Wardell.

Table 5 Summary Report Wardell Reticulation

Characteristic	G/L	Units	Mean	Median	Std dev	Min	Max	N	Ex. count	95th %ile	5th %ile	% compliant
Aluminium	0.2	mg/L	0.026	0.020	0.016	0.005	0.050	9	0	0.050	0.005	100.00
Antimony	0.003	mg/L	0.0005	0.0005	0.0000	0.0005	0.0005	9	0	0.0005	0.0005	100.00
Arsenic	0.01	mg/L	0.0006	0.0005	0.0002	0.0005	0.0010	9	0	0.0010	0.0005	100.00
Barium	2	mg/L	0.0045	0.0050	0.0016	0.0025	0.0060	9	0	0.0060	0.0025	100.00
Boron	4	mg/L	0.05	0.05	0.00	0.05	0.05	9	0	0.05	0.05	100.00
Cadmium	0.002	mg/L	0.00025	0.00025	0.00000	0.00025	0.00025	9	0	0.00025	0.00025	100.00
Calcium		mg/L	7.5	7.7	0.7	5.9	8.2	9	0	8.2	5.9	100.00
Chloride	250	mg/L	17	17	1	16	18	9	0	18	16	100.00
Chromium	0.05	mg/L	0.0025	0.0025	0.0000	0.0025	0.0025	9	0	0.0025	0.0025	100.00
Copper	2	mg/L	0.0093	0.0025	0.0205	0.0025	0.064	9	0	0.0640	0.0025	100.00
E. coli	0	cfu/100 mL	1	0	6	0	66	131	2	0	0	98.47
Fluoride	1.5	mg/L	0.05	0.05	0.00	0.05	0.05	9	0	0.05	0.05	100.00
Free Chlorine	5	mg/L	0.59	0.57	0.31	0	1.44	109	0	1.12	0.08	100.00
Hardness as CaCO3	200	mg/L	22.6	23.0	2.1	17.7	24.7	9	0	24.7	17.7	100.00
Iodine	0.5	mg/L	0.02	0.02	0.01	0.01	0.04	9	0	0.04	0.01	100.00
Iron	0.3	mg/L	0.04	0.02	0.03	0.01	0.10	9	0	0.10	0.01	100.00
Lead	0.01	mg/L	0.001	0.001	0.001	0.001	0.003	9	0	0.003	0.001	100.00
Magnesium		mg/L	0.94	0.94	0.09	0.75	1.07	9	0	1.07	0.75	100.00
Manganese	0.5	mg/L	0.0029	0.0025	0.0012	0.0025	0.006	9	0	0.0060	0.0025	100.00
Mercury	0.001	mg/L	0.00005	0.00005	0.00000	0.00005	0.00005	9	0	0.00005	0.00005	100.00
Molybdenum	0.05	mg/L	0.0025	0.0025	0.0000	0.0025	0.0025	9	0	0.0025	0.0025	100.00
Nickel	0.02	mg/L	0.005	0.005	0.000	0.005	0.005	9	0	0.005	0.005	100.00
Nitrate	50	mg/L	1.2	1.0	0.5	0.5	2.0	9	0	2.0	0.5	100.00
Nitrite	3	mg/L	0.07	0.05	0.05	0.05	0.2	9	0	0.20	0.05	100.00
pH	6.5 - 8.5		9.1	9.1	0.2	8.7	9.3	9	9	9.3	8.7	0.00
pH	6.5 - 8.5		8.25	8.23	0.37	7.2	9.24	108	14	9.01	7.75	87.04
Selenium	0.01	mg/L	0.001	0.001	0.000	0.001	0.001	9	0	0.001	0.001	100.00
Silver	0.1	mg/L	0.001	0.001	0.000	0.001	0.001	9	0	0.001	0.001	100.00
Sodium	180	mg/L	27	25	8	16	38	9	0	38	16	100.00
Sulfate	500	mg/L	26	28	15	7	49	9	0	49	7	100.00
TDS	600	mg/L	94	92	21	68	126	9	0	126	68	100.00
Thermotolerant Coliforms	0	cfu/100 mL	0	0	0	0	0	60	0	0	0	100.00
Total Chlorine	5	mg/L	0.66	0.63	0.35	0	1.82	57	0	1.45	0.12	100.00
Total Coliforms	0	cfu/100 mL	1	0	6	0	66	131	7	1	0	94.66
True Colour	15	Hazen Units (HU)	0.7	0.5	0.3	0.5	1	9	0	1	0.5	100.00
Turbidity	5	NTU	0.2	0.2	0.1	0.1	0.3	9	0	0.3	0.1	100.00
Turbidity	5	NTU	0	0	0	0	3	102	0	0	0	100.00
Zinc	3	mg/L	0.016	0.005	0.017	0.005	0.05	9	0	0.050	0.005	100.00

Figures 23-27 show the charts for pH, *E coli*, total coliforms, turbidity and free chlorine.

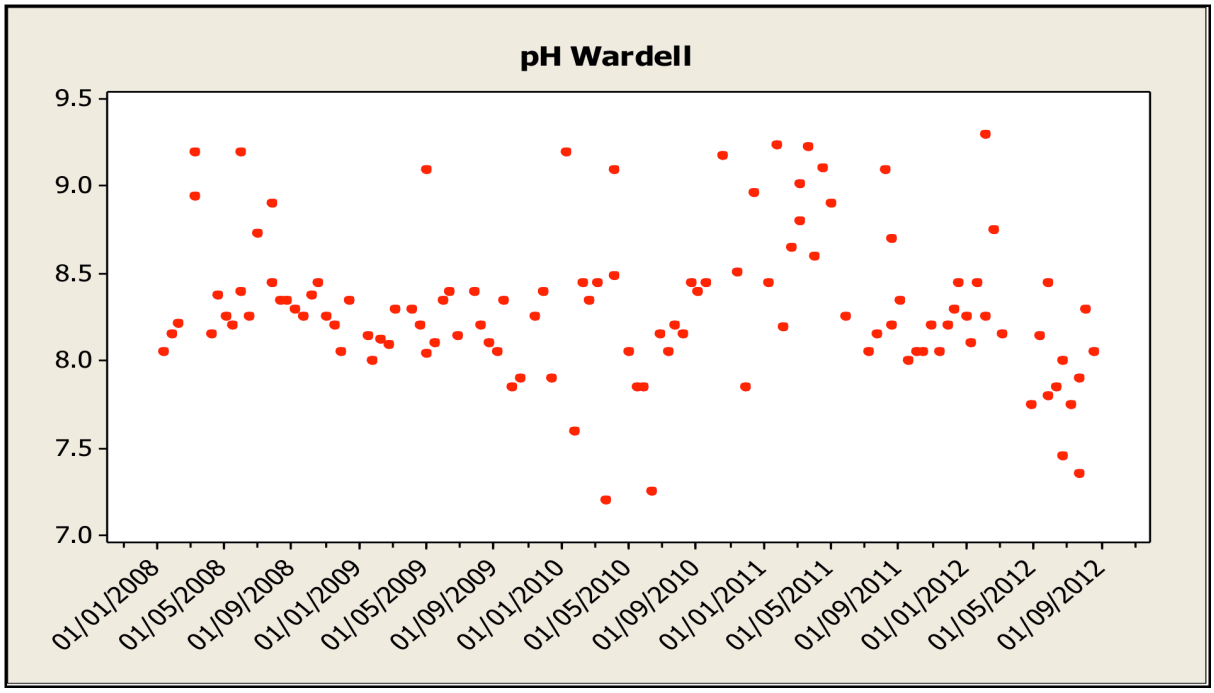


Figure 23 Wardell - pH

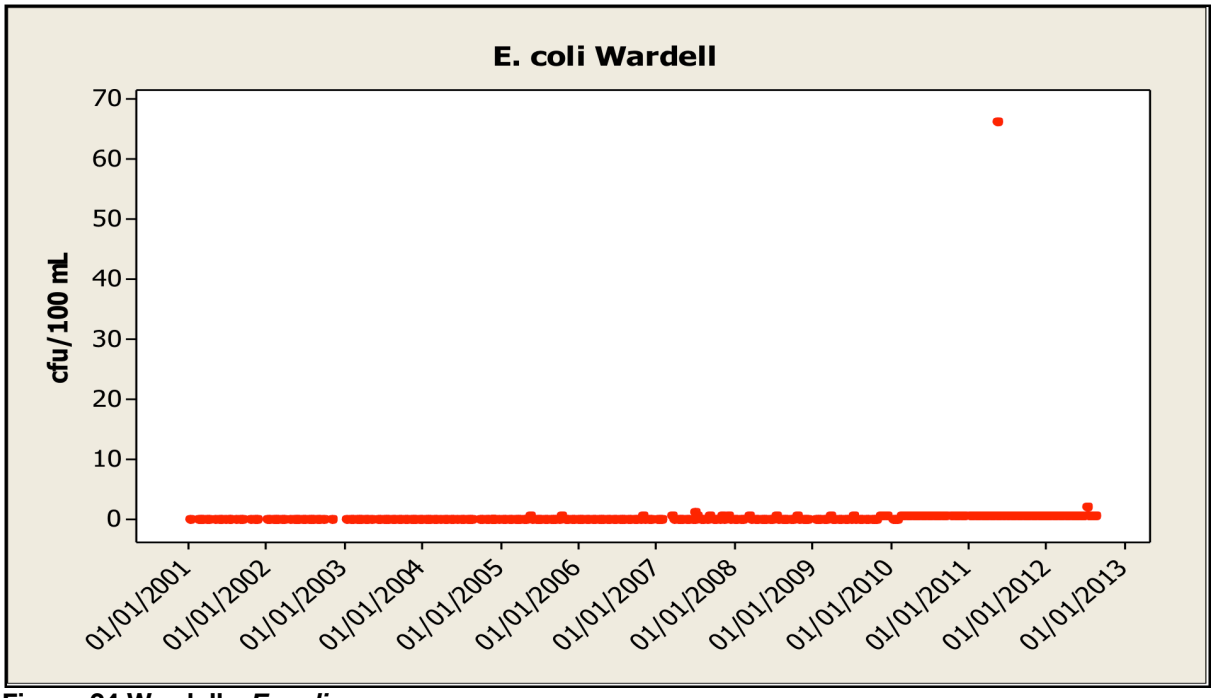


Figure 24 Wardell – *E. coli*

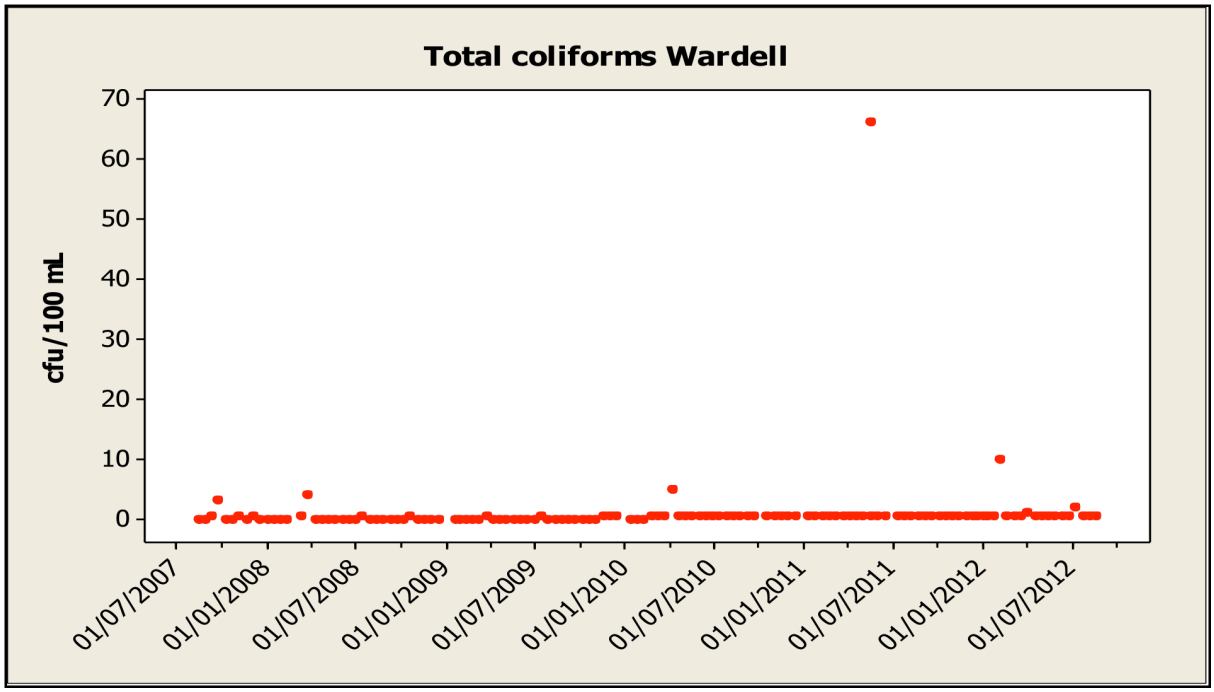


Figure 25 Wardell – Total coliforms

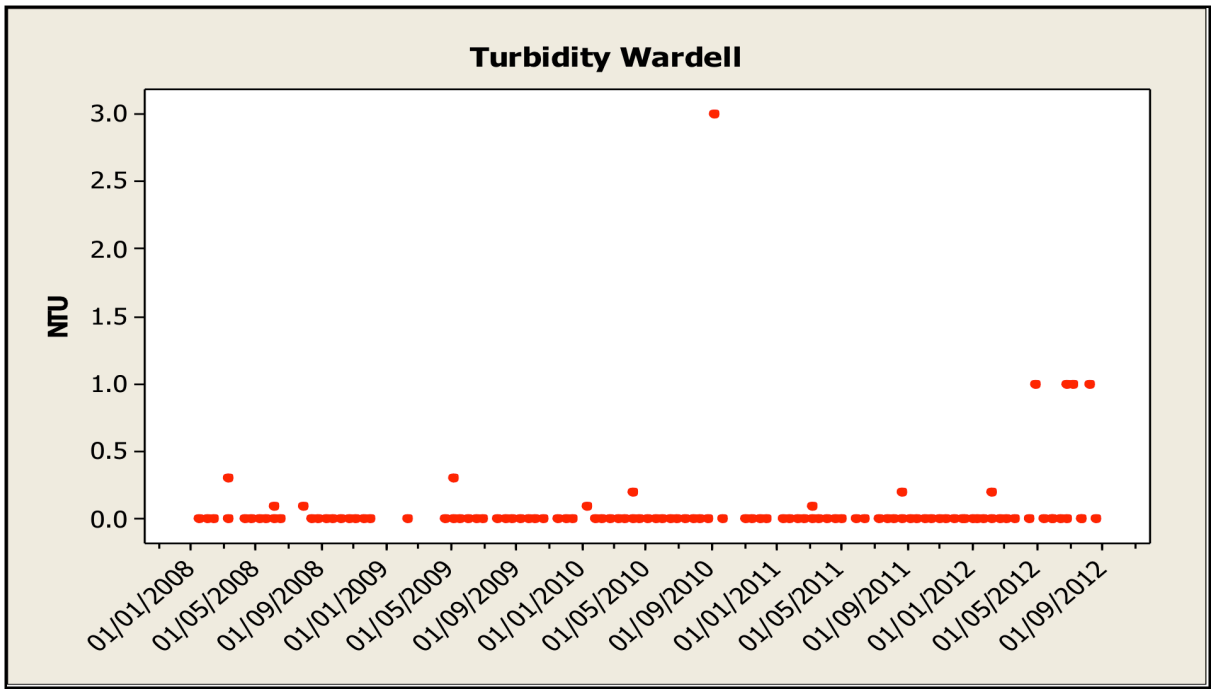


Figure 26 Wardell - Turbidity

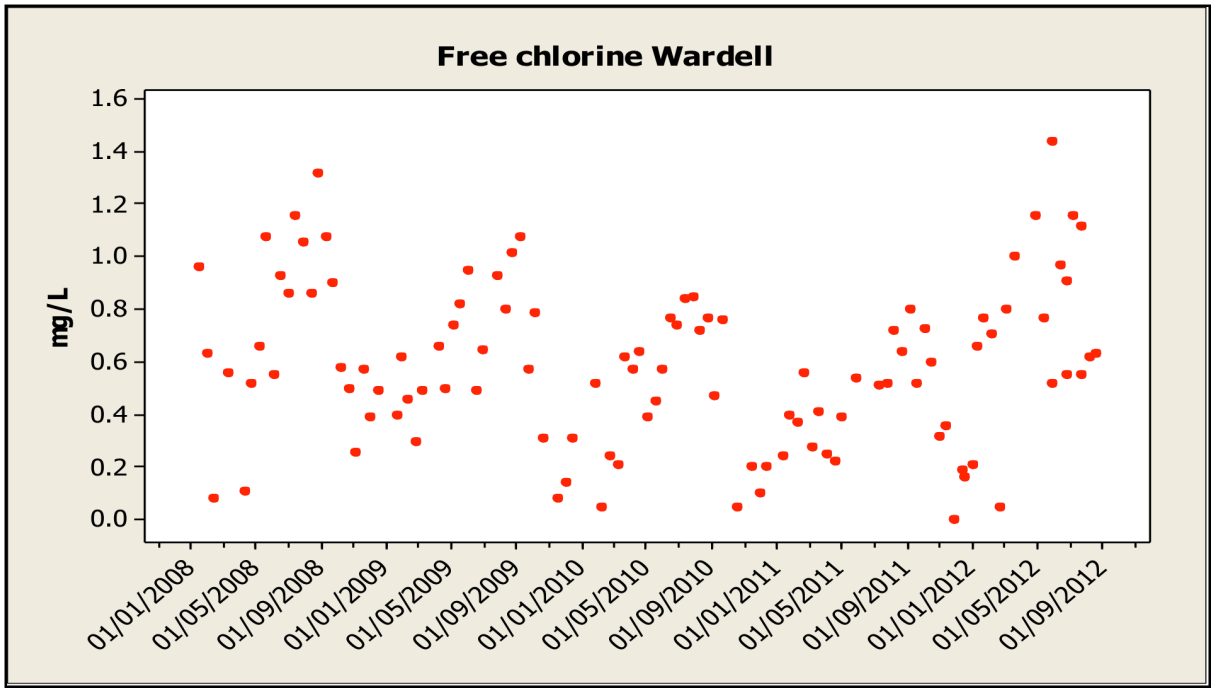


Figure 27 Wardell – Free chlorine

5.1.9 Cabbage Tree Island

Table 6 contains a summary report from the NSW health database for the Cabbage Tree Island reticulation. The sampling point is at Cabbage Tree Road, Cabbage Tree Island.

Table 6 Summary report Cabbage Tree Island reticulation

Characteristic	G/L	Unit	Mean	Median	Std Dev	Min	Max	N	Exception Count	95th % ile	5th %ile	% compliant
E. coli	0	cfu/100 mL	0	0	0	0	0	63	0	0	0	100
Free Chlorine	5	mg/L	0.64	0.64	0.30	0.09	1.42	55	0	1.08	0.1	100
pH	6.5 - 8.5		8.12	8.05	0.31	7.2	8.83	55	6	8.66	7.7	89.09
Thermotolerant Coliforms	0	cfu/100 mL	0	0	0	0	0	31	0	0	0	100
Total Chlorine	5	mg/L	0.74	0.79	0.39	0.1	1.62	30	0	1.3	0.13	100
Total Coliforms	0	cfu/100 mL	2	0	13	0	101	63	4	1	0	93.65
Turbidity	5	NTU	0	0	0	0	1	50	0	1	0	100

Figures 28 - 32 show the charts for pH, free chlorine, turbidity, *E coli* and total coliforms.

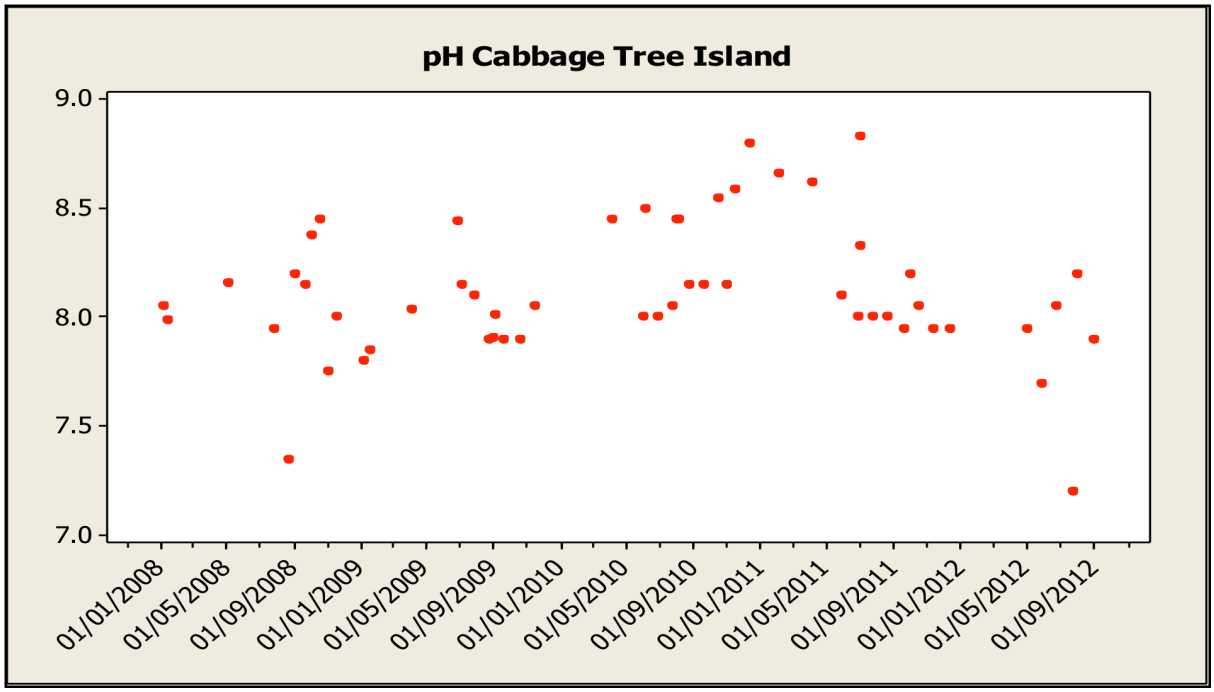


Figure 28 Cabbage Tree Island – pH

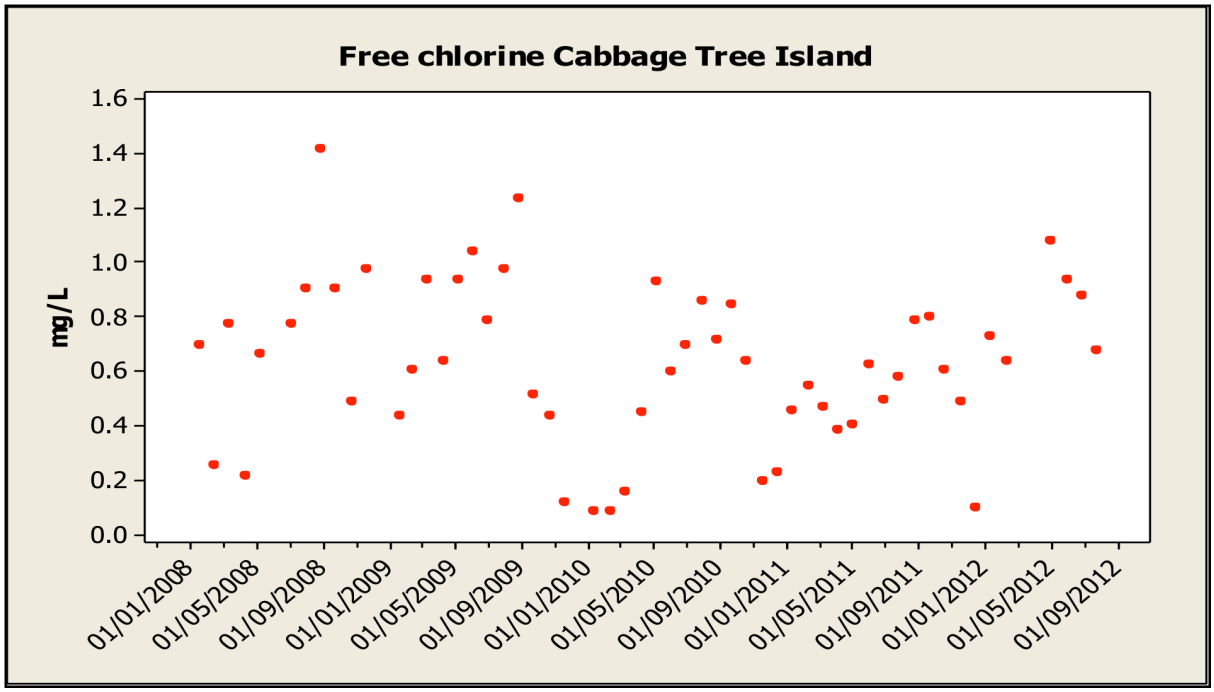


Figure 29 Cabbage Tree Island – Free chlorine

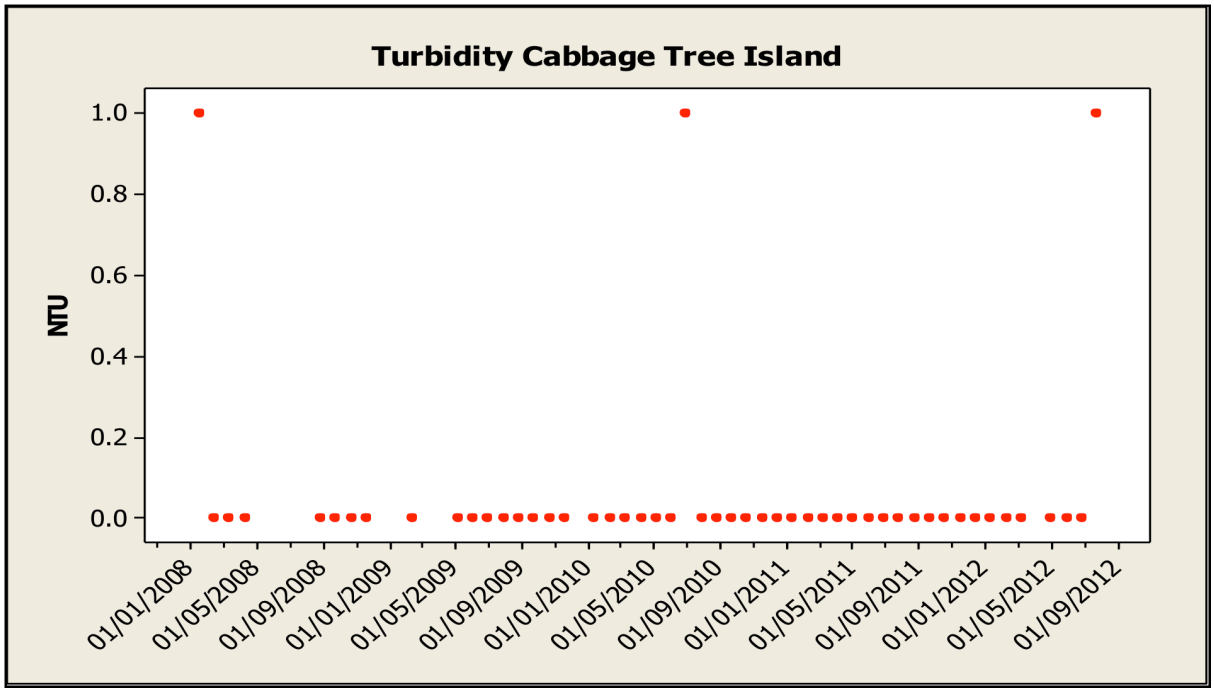


Figure 30 Cabbage Tree Island - Turbidity

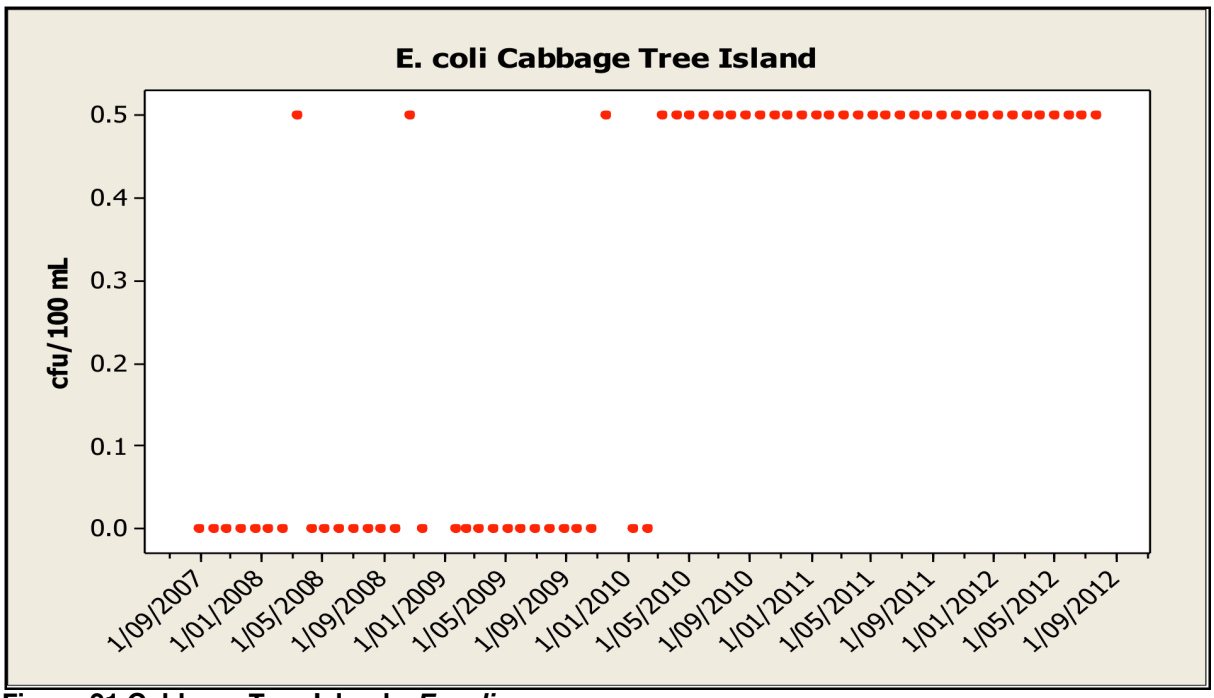


Figure 31 Cabbage Tree Island – *E. coli*

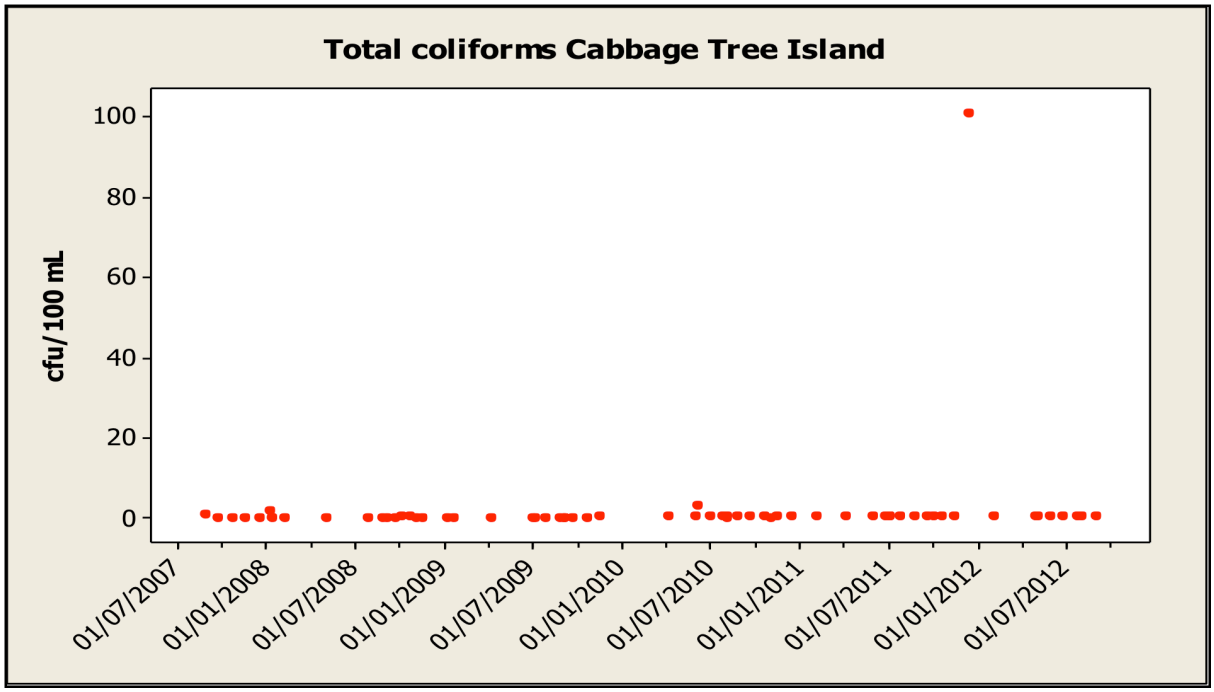


Figure 32 Cabbage Tree Island – Total coliforms

5.2 Bulk Water Distribution – Data and Interpretation

The bulk water distribution data consists of two supply systems: the Ballina scheme, which is supplied from Rous Water's Dorroughby to St Helena bulk supply pipelines near Bangalow, and the Wollongbar scheme, which is supplied from Rous Water bulk supply system at Lismore. Towns supplied by the Ballina scheme include Ballina Island, Lennox Head and West Ballina, and towns supplied by the Wollongbar scheme include Alstonville and Wollongbar.

5.2.1 Ballina Island

Table 7 contains a summary report from the NSW health database for the Ballina Island reticulation. The sampling points are at corner of Bentinck and Cherry Streets, Northern end of River Street, and Shelly Beach Road.

Table 7 Summary report Ballina Island reticulation

Characteristic	G/L	Units	Mean	Median	Std Dev	Min	Max	N	< LOR	95th %ile	5th %ile	% Compliant
Aluminium	0.2	mg/L	0.011	0.008	0.008	0.005	0.050	60	0	0.03	0.005	100.00
Antimony	0.003	mg/L	0.0005	0.0005	0.0000	0.0005	0.0005	60	0	0.0005	0.0005	100.00
Arsenic	0.01	mg/L	0.0006	0.0005	0.0002	0.0005	0.002	60	0	0.001	0.0005	100.00
Barium	2	mg/L	0.0030	0.0025	0.0011	0.0025	0.006	60	0	0.005	0.0025	100.00
Boron	4	mg/L	0.05	0.05	0.00	0.05	0.05	60	0	0.05	0.05	100.00
Cadmium	0.002	mg/L	0.0003	0.0003	0.0003	0.00025	0.0019	60	0	0.0013	0.00025	100.00
Calcium		mg/L	23.59	24.15	2.69	16.25	28.4	60	0	27	18.05	100.00
Chloride	250	mg/L	14	13	2	11	19	60	0	17.7	12	100.00
Chromium	0.05	mg/L	0.0025	0.0025	0.0003	0.0025	0.005	60	0	0.0025	0.0025	100.00
Copper	2	mg/L	0.0504	0.0275	0.0948	0.0025	0.588	60	0	0.107	0.008	100.00
Fluoride	1.5	mg/L	0.050	0.050	0.002	0.037	0.05	60	0	0.05	0.05	100.00
Fluoride Ratio	0.8 - 1.2		0.0000	0.0000	0.0000	0	0	4	0	0	0	100.00
Iodine	0.5	mg/L	0.01	0.01	0.01	0.01	0.03	60	0	0.026	0.01	100.00
Iron	0.3	mg/L	0.015	0.005	0.019	0.005	0.08	60	0	0.05	0.005	100.00
Lead	0.01	mg/L	0.001	0.001	0.001	0.001	0.006	60	0	0.001	0.001	100.00
Magnesium		mg/L	0.91	0.82	0.26	0.64	1.69	60	0	1.53	0.71	100.00
Manganese	0.5	mg/L	0.0027	0.0025	0.0009	0.0025	0.007	60	0	0.005	0.0025	100.00
Mercury	0.001	mg/L	0.0001	0.0001	0.0000	0.00005	0.0001	60	0	0.00005	0.00005	100.00
Molybdenum	0.05	mg/L	0.0025	0.0025	0.0000	0.0025	0.0025	60	0	0.0025	0.0025	100.00
Nickel	0.02	mg/L	0.005	0.005	0.000	0.005	0.005	60	0	0.005	0.005	100.00
Nitrate	50	mg/L	1.232	0.500	1.076	0.307	4	60	0	3.4	0.5	100.00
Nitrite	3	mg/L	0.2	0.1	0.4	0	1.8	60	0	1.3	0.05	100.00

Characteristic	G/L	Units	Mean	Median	Std Dev	Min	Max	N	< LOR	95th %ile	5th %ile	% Compliant
pH	6.5 - 8.5		7.9	7.9	0.2	7.6	8.3	60	0	8.2	7.6	100.00
Selenium	0.01	mg/L	0.001	0.001	0.000	0.001	0.001	60	0	0.001	0.001	100.00
Silver	0.1	mg/L	0.001	0.001	0.000	0.001	0.001	60	0	0.001	0.001	100.00
Sodium	180	mg/L	9.2	9.0	1.9	7	16.1	60	0	14	7	100.00
Sulfate	500	mg/L	19	20	5	3	31	60	0	24	8.7	100.00
Total Dissolved Solids (TDS)	600	mg/L	94	92	6	83	112	60	0	104	86	100.00
Total Hardness as CaCO3	200	mg/L	62.6	63.6	6.2	47.1	75	60	0	72.9	51.4	100.00
True Colour	15	HU	0.7	0.5	0.3	0.5	1.9	60	0	1	0.5	100.00
Turbidity	5	NTU	0.15	0.10	0.12	0.05	0.7	60	0	0.3	0.05	100.00
Zinc	3	mg/L	0.014	0.010	0.015	0.005	0.09	60	0	0.04	0.005	100.00
E. coli	0	cfu/100 mL	0	0	0	0	3	580	4	0	0	99.31
Free Chlorine	5	mg/L	0.45	0.45	0.32	0	1.52	392	0	1.01	0	100.00
pH	6.5 - 8.5		7.6	7.7	0.4	0	8.6	469	2	7.9	7.4	99.57
Thermotolerant Coliforms	0	cfu/100 mL	0	0	0	0	3	279	4	0	0	98.57
Total Chlorine	5	mg/L	0.29	0.18	0.29	0	1.52	234	0	0.78	0	100.00
Total Coliforms	0	cfu/100 mL	1	0	11	0	200	580	81	4	0	86.03
Turbidity	5	NTU	0	0	0	0	5	428	0	0	0	100.00

Figures 33-39 show the charts for pH, free chlorine, turbidity, *E coli*, total and thermotolerant coliforms.

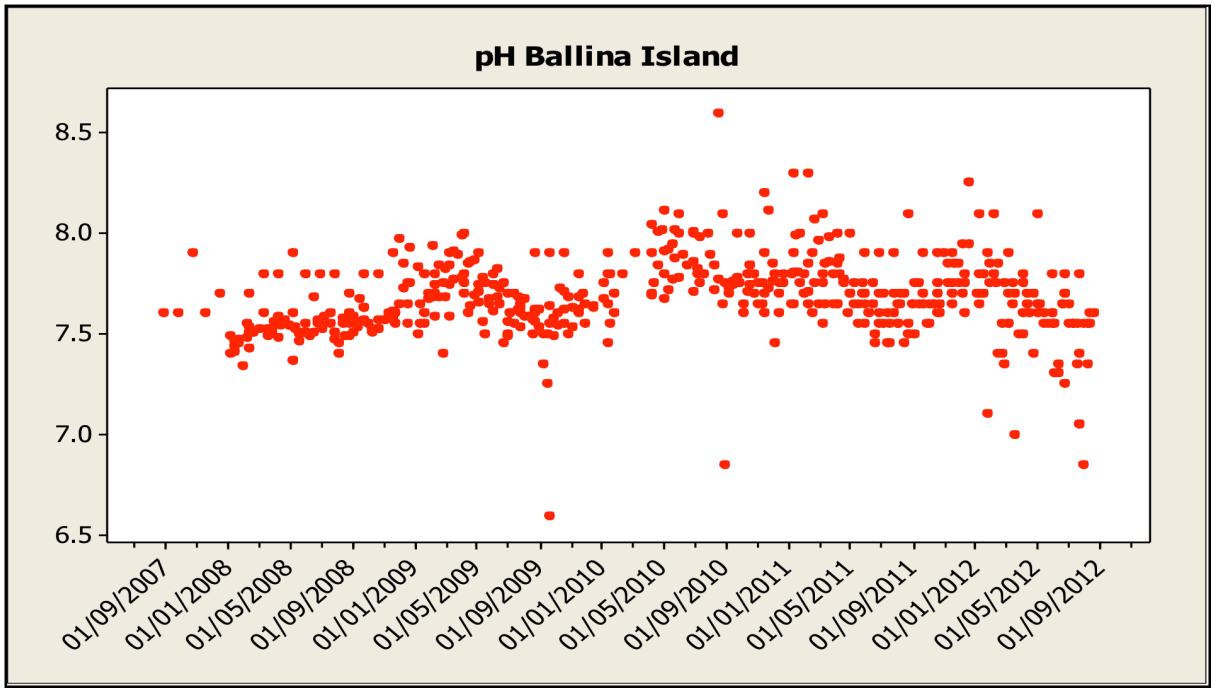


Figure 33 Ballina Island - pH

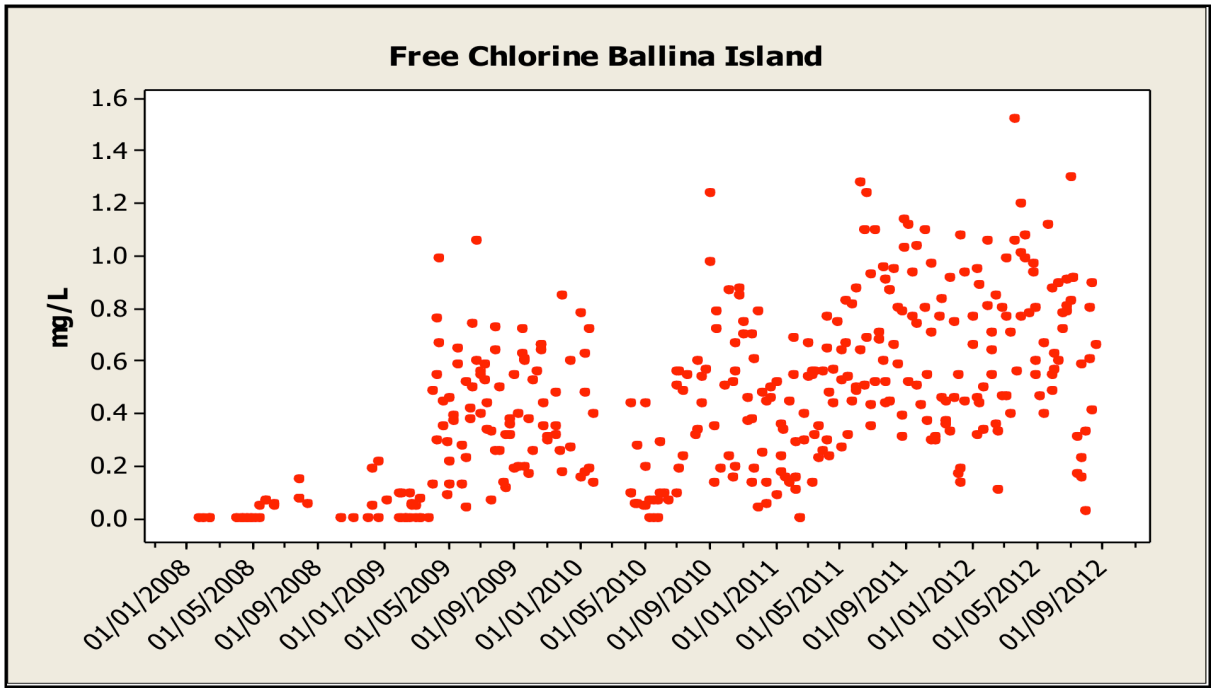


Figure 34 Ballina Island – Free chlorine

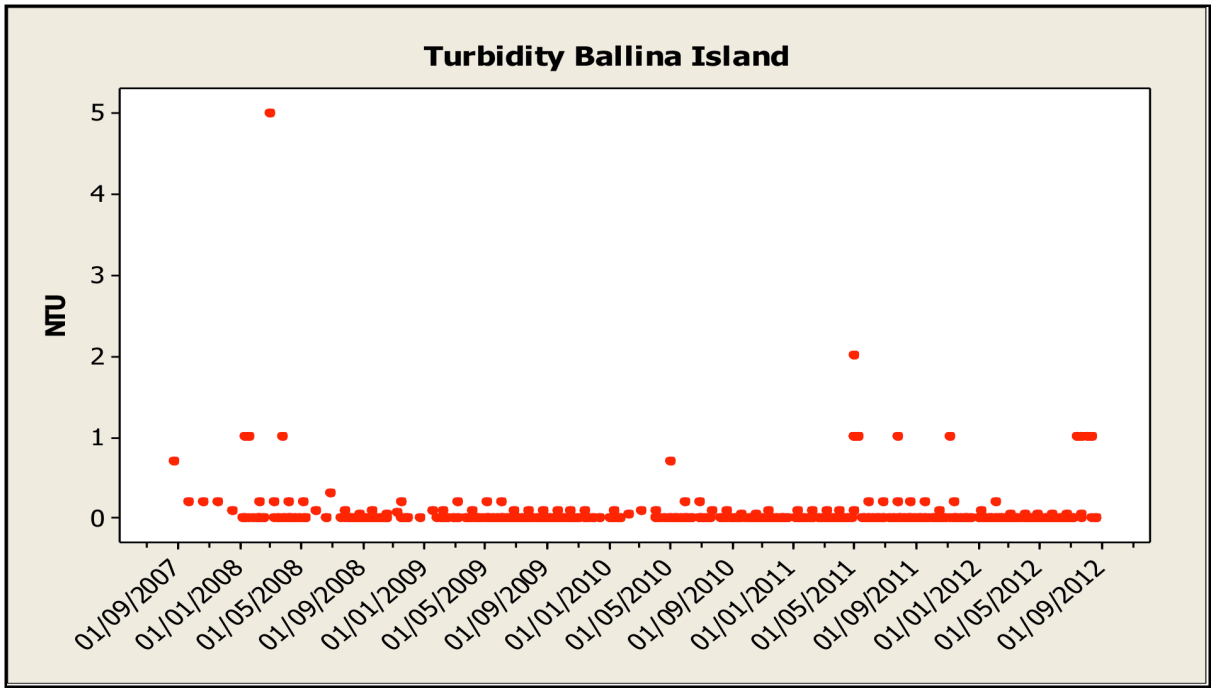


Figure 35 Ballina Island - Turbidity

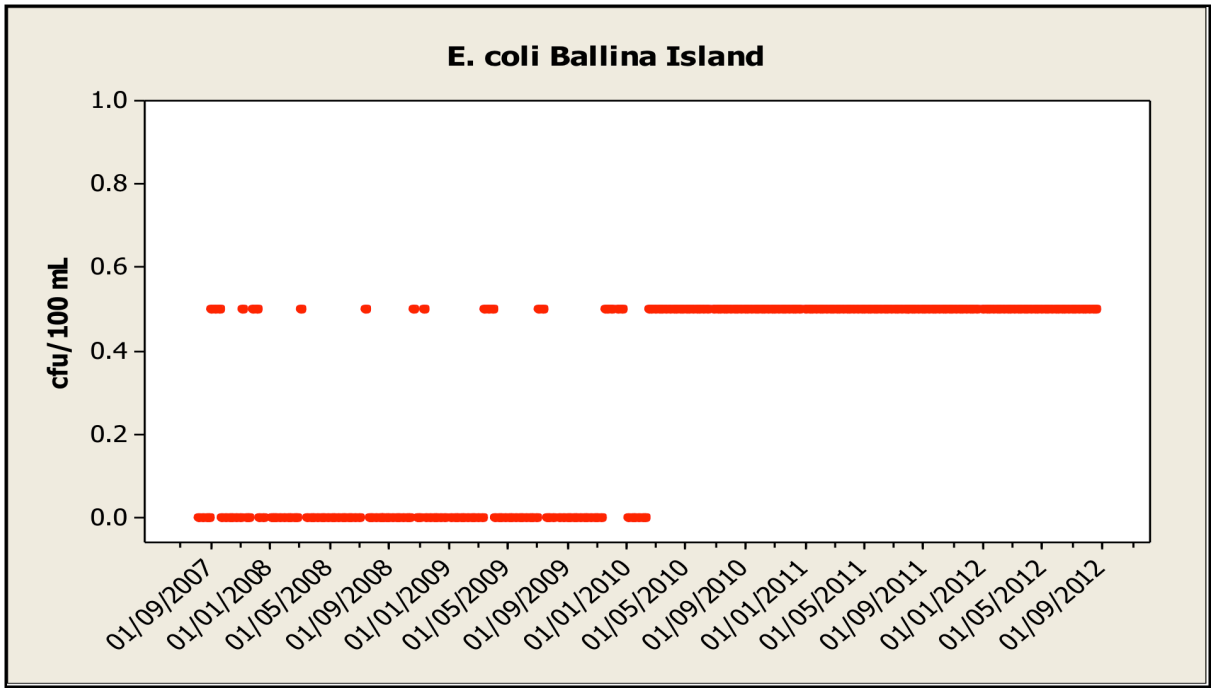


Figure 36 Ballina Island – *E. coli*

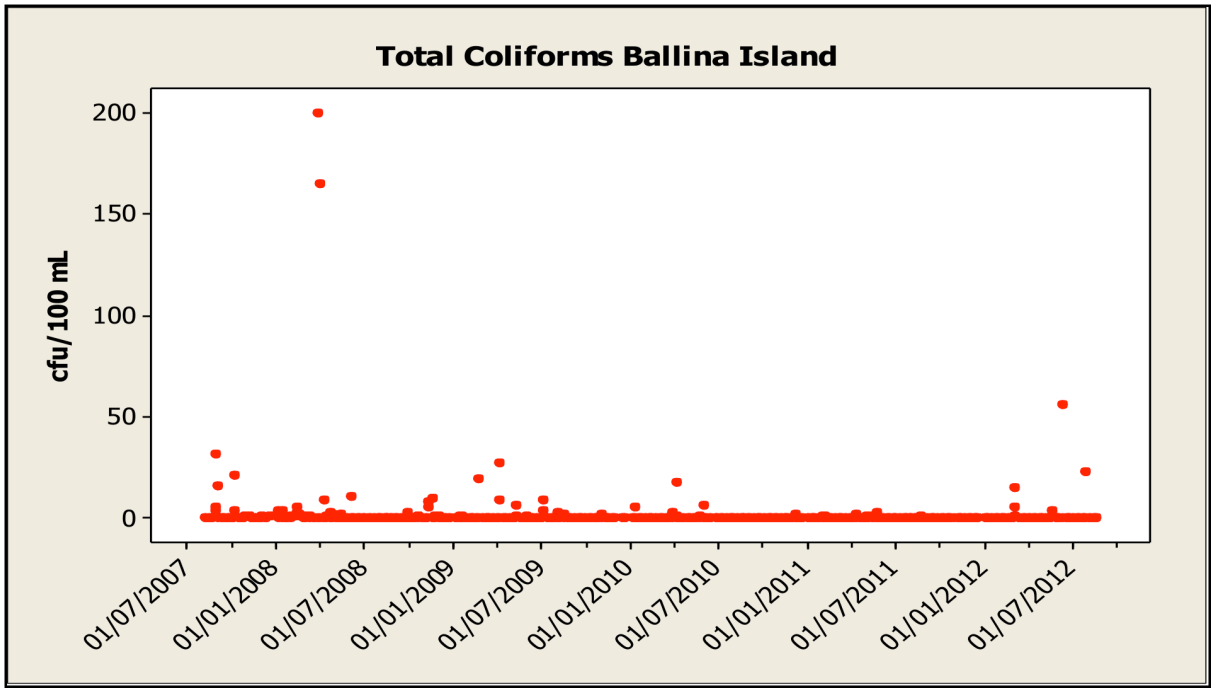


Figure 37 Ballina Island – Total coliforms

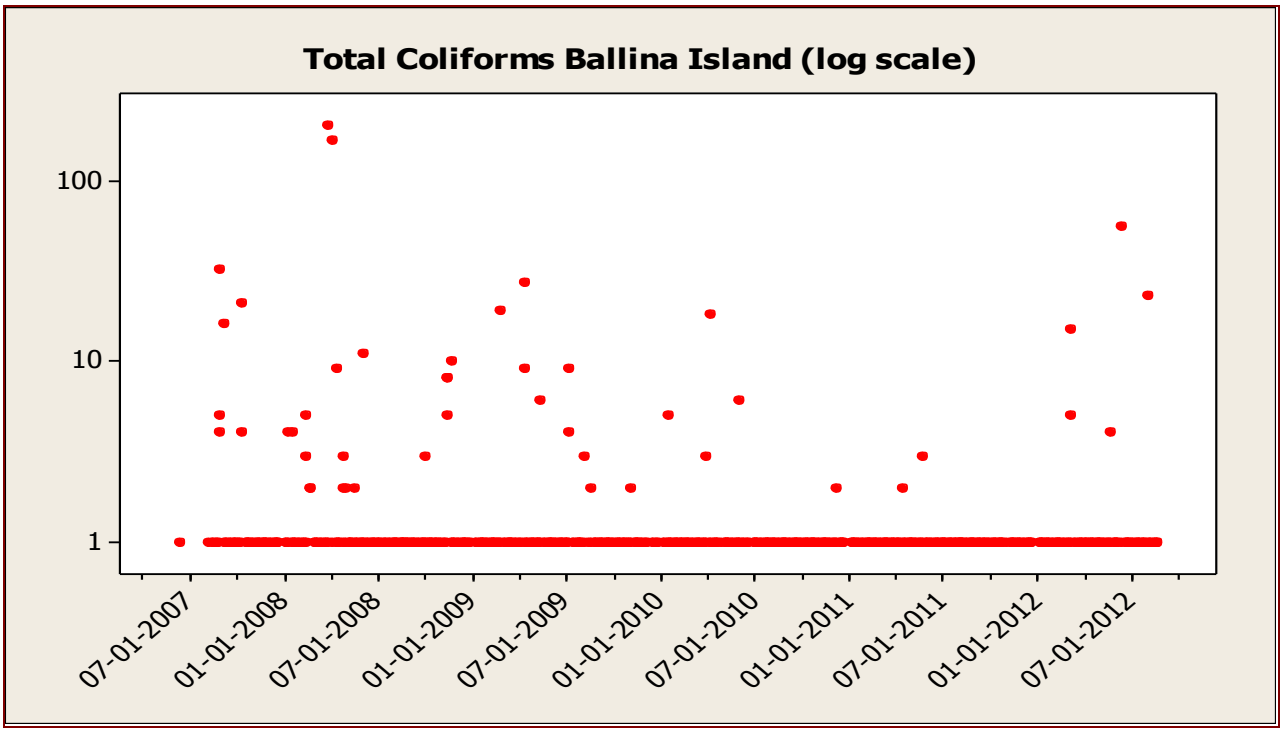


Figure 38 Ballina Island – Total coliforms (log scale)

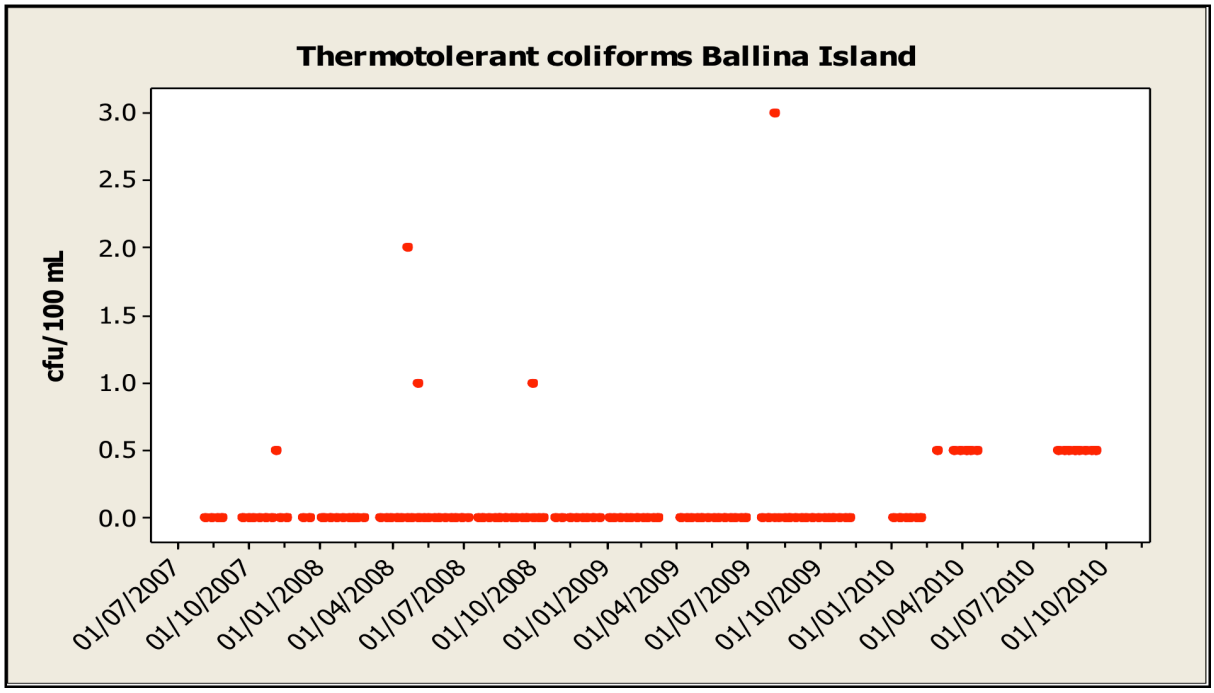


Figure 39 Ballina Island – Thermotolerant coliforms

5.2.2 Lennox Head

Table 8 contains a summary report from the NSW health database for Lenox Island reticulation. The sampling point is at corner of Ross Lane and Pacific Parade, Lennox Head.

Table 8 Summary report Lennox Head reticulation

Characteristic	G/L	Units	Mean	Median	Std Dev	Min	Max	N	< LOR	95th %ile	5th %ile	% Compliant
E. coli	0	cfu/ 100 mL	1	0	10	0	109	130	1	0	0	99.23
Free Chlorine	5	mg/L	0.53	0.53	0.30	0	1.38	97	0	0.99	0	100
pH	6.5 - 8.5		7.61	7.60	0.14	7.05	8.3	112	0	7.85	7.45	100
Thermo tolerant Coliforms	0	cfu/ 100 mL	0	0	0	0	0	60	0	0	0	100
Total Chlorine	5	mg/L	0.32	0.37	0.27	0	1.01	53	0	0.72	0	100.00
Total Coliforms	0	cfu/ 100 mL	6	0	24	0	200	130	25	36	0	80.77
Turbidity	5	NTU	0	0	0	0	1	102	0	0	0	100

Figures 40-46 show the charts for pH, turbidity, free chlorine, *E. coli*, total and thermotolerant coliforms for Lennox Head.

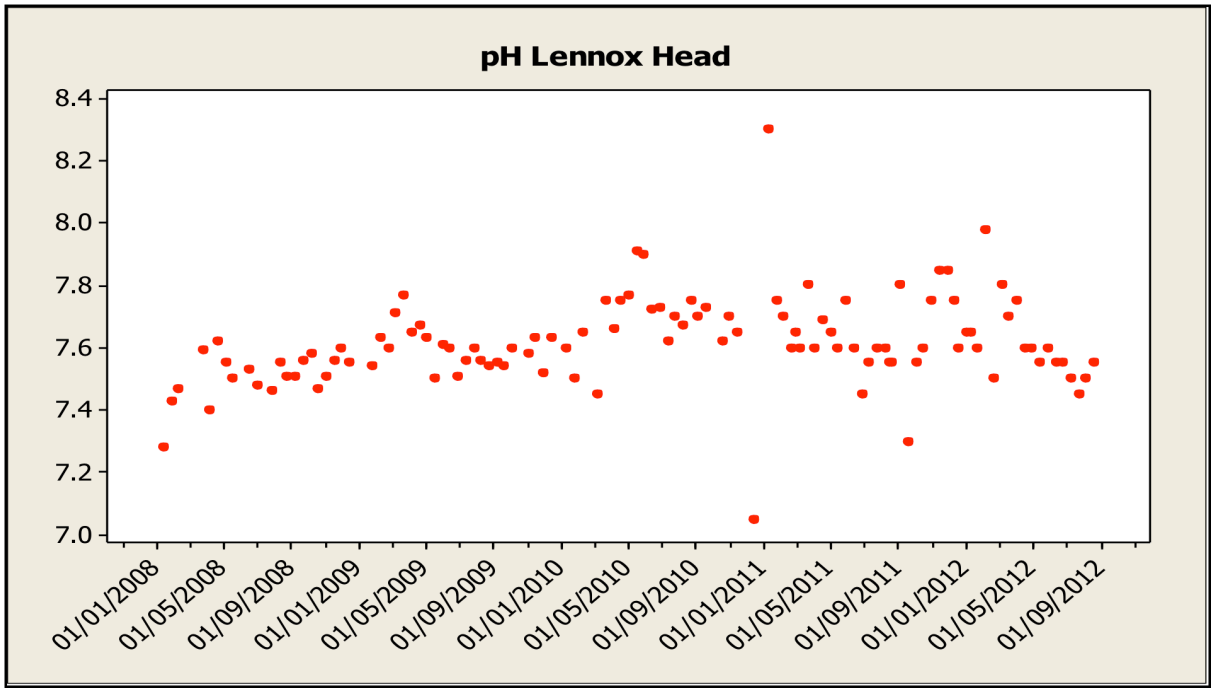


Figure 40 Lennox Head - pH

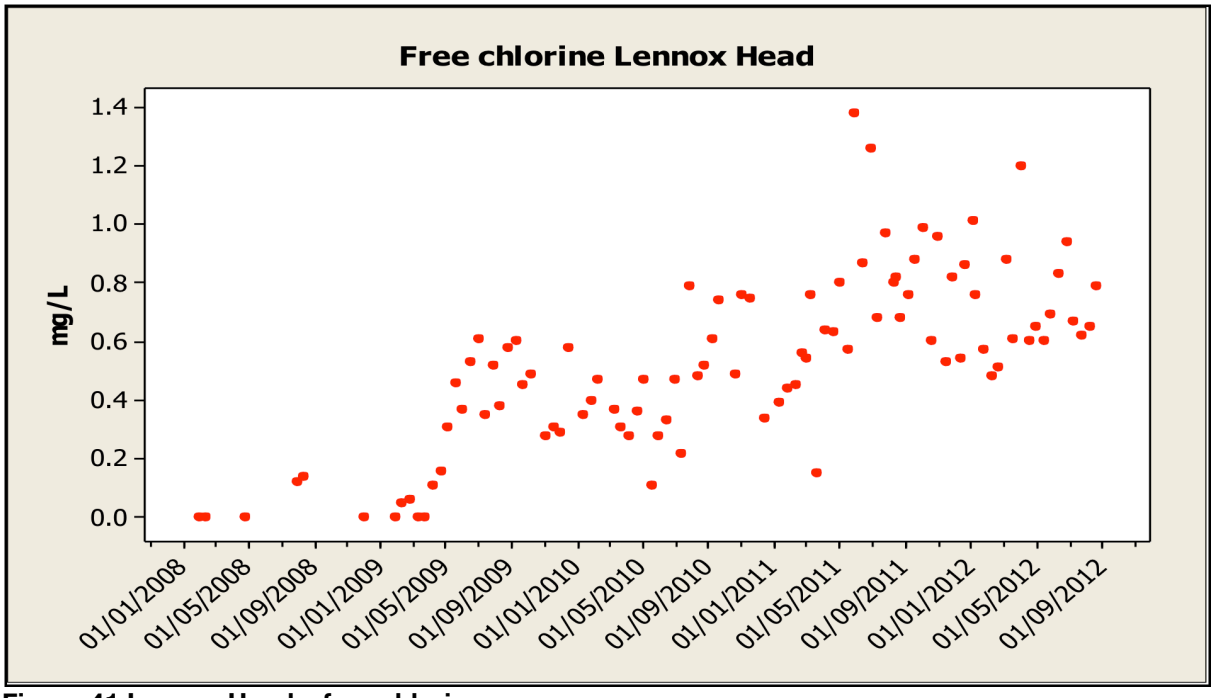


Figure 41 Lennox Head – free chlorine

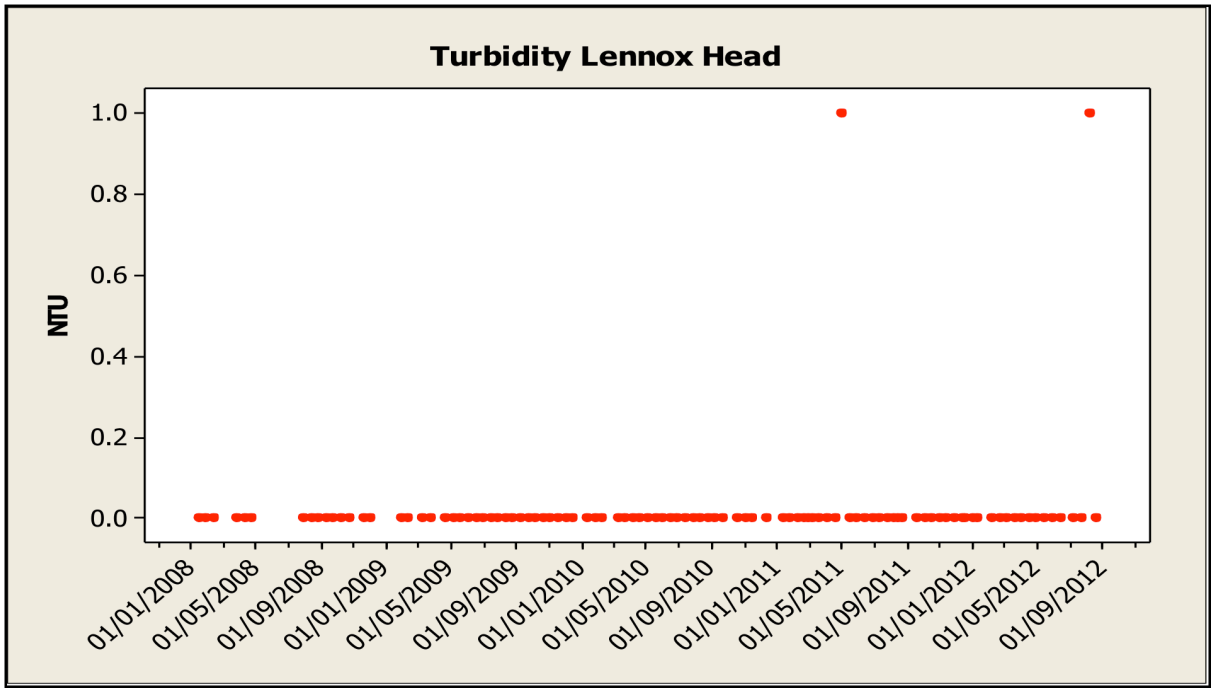


Figure 42 Lennox Head - turbidity

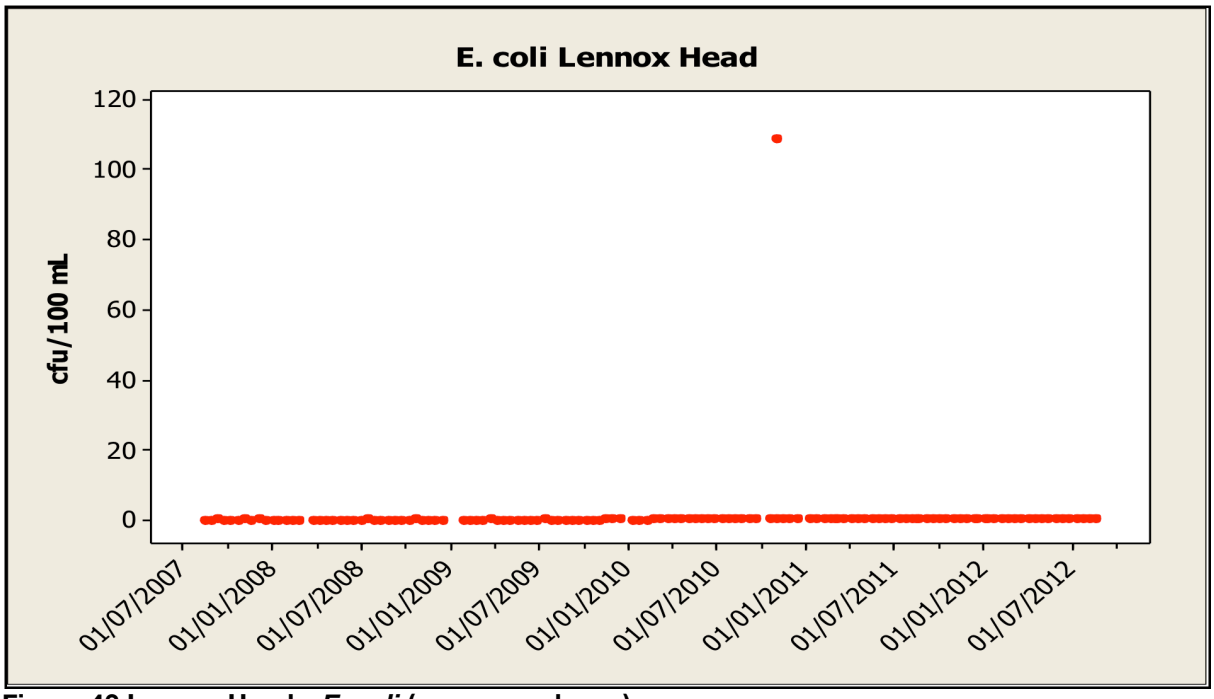


Figure 43 Lennox Head – *E. coli* (one exceedence)

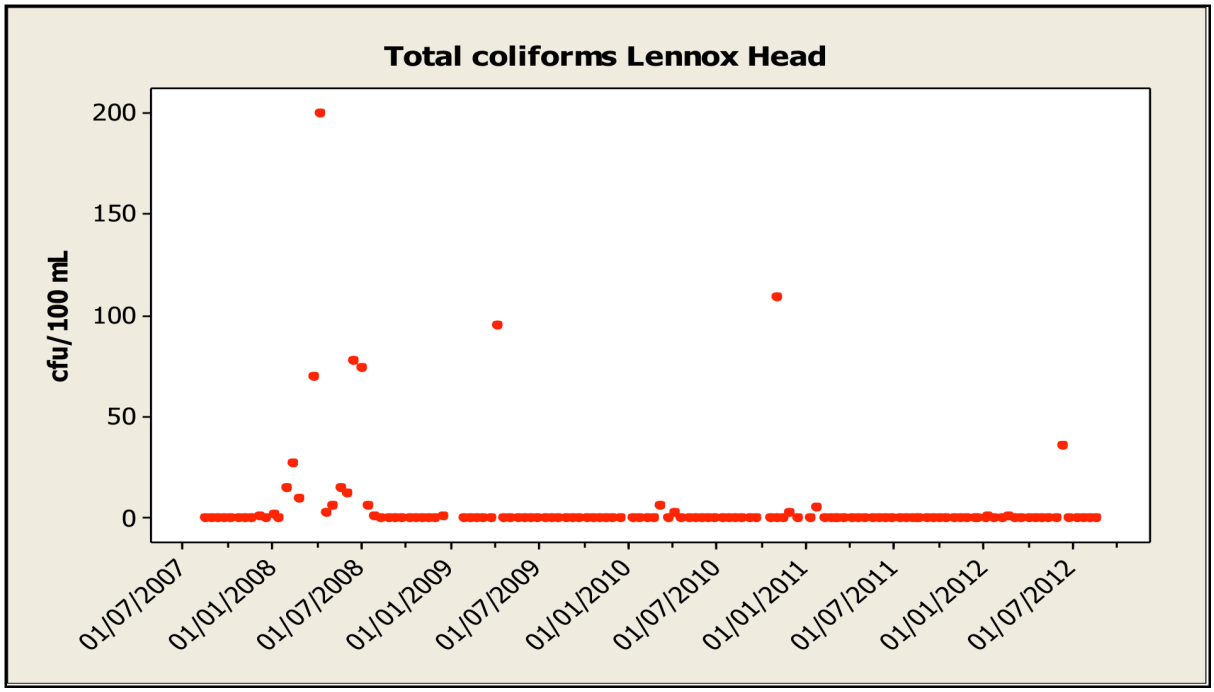


Figure 44 Lennox Head – total coliforms

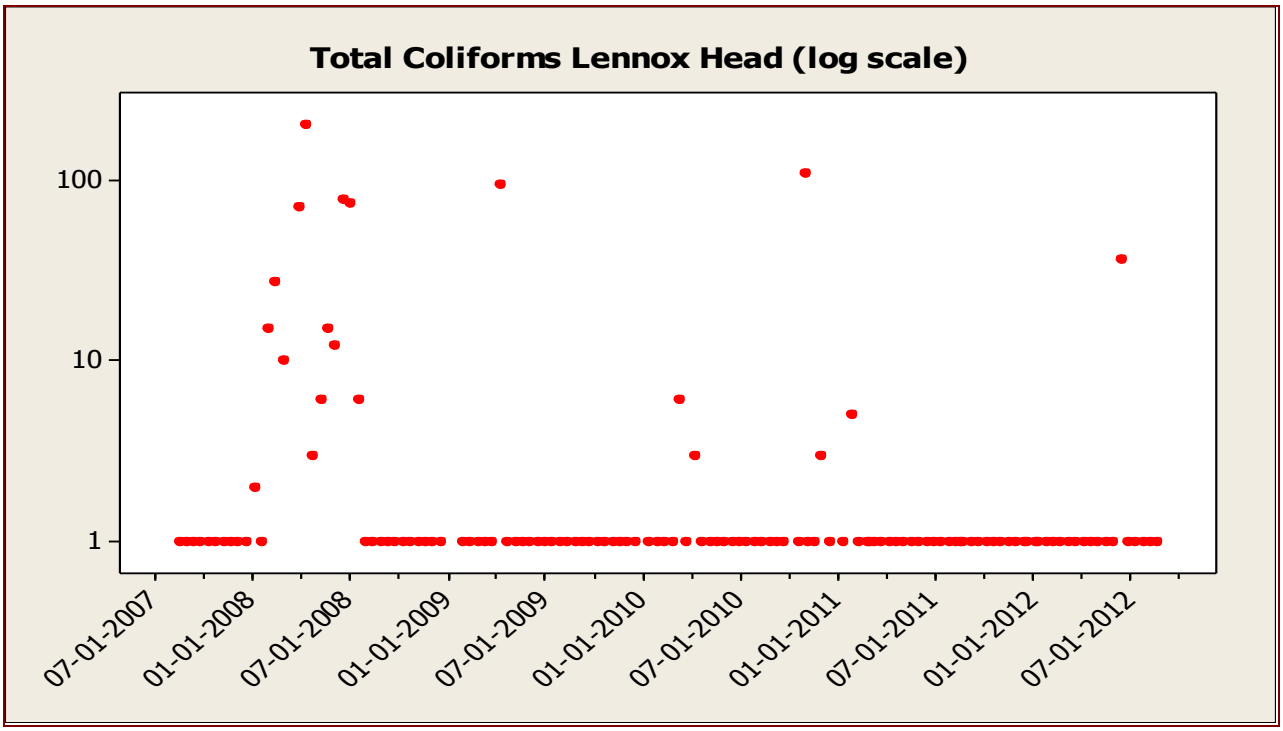


Figure 45 Lennox Head – total coliforms (log scale)

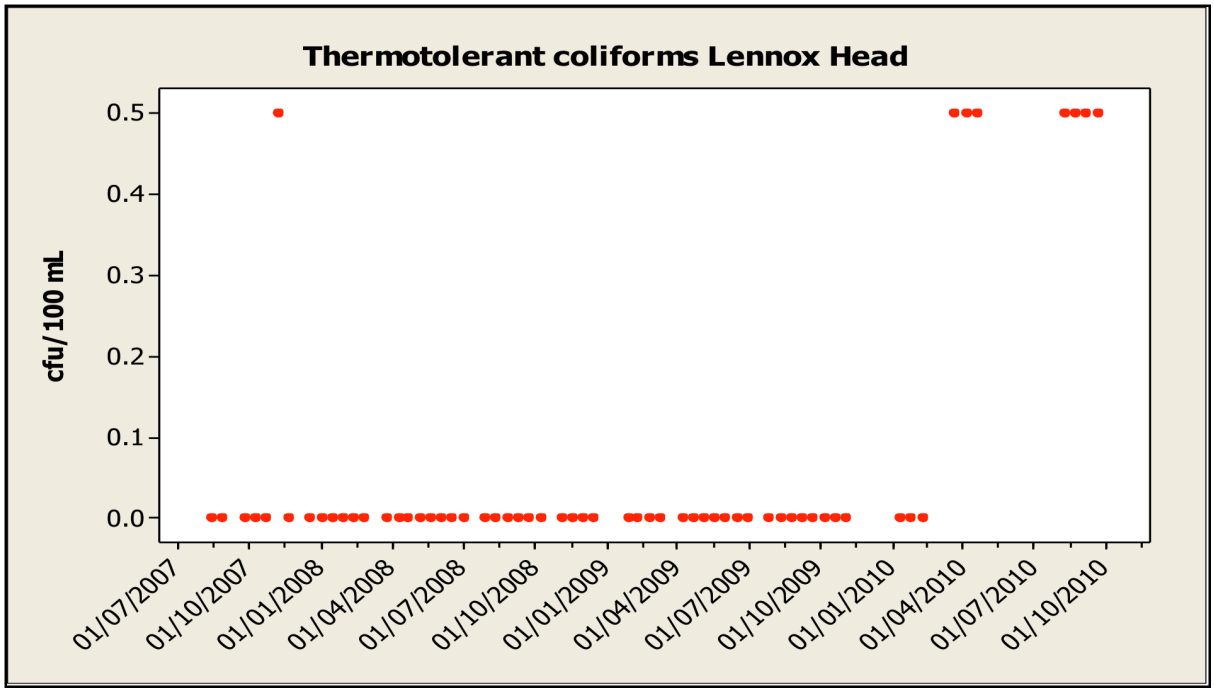


Figure 46 Lennox Head – Thermotolerant coliforms

5.2.3 West Ballina

Table 9 contains a summary report from the NSW health database for Lenox Island reticulation. The sampling point is at Riverside Drive, West Ballina.

Table 9 Summary report West Ballina reticulation

Characteristic	G/L	Unit	Mean	Median	Std Dev	Min	Max	N	Exception Count	95th %ile	5th %ile	% compliant
E. coli	0	cfu/ 100 mL	0	0	0	0	0	127	0	0	0	100
Free Chlorine	5	mg/L	0.41	0.42	0.23	0	0.95	81	0	0.82	0.02	100
pH	6.5 - 8.5		7.7	7.7	0.2	7	8.6	102	1	8.06	7.4	99.02
Thermotolerant Coliforms	0	cfu/ 100 mL	0	0	0	0	0	61	0	0	0	100
Total Chlorine	5	mg/L	0.25	0.16	0.23	0	0.86	56	0	0.7	0	100
Total Coliforms	0	cfu/ 100 mL	0	0	2	0	16	127	11	1	0	91.34
Turbidity	5	NTU	0	0	0	0	1	95	0	1	0	100

Figures 47-51 show the charts for pH, turbidity, free chlorine, *E. coli* and total coliforms for West Ballina.

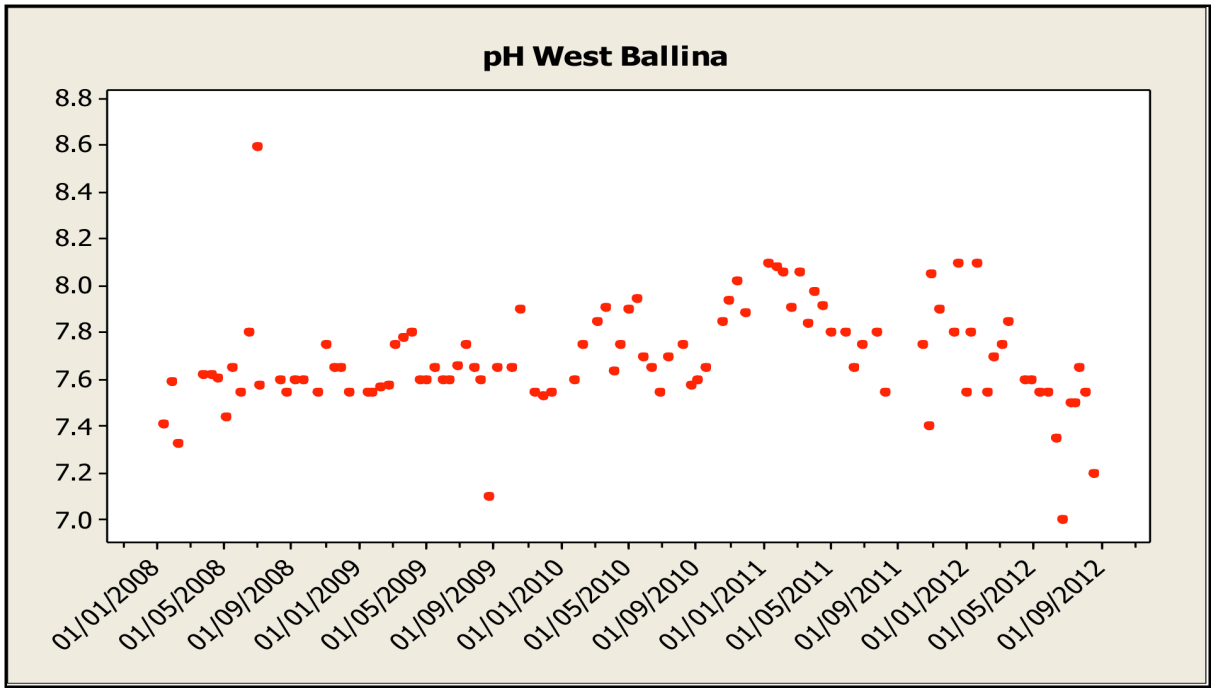


Figure 47 West Ballina - pH

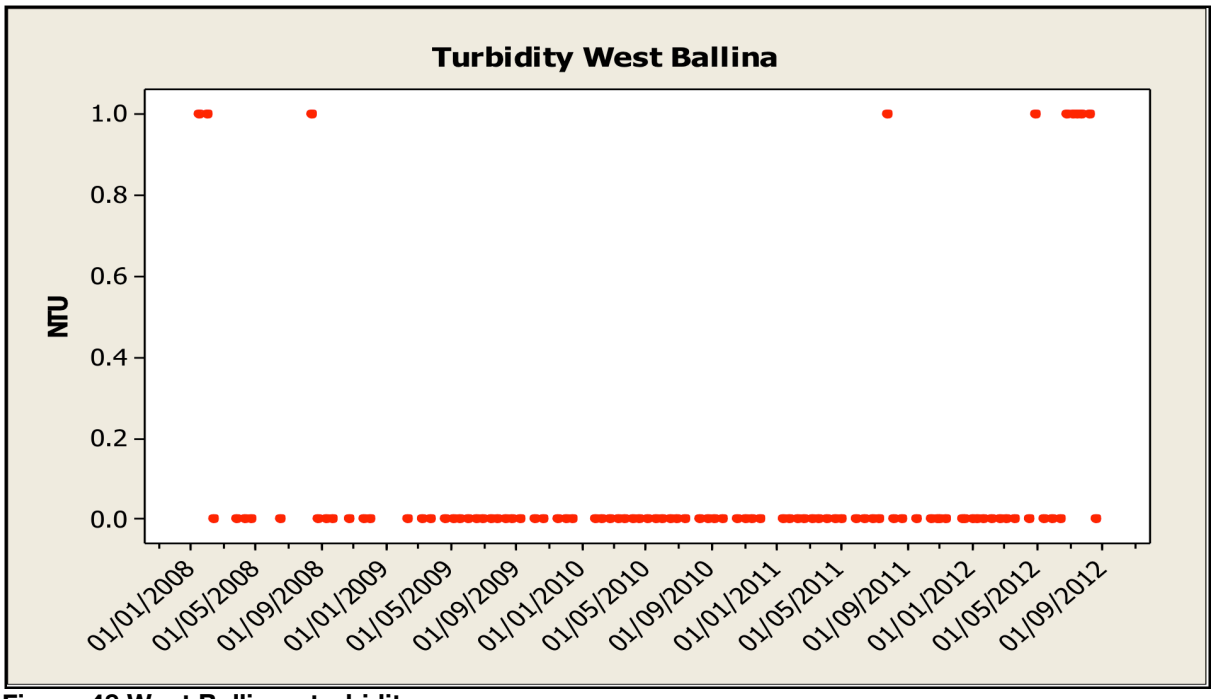


Figure 48 West Ballina - turbidity

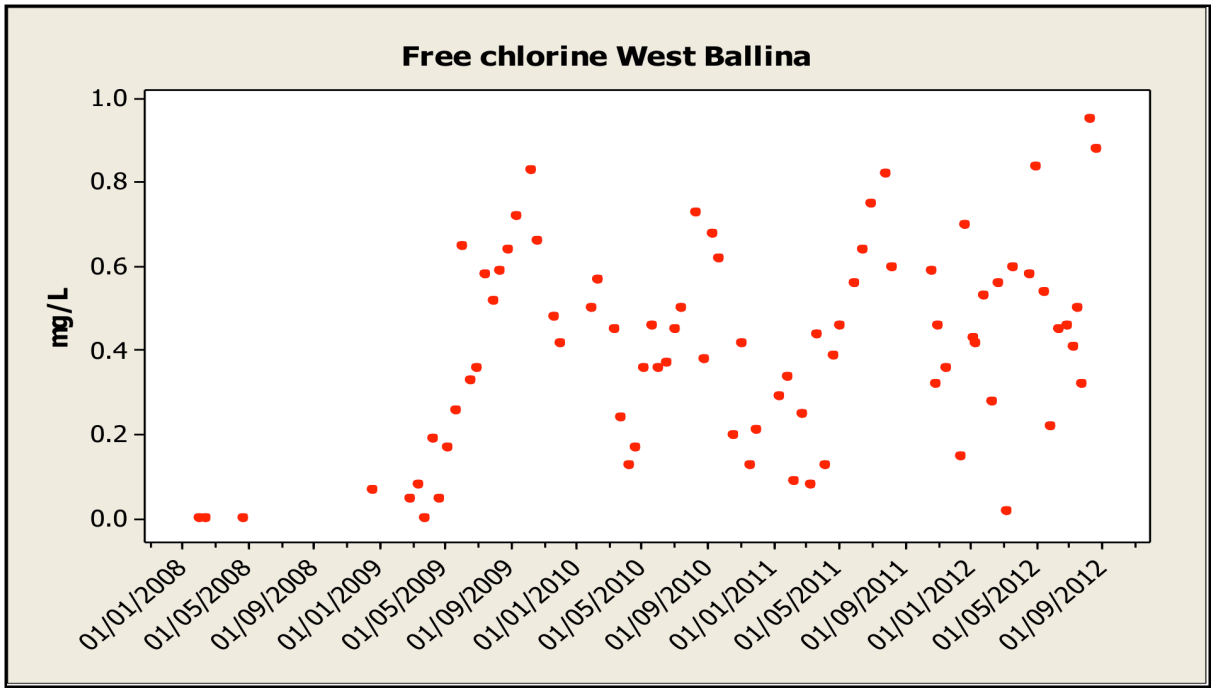


Figure 49 West Ballina – free chlorine

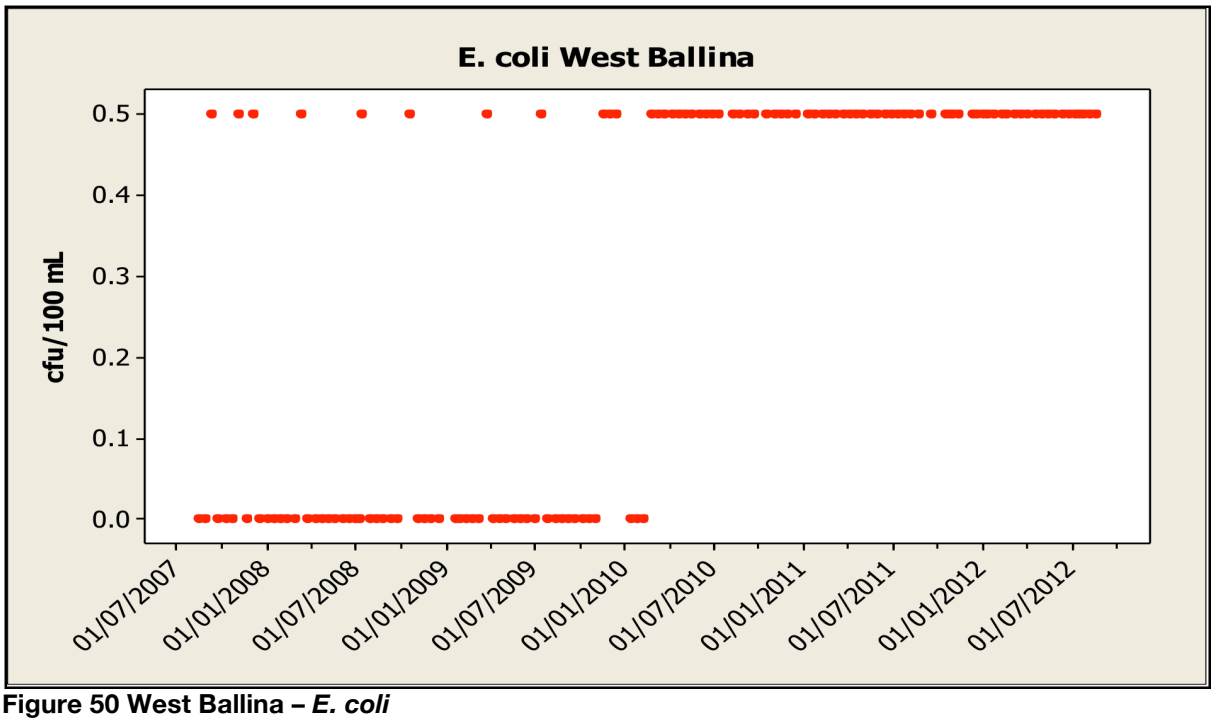


Figure 50 West Ballina – *E. coli*

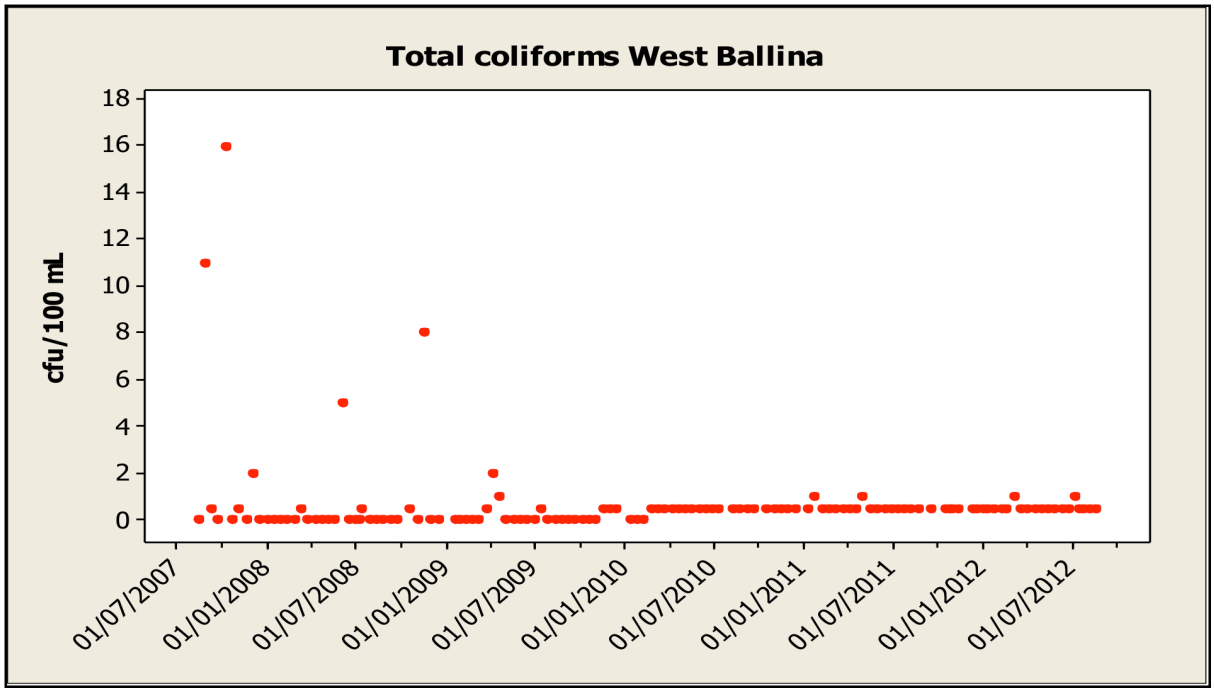


Figure 51 West Ballina – total coliforms

5.2.4 Alstonville

Table 10 contains a summary report from the NSW health database for Alstonville reticulation. The sampling points are at Mellis Circuit and 999 not defined Alstonville.

Table 10 Summary report Alstonville reticulation

Characteristic	G/L	Unit	Mean	Median	Std Dev	Min	Max	N	Exception Count	95th %ile	5th %ile	% com-pliant
Aluminium	0.2	mg/L	0.019	0.010	0.064	0.005	0.5	59	1	0.03	0.005	98.31
Antimony	0.003	mg/L	0.0005	0.0005	0.0000	0.0005	0.0005	59	0	0.0005	0.0005	100.00
Arsenic	0.01	mg/L	0.0006	0.0005	0.0003	0.0005	0.002	59	0	0.001	0.0005	100.00
Barium	2	mg/L	0.0027	0.0025	0.0007	0.0025	0.005	59	0	0.005	0.0025	100.00
Boron	4	mg/L	0.05	0.05	0.01	0.05	0.1	59	0	0.05	0.05	100.00
Cadmium	0.002	mg/L	0.0004	0.0003	0.0004	0.00025	0.0019	59	0	0.0016	0.00025	100.00
Calcium		mg/L	25.1	25.4	2.4	17.8	30.7	59	0	30	21.27	100.00
Chloride	250	mg/L	13.1	13.0	1.4	11	19.9	59	0	15	11	100.00
Chromium	0.05	mg/L	0.0027	0.0025	0.0008	0.0025	0.008	59	0	0.0025	0.0025	100.00
Copper	2	mg/L	0.0073	0.0060	0.0050	0.0025	0.026	59	0	0.018	0.0025	100.00
Fluoride	1.5	mg/L	0.05	0.05	0.01	0.037	0.11	59	0	0.05	0.05	100.00
Fluoride Ratio	0.8 - 1.2		0	0	0	0	0	3	0	0	0	100.00
Iodine	0.5	mg/L	0.01	0.01	0.01	0.01	0.04	59	0	0.026	0.01	100.00
Iron	0.3	mg/L	0.035	0.005	0.144	0.005	1.11	59	1	0.05	0.005	98.31
Lead	0.01	mg/L	0.001	0.001	0.000	0.001	0.001	59	0	0.001	0.001	100.00
Magnesium		mg/L	0.85	0.72	0.56	0.55	4.48	59	0	1.82	0.57	100.00
Manganese	0.5	mg/L	0.0030	0.0025	0.0017	0.0025	0.012	59	0	0.008	0.0025	100.00
Mercury	0.001	mg/L	0.0001	0.0001	0.0000	0.00005	0.0003	59	0	0.00005	0.00005	100.00
Molybdenum	0.05	mg/L	0.0025	0.0025	0.0000	0.0025	0.0025	59	0	0.0025	0.0025	100.00

Characteristic	G/L	Unit	Mean	Median	Std Dev	Min	Max	N	Exception Count	95th %ile	5th %ile	% compliant
Nickel	0.02	mg/L	0.005	0.005	0.000	0.005	0.005	59	0	0.005	0.005	100.00
Nitrate	50	mg/L	1.292	0.500	1.194	0.322	4.1	59	0	3.8	0.5	100.00
Nitrite	3	mg/L	0.09	0.05	0.12	0	0.7	59	0	0.3	0.05	100.00
pH	6.5 - 8.5		7.9	7.9	0.2	7.7	8.4	59	0	8.3	7.7	100.00
Selenium	0.01	mg/L	0.001	0.001	0.000	0.001	0.002	59	0	0.001	0.001	100.00
Silver	0.1	mg/L	0.001	0.001	0.000	0.001	0.001	59	0	0.001	0.001	100.00
Sodium	180	mg/L	9.1	8.7	2.0	7	19.3	59	0	14.4	7	100.00
Sulfate	500	mg/L	20	20	5	1	34	59	0	24	9.1	100.00
TDS	600	mg/L	98	96	11	82	140	59	0	116	86	100.00
Tot Hardness as CaCO3	200	mg/L	66.3	66.5	6.4	46.9	79.5	59	0	78	55.9	100.00
True Colour	15	HU	0.7	0.5	0.3	0.5	2	59	0	1.4	0.5	100.00
Turbidity	5	NTU	0.3	0.1	1.4	0.05	11.2	59	1	0.3	0.05	98.31
Zinc	3	mg/L	0.012	0.010	0.011	0.005	0.06	59	0	0.04	0.005	100.00
E. coli	0	cfu/100 mL	0	0	3	0	50	257	2	0	0	99.22
Free Chlorine	5	mg/L	0.54	0.55	0.29	0	1.68	166	0	0.94	0.07	100.00
pH	6.5 - 8.5		7.60	7.60	0.16	6.9	8.45	212	0	7.85	7.35	100.00
Thermotolerant Coliforms	0	cfu/100 mL	0	0	5	0	50	122	1	0	0	99.18
Total Chlorine	5	mg/L	0.28	0.14	0.30	0	0.96	113	0	0.85	0	100.00

Characteristic	G/L	Unit	Mean	Median	Std Dev	Min	Max	N	Exception Count	95th %ile	5th %ile	% com-pliant
Total Coliforms	0	cfu/ 100 mL	5	0	28	0	200	257	41	7	0	84.05
Turbidity	5	NTU	0	0	0	0	1	195	0	0	0	100.00

Figures 52-58 show the charts for pH, turbidity, free chlorine, *E. coli*, total and thermotolerant coliforms for Alstonville.

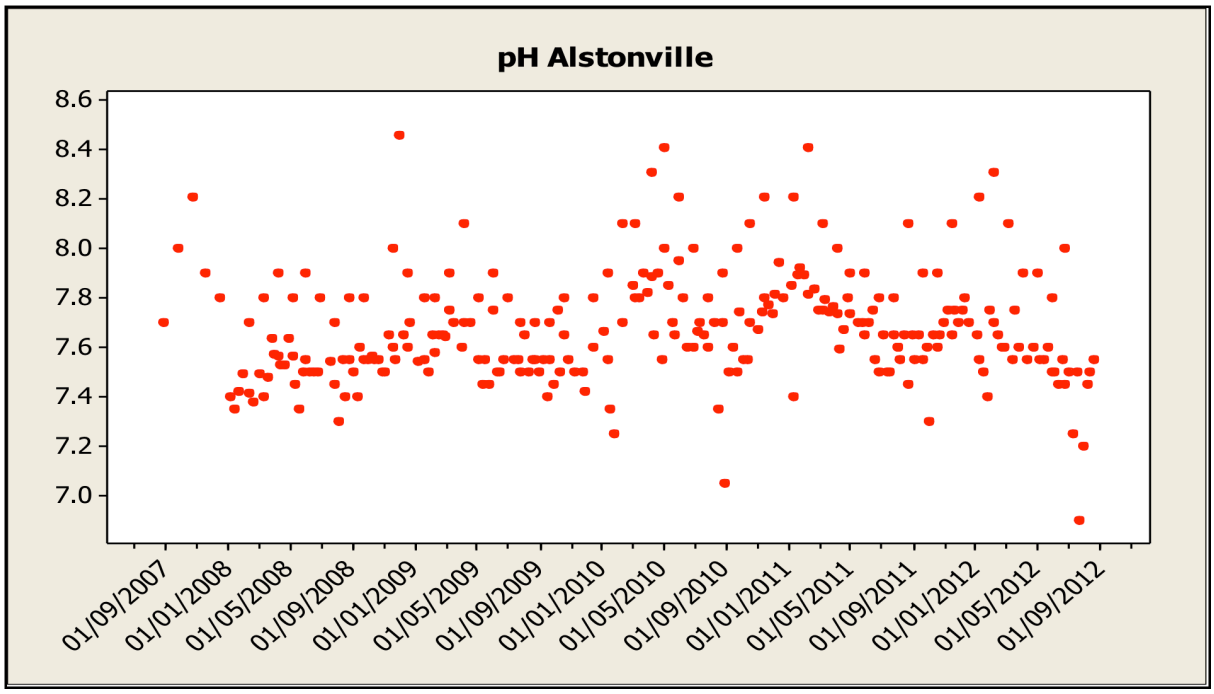


Figure 52 Alstonville - pH

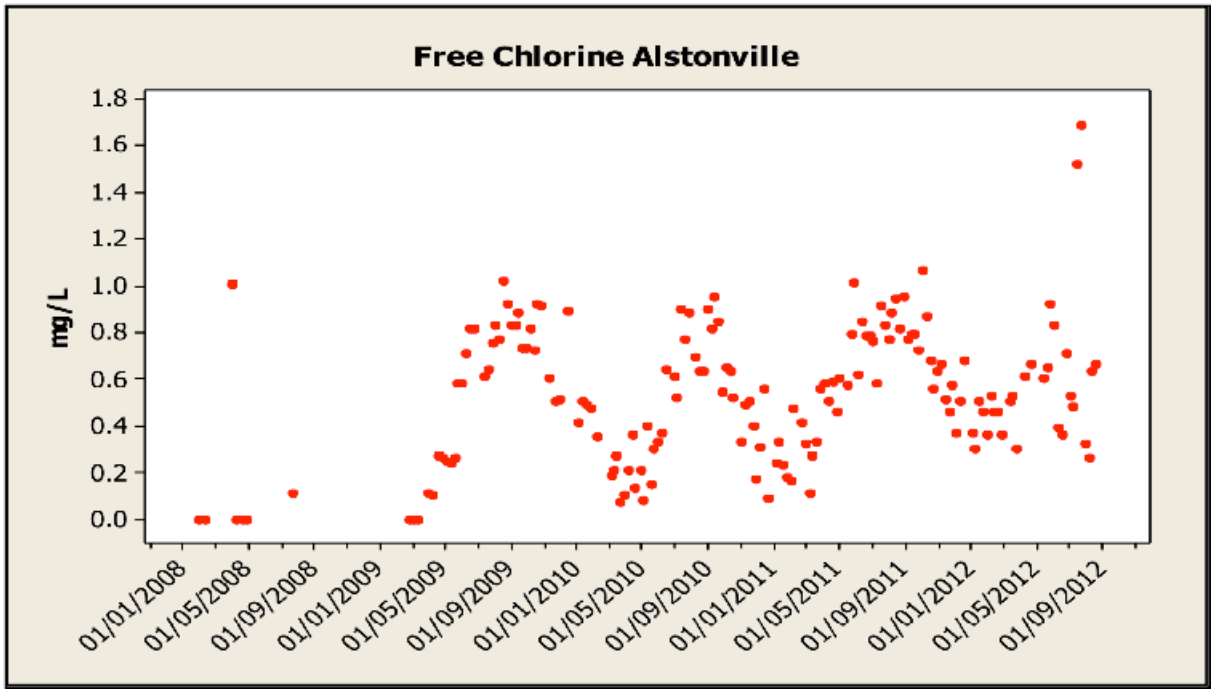


Figure 53 Alstonville – free chlorine

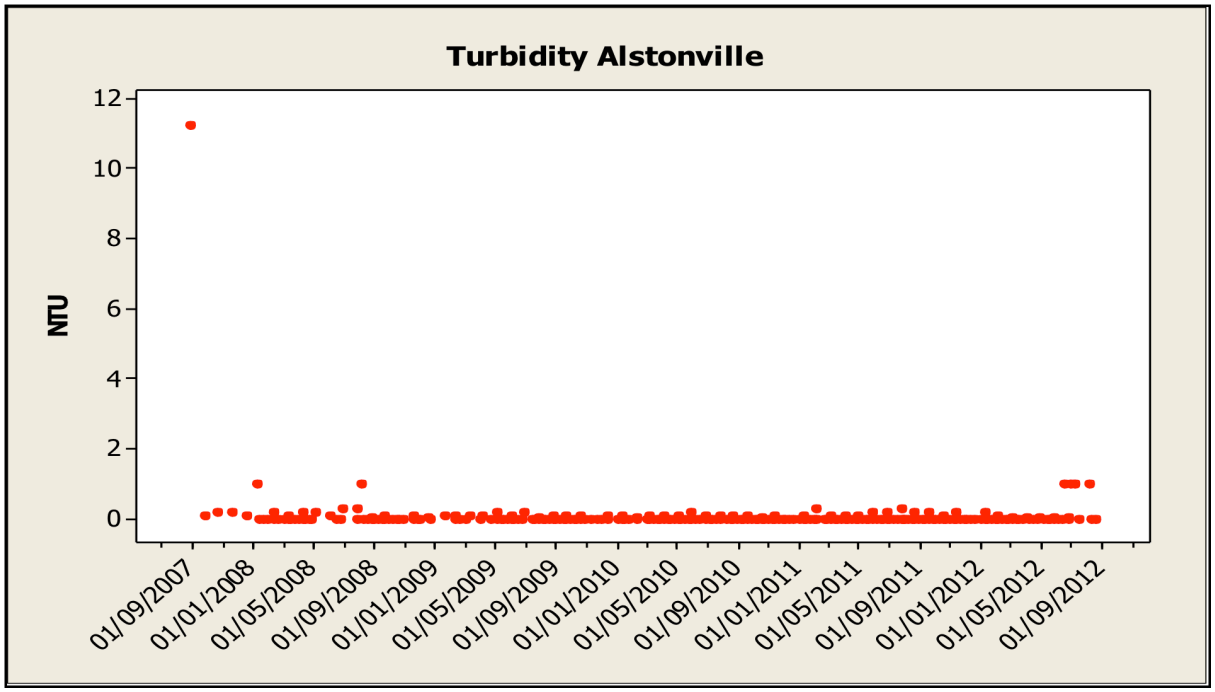


Figure 54 Alstonville – turbidity

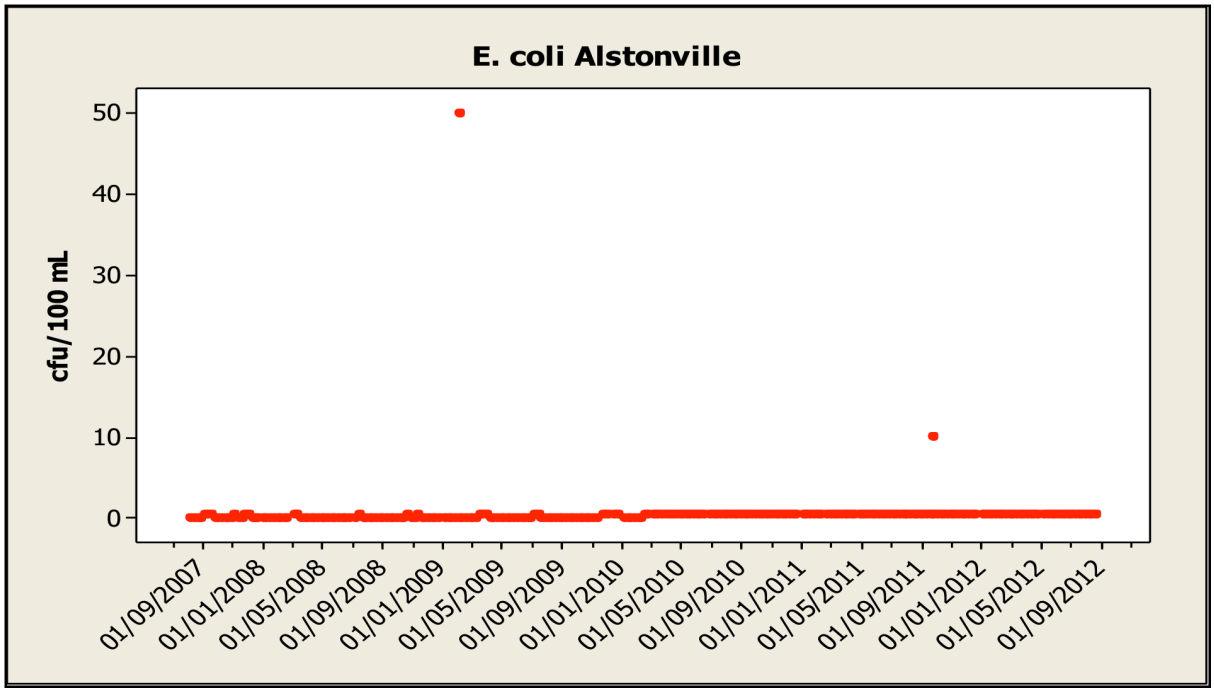


Figure 55 Alstonville – *E. coli*

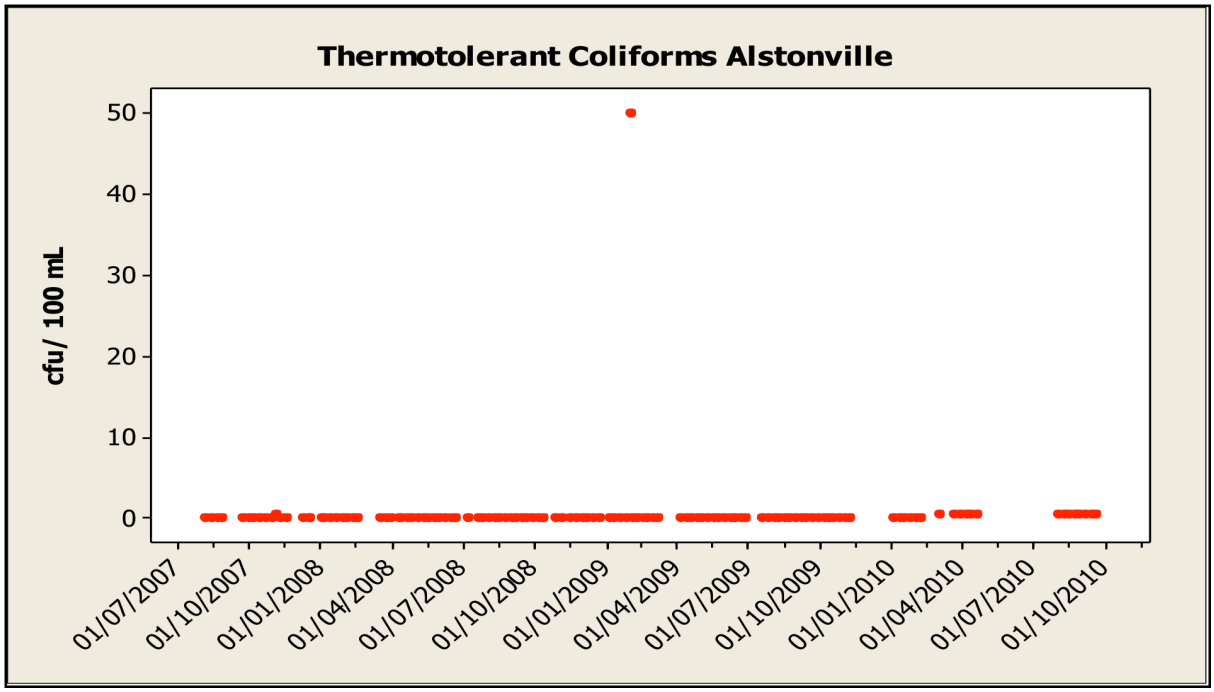


Figure 56 Alstonville – Thermotolerant coliforms

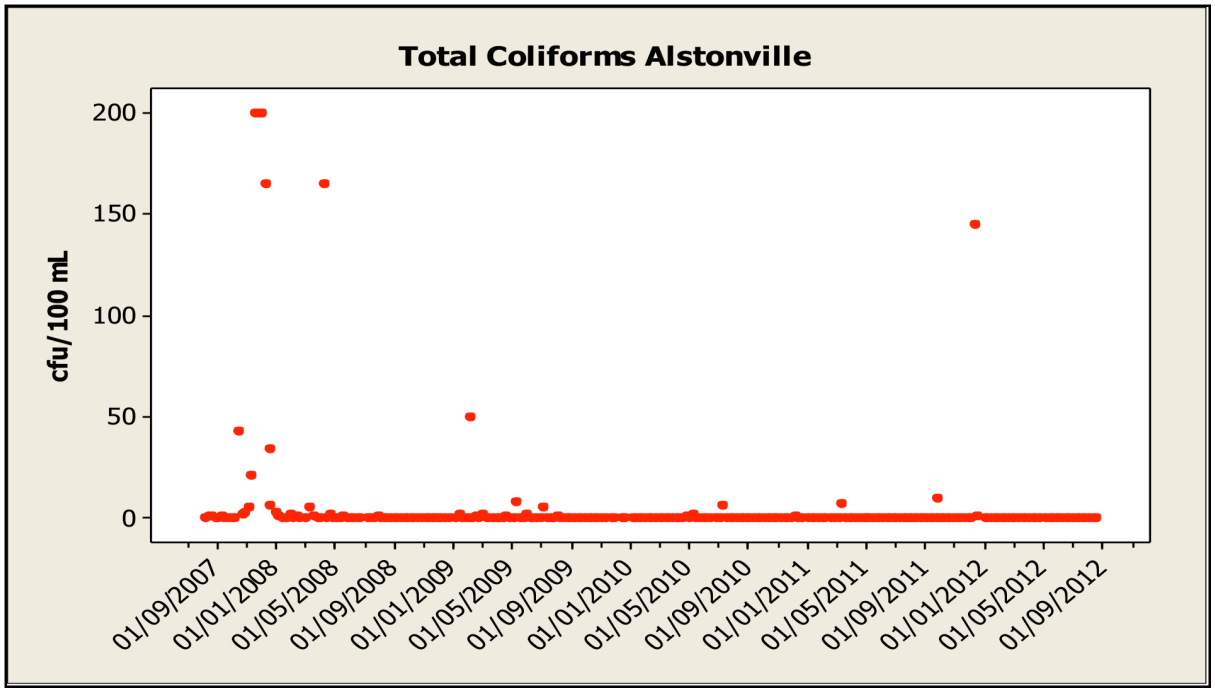


Figure 57 Alstonville – Total coliforms

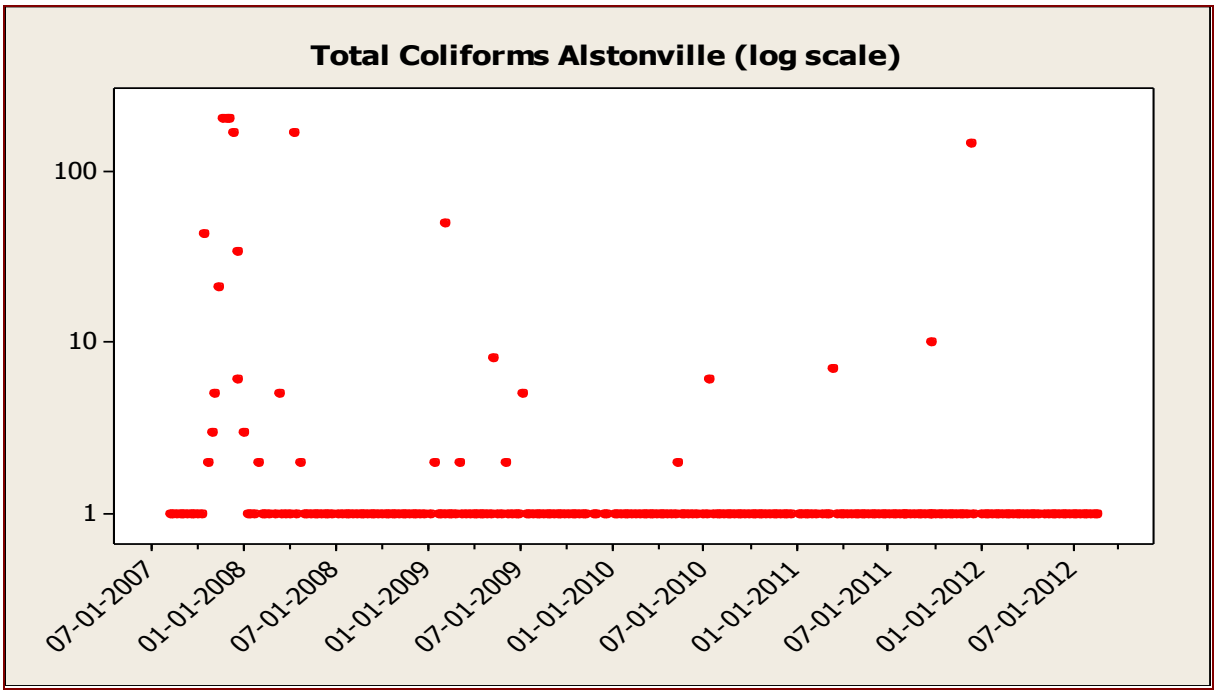


Figure 58 Total Coliform Alstonville (log scale)

5.2.5 Wollongbar

Table 11 contains a summary report from the NSW health database for Wollongbar reticulation. The sampling point is at Simpson Avenue, Wollongbar.

Table 11 Summary report Wollongbar reticulation

Characteristic	G/L	Units	Mean	Median	Std dev	Min	Max	N	Ex. count	95th %ile	5th %ile	% compliant
E. coli	0	cfu/100 mL	0	0	0	0	1	128	1	0	0	99.22
Free Chlorine	5	mg/L	1	0.66	0.30	0	1.46	78	0	1.12	0	100.00
pH	6.5 - 8.5		8	7.6	0.8	0	7.9	100	1	7.8	7.35	99.00
Thermotolerant Coliforms	0	cfu/100 mL	0	0	0	0	1	62	1	0	0	98.39
Total Chlorine	5	mg/L	0	0.27	0.34	0	1.12	55	0	1.04	0	100.00
Total Coliforms	0	cfu/100 mL	6	0	31	0	200	128	16	18	0	87.50
Turbidity	5	NTU	0	0	1	0	3	92	0	1	0	100.00

Figures 59-65 show the charts for pH, turbidity, free chlorine, *E. coli*, total and thermotolerant coliforms for Wollongbar.

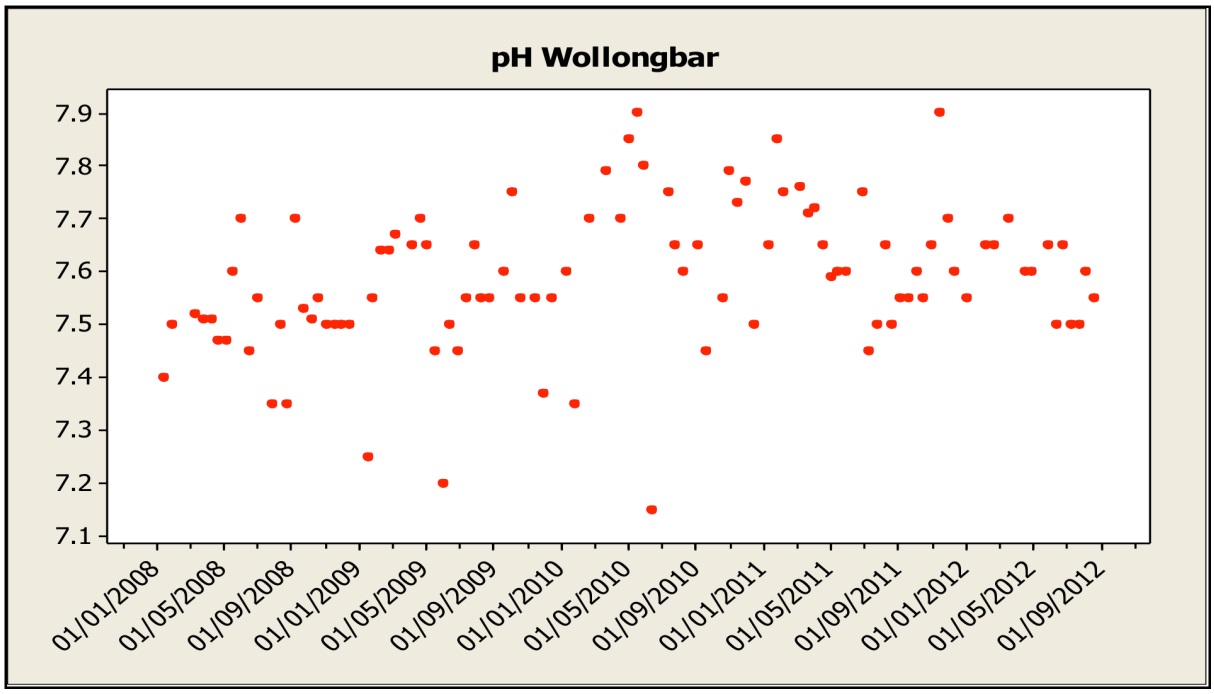


Figure 59 Wollongbar - pH

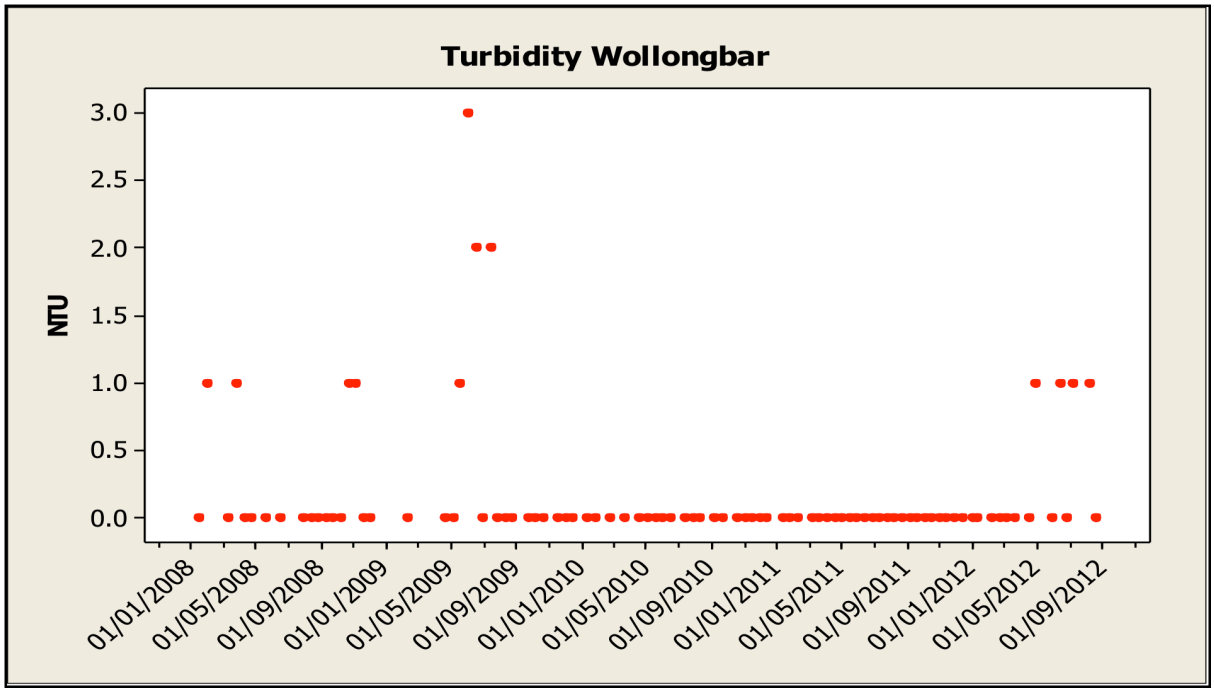


Figure 60 Wollongbar - turbidity

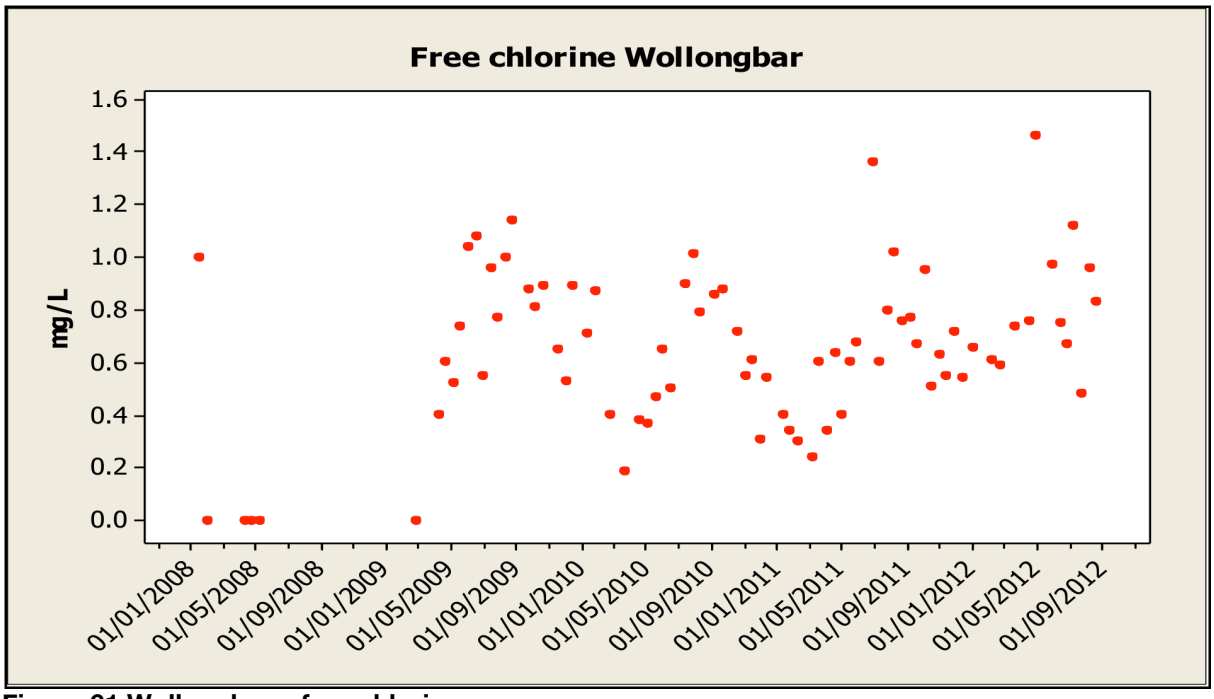


Figure 61 Wollongbar – free chlorine

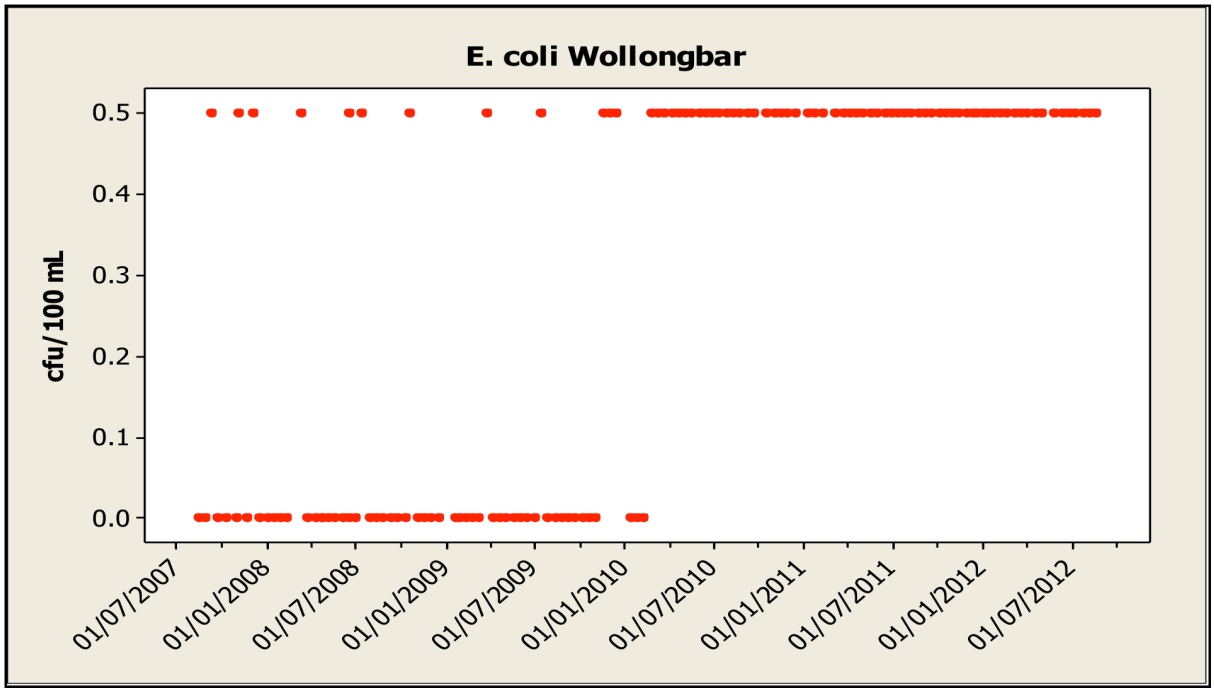


Figure 62 Wollongbar – *E. coli*

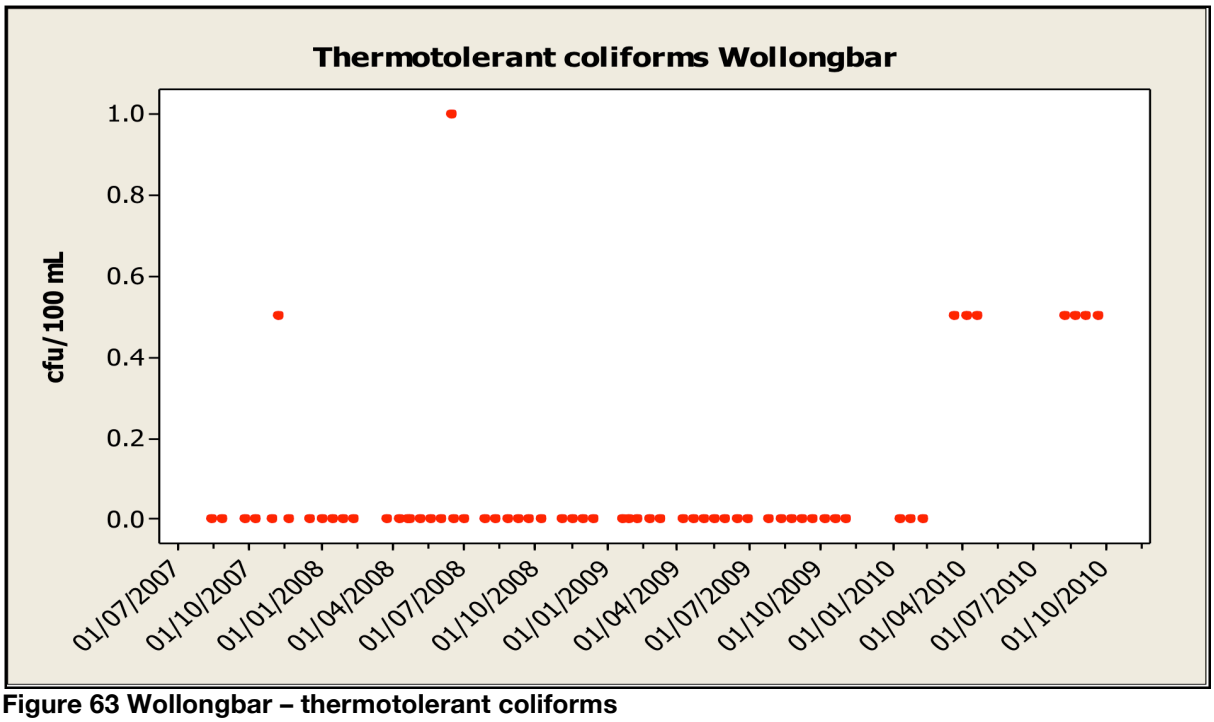


Figure 63 Wollongbar – thermotolerant coliforms

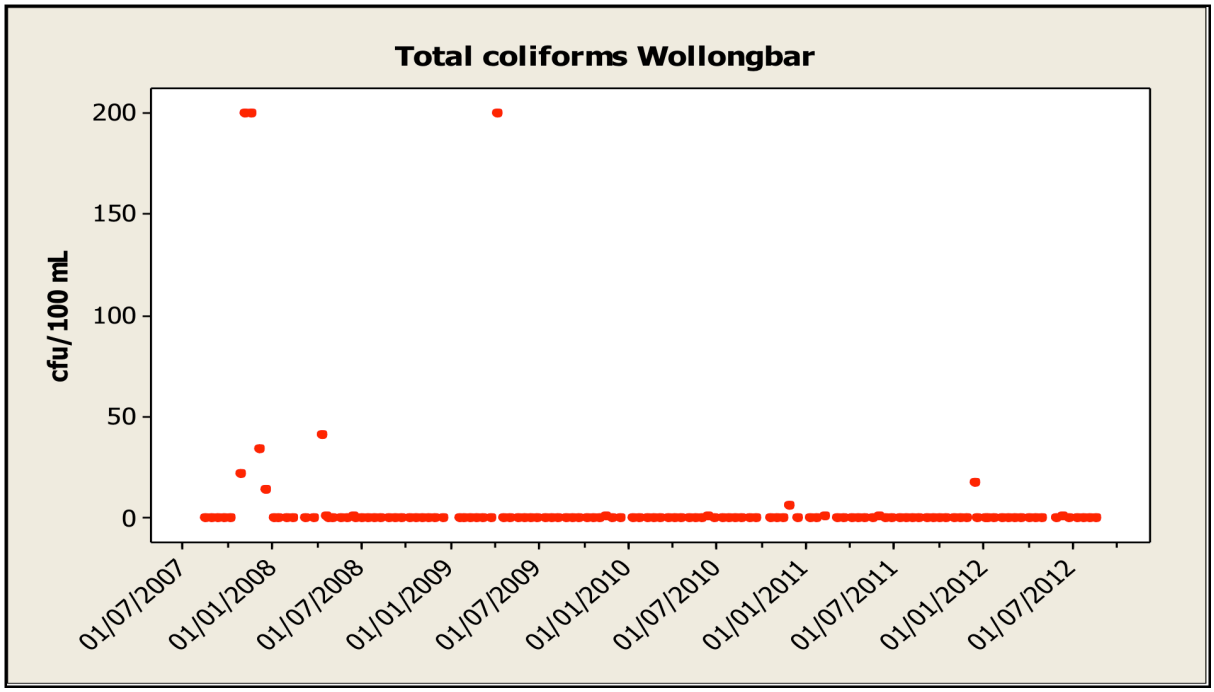


Figure 64 Wollongbar – total coliforms

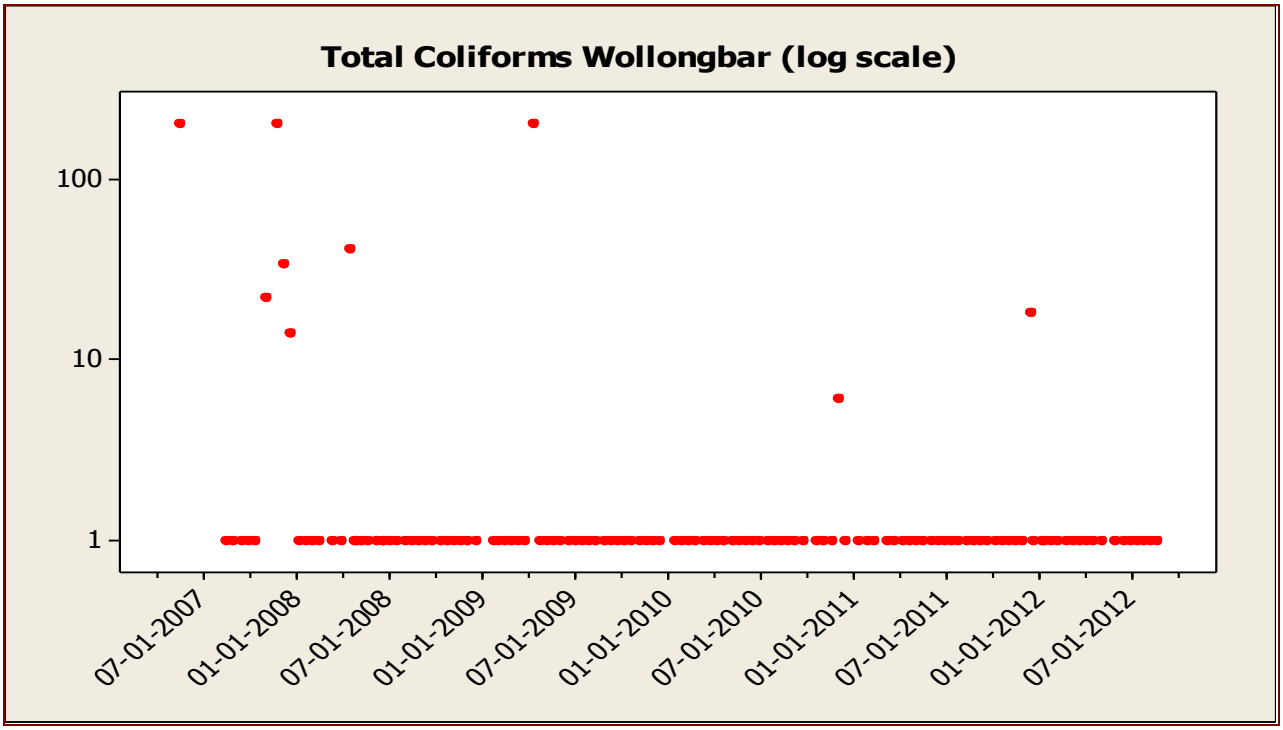


Figure 65 Wollongbar - total coliforms (log scale)

6 Residual Risks from Rous Water Supply

Rous Water has undertaken a water quality risk assessment for their bulk water supply to constituent councils including Ballina Shire Council. The residual risk identified in Rous Water's distribution system, form the inherent risks for Ballina Shire Council's water supply (excluding the Wardell supply).

The Rous Water risk assessment process identified two unacceptable residual risks that are passed onto Ballina Shire Council to manage in the distribution system. The hazardous events that cause the unacceptable risk (Table 13) are:

1. Ingress of contaminants non-potable water (Medium 8)
2. Backflow (High 10)

Table 13 Unacceptable residual risks from the Rous Supply

Ref	Component	Hazardous event	Potential hazard	Limiting hazard/s	Residual risk
Risk D-5	Pipelines	**Ingress of contaminants non-potable water** Ingress through: - Pipe joints - Air valves - Leaking valves and hydrants - Aging infrastructure - Scours - Pipe burst - Pipe repairs - Low pressure - very high flows (e.g. firefighting)	- Bacteria - Taste & order - Colour - Turbidity - Protozoa - Viruses - Toxic metals - Hydrocarbons - Toxins	Pathogens	**Medium (8)**
Risk D-6	Pipelines	**Backflow** Backflow from a third parties asset: - Illegal connection (connection not to the plumbing regulation). - Unintentional flow from a downstream water utility asset due to operational error. - Two-way operation of a main.	- Bacteria - Opportunistic pathogens - Protozoa - Viruses - Hydrocarbons - Taste and odour	Bacteria	**High (10)**

7 Risk Assessment Methodology

Likelihood	Description	Example
Almost certain	Is expected to occurin most circumstances	Occurs more often than once per week (52/yr)
Likely	Will probably occur in most circumstances	Occurs more often than once per month (12/yr) and up to once per week (52/yr)
Possible	Might occur or should occur at some time	Occurs more often than once per year and up to once a month (12/yr)
Unlikely	Could occur at some time	Occurs more often than once every 5 years and up to once per year
Rare	May occur only in exceptional circumstances	Occurs less than or equal to once every 5 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 exceedence of chronic health parameter.
Insignificant	Isolated exceedence of aesthetic parameter with little or no disruption to normal operation

Likelihood	Consequence				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Medium (6)	High (10)	High (15)	Extreme (20)	Extreme (25)
Likely	Medium (5)	Medium (8)	High (12)	High (16)	Extreme (20)
Possible	Low (3)	Medium (6)	Medium (9)	High (12)	High (15)
Unlikely	Low (2)	Low (4)	Medium (6)	Medium (8)	High (10)
Rare	Low (1)	Low (2)	Low (3)	Medium (5)	Medium (6)

Uncertainty	Description
Certain	There is 5 years of continuous monitoring data, which has been trended and assessed, with at least daily monitoring; or The processes involved are thoroughly understood.
Confident	There is 5 years of continuous monitoring data, which has been collated and assessed, with at least weekly monitoring or for the duration of seasonal events; or 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; or There is a reasonable understanding of the processes involved.
Estimate	There is limited monitoring data available; or There is a limied understanding of the processes involved.
Uncertain	There is limited or no monitoring data available; or The processes are not well understood.

8 References

Ballina Shire Council Comprehensive State of Environment Report (2004).

Ballina Shire Council. Fact Sheet: What is Ballina Shire's current water supply?

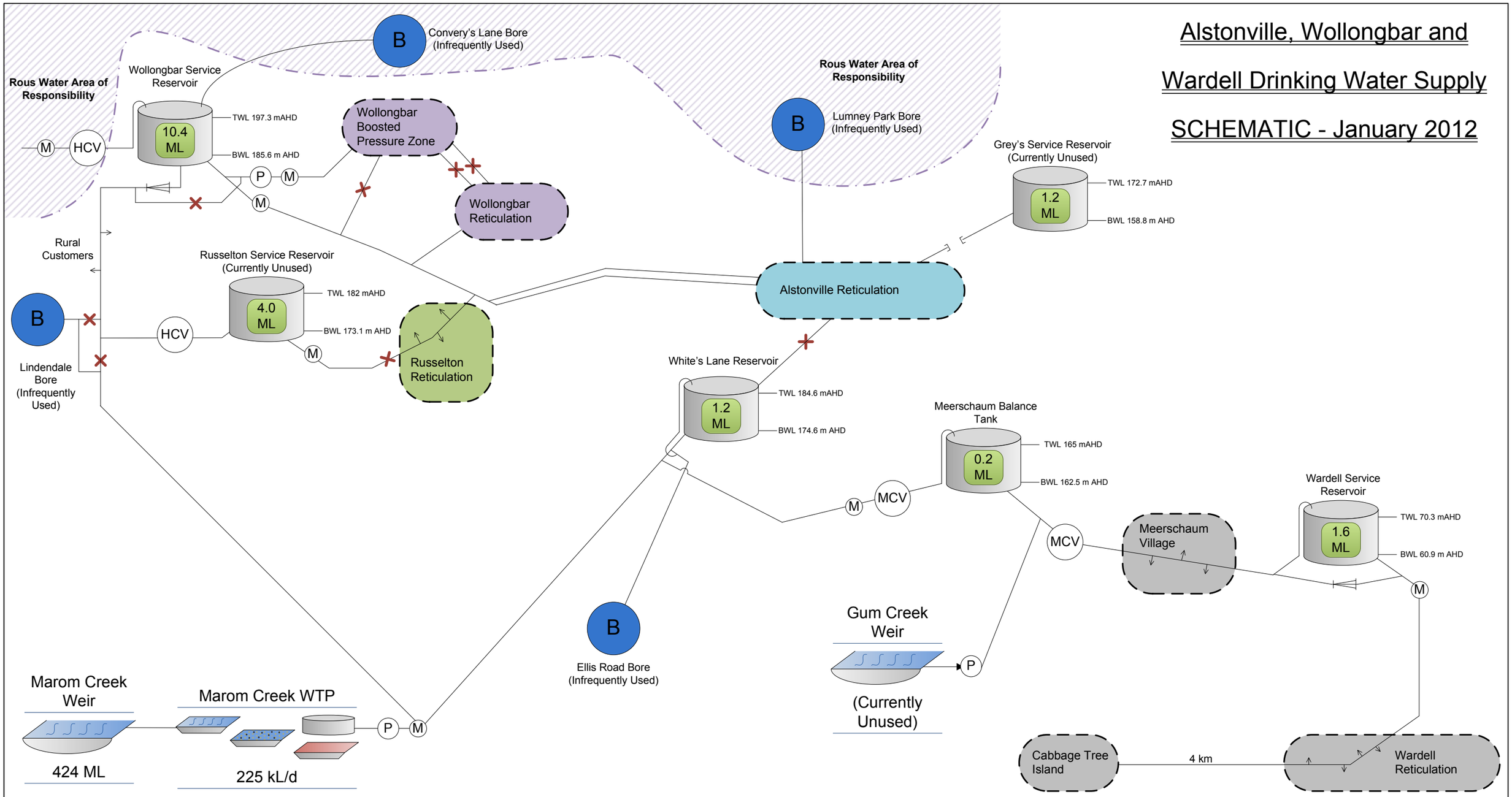
Ballina Shire Council. Wardell and Cabbage Tree Island Floodplain Risk Management Study. Issue No. 4 February 2007 .

NSW Health and NSW Office of Water. (2012). *NSW Guidelines for Drinking Water Management Systems (Draft).* Visited online 06/08/2012, http://www.health.nsw.gov.au/resources/publichealth/environment/water/pdf/nsw_guidelines_for_dwms.pdf

9 Appendix A: Schematic Layout

Alstonville, Wollongbar and Wardell Drinking Water Supply

SCHEMATIC - January 2012



ballina shire council

Legend		
Symbol	Count	Description
	8	Boundary Valve
	6	Reservoir
P	3	Pump

Legend		
Symbol	Count	Description
M	7	Flow Meter
HCV	2	Hydraulically Controlled Valve
MCV	2	Motorised Control Valve

Legend		
Symbol	Count	Description
	2	Reflux Valve
	2	Weir (General)
	1	WTP (Sand Filter)

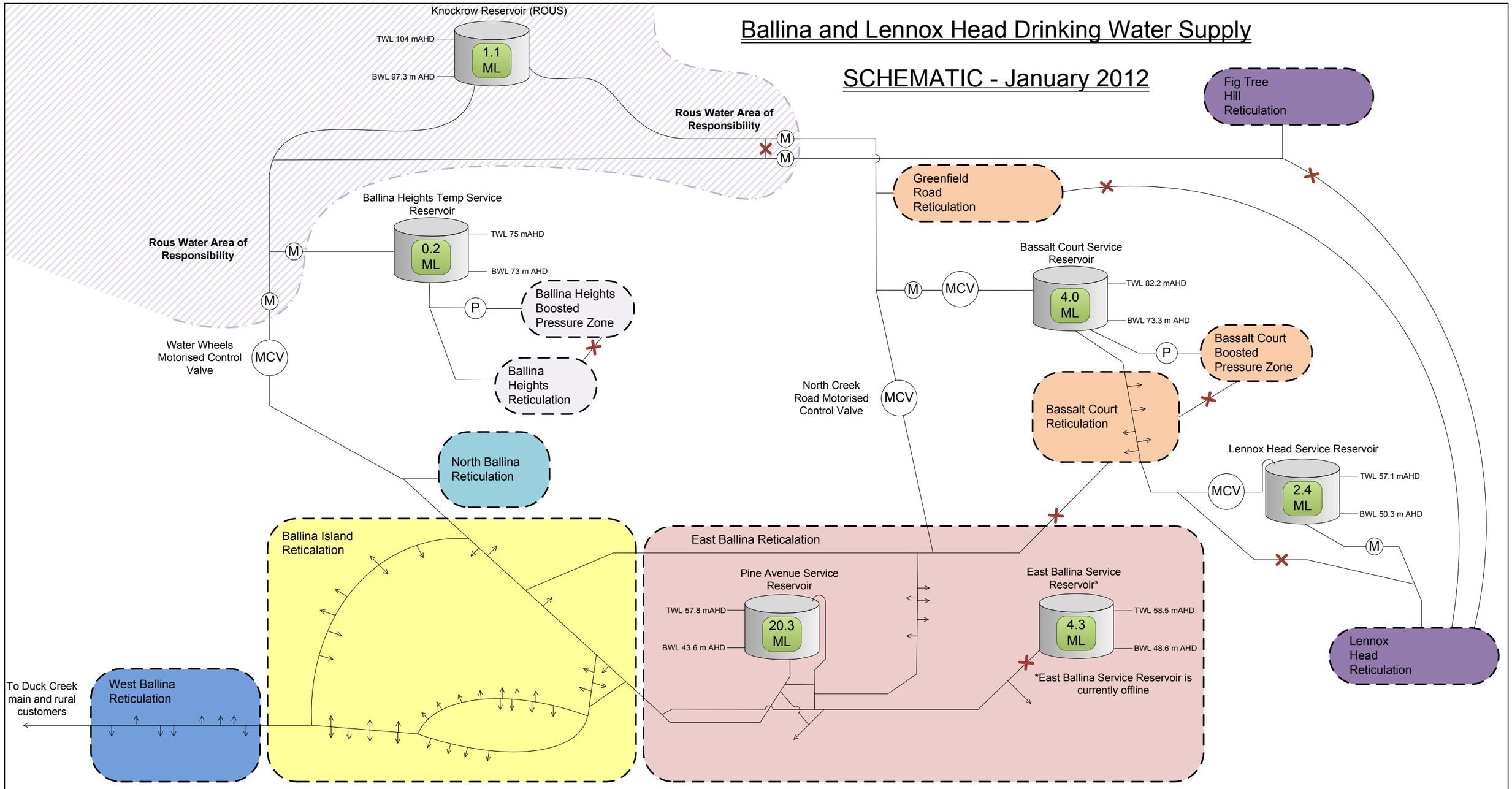
Ballina Shire Council

A'ville, W'bar and Wardell Drinking Water Supply

SIZE	Date	DWG NO	REV
A3	7 January 2012	FIGURE 3: Report for Water Infrastructure Planning	1
SCALE	NTS		SHEET 1 OF 1

Ballina and Lennox Head Drinking Water Supply

SCHEMATIC - January 2012



ballina shire council

Legend		
Symbol	Count	Description
X	8	Boundary Valve
▭	6	Reservoir
M	6	Flow Meter

Legend		
Symbol	Count	Description
P	2	Pump
MCV	3	Motorised Control Valve

Ballina Shire Council

Ballina and Lennox Head Drinking Water Supply

SIZE	Date	DWG NO	REV
A3	7 January 2012	FIGURE 1: Report for Water Infrastructure Planning	1
SCALE	NTS		SHEET 1 OF 1

Appendix B

Inherent Risk Register

Inherent Risk

Hazard	Impact	Source	Marom Creek			Bores			Notes
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk	
Biological									
Bacteria	H	**Wardell supply** - Wildlife - Dairies - Rural septic systems - Agriculture	Catastrophic	Likely	**Extreme (20)**	Major	Unlikely	**Medium (8)**	No current controls to limit development near bores.
Cyanotoxins	H	- Nutrient sources - Dairies - Rural septic systems - Retail and wholesale nurseries	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Marom Creek has continuous flow limiting growth of algae.
Opportunistic Pathogens (Naglaria & Legionella)	H	Elevated water temperature	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Raw water temp expected to be around 20 - 21 degrees.
Problem alga/ bacteria/ macrophytes	A	Environmental conditions	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	No known incidences of problem bacteria in bores Submerged intake at Marom Creek.
Protozoa	H	**Wardell supply** - Dairies - Cattle - Rural septic systems **Distribution** - Maintenance activities - Ingress of non potable water into mains	Catastrophic	Possible	**High (15)**	Major	Rare	**Medium (5)**	Cattle can be a source of *Cryptosporidum parvum*. Based on the upstream activiities it is possible that it may be present. It is considered that there is no surface water interfence on the bore supply.
Viruses	H	**Wardell supply** - Rural septic systems **Distribution** - Maintenance activities - Ingress of non potable water into mains	Major	Possible	**High (12)**	Major	Unlikely	**Medium (8)**	Rural septics are a potential source of viruses which can persist in groundwater and may be present in bores.
Chemical									
Aluminium	A	Local geology	Minor	Likely	**Medium (8)**	Minor	Possible	**Medium (6)**	- Regional data indicates aluminium in similar catchment. - Raw water data indicates Al concentrations up to 0.1 mg/L.
Arsenic	H	- Decommissioned dip sites - Natural geology	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	No evidence in samples taken
Cadmium	H	No known sources	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	No evidence in samples taken.
Chlorine	H	**Distribution** '- Superchlorination of new mains - Rechlorination (if required)	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	No sources in raw water.
Copper	H	No known sources	Minor	Rare	**Low (2)**	Minor	Rare	**Low (2)**	One known farm dam in catchment treated with Control.
Disinfection by-products (e.g. THMs, NDMA & HAAs)	H	No known sources	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	No sources in raw water.
Fluoride	H	Naturally occurring	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Not identified as an issue
Hydrocarbons	H	- Road run-off (major highway) - Diesel pumps - Urban stormwater (minor contribution) - Petrol station in catchment - Creek crossings	Minor	Possible	**Medium (6)**	Insignificant	Rare	**Low (1)**	No oil films observed at intake.
Hydrogen sulphide/ sulphide	A/H	Ground water	Minor	Rare	**Low (2)**	Moderate	Almost certain	**High (15)**	Ellis Road has a vent for hydrogen sulphide.
Iron	A	Natural geology	Moderate	Almost certain	**High (15)**	Moderate	Almost certain	**High (15)**	Not identified as an issue
Lead	H	No known sources	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Not identified as an issue
Manganese	A/H	Natural geology	Minor	Rare	**Low (2)**	Minor	Rare	**Low (2)**	Not identified as an issue
Mercury	H	No known sources	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Not identified as an issue
Nickel	H	No known sources	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Not identified as an issue

Hazard	Impact	Source	Marom Creek			Bores			Notes
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk	
Nitrate & nitrite	H	- Fertilisers - Dairies - Piggeries - Nurseries	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	To confirm if piggery is still active
Pesticides (all types)	H	- Agriculture - Nurseries	Insignificant	Possible	**Low (3)**	Insignificant	Rare	**Low (1)**	Traces have been identified in tributaries but not detected in Marom Dam.
Pharmaceuticals and EDCs	H	- Septic systems - Agriculture	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Not identified as an issue
Sodium	A	- No known natural sources	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Not identified as an issue
Sulphate	H	No known sources	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Not identified as an issue
Toxins (unknown contaminant)	H	- Intentional contamination - Accidental chemcial spills - Backflow	Catastrophic	Rare	**Medium (6)**	Catastrophic	Rare	**Medium (6)**	No recorded events
Zinc	H	Natural sources	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Not identified as an issue
Physical									
Colour	A	**Wardell supply** - Naturally occurring - Storm events **Distribution** - Disturbance of sediments in distribution	Moderate	Almost certain	**High (15)**	Insignificant	Rare	**Low (1)**	Max colour 100 Pt-Co at Marom Creek
DO	A	No known sources	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Not identified as an issue
Hardness	A	Naturally occurring	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	No known issues
Corrosivity (low LSI)	A	N/A	Minor	Rare	**Low (2)**	Minor	Rare	**Low (2)**	Intermittent minor blue water complaints.
pH	A	**Wardell supply** - Naturally occurring **Distribution** - Mineralisation of water	Moderate	Almost certain	**High (15)**	Minor	Unlikely	**Low (4)**	Feb 11- Feb 12 ; pH 6.4-6.7 (N=7)
Radiological	H	No known sources	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Chemistry lab at research station may be a source.
Taste and odour	A	- Suspended solids - Naturally occurring manganese - Algae	Moderate	Unlikely	**Medium (6)**	Moderate	Almost certain	**High (15)**	Not identified as an issue
Total dissolved solids		Natural geology	Insignificant	Rare	**Low (1)**	Insignificant	Rare	**Low (1)**	Not identified as an issue
Turbidity	A	**Wardell supply** - Naturally occurring - Storm events **Distribution** - Disturbance of sediments in distribution	Moderate	Likely	**High (12)**	Insignificant	Rare	**Low (1)**	Max turbidity 14 NTU at Marom Creek

Appendix C

Maximum and Residual Risk Register – Wardell Supply

Treatment - Maximum & Residual Risk

Ref	Component	Hazardous Event	Potential Hazard		Limiting Hazard/s	Maximum Consequence	Maximum Likelihood	Maximum Risk	Preventive Measures	Monitoring	Residual Consequence	Residual Likelihood	Hazardous Event Risk	Comments	Level of Uncertainty	Risk Treatments
Risk T-1	Source Water	**Algal bloom in Marom Creek**	Environmental conditions lead to algal bloom (e.g. low flows, high nutrients). Discharge from upstream dams	Cyanotoxins	Cyanotoxins	Insignificant	Rare	Low (1)	- Selective abstraction. - Continuous flow at Marom Creek. - In low flow conditions water is pumped over weir to maintain flows. - Alternate sources (bores once operational). - Protection zone within Marom Creek catchment	- Catchment monitoring. - Monthly monitoring at Marom Creek.	Insignificant	Rare	Low (1)	- Requirements to maintain flows for environment and downstream users. - If conditions change in future, reassessment of risk required.	Confident	N/A
Risk T-2	Source Water	**Out of Specification Source Water**	Source water exceeds treatment capacity due to: - storm event - nursery dam discharge - other	- T&O - Turbidity - Bacteria - Viruses - Protozoa - pH - Iron - Cyanotoxins	Protozoa	Catastrophic	Possible	High (15)	- Selective abstraction - Alternate source - Up to 7 days storage in system	- Daily visual inspection - Daily turbidity at Marom Creek - Review of weather	Major	Unlikely	Medium (8)	- One incidence where nursery dam with BGA overflowed in the catchment, was monitored at the time but no issues eventuated. - 2 days' water in flocculation pond allowing for selective abstraction. - Dam does not display a rapid response to extreme rainfall (turbidity changes over a period of 1 - 2 days).	Confident	Investigate installation of online raw water turbidity to alarm and trigger plant shut down.
Risk T-3	Source Water - Bores	**Infiltration of surface water**	Source water exceeds treatment capacity due to infiltration.	- T&O - Turbidity - Bacteria - Viruses - Protozoa - Iron	Protozoa	Catastrophic	Unlikely	High (10)	- Ellis Road bore covered - Lindendale Road bore covered and locked - Freeboard - Regular maintenance	- Daily pH and Cl testing of treated water when operational - Weekly bacto testing - Weekly visual inspection	Major	Rare	Medium (5)	- Potential to identify hazard areas (exclusion zones) around bores. - Bore sites are not known to flood. - Approvals for onsite sewage treatment have been issued adjacent to Lindendale Road Bore, with conditions for a high level of treatment. - Potential for adjacent agricultural bores to contaminate aquifer (unknown).	Reliable	- Investigate data collection options to allow for review water quality results (turbidity vs rainfall) to determine impacts. - Investigate implementing policy for land uses adjacent to bore sites.
Risk T-4	Coagulation	**Underdosing or overdosing alum**	Failure of coagulation (due to pump failure or failure of flash mixer).	- Turbidity - Bacteria - Viruses - Protozoa - DBPs - Colour - Iron - Aluminium	Protozoa	Catastrophic	Unlikely	High (10)	- Dose pumps linked to raw water pumps - Alarm if pumps fail - Spare pumps available onsite - Monthly maintenance - Plant is manned 7 days per week - Ability to drain flocculation pond to infiltration pond if required	- Drop test fortnightly - Visual inspection daily - Daily clear water turbidity testing	Major	Rare	Medium (5)	- Dose pumps linked to raw water pumps. - Fixed rate dosing. - No previous issues or failures with pumps or lines. - Gradual changes in raw water quality.	Confident	Investigate operator testing of aluminium in flocculation pond.

Ref	Component	Hazardous Event	Potential Hazard		Limiting Hazard/s	Maximum Consequence	Maximum Likelihood	Maximum Risk	Preventive Measures	Monitoring	Residual Consequence	Residual Likelihood	Hazardous Event Risk	Comments	Level of Uncertainty	Risk Treatments
Risk T-5	Coagulation	**Underdosing or overdosing caustic**	Failure of coagulation (due to pump failure or failure of flash mixer)	- Turbidity - Bacteria - Viruses - Protozoa - DBPs - Colour - Iron - Aluminium	Protozoa	Catastrophic	Unlikely	**High (10)**	- Dose pumps linked to raw water pumps - Alarm if pumps fail - Spare pumps available onsite - Monthly maintenance - Plant is manned 7 days per week - Ability to drain flocculation pond to infiltration pond if required - Fixed dose rate	- Drop test fortnightly - Visual inspection daily - Daily clear water turbidity testing - Daily pH testing in raw water	Major	Rare	**Medium (5)**	- Dose pumps linked to raw water pumps. - Fixed rate dosing. - No previous issues or failures with pumps or lines. - Gradual changes in raw water quality. - Target pH for finished water 7.0 - 7.1. - No exceedences in pH in treated water.	Confident	N/A
Risk T-6	Flocculation	**Carry over of solids**	Failure to settle	- Turbidity - Bacteria - Viruses - Protozoa - DBPs	Bacteria	Major	Unlikely	**Medium (8)**	- Cleaning of flocculation pond yearly - Coarse screens at overflow to filter - Maintenance program	- Visual inspection daily - Daily clear water turbidity testing	Major	Rare	**Medium (5)**	- Sludge removed every 12 months. - No previous issue with overflow.	Confident	N/A
Risk T-7	Flocculation	**Wildlife in flocculation pond**	Faecal contamination from wildlife	- Bacteria - Turbidity	Bacteria	Major	Unlikely	**Medium (8)**	Flocculation pond completely netted	Daily visual inspection	Insignificant	Rare	**Low (1)**	Water dragons can access flocculation pond.	Certain	N/A
Risk T-8	Media filtration	**Filter breakthrough**	High turbidity in filtered water	- T&O - Turbidity - Bacteria - Viruses - Protozoa - pH - Iron - Manganese	Bacteria	Major	Likely	**High (16)**	- Backwash triggered on headloss. - Manual backwash every 2-3 weeks. - Plant is manned 7 days per week.	- Visual inspection daily. - Daily clear water turbidity testing.	Major	Unlikely	**Medium (8)**	- Filtered water turbidity testing is not currently undertaken. - Filter is a single cell. - Plans to replace filter media when bores come online.	Estimate	- Review auto backwash to avoid media blow out. - Investigate online turbidity testing on filtered water turbidity. - Investigate quality of media and options for improvement (core sampling).

Ref	Component	Hazardous Event	Potential Hazard		Limiting Hazard/s	Maximum Consequence	Maximum Likelihood	Maximum Risk	Preventive Measures	Monitoring	Residual Consequence	Residual Likelihood	Hazardous Event Risk	Comments	Level of Uncertainty	Risk Treatments
Risk T-9	Residual Disinfection	**Insufficient chlorine Ct (concentration x time)**	Poor disinfection	- Viruses - Bacteria	Bacteria	Catastrophic	Possible	**High (15)**	- Spare pumps on site. - Chlorine pump linked to raw water pumps. - Plant is manned 7 days per week.	- Daily chlorine testing in clear water and reservoir outlet. - Weekly bacto testing. - Daily visual inspection.	Major	Rare	**Medium (5)**	- More than 30 mins contact time in clear water tank. - Clear water tank top fill and bottom out (90 degree angle).	Certain	- Investigate linking dose pumps to SCADA and alarms. - Investigate online chlorine and pH on finished water.
Risk T-10	Residual Disinfection - bores	**Insufficient chlorine Ct (concentration x time) in bores**	Poor disinfection	- Viruses - Bacteria	Bacteria	Major	Unlikely	**Medium (8)**	Daily visual inspection	- Daily chlorine testing when operational. - Daily visual inspection.	Major	Rare	**Medium (5)**	- Bores not currently operational. - No telemetry control for dosing pumps. - Target 1.5	Estimate	- Investigate options for recording and reviewing water quality data (e.g. database). - Develop control strategy for operating Marom Creek WTP and bores. - Start up and operation procedure for bringing bores back online (include provisions for fluoridation and notification when dosing commences). - Investigate installation of telemetry at bores (dosing pumps). - Investigate CT for first customers from bores.
Risk T-11	Residual Disinfection	**Over dose of chlorine**	Chlorine higher than ADWG guideline value in treated water.	Chlorine	Chlorine	Minor	Possible	**Medium (6)**	Daily visual inspection.	- Daily chlorine testing. - Daily visual inspection.	Minor	Rare	**Low (2)**	Results do not indicate high chlorine is an issue.	Confident	N/A
Risk T-12	Residual Disinfection - bores	**Over dose of chlorine**	Chlorine higher than ADWG guideline value in treated water.	Chlorine	Chlorine	Minor	Possible	**Medium (6)**	- Daily visual inspection. - Dose pumps are linked to water pumps.	- Daily chlorine testing when operational. - Daily visual inspection	Minor	Rare	**Low (2)**	- Bores are operated irregularly. - Large amount of dilution expected.	Reliable	Investigate feedback loop for dosing.

Appendix D

Maximum and Residual Risk Register –Distribution

Distribution - Maximum & Residual Risk

Ref	Component	Hazardous Event	Potential Hazard		Limiting Hazard/s	Maximum Consequence	Maximum Likelihood	Maximum Risk	Preventive Measures	Monitoring	Residual Consequence	Residual Likelihood	Residual Risk	Comments	Level of Uncertainty	Risk Treatments
Risk D-1	Source Water - Bulk	**Receipt of out of specification water**	Water quality that does not meet requirements of ADWG.	All hazards in ADWG.	Bacteria	Catastrophic	Unlikely	**High (10)**	Service Level Agreement.	Access to Rous Water monitoring at sell points (available on the internet).	Catastrophic	Unlikely	**High (10)**	- Water quality criteria to be added to Service Level Agreement and chlorine residual targets (and pH and turbidity) at sell points addressed. - Investigate summer/winter operations.	Confident	Review of Service Level Agreement between Rous Water and Ballina Shire.
Risk D-2	Source Water - Bulk	**Receipt of water with low chlorine**	Water quality that does not have adequate chlorine residual resulting in the regrowth of pathogens.	- Bacteria - Viruses - Opportunistic pathogens	Bacteria	Major	Unlikely	**Medium (8)**	Informal notification of low chlorine between BSC and Rous Water.	- Access to Rous Water monitoring at sell points (internet). - Weekly chlorine grab samples. - Weekly bacto monitoring.	Major	Unlikely	**Medium (8)**	- Water quality criteria to be added to Service Level Agreement and chlorine residual targets (and pH and turbidity) at sell points addressed. - Investigate summer/winter operations.	Confident	- Review of Service Level Agreement between Rous Water and Ballina Shire Council. - Contact Richmond Water Labs to gain access to Rous Water results. - Investigate options for allowing review of chlorine residuals in a water quality database.
Risk D-3	Reservoirs	**Contamination of reservoirs due to access by third parties**	Access by humans, including maintenance and willful opportunistic vandalism (e.g. phone tower).	- Bacteria - Viruses - Protozoa - Toxins - Hydrocarbons	Protozoa	Catastrophic	Unlikely	**High (10)**	- Pine Ave is fitted with a surveillance camera. - Some operational reservoirs are fenced (Basalt Court, Pine Ave, North Creek Rd). - All access ladders and hatches are locked. - Chlorine residual.	- Weekly bacto testing. - Monthly inspection. - Weekly check.	Major	Rare	**Medium (5)**	- Telcos have equipment on most reservoirs. - Telcos have own lock and access the site as needed - BSC have not had incidence of damage following telco access. - No history of access to tanks. - Most vandalism comprises of graffiti (aesthetic damage).	Confident	N/A
Risk D-4	Reservoirs	**Poor mixing within a reservoir**	Poor mixing in a reservoir leading to: - Pockets of increased water age and reduced quality water - Taste and odour issues - Potential growth of bacteria in the system - Loss of DO	- Bacteria - Opportunistic pathogens - Turbidity	Bacteria	Major	Possible	**High (12)**	- Chlorine residual. - Design of inlets and outlets at some reservoirs (top fill). - Operational range to ensure turnover.	- Chlorine residual monitoring - Weekly bacto sampling	Major	Rare	**Medium (5)**	- Anecdotal evidence of poor mixing in Wardell (bottom fill/out). Further investigation required. - BSC have increased range in Wardell to improve turnover. - No water quality issues directly linked to poor mixing have been identified.	Estimate	- Investigate options for database to review water quality results. - Investigate mixing in Wardell reservoir.

Ref	Component	Hazardous Event	Potential Hazard		Limiting Hazard/s	Maximum Consequence	Maximum Likelihood	Maximum Risk	Preventive Measures	Monitoring	Residual Consequence	Residual Likelihood	Residual Risk	Comments	Level of Uncertainty	Risk Treatments
Risk D-5	Reservoirs	**Disturbance of Sediment**	Stirring of foreign matter leading to: - Increased turbidity - Taste and odour issues - Mobility of pathogens in the system - Loss of DO	- Bacteria - Viruses - Protozoa - Turbidity - Taste and odour - Colour - Alkalinity, hardness & LSI - pH	Turbidity	Minor	Unlikely	**Low (4)**	- Divers clean reservoirs every 5 years. - Secure reservoirs. - Selective abstraction based on raw water turbidity at Marom Creek WTP.	- 5 yearly reservoir inspection. - Weekly turbidity monitoring.	Insignificant	Rare	**Low (1)**	- No previous issues with sediment disturbance. - Construction debris (large plank of wood) identified in reservoir.	Certain	N/A
Risk D-6	Reservoirs	**Stagnation in reserviors**	Stagnation leading to: - Taste and odour issues - Potential growth of bacteria in the system - Loss of DO - Change in pH potentially due to dissolution of assets	- Bacteria - Opportunistic pathogens - Turbidity	Bacteria	Major	Unlikely	**Medium (8)**	Management of reservoir levels in Wollongbar (controlled by Rous Water SCADA).	- Weekly free chlorine testing in reservoirs. - Weekly bacto testing.	Major	Rare	**Medium (5)**	- Data indicates free chlorine at Alstonville and Wollongbar reticulation fluctuates - further investigation required. - Pine Ave may have a low turnover however no issues have been identified.	Reliable	N/A
Risk D-7	Reservoirs	**Contamination by vermin**	Access by animals - including birds, leading to: - Microbiological contamination from animal droppings and dead animals - Loss of disinfection residual due to addition chlorine demand	Bacteria	Bacteria	Catastrophic	Unlikely	**High (10)**	- Chlorine residual - Vermin protection on reservoirs - Reservoirs are roofed	- Monthly reservoir inspection - Weekly free chlorine testing in reservoirs - Diver inspections (5 yearly) - Weekly bacto testing	Major	Rare	**Medium (5)**	- Some reservoirs are fully bird proofed, others have a checker plate mesh which may allow birds and other vermin to access reservoirs. - Aqualift investigate bird proofing and determined to be adequate.	Confident	N/A
Risk D-8	Pipelines	**Ingress of contaminants non-potable water**	Ingress through: - Pipe joints - Air valves - Leaking valves and hydrants - Aging infrastructure - Scours - Pipe burst - Pipe repairs - Low pressure - very high flows (e.g. firefighting) Ingress of contaminants leading to: - Microbiological contamination - Turbidity from entrained soil - Potential for chemical contamination - including heavy metals and petrochemicals (leachate from contaminated soil, groundwater or effluent re-use) - Taste and odour compounds	- Bacteria - Taste & order - Colour - Turbidity - Protozoa - Viruses - Toxic metals - Hydrocarbons - Toxins	Protozoa	Catastrophic	Unlikely	**High (10)**	- Flushing of lines after maintenance works. - Chlorine residual.	Weekly bacto testing	Major	Unlikely	**Medium (8)**	- Some older pipelines in Ballina Island are prone to breaks, approximately one every few months, appears to be related to climate. - Maintenance procedures include a requirement to test, however this is currently undertaken on a case by case basis (chlorine residual testing has not been undertaken in the past).	Reliable	Determine and implement testing requirements following repairs to pipelines.

Ref	Component	Hazardous Event	Potential Hazard		Limiting Hazard/s	Maximum Consequence	Maximum Likelihood	Maximum Risk	Preventive Measures	Monitoring	Residual Consequence	Residual Likelihood	Residual Risk	Comments	Level of Uncertainty	Risk Treatments
Risk D-9	Pipelines	**Ingress of contaminants non-potable water**	Cross connection with recycled water dual reticulation network	- Bacteria - Taste & odour - Protozoa - Viruses - Toxic metals - Toxins - TDS - DBPs	- Bacteria - Virus	Catastrophic	Possible	**High (15)**	- HACCP Plan for dual reticulation scheme. - Recycled water 'fit for use' for dual reticulation. - Preventative measures from RWMP HACCP Plan.	As per RWMP HACCP Plan	Major	Rare	**Medium (5)**	- Water quality for dual reticulation is based on ADWR DALYs. - BSC to include risk assessment outcomes from HACCP Plan into DWMS risk assessment.	Estimate	N/A
Risk D-10	Pipelines	**Backflow**	Backflow from a third parties asset: - Illegal connection (connection not to the plumbing code) - Unintentional flow from a downstream entities asset due to operational error - Two-way operation of a main Leading to: - Potential microbiological contamination - Chemical contamination - Taste and odour issues	- Bacteria - Opportunistic pathogens - Protozoa - Viruses - Hydrocarbons - Taste and odour - Toxins - Radiological	Toxins (unknown contaminant)	Catastrophic	Possible	**High (15)**	- Positive pressure in system. - Plumbing Code. - Plumbing inspections. - Installation of testable devices. - All new high risk connections are required to have backflow prevention (Metering Policy). - Backflow prevention policy. - ASNZS:3500. - Dedicated filling stations. - Licensed water carters.	- Informal review of test results submitted to BSC. - Plumbing inspections.	Catastrophic	Rare	**Medium (6)**	-High risk customers include agricultural uses, medical and dental facilities, toxic chemical users such as sand blasting and painting, pump stations, TAFE and Universities (isotopes). - TAFE college has a venting RPZ. - All high risk users should have an RPZ or testable device depending on classification from the AS. - BSC do not currently have a register, however owners of properties do submit the results of yearly tests.	Estimate	Investigate options for maintaining a register to ensure devices are installed and tested in accordance with ASNZS:3500.
Risk D-11	Pipelines	**Stagnant water in pipelines**	Stagnant water in pipelines caused by: - Dead ends - Pipes low water demands or moth balling Leading to: - Microbiological contamination from low chlorine residuals and low dissolved oxygen - Taste and odour compounds - Low chlorine residuals - Low dissolved oxygen	- Iron - Manganese - Colour - Dissolved oxygen - pH - Taste and odour - Turbidity	Bacteria	Major	Unlikely	**Medium (8)**	Weekly flushing program	- Weekly bacto testing - Weekly chlorine residual testing	Major	Rare	**Medium (5)**	-Flushing program for dead ends (weekly rotating program). - BSC receive occasional complaints relating taste, odour and dirty water which may trigger flushing. - No identified problem areas in network.	Reliable	N/A
Risk D-12	New Assets	**New asset installation**	Construction debris in network	- Turbidity - Taste & odour - Bacteria - Colour - Viruses - Protozoa - Aluminium - Iron - Manganese - Chlorine	Protozoa	Catastrophic	Unlikely	**High (10)**	- Northern Rivers Local Government Development Design and Construction Manuals. - Internal procedure for chlorination and flushing of new assets.	None	Major	Unlikely	**Medium (8)**	- BSC have a procedure for chlorination and bacto testing of new assets before hand over to BSC (less than 1 test/km). - Unclear if procedure is being followed by developers.	Estimate	Investigate options for implementing procedure within BSC.

Appendix E

Maximum and Residual Risk Register – Whole of system

System - Maximum & Residual Risk

Ref	Component	Hazardous Event	Potential Hazard		Limiting Hazard/s	Maximum Consequence	Maximum Likelihood	Maximum Risk	Preventive Measures	Monitoring	Residual Consequence	Residual Likelihood	Residual Risk	Comments	Level of Uncertainty	Risk Treatments
Risk A-1	Whole of System	**Formation of disinfection by-products**	The addition of chlorine to water containing disinfection by-product precursors. Leading to the formation of: - THMs - HAAs - Chlorate	Disinfection by-products	Disinfection by-products (e.g. THMs, NDMA & HAAs)	Minor	Possible	**Medium (6)**	- Removal of precursors in treatment process	- Rous Water monitor THMs in their network	Minor	Possible	**Medium (6)**	Max TTHMs in distribution system 170 E-6g/l	Uncertain	N/A
Risk A-2	Whole of System	**The use of unsuitable chemicals or materials**	Use of contaminated and unsuitable materials in the system, leading to chemical contamination of water.	- Disinfection by-products - Hydrocarbons - Toxic metals - Toxins - pH	Toxins (unkown contaminant)	Moderate	Possible	**Medium (9)**	- Informal processes - Plumbing code - Australian Standards - Construction specifications	- Informal review of contracts - NSW Health monitoring programs	Minor	Possible	**Medium (6)**	- Chemcial use exepcted to be reveiwed as part of contract rewiew. It is unclear if this would be undertaken for smaller works to water infrastructure. - No incidences of issues related to unsuitable chemicals. - Contractors have previously used incorrec	Estimate	- Formalise, implement and monitor complaince with codes and specifications.
Risk A-3	Whole of System	**Telemetry or control system failure**	Failure of communication processes resulting in multiple possible impacts Leading to equipment operating unsupervised and potential water quality hazards.	- Bacteria - Protozoa - Viruses - Turbidity	Reduced output volume	Major	Possible	**High (12)**	- Master and Slave set up - UPS on each system - Back up CPU for SCADA	- SCADA	Major	Rare	**Medium (5)**	- Failure of telemetry at reservoirs would result in loss of supply - Prevous issue with polling between Water Wheels valve and North Creek Valve. Water wheels valve did not open resulting in stagnant water in main and loss of residual	Confident	-Investigate telemetry options for Water Wheels at time of upgrade. (e.g. BSC may be able to assume operation of valve with Rous Water maintaining ability to override when needed) - Agreement on chlorine targets as part of Service Level Agreement with Rous Water
Risk A-4	Whole of System	**Lack of training or experience**	Lack of training and experience of staff, including contractors, leading to potential water quality impacts.	All hazards	Protozoa	Catastrophic	Possible	**High (15)**	- Training register - Position Descriptions and competency based skills assessment - Operators - Cert III (& IV) and NOW course	- HR review - Annual performance appraisal (Training Identification)	Major	Rare	**Medium (5)**	- No issues with staff (confident) - Appears to be more potential for issues contractors and private works (Less confident)	Reliable	N/A
Risk A-5	Whole of System	**Loss of corporate knowledge**	Lack of documented procedures (including informal processes) resulting in loss of corporate knowledge when staff leave, retire or are on leave	All hazards	All hazards	Moderate	Possible	**Medium (9)**	- Procedure development - Informal mentoring - Action plan when staff go on leave - Onsite diaries	N/A	Moderate	Possible	**Medium (9)**	N/A		- Onging procedure development
Risk A-6	Whole of System	**Lack of resources**	Lack of resources resulting in reduction of proactive O&M work and subsequent system issues (e.g. control measures not appropriately implemented), leading to potential water quality impacts.	All hazards	Bacteria	Major	Unlikely	**Medium (8)**	- Implementation of gap analysis - Resource sharing within NRWG	- Gap analysis	Major	Unlikely	**Medium (8)**	-Workforce availability study has been undertaken for the region. - No issues recently, however previously it has been hard to fill some positions with qualified staff - At present there are not sufficient resources to review water quality results	Certain	- Develop database to allow for review of water quality results - Investigate options for direct input from labs and field staff into database

Ref	Component	Hazardous Event	Potential Hazard		Limiting Hazard/s	Maximum Consequence	Maximum Likelihood	Maximum Risk	Preventive Measures	Monitoring	Residual Consequence	Residual Likelihood	Residual Risk	Comments	Level of Uncertainty	Risk Treatments
Risk A-7	Whole of System	**Lack of hygiene during operation and maintenance**	Reservoir and pipeline maintenance, cleaning and inadequate hygiene practices. Leading to: - Microbiological contamination - Chemical contamination - e.g. aluminium, manganese, iron - Turbidity	- Bacteria - Viruses - Taste and odour - Turbidity - Colour - Chlorine	Protozoa	Major	Possible	**High (12)**	- Separate crews working on sewer and water (or separate equipment) - Recycled water treated as sewage - Competency - Procedures	- Workplace Health and Saftey Inspections (3 monthly)	Major	Rare	**Medium (5)**	- All sewer and water operators work out of the same depot - Potential for cross contamination with resources shared at depot	Confident	N/A