Central NSW Shire Council

Risk Assessment Workshop Summary

Central River and Little Bore water supply systems

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EXECUTIVE SUMMARY

BACKGROUND TO RISK ASSESSMENT PROCESS

As part of a pilot program involving four NSW council local water utilities, Central Shire Council has partnered with NSW Health and the NSW Office of Water in developing a Drinking Water Management System consistent with the Framework for Management of Drinking Water Quality in the Australian Drinking Water Guidelines 2011 - "the Framework" (NHMRC/NRMMC 2011). The implementation of such a system is required to conform to the *Public Health Act 2010* (NSW) (the Act) (NSW Government 2010) and its supporting regulation (in development). The Act sets out the need for a *Quality Assurance Program* (QAP), which would ideally be consistent with the Framework as a model for best practice.

A key part of the Framework is the water quality risk assessment process. This document summarises the risk assessment process completed by Council through a series of workshops held during September 2011. The process involved the following steps:

- Summarising the water supply system using a system description and process flow diagram.
- Summarising pertinent water quality data.
- Reviewing the above information and assessing risks using a workshop approach.
- Identifying critical control points using a workshop approach.

SUMMARY OF RISKS IDENTIFIED

The workshop risk assessment team identified 60 risks for the Central River system and 16 risks for the Little Bore system. The risk distribution of the residual (controlled) risks arising from the risk assessments is shown in the following tables for the two systems. 17 improvements actions to address significant risks were identified as part of an Action Plan which is carried into the main Drinking Water Management System (DWMS) document.

Residual (controlled) risk distribution for the Central River system

Process step	Very High	High	Moderate	Low	Unrated	Sub-total
Bulk raw water transfer				2		2
Clarification			3	1		4
Coagulant dosing			3			3
Disinfection			2	1		3
Distribution				4		4
Filtration		2	1	1		4
Low Level Res			1	3		4
High Level Res			1	3		4
LT20 dosing				2		2
Central River Dam		1		4		5
Central River Dam Catchment and Rivers			3	3		6
PAC dosing		1	2	1	1	5
pH correction				2		2
Plant Bypass			1			1
Pre-oxidation				3		3
Whole of Plant		2	1	2		5
Whole of System (all council systems)	1		1	1		3
Sub-total	1	6	19	33	1	60

Residual (controlled) risk distribution for the Little Bore system

Process step	Very High	High	Moderate	Low	Unrated	Sub-total
Bore			2	1		3
Disinfection				2		2
Distribution			1	2		3
Pressure tank					1	1
Treated water storage			1	3		4
Whole of Plant				2	1	3
Sub-total	0	0	4	10	2	16

1 INTRODUCTION

Central Shire Council has partnered with NSW Health and the NSW Office of Water in developing a drinking water quality management plan consistent with the Framework for Management of Drinking Water Quality in the Australian Drinking Water Guidelines 2011 (ADWG) - "the Framework" (Table 1-1 and Figure 1-1) (NHMRC/NRMMC 2011). The document has been developed to conform to the *Public Health Act 2010* (NSW) (the Act) (NSW Government 2010) and its anticipated supporting regulation (in development). The Act sets out the need for a *Quality Assurance Program* (QAP) which would ideally be consistent with the Framework as a model for best practice.

The Framework was developed to guide the design of a structured and systematic approach for the management of drinking water quality and includes twelve elements that are considered good practice for systematic management of drinking water supplies. The Framework is effectively a quality management system that has been developed specifically for the water industry. The framework incorporates a preventive risk management approach from catchment to consumer and includes elements that are analogous to relevant aspects of generic management systems such as:

- Hazard Analysis and Critical Control Point (HACCP);
- Food Safety Management Systems-Requirements for any Organization in the Food Chain (ISO 22000);
- Quality Management Systems (ISO 9001); and
- Risk Management (ISO 31000:2009).

Table 1-1 Framework for Management of Drinking Water Quality (ADWG 2011).

1. Commitment to Drinking Water Quality Management	6. Management of Incidents and Emergencies
Drinking water quality policy	Communication
Regulatory and formal requirements	Incident and emergency response protocols
Engaging stakeholders	7. Employee Awareness and Training
2. Assessment of the Drinking Water Supply System	Employee awareness and involvement
Water supply system analysis	Employee training
Assessment of water quality data	8. Community Involvement and Awareness
Hazard identification and risk assessment	Community consultation
3. Preventive Measures for Drinking Water Quality Management	Communication
Preventive measures and multiple barriers	9. Research and Development
Critical control points	Investigative studies and research monitoring
4. Operational Procedures and Process Control	Validation of processes
Operational procedures	Design of equipment
Operational monitoring	10. Documentation and Reporting
Corrective action	Management of documentation and records
Equipment capability and maintenance	Reporting
Materials and chemicals	11. Evaluation and Audit
5. Verification of Drinking Water Quality	Long-term evaluation of results
Drinking water quality monitoring	Audit of drinking water quality management
Consumer satisfaction	12. Review and Continual Improvement
Short-term evaluation of results	Review by senior executive
Corrective action	Drinking water quality management
	Improvement plan

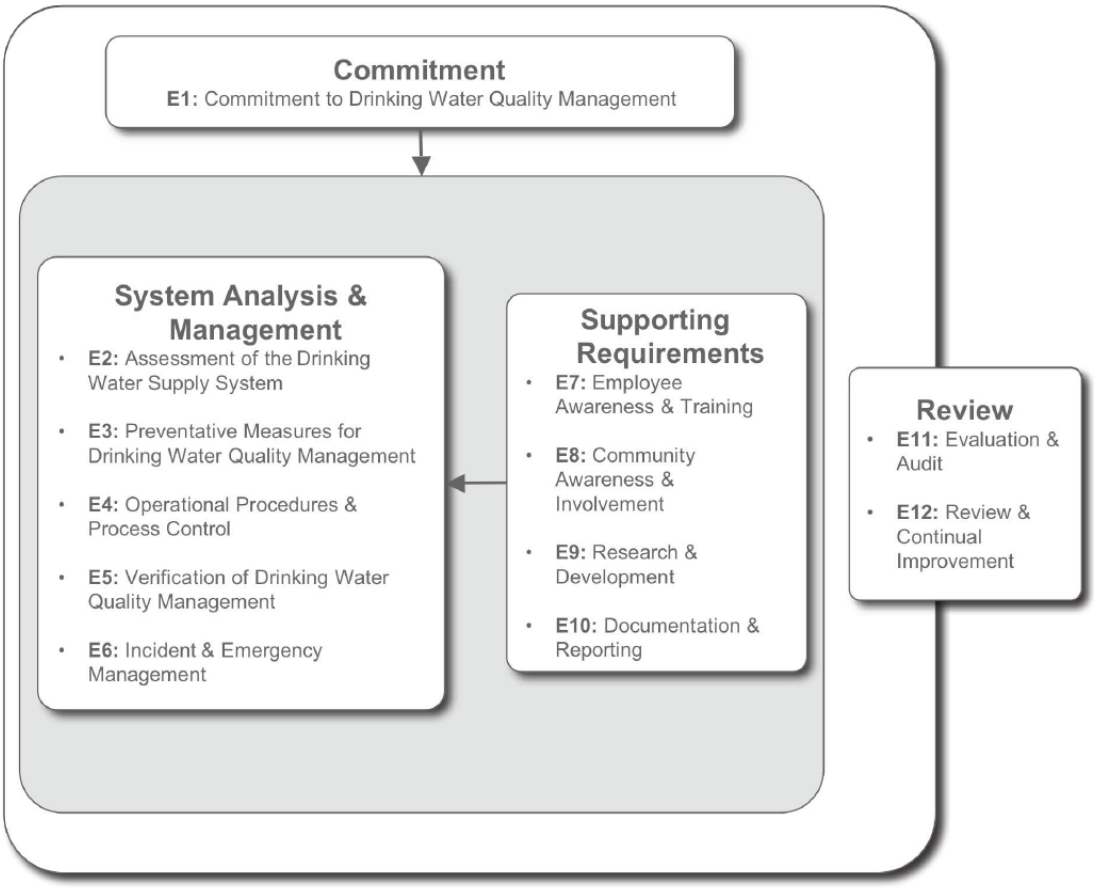

Figure 1-1. Diagrammatic representation of the Framework for Management of Drinking Water

1.1 STRUCTURE OF THE DOCUMENT

This document summarises the implementation of parts of Elements 2 to 3 of the Framework and is structured in accordance with relevant components of the ADWG.

2 ELEMENT 2 - ASSESSMENT OF THE DRINKING WATER SUPPLY SYSTEM

Element 2 of the ADWG Framework has three components:

- Water supply system analysis;
- Assessment of water quality data; and
- Hazard identification and risk assessment.

2.1 WATER SUPPLY SYSTEM ANALYSIS

Prior to completing the workshop, the system was described as recommended by the ADWG Framework.

Actions

- Assemble a team with appropriate knowledge and expertise.
- Construct a flow diagram of the water supply system from catchment to consumer.
- Assemble pertinent information and document key characteristics of the water supply to be considered.
- Periodically review the water supply system analysis.

2.1.1 Team with appropriate knowledge and expertise

Council assembled a team to complete a system description and water quality risk assessment for its water supply systems during September 2011. Council staff, government stakeholders and external specialists were involved in the process. A separate Risk Assessment Report was generated from the process which carries the full details. For ease of reference, the following Council roles and stakeholders that were involved in the workshop are noted in Table 2-1.

Table 2-1. Summary of stakeholders involved in the system assessment

Organisation	***Positions represented***
Council	Operations Manager
	Urban Services Coordinator and Overseer (two)
	Water Operators (three)
	Contract Project Engineer
	Environmental Health Officer
	Asset Manager
NSW Department of Health	Area Health Service Public Health Unit Environmental Health staff (three)
	NSW Health Water Unit representative
NSW Office of Water	Office of Water Inspector for the area
Independent technical consultant	Water engineering consultant involved in assisting Council develop procedures to support the DWMS
Water quality management system consultant	Facilitation and water quality risk assessment consultant to independently facilitate the workshop and assist Council develop the DWMS (team of two used)

2.1.2 Flow diagram of the water supply system from catchment to consumer

Process flow diagrams were constructed for each water supply system as shown in Figure 2-1 (Central River) and Figure 2-2 (Little Bore).

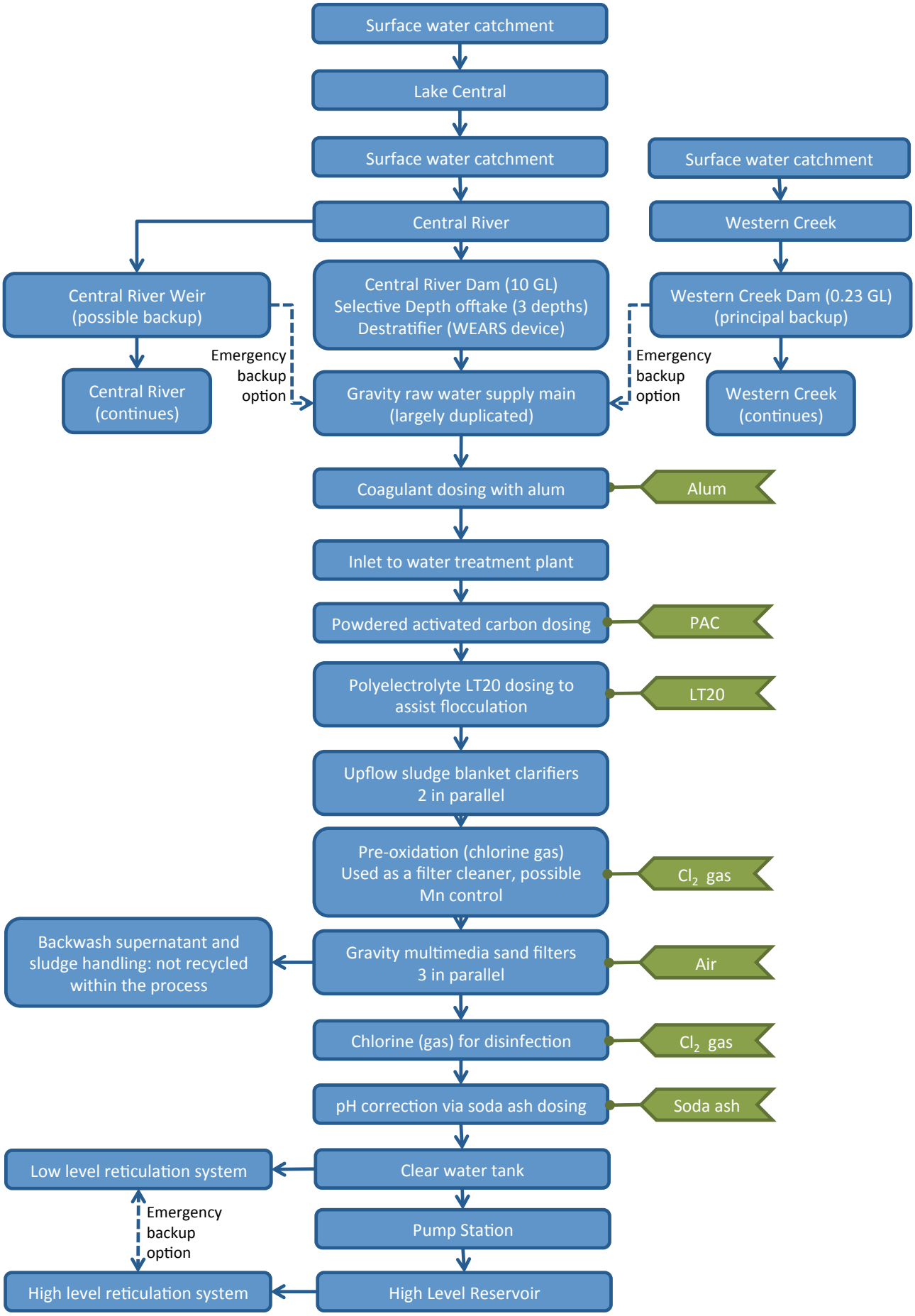

Figure 2-1. Conceptual process flow diagram of the Central River water supply system.

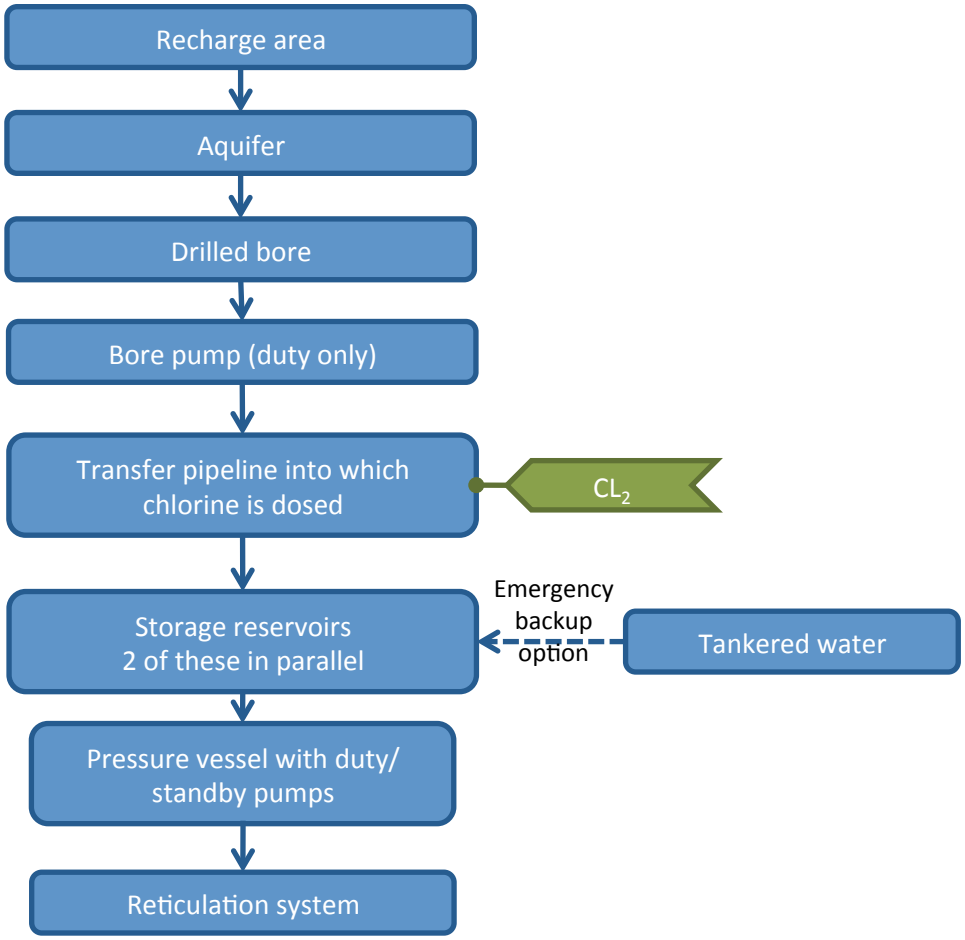

Figure 2-2. Conceptual process flow diagram of the Little Bore water supply system.

2.1.3 Pertinent information and key characteristics of the water supply to be considered

Central Shire Council manages four water supply schemes. This pilot project considers two of these: the Central River and Little Bore schemes, being the two potable water supply schemes. A map and overview of the schemes is provided in Figure 2-3, **Error! Reference source not found.** and in the following sections.

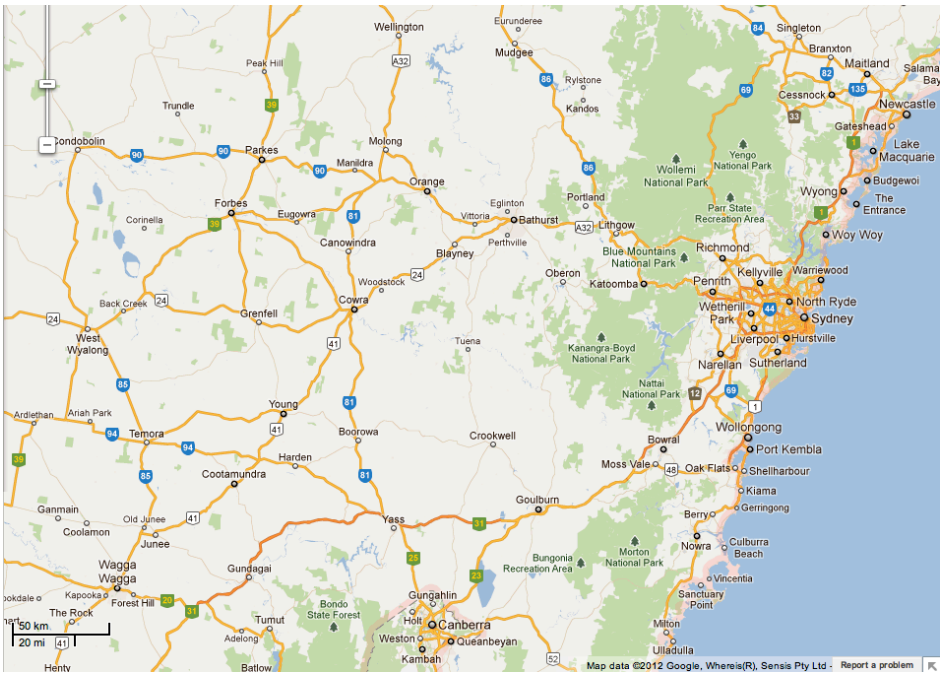

Figure 2-3. Map of water supply schemes (de-identified, shown here for illustration only).

Table 2-2. Water supply system – overview description.

SYSTEM COMPONENT	Central River system	Little Bore system
Population Served	1569 (2006 census)	40 (estimate) 16 rural residential properties
Water Source	Open rural residential, grazing and horticultural catchments Central River Western Creek (backup)	Bore (recently drilled) Pump station (two pumps, second pump provides hot standby and peak)
Raw Water Storage	Central River Dam (1 GL capacity) Central River Weir (backup) Western Creek Dam (backup) (0.23 GL capacity)	Aquifer
Water Treatment	Dual gravity main to treatment plant Central Water Treatment Plant: • Alum dosing to begin coagulation and flocculation • Powdered activated carbon dosing for taste and odour and toxin removal • Polyelectrolyte LT20 dosing to assist flocculation • Upflow sludge blanket clarifiers (2 parallel) for clarification • Pre-oxidation (chlorine gas) to assist Mn removal • Gravity multimedia sand filters (3 parallel) for filtration • Chlorine (gas) for disinfection • pH correction via soda ash dosing	Chlorine disinfection
Storage After Treatment	Clear water storage/ chlorine contact tank, low level (1.4 ML) Pump station High Level (1.6 ML) closed, bird-mesh protected storages.	Two concrete storages (each 91 kL).
Distribution of Product	Reservoir-pressurised pipes of various diameters and materials and approximately 22 km in length	Pump-pressurised reticulation system
Any Special Controls Required	None	None

2.1.3.1 Water sources

The Central Scheme can be supplied from the Central River via the Central River Weir, the Central River Dam (1 GL capacity) and from Western Creek via the Western Creek Dam (0.23 GL capacity). All of these water sources are located well upstream of the township. Western Creek Dam is now considered to be a backup dam that is seldom used in practice, like the Central Creek Weir. The catchment (which has been mapped by Council and for which maps can be readily produced by the Council GIS group) includes:

- Recreational activities on the upstream lake.
- Stock grazing.
- Horticulture activities (orchards: apple, stone fruit, cherries; vineyards).
- Forestry (including pine).
- Small unsewered towns and residences including scattered rural housing with septic tanks.

Central River Dam is approximately 8 metres deep and stratifies at about 3 metres below the surface. Unless destratified, the dam stratifies severely during the summer months. There are three optional draw-

off depths from the dam and the water depth targeted to supply is typically 2 to 4 m below the dam surface – to avoid algae. A WEARS device destratification unit has been installed in the reservoir.

Some irrigators pump directly from the dam using electric powered pumps. Cattle and sheep can access the dam directly. There are aquatic bird populations on the dam. Dissolved oxygen dam profiles are conducted once per week. Taste and odour tests are conducted with boiled water along with visual tests, and algal counts are undertaken weekly. There is a Catchment Management Plan in place. Council has developed the *Central Water Supply Catchment Management Plan Policy* and conducts weekly inspections of the dam area.

Due to the limited size of Central River Dam (only a few days storage), water must be taken at all times and hence selective abstraction of water can only be used as a short term measure, should a water quality issue occur.

Water is delivered to the Central Water Treatment Plant by a mostly duplicated gravity main of over 20 km in length. There is a raw water turbidity meter on line and the feed to the water treatment plant is shut-off at above 30 NTU. The duplication of the pipe provides supply backup.

The Little Bore water supply source draws from the aquifer that has been designed to provide 4.5 kL per lot. Water carting is used to service the town in the event of a process loss at the source.

2.1.3.2 Water treatment

Water is fully treated at Central Water Treatment Plant. Raw water is delivered to the treatment plant via gravity. The plant has an estimated 1.9 to 2.4 ML/d peak production capacity. Average daily demand is 0.7 ML/d and peak daily demand is between 1.4 and 2.1 ML/day. The plant does not run continuously; it runs for anywhere between 3 and 10 hours a day. There is no fluoridation at the plant although community consultation is taking place in relation to fluoridation. The treatment steps are listed above in **Error! Reference source not found.** and the process is summarised here:

- Water from Central River Dam is dosed with an aluminium chlorohydrate solution prior to the addition of powdered activated carbon (PAC) (if and as required) and polyelectrolyte.
- The dosed water is then directed to two up-flow clarifiers operating in parallel.
- Sludge collection cones collect settled aluminium chlorohydrate sludge and direct sludge to a neighbour's dam.
- Following clarification, the water enters three sand filters for final polishing.
- The backwashing of the filters occurs daily and in addition is manually triggered by the operators when the head loss across the bed is 2 m.
- The backwash is air scour assisted and occurs separately at each filter in sequence. It is a manual process with the waste also discharged to the neighbour's dam and not to the head of the plant.
- Chlorine is added to the water entering the filters to help oxidise soluble manganese for its subsequent removal in the filters.
- Chlorine is also added to filtered water prior to its discharge to the treated water clearwater storage.
- There are duty and standby chlorine cylinders and pumps with auto changeover.
- Soda ash is dosed following the addition of chlorine, to increase the pH.

At Central Water Treatment Plant on line telemetered monitoring takes place to cover the following points:

- raw water turbidity (100 NTU intake shut off);
- filtered water turbidity for individual filters (with a 0.5 NTU shut off point);
- head loss across the filters (to control backwash at 2 m);
- chemical pump alarms for alum and electrolyte; and
- pH and online chlorine monitoring on the outlet of the clearwater reservoir (with 0.5 mg/L shut off).

For Little Bore, raw water is pumped directly via the Pump Station and is disinfected by chlorine. There are two pumps, the second pump providing a hot standby and peak demand flow rate pump.

The treatment chemicals used by Council are summarized in (Table 2-3).

Table 2-3. Summary of treatment chemicals used.

Chemical	Use	Dosing concentrations	Notes
Polyaluminium chlorohydrate	Primary coagulant	11-26 ppm	Flow paced dosed per volume of raw water.
Powdered Activated Carbon (PAC)	Treat taste and odour and potential toxlns	When problematic: 4-5% solution. When under control: 3% solution	Flow paced dosing. Only used when cyanobacteria at the dam are an issue. Dosed according to the level needed to remove taste and odour of treated water at the filtration plant.
Polyelectrolyte LT20	Flocculant aid	0.05 ppm	Flow paced dosing to coagulated water.
Chlorine gas	Disinfectant and manganese oxidation	3 to 8 ppm	Dosed to inlet to the filters (manual) and filtered water (flow paced).
Sodium hypochlorite	Disinfectant	3 to 8 ppm	Dosed at the bore water supply and to provide top up chlorination in reservoirs
Soda Ash (Sodium carbonate)	pH correction	0 or 17-17.5 ppm	Flow paced, used only on occasions when pH is less than 7.3 in treated water.

2.1.3.3 Water distribution

For the at Central Water Treatment Plant system, treated water is transferred by a gravity main to a clear water storage low level reservoir (1.36 ML capacity, dated 1928) which directly supplies low level areas of the town. Water is pumped via a Pumping Station to the second High Level reservoir that supplies the high level areas of the town. Both reservoirs are roofed and bird-proofed. The reservoirs both have telemetered continuously monitored low level alarms. The reservoirs are inspected and reported upon by a diving company. Residual chlorine levels are tested daily and remain greater than 0.1 mg/L, even at the extremities of town due to the relatively small distribution system.

For the Little Bore system, the scheme supplies 16 rural residential properties. Treated water is stored in two concrete storages (each 91 kL) and supplied via a reticulation system.

2.1.4 Periodic review

The information contained within this document is current at the time of writing. The information will need to be periodically reviewed and updated. The information will be formally reviewed annually and updated in response to significant system changes.

2.2 ASSESSMENT OF WATER QUALITY DATA

Actions

- Assemble historical data from source waters, treatment plants and finished water supplied to consumers (over time and following specific events).
- List and examine exceedances.
- Assess data using tools such as control charts and trend analysis to identify trends and potential problems.

2.2.1 Assemble historical data…

Water quality information was collected from the raw water, treatment plant and finished water supplied to consumers. Raw water and treated water data is electronically recorded daily on the plant water quality spreadsheets and analysed monthly for trends. These results are reported in the Council operations section monthly, quarterly and annual reports. Historical summaries are given in Table 2-4 to Table 2-7, below.

2.2.2 List and examine exceedances

Finished water supplied to consumers is collected and analysed as part of the NSW Health Drinking Water Monitoring Program. Health-related water quality exceedances are reported to the council and local Public Health Unit by telephone and fax and are recorded in the NSW Drinking Water Database. Summaries of exceedances are given in Table 2-4 to Table 2-7, below.

2.2.3 Assessment of data…

Water quality data were sourced from Council and via the NSW Drinking Water Database. To allow statistical formulae to handle the full body of data, non-detects were transformed to half the detection limit and values above the upper dynamic range of the assay to twice the upper limit. The water quality parameters are summarised in in Table 2-4 to Table 2-7, below.

In addition, a series of plots was produced in the form of control charts that compared results to guideline values and illustrated trends. Some of these plots are shown in Appendix A and broadly followed the example given here of how the data was presented (Figure 2-4).

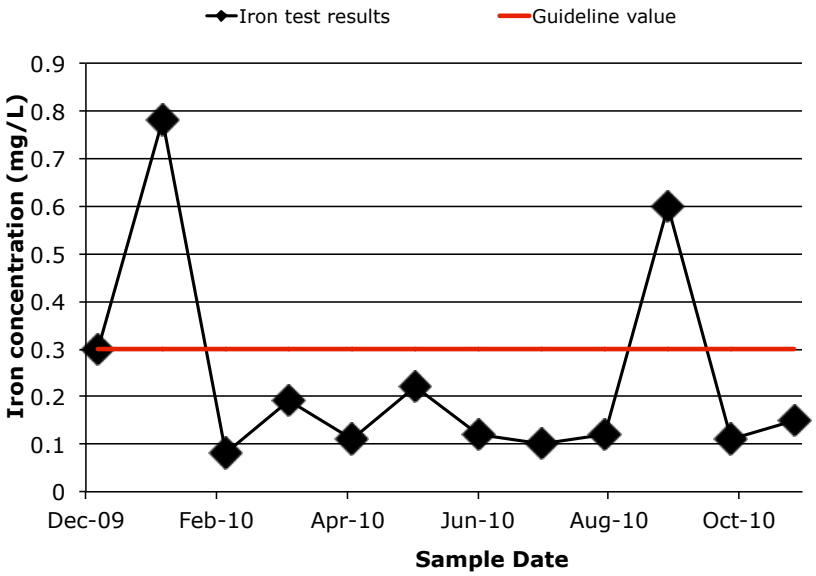

Figure 2-4. Example of how water quality data was presented as part of the analysis.

2.2.3.1 Central River water supply system

Table 2-4. Summary of water quality data for Central River scheme (NSW Drinking Water Monitoring Program Data for treated water between 30 January 2001 and 29 August 2011).

Parameters	Number of Samples	Minimum	Mean	95%ile	Maximum	ADWG guideline value	No. of exceedances
pH	207	0.7	7.7	8.1	> 9	6.5 - 8.5	1
True Colour (HU)	15	1.0	1.3	2.9	5.9	15	0
Turbidity (NTU)	158	0.1	0.8	1.5	3.6	1 (desirable*) 5 (aesthetic)	38 0
Iron (mg/L)	16	0.01	0.02	0.07	0.11	0.3	0
Manganese (mg/L)	20	0.005	0.011	0.031	0.099	0.1 (aesthetic) 0.5 (health)	0 0
Total coliforms (CFU or MPN /100 ml)	546	0	1	2	66	N/A	N/A
***E. coli* (CFU or MPN /100 ml)**	547	0	0	0	5	0	1
Total Hardness (mg/L as $CaCO_3$)	16	50	79	108	113	200	0

**this guideline value is the desirable turbidity at the point of disinfection and can be exceeded further into the reticulation system.*

Table 2-5. Water quality exceedance summary for Central River scheme.

Issue	Frequency	Comment
Turbidity	Often	Turbidity is often higher than the guideline value
E. coli	Rarely	*E. coli* is sometimes above the guideline value

2.2.3.2 Little Bore water supply system

Table 2-6. Summary of water quality data for Little Bore scheme (NSW Health Data – treated water).

Parameters	Number of Samples	Minimum	Mean	95%ile	Maximum	ADWG guideline value	No. of exceedances
pH	61	6.2	7.0	7.3	7.9	6.5 - 8.5	1
True Colour (HU)	15	1.0	2.3	8.4	18.8	15	1
Turbidity (NTU)	49	0.1	1.1	2.3	6.7	1 (desirable*) 5 (aesthetic)	18 1
Iron (mg/L)	15	0.08	0.19	0.44	0.78	0.3	1
Manganese (mg/L)	19	0.005	0.004	0.006	0.008	0.1 (aesthetic) 0.5 (health)	0 0
Total coliforms (CFU or MPN /100 ml)	123	0	21	123	150	N/A	N/A
***E. coli* (CFU or MPN /100 ml)**	129	0	1	0	130	0	3
Total Hardness (mg/L as $CaCO_3$)	15	112	123	131	134	200	0

**this guideline value is the desirable turbidity at the point of disinfection and can be exceeded further into the reticulation system.*

Table 2-7. Water quality exceedance summary for Little Bore scheme.

Issue	Frequency	Comment
Turbidity	Often	Turbidity is often higher than the guideline value
E. coli	Occasionally	*E. coli* is sometimes above the guideline value
Iron	Occasionally	Iron is occasionally higher than the guideline value
Colour	Rarely	Colour is sometimes higher than the guideline value

2.3 HAZARD IDENTIFICATION AND RISK ASSESSMENT

Actions

- Define the approach and methodology to be used for the hazard identification and risk assessment.
- Identify and document hazards sources and hazardous events for each component of the water supply system.
- Estimate the level of risk for each identified hazard or hazardous event.
- Evaluate the major sources of uncertainly associated with each hazard and hazardous event and consider actions to reduce uncertainty.
- Determine significant risks and document priorities for risk management.
- Periodically review and update the hazard identification and risk assessment to incorporate any changes.

2.3.1 Approach and methodology used for the hazard identification and risk assessment

The approach and methodology used to assess risk followed the example given in the ADWG. A workshop process was used to complete the risk assessment. A preliminary set of hazard and risk scenarios were provided in the workshop to provide participants with worked examples and to help facilitate discussion. Participants then added to these identified risks. The results were captured during the workshop via an Excel® spreadsheet (Appendix B-1 and B-2). The risk assessment workshop conducted on 20th and 21st September 2011 at Council's offices.

2.3.2 Identify and document hazards sources and hazardous events for each component of the water supply system

Hazardous events and hazards were identified for each process step as shown in Appendix B. The workshop objectives included understanding and prioritising (assessing) the events, hazards and risks to drinking water consumers. The hazards identified as exceedances were considered in the risk assessment (Table 2-5 for the Central River supply, Table 2-7 for the Little Bore supply). For the Central River system, the catchment was considered compromised due to rural residential development, storm events and agriculture, particularly cattle grazing, viticulture and horticulture. Key terms used in the risk assessment were as given in the ADWG:

Hazard A biological, chemical, physical or radiological agent that has the potential to cause harm.

[Examples of hazards might be:

- Human-infectious pathogens from failing septic tanks
- Particles and nutrients from land clearing practices]

Hazardous events An incident or situation that can lead to the presence of a hazard (what can happen and how)

[Examples of a hazardous events might be:

- cyanobacterial bloom resulting in toxins that cannot be removed by downstream processes
- reservoir contamination by vermin resulting in pathogens in the distribution system]

The hazards identified as exceedances were considered in the risk assessment (Table 2-5 for Central River, Table 2-7 for Little Bore). In addition, during 2008, a preliminary risk assessment was drafted, but not completed, by XYZ for the Central River Water Treatment Plant. The catchment was considered compromised due to rural residential development, storm events and agriculture, particularly cattle

grazing, viticulture and horticulture. Nonetheless, the Central River Water Treatment Plant and overall water supply scheme was considered to provide an effective barrier to several hazards including:

- Colour
- Hardness
- Pesticides
- *E. coli*

However, the risk assessment determined that the following hazards were not under effective control and that the level of residual risk to customers was not acceptable and required improvement:

- *Cryptosporidium*
- Manganese
- Turbidity
- Taste and Odour

Furthermore, the risk assessment determined that the residual risk posed by the following hazards was marginal and required intensive monitoring and control:

- Viruses
- pH
- Algal toxins

It was noted that:

- Raw water turbidities rose to 40 NTU following storm events.
- Blooms of cyanobacteria in the surface layers of Central River Dam with *Anabaena* spp. reported at up to 46,000 cells/mL and total cyanobacteria concentrations exceeding 180,000 cells/ml.

In addition, the risk of plant bypass was considered high and it was noted that such an event had occurred previously due to the nature of the plant layout and valve arrangements. The risk of filter breakthrough was also considered high.

A number of important controls have been implemented since the completion of the XYZ risk assessment so that many of these risks have been reduced.

2.3.3 Estimate the level of risk for each identified hazard or hazardous event

Risks posed by each of the events were assessed, through a consideration of likelihood and consequence, as per the ADWG example, reproduced here for ease of reference. Likelihood (Table 2-8) x Consequence (Table 2-9) was assessed with the risk assessment matrix being used to assess risks (Table 2-10). This approach is illustrated in the risk assessment worksheet (Appendix B-1 and B-2). Risk was defined as given in the ADWG:

Risk	The likelihood of identified hazards causing harm in exposed populations in a specified timeframe, including the severity of the consequences
Maximum Risk	Risk assessed in the absence of preventive measures
Residual Risk	Risk assessed after consideration of existing preventive measures

Table 2-8. Likelihood table (ADWG, 2011).

Level	Descriptor	Example description
A	Almost certain	Is expected to occur in most circumstances
B	Likely	Will probably occur in most circumstances
C	Possible	Might occur or should occur at some time
D	Unlikely	Could occur at some time
E	Rare	May occur only in exceptional circumstances

Table 2-9. Consequence table (ADWG, 2011).

Level	Descriptor	Example description
1	Insignificant	Insignificant impact, little disruption to normal operation, low increase in normal operation costs
2	Minor	Minor impact for small population, some manageable operation disruption, some increase in operating costs
3	Moderate	Minor impact for large population, significant modification to normal operation but manageable, operation costs increased, increased monitoring
4	Major	Major impact for small population, systems significantly compromised and abnormal operation if at all, high level of monitoring required
5	Catastrophic	Major impact for large population, complete failure of systems

Table 2-10. Risk matrix (ADWG, 2011).

Likelihood	Consequences				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (almost certain)	Moderate	High	Very high	Very high	Very high
B (likely)	Moderate	High	High	Very high	Very high
C (possible)	Low	Moderate	High	Very high	Very high
D (unlikely)	Low	Low	Moderate	High	Very high
E (rare)	Low	Low	Moderate	High	High

2.3.4 Evaluation of the major sources of uncertainly associated with each hazard and hazardous event and consider actions to reduce uncertainty.

Uncertainty was not explicitly assessed, but follow up actions were recorded where risks were considered to need additional information to improve their assessment. In addition, the basis for risk scoring was recorded in the risk assessment worksheets (Appendix B).

2.3.5 Determine significant risks and document priorities for risk management.

In total, 60 risks were identified for the Central River system and 16 for the Little Bore system. A detailed breakdown of the identified risks is given in Appendix B-1 and B-2. A summary of the risks identified and their distribution is given in Table 2-11 to Table 2-14 for the Central and Little Bore systems for both the residual (controlled) and maximum (uncontrolled) situations.

Significant risks were those that were not “low”. Significant risks were considered further to determine the controls in place, and their effectiveness. In total, 60 risks were identified for the Central River system and 16 for the Little Bore system. A detailed breakdown of the identified risks is given in Appendix B and a concise summary is provided here, within the body of the document.

Although a number of risks rated “very high” at the “maximum risk” level, only on risk rated “very high” at the “residual risk” level. Specifically, it was noted that there was no process in place to maintain skilled

operators for the long term. It was considered that the loss of one or more experienced operators remained a "very high" risk even with current controls in place.

A number of risks rated "high" for the surface water source even with the current controls in place, i.e. at the "residual risk" level. Specifically, these risks were:

- Malicious contamination of the source water reservoir.
- Malicious contamination of the treated water reservoirs.
- Failure to dose powdered activated carbon in time when required.
- Inability to backwash the filters when required due to the nature of the backwashing process.
- Pathogen breakthrough through filters due to a range of underlying causes.
- Failure of process monitoring devices to provide accurate signals, due to a range of underlying causes.

No risks rated high at the "residual risk" level for the bore water source. However, a number of risks rated "moderate" for either the bore water or surface water source, including, but not limited to:

- Pathogen breakthrough through disinfection filters due to a range of underlying causes.
- Contaminants from spills in the catchment.
- Pathogen or contaminant breakthrough through filters due to a range of underlying causes such as chemical under- or over-dosing.
- Raw water bypass valve being operated leading to plant bypass.
- Backflow from contaminated sources within the distribution system.
- Treatment chemical contamination.

Section 3.12 of the DWMS captures Improvement Actions to address many of these risks.

Table 2-11. Residual (controlled) risk distribution for the Central River system.

Process step	Very High	High	Moderate	Low	Unrated	Sub-total
Bulk raw water transfer				2		2
Clarification			3	1		4
Coagulant dosing			3			3
Disinfection			2	1		3
Distribution				4		4
Filtration		2	1	1		4
Low level Res			1	3		4
High level res			1	3		4
LT20 dosing				2		2
Central River Dam		1		4		5
Central River Dam Catchment and Rivers			3	3		6
PAC dosing		1	2	1	1	5
pH correction				2		2
Plant Bypass			1			1
Pre-oxidation				3		3
Whole of Plant		2	1	2		5
Whole of System (all council systems)	1		1	1		3
Sub-total	1	6	19	33	1	60

Table 2-12. Residual (controlled) risk distribution for the Little Bore system.

Process step	Very High	High	Moderate	Low	Unrated	Sub-total
Bore			2	1		3
Disinfection				2		2
Distribution			1	2		3
Pressure tank					1	1
Treated water storage			1	3		4
Whole of Plant				2	1	3
Sub-total	0	0	4	10	2	16

Table 2-13. Maximum (uncontrolled) risk distribution for the Central River system.

Process step	Very High	High	Moderate	Low	Unrated	Sub-total
Bulk raw water transfer	1		1			2
Clarification		2	2			4
Coagulant dosing		3				3
Disinfection	2			1		3
Distribution	1	1	1	1		4
Filtration	3			1		4
Low level Res			4			4
High level res			4			4
LT20 dosing		1		1		2
Central River Dam	1	2	1	1		5
Central River Dam Catchment and Rivers	2	3		1		6
PAC dosing	1	2		1	1	5
pH correction				2		2
Plant Bypass	1					1
Pre-oxidation				3		3
Whole of Plant	1	2	1	1		5
Whole of System (all council systems)	1	1	1			3
Sub-total	14	17	15	13	1	60

Table 2-14. Maximum (uncontrolled) risk distribution for the Little Bore system.

Process step	Very High	High	Moderate	Low	Unrated	Sub-total
Bore	1			2		3
Disinfection			1	1		2
Distribution	1	1	1			3
Pressure tank					1	1
Treated water storage			1	3		4
Whole of Plant			1	1	1	3
Sub-total	2	1	4	7	2	16

3 ELEMENT 3 - PREVENTIVE MEASURES FOR DRINKING WATER QUALITY MANAGEMENT

This element has two components:

- Preventive measures and multiple barriers; and
- Critical control points (CCPs).

3.1 PREVENTIVE MEASURES AND MULTIPLE BARRIERS

Actions

- Identify existing preventive measures from catchment to consumer for each significant hazard or hazardous event and estimate the residual risk.
- Evaluate alternative or additional preventive measures where improvement is required.
- Document the preventive measures and strategies into a plan addressing each significant risk.

3.1.1 Identify existing preventive measures from catchment to consumer for each significant hazard or hazardous event and estimate the residual risk.

Preventive measures were defined as suggested in the ADWG and the term 'controls' or 'control measures' was used interchangeably with 'preventive measures'. The "maximum risks" were reassessed to define the "residual risks", as shown in Appendix B. In outline, the definition used was as follows:

Preventive measures

Processes that reduce the hazard or the hazardous event:

Examples of preventive measures include:

- Catchment management programs to reduce nutrients in the river thereby reducing cyanobacterial blooms
- Process steps within a water treatment plant
- A backflow prevention program

The residual risk was then assessed, as shown in Appendix B.

3.1.2 Evaluate alternative or additional preventive measures where improvement is required.

The preventive measures for the water supply system explicitly encompassed within the risk assessment have been considered adequate to control the identified risks, but with room for improvement. Improvement processes and other follow up actions were recorded where risks were considered to need additional mitigation, as shown in Appendix B, and as captured in the Improvement Plan in the DWMS.

3.1.3 Document the preventive measures and strategies into a plan addressing each significant risk.

The preventive measures and strategies for addressing the significant risks are summarised in the following section that deals with Critical Control Points.

3.2 CRITICAL CONTROL POINTS

Actions

- Assess preventive measures from catchment to consumer to identify critical control points.
- Establish mechanisms for operational control.
- Document critical control points, critical limits and target criteria.

Critical control points were selected as follows, based on their necessity to manage significant risks. For the surface water source, they were:

- 1. Raw water abstraction
- 1. Well head protection
- 2. Powdered activated carbon dosing system
- 3. Pre-oxidation using chlorine
- 4. Coagulation, flocculation, sedimentation, media filtration
- 5. Chlorine disinfection
- 6. Distribution reservoirs
- 7. Distribution network
- 8. Customer connections

For the bore water source, they were:

- 1. Well head protection
- 2. Chlorine disinfection
- 3. Distribution network
- 4. Customer connections

Further detail on the critical control points and other preventive measures is given in the Drinking Water Management System document, provided separately.

The workshop identified 17 actions where were rolled up into the DWMS document, provided separately.

4 REFERENCES

Central NSW Shire Council. 2012. Drinking Water Management System. Working Draft Version 4, June 2012. Shown as a separate document.

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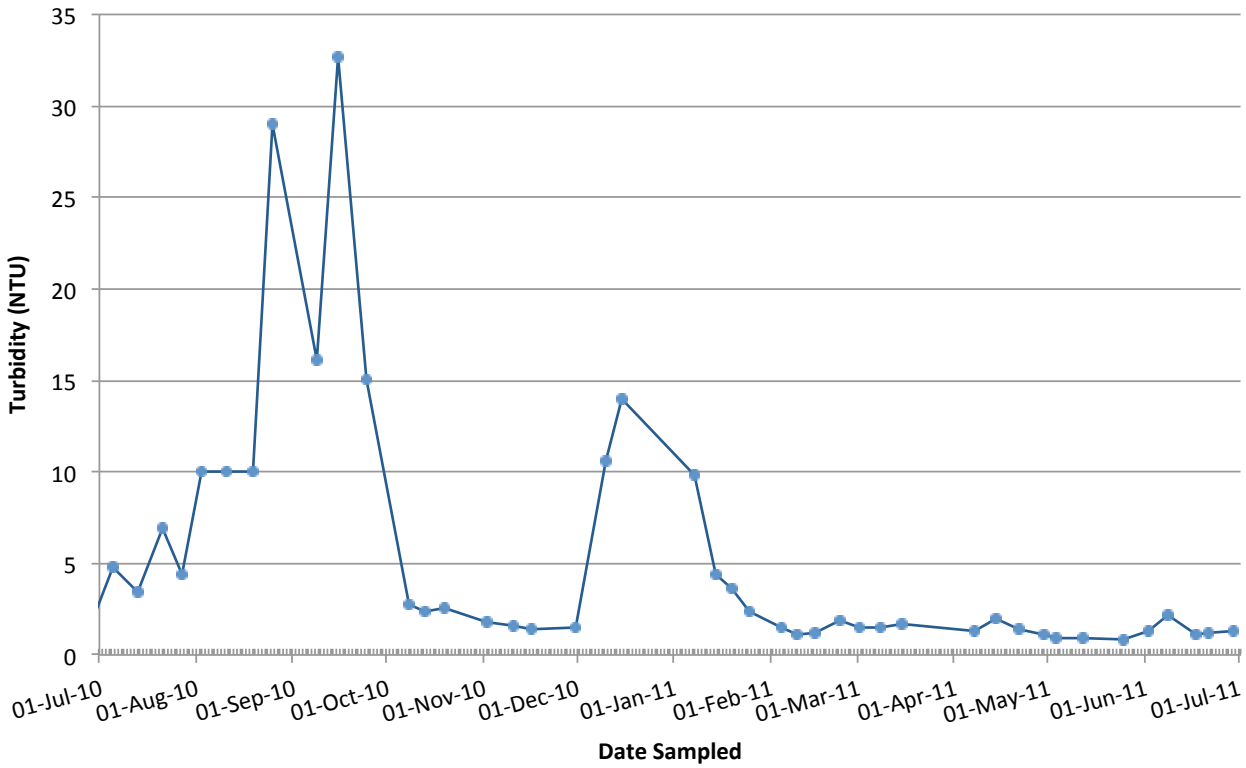
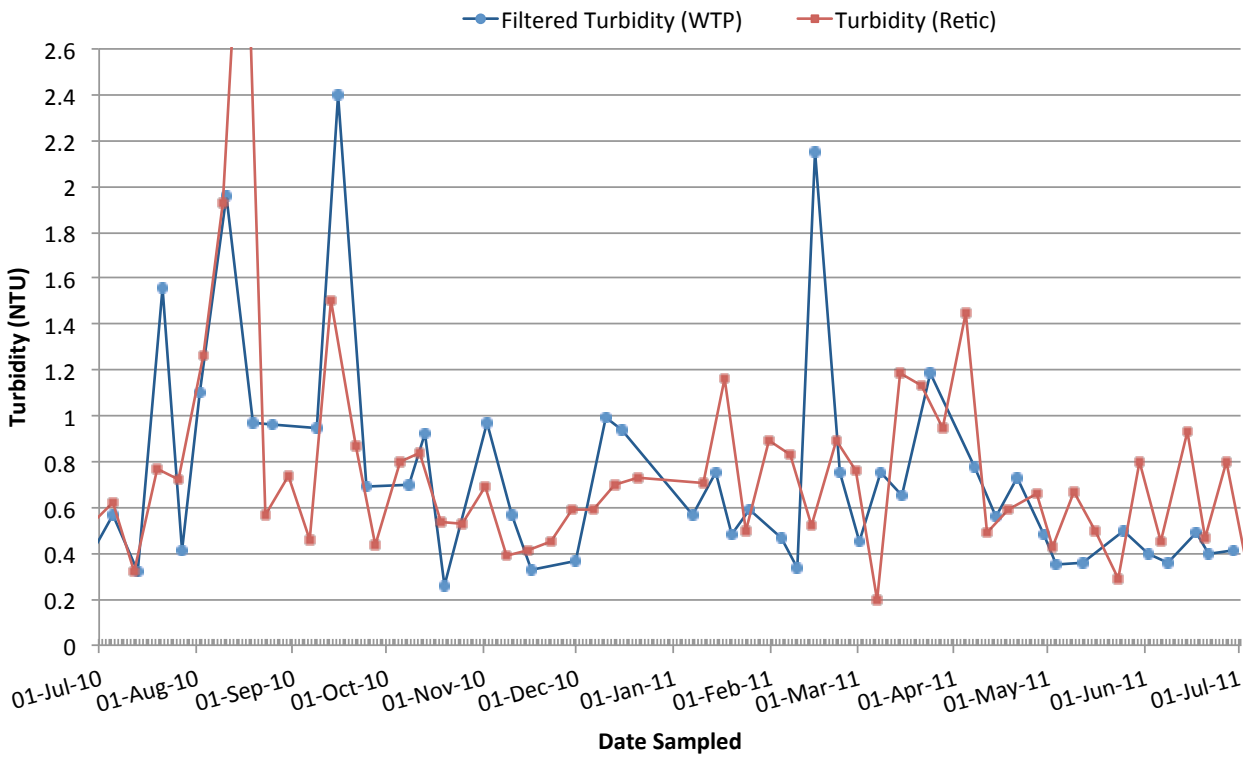
APPENDIX A. WATER QUALITY DATA TIME SERIES.

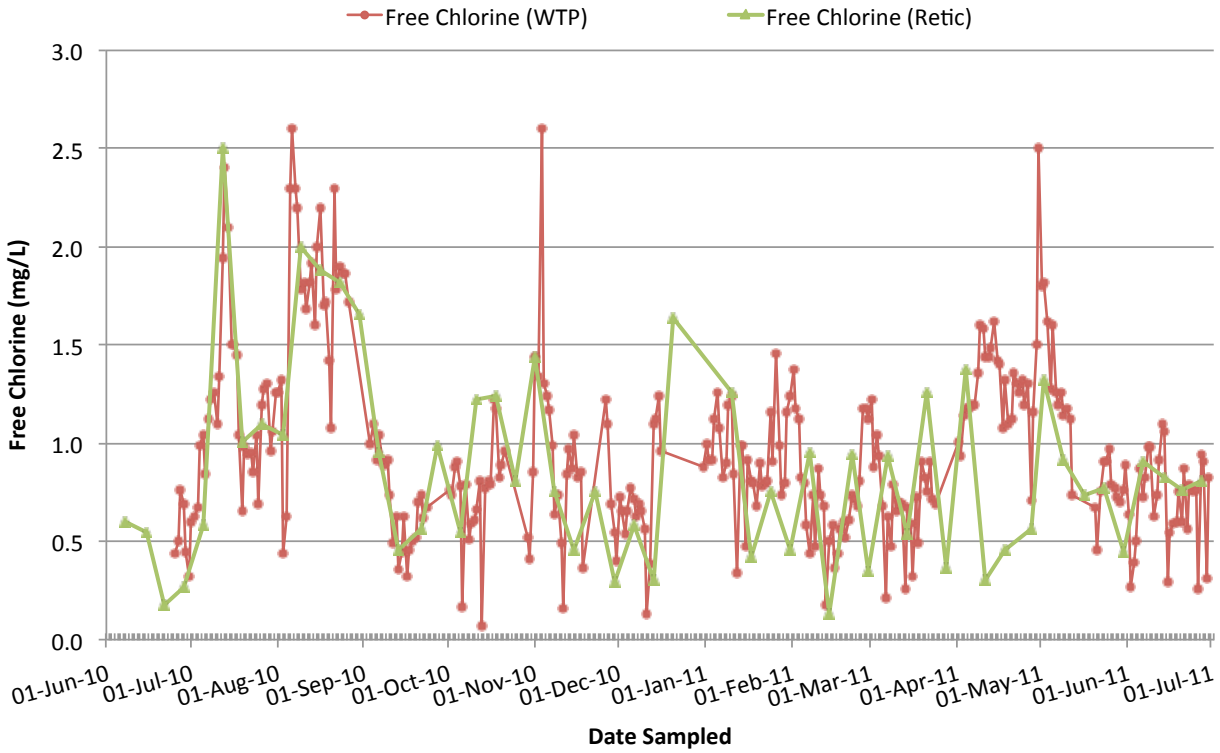
Central River water supply system



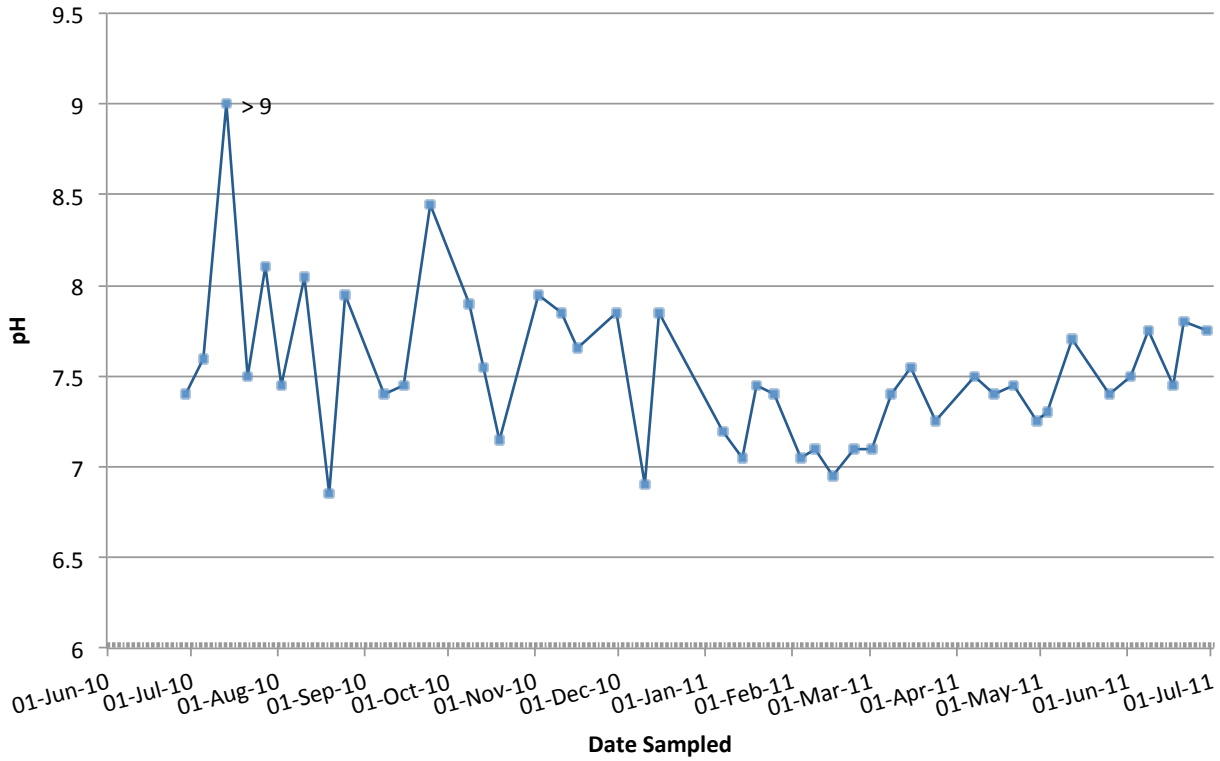
Central River raw water turbidity at the plant



Central River treated water turbidity at the plant and in the reticulation system

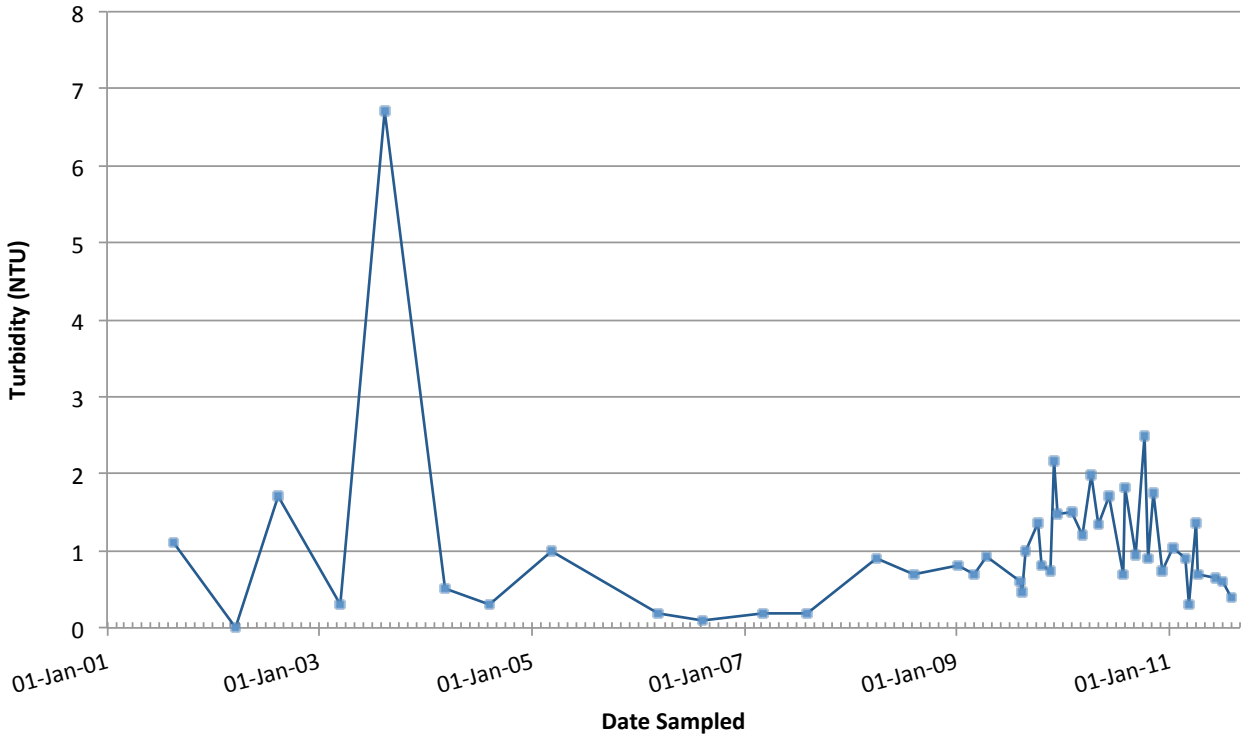


Central River treated water chlorine at the plant and in the reticulation system

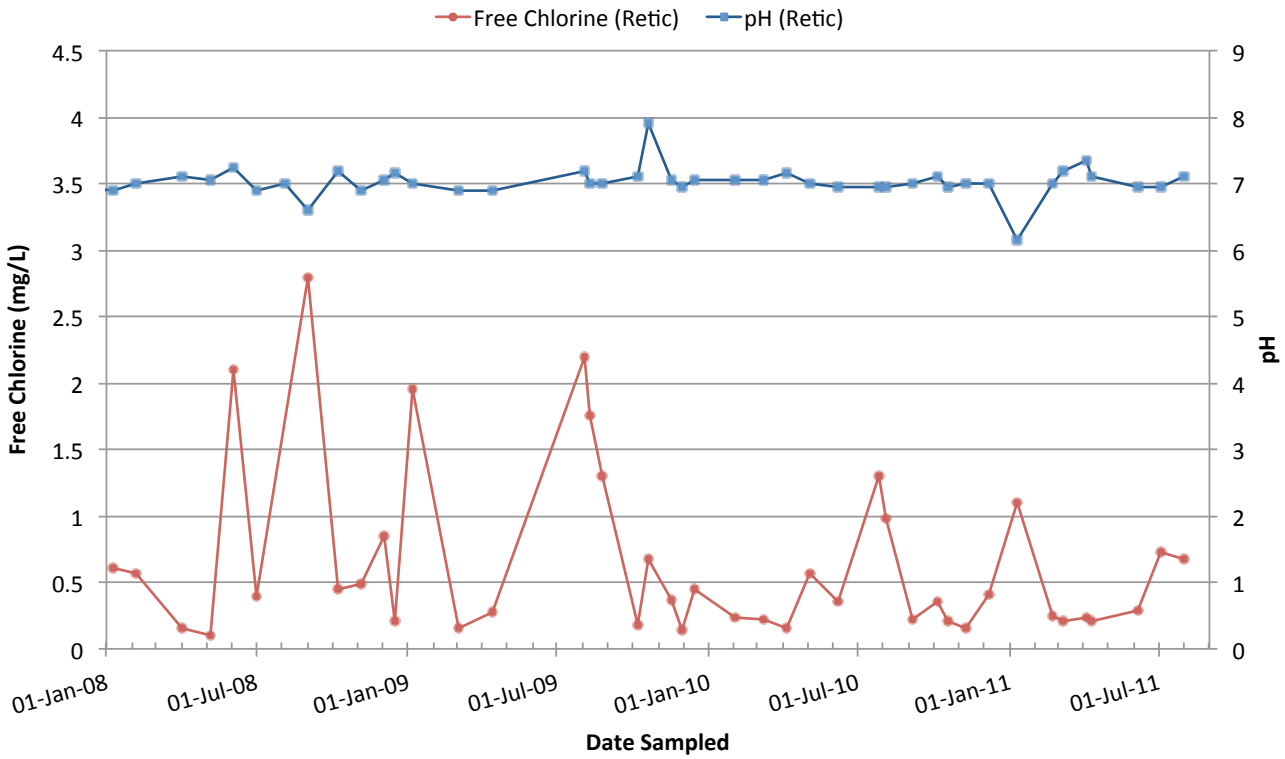


Central River filtered water pH at the plant

Little Bore water supply system



Little Bore treated water turbidity in the reticulation system



Little Bore treated water pH and chlorine in the reticulation system

APPENDIX B SUMMARY OF DRINKING WATER QUALITY RISK ASSESSMENT WORKSHOP

APPENDIX B-1. CENTRAL RIVER SYSTEM RISK ASSESSMENT WORKSHEET.

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
1	Central River Dam Catchment and Rivers	Pathogens from rural residential and agricultural faecal inputs reaching the abstraction point from the dam	Chlorine-resistant pathogens e.g. *Cryptosporidium*	- Limited work by CMA - Septic tanks are registered and inspected by Council - Residence time in the River and dams - Coagulation, clarification and filtration	Council (unless otherwise stated)	B	1	Moderate	B	3	High	There are calves and lambs free to access the tributaries and Central River dam, but not intensively grazed. Risk assessed as controlled given intensity is not high and plant is typically 0.3 to 0.4 NTU.	Check Health and Building on the septic safe program. Check how council controls new intensive developments, e.g. dairies, feedlots etc. Clarify the catchment zoning in the LEP. Possible: Fence dam to keep pre-weaned calves out: note agreement with landholder may preclude this.
2	Central River Dam Catchment and Rivers	Pathogens from rural residential and agricultural and birdlife faecal inputs reaching the abstraction point from the dam	Chlorine-sensitive pathogens e.g. Bacteria and Viruses	- Limited work by CMA - Septic tanks are registered and inspected by Council - Residence time in the River and dams - Coagulation, clarification and filtration - Chlorine	Council (unless otherwise stated)	A	1	Moderate	A	5	Very High	Wildlife is uncontrollable at the source	
3	Central River Dam Catchment and Rivers	Spills occurring in catchment on roads or on properties	Chemicals (various)	- Hazardous material controls on transport vehicles (state/national requirements) - Large storage - dilution - Can dose PAC - Could bring in backup supply pending a suitable risk assessment of that backup supply	Council (unless otherwise stated)	E	3	Moderate	E	4	High	There is a trunk road and some smaller roads in the catchment. The roads cross the creek and tributaries. This is inherently unlikely to occur. The risk was scored moderate due to the 3 score for consequence arising from the operational difficulties of responding.	Review notification procedures by first-responders to see how Council would find out.

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
4	Central River Dam Catchment and Rivers	Pesticides above ADWG health values in the raw water offtake from agricultural activity such as stock dips, horticulture	Pesticides	- Pesticides Act 1997 (OEH) - Landholders pesticide management actions - PAC could be used if there were a spill)	OEH	C	1	Low	C	1	Low	Annual pesticide test at The Meadows (d/s Lake Canobolas) and Fairbridge sample sites. Results have been < detection limit. Tests conducted by Hunter Water Australia.	Review targeting pesticide testing to peak application periods monthly baseline plus post rain events with Marnie or Gerard.
5	Central River Dam Catchment and Rivers	Nutrients that create adverse water quality downstream arising from landuse	Nutrients	- Destrat - PAC - CMA activities	Council (unless otherwise stated)	C	1	Low	C	3	High	The risk was assessed with consideration being given to algal blooms occurring.	
6	Central River Dam Catchment and Rivers	Storm events leading to elevated turbidity at the dam offtake	Turbidity	- Coagulation, clarification and filtration, detected from daily turbidity testing - Plant automatic shut down at 30 NTU from on line analyser - Jar testing and enhanced coagulation	Council	C	1	Low	C	4	Very High	The dam will short circuit during storms and runoff reaches the offtake with elevated turbidity	
7	Central River Dam	Cyanobacterial blooms leading to toxins above health-related guideline values at the dam offtake point	Cyanotoxins	- Destrat - Three offtake depths - CMA activities (upstream) - PAC (for most toxins) - Chlorination (for some toxins) - Filtration (if turn off pre-oxidation) - Use of alternate source pending risk assessment of the suitability of that source	Council (unless otherwise stated)	E	2	Low	C	5	Very High	The RACC is monitoring and reporting on the algae to monitor and manage the risk	Conduct a risk assessment of the alternate source option to establish the criteria for using this source if required
8	Central River Dam	Cyanobacterial or algal blooms leading to taste and odour compounds above aesthetic guideline values	MIB Geosmin Other	- Destrat - Three offtake depths - CMA activities (upstream) - PAC (for most toxins) - Use of alternate source if extreme pending risk assessment of the suitability of that source	Council (unless otherwise stated)	E	2	Low	C	2	Moderate	Aesthetic issues were not scored as high risks under this assessment	Conduct a risk assessment of the alternate source option to establish the criteria for using this source if required
9	Central River Dam	Turnover of reservoir leading elevated metals above aesthetic guideline values	Mn Fe	- Destrat system combined with weekly profiling (DO) - Three offtake depths - Pre-oxidation and filtration	Council	E	1	Low	B	3	High	Prior to the destrat system being in place this was an issue.	
10	Central River Dam	Elevated suspended solids outside of storm events	Turbidity		Council	E	1	Low	E	1	Low	Not observed	
11	Central River Dam	Malicious contamination	Various	- Dilution - Reservoir not subject to public access - 3 x per week inspection	Council	E	4	High	E	4	High	1 GL reservoir. Not at all likely but very costly and disruptive to follow up.	

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
12	Bulk raw water transfer	Risks to raw water customers	Various	- A special agreement is signed with council	Customer	E	1	Low	C	5	Very High	The main use appears to be stock and domestic only	Is there a need for a reminder in case of rented properties? Perhaps using the bill or some other means.
13	Bulk raw water transfer	Risks of backflow from raw water customers	Various	- The water is metered via backflow prevention	Customer	E	1	Low	D	3	Moderate		
14	Coagulant dosing	Under-dosing e.g. due to a change in water quality or set point not correct	Pathogens	- Drop testing to verify dose rates - Turbidity testing of raw water on line and manual used to adjust dosing - Jar testing used to inform dosing - Operator observations - Filter run times	Council	C	2	Moderate	B	3	High	Impacts are lower than total dose failure - this is about dosing being imperfect not zero	
15	Coagulant dosing	Over-dosing e.g. due to a change in water quality or set point not correct	PACl (Alchlor)	- Use of Alchlor rather than Alum - Drop testing to verify dose rates - Turbidity testing of raw water on line and manual used to adjust dosing - Jar testing used to inform dosing - Operator observations - Filter run times - Shut down upon excessive head loss	Council	C	2	Moderate	B	2	High	If this occurs the flow becomes too large and carries over into the filters. This is an operational issue. Pin flocs may arise. The raw water quality is fairly stable from the dam. This type of coagulant is of low health significance.	
16	Coagulant dosing	Complete loss of dosing due to various possible causes…pump failure, dosing line clogged	Pathogens	- Telemetry alarm on the pump run - Standby pump with manual changeover - Operator observation - Filter head loss leading to shut down	Council	D	3	Moderate	C	3	High	There is a duty and manual standby pump Such a failure mode is quite unlikely to affect customers and is more likely to clog the filter quite rapidly	
17	PAC dosing	Under-dosing leading to some contaminants getting through when the contaminants are present	Toxins and taste and odours	- Staff drink and use the water on a daily basis (informal) - Dosing adjusted to match how the water tastes and smells and based on toxin test results	Council	E	3	Moderate	C	3	High	Under-dosing would still provide some benefit. The uncertainty in this risk assessment is high.	

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
18	PAC dosing	Not dosing when required	Toxins and taste and odours	- Staff drink and use the water on a daily basis (informal) - Customer complaints - On going algae testing if observations reveal elevated green colouration - Destratification	Council	E	4	High	C	4	Very High		
19	PAC dosing	Dosing system does not operate, e.g. blocks up	Toxins and taste and odours	- Daily drop tests to compare dosing rates to planned rates. - Daily routine chemical checks.	Council	E	3	Moderate	E	4	High	The controlled risk is moderate since assessed based on operational impacts. The uncontrolled risk is assessed based on the health impacts.	
20	PAC dosing	Over-dosing	PAC	- In practice over-dosing is acceptable and normal operation - the dosing is designed to be ≥ the required amount - System has limited dosing rate		E	1	Low	E	1	Low	Trivial issue. Dialysis machines may become blocked by excess PAC.	Review whether or not dialysis patients might be present in the area and how they might be notified.
21	PAC dosing	Wrong type of PAC	Toxins and taste and odours	- Selection process for PAC								This risk is uncertain.	
22	LT20 dosing	Under-dosing & no dosing	Pathogens	- Drop testing to verify dose rates - Turbidity testing of raw water on line and manual used to adjust dosing - Jar testing used to inform dosing - Operator observations - Filter run times	Council	C	1	Low	B	2	High		
23	LT20 dosing	Over-dosing	LT20	- Drop testing to verify dose rates - Turbidity testing of raw water on line and manual used to adjust dosing - Jar testing used to inform dosing - Operator observations - Filter run times - Shut down upon excessive head loss	C	E	1	Low	D	2	Low		
24	Clarification	Failure to form a floc e.g. water too clean, strange chemistry	Pathogens	- Chemical dosing controls. - Jar testing. - Operator observation. - Upstream valve (sluice and automatic). - Filtration - Plant shutdown on high filter head	Council	E	3	Moderate	E	3	Moderate	Water chemistry is pretty stable	

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
25	Clarification	Loss of blanket from various causes e.g. due to over de-sludging	Pathogens	- Chemical dosing controls. - Jar testing. - Operator observation. - Upstream valve (sluice and automatic). - Filtration - Plant shutdown on high filter head	Council	D	2	Low	C	2	Moderate		
26	Clarification	Some solids carryover e.g. due to pin flocs	Pathogens	- Chemical dosing controls. - Jar testing. - Operator observation. - Upstream valve (sluice and automatic). - Filtration - Plant shutdown on high filter head	Council	B	1	Moderate	B	2	High		
27	Clarification	Rising blanket (above the launders) e.g. due to air, velocity, temperature or blocked sludge cones	Pathogens	- Chemical dosing controls. - Jar testing. - Operator observation. - Upstream valve (sluice and automatic). - Filtration - Plant shutdown on high filter head	Council	C	2	Moderate	B	2	High		
28	Pre-oxidation	Under-dosing (routine)	Slimes in filter	- Automatic changeover. - Operator checks daily.	Council	E	1	Low	E	1	Low		Review the need for this pre-oxidation, review the risk of disinfection by products. Consider DBP testing - available through NSW Health
29	Pre-oxidation	Under-dosing (manganese control)	Mn	- Automatic changeover. - Operator checks daily - Weekly Mn and DO testing.	Council	E	2	Low	E	2	Low		
30	Pre-oxidation	Over-dosing	Chlorine		Council	E	1	Low	E	1	Low		
31	Filtration	Failure to backwash e.g. due to problems getting water into the high level reservoir and lack of service water	Pathogens	- Three filters in parallel - Reservoir level 80%	Council	E	4	High	D	5	Very High	This would lead to breakthrough. No back up service water source. May not be able to restart plant.	Consider developing a contingency plan for this risk.
32	Filtration	Ineffective backwash	Pathogens	- Fully manual backwash - Trained operators.	Council	D	3	Moderate	A	4	Very High	Have the potential to remove the media. Chlorination give some control of chlorine sensitive pathogens	

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
33	Filtration	Breakthrough e.g. due to mud balls, problems with the underdrains or excessive run time. Loss of media	Pathogens	- Post filtration turbidity meter. - Operators observation, different operators so no complacency. - Topping up for media. - NOW Inspectors inspect the filters. - Hasn't been observed previously	Council	E	4	High	C	4	Very High		
34	Filtration	Birds and other contaminants into the filtered water channel	Pathogens	- Good housekeeping	Council	D	1	Low	D	1	Low	The filtered water channel is uncovered and open	
35	Disinfection	Failure of dosing	Pathogens	- Chlorine flow is alarmed. - Reservoir residual. - Chlorine gas, automatic changeover, residual analysis at Low Level, distribution main direct to reservoir. - Daily testing town. - Could spot dose with hypo if required.	Council	D	3	Moderate	D	5	Very High		
36	Disinfection	Under-dosing	Pathogens	- Chlorine flow is alarmed. Reservoir residual. Chlorine gas, automatic changeover, residual analysis at Low Level, distribution main direct to reservoir. - Daily testing town. - Could spot dose with hypo if required.	Council	E	3	Moderate	D	5	Very High	Stable water quality reduced the risk	
37	Disinfection	Over-dosing	Chlorine	- Operator observation - Residual monitoring	Council	D	1	Low	D	1	Low	No direct feed to customers. Consider contacting dialysis patients with very high feed	
38	pH correction	Under-dosing	Low pH (asset management)	- Daily testing - Drop tests	Council	E	1	Low	D	1	Low	Given the nature of the water. Assessed for drinking water safety (no asset maintenance)	
39	pH correction	Over-dosing Na2CO3	Loss of chlorine efficiency	- Daily testing. - Drop tests. - Separate inlet outlet reservoir (opposite sides). - Excellent contact time - Manual batching of soda-ash. - Pre-chlorination.	Council	E	1	Low	D	2	Low		
40	Plant Bypass	Raw water bypass of valve	Pathogens	- Manual sluice valve	Council	E	3	Moderate	D	5	Very High		Council to investigate to removing this valve or engineer this issue out.

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
41	Low level Res	Ingress of vermin faecal matter	Bacteria	- Good roofs, well sealed - Common inlet outlet - Annual cleaning and inspection (detailed reporting with WQ inspection)	Council	E	1	Low	D	3	Moderate		
42	Low level Res	Malicious contamination	Various	- Manproof fence - Hatch is locked	Council	E	3	Moderate	E	3	Moderate		
43	Low level Res	Access to reservoirs by unauthorised personnel	Various	- Manproof fence - Hatch is locked	Council	E	1	Low	E	3	Moderate		
44	Low level Res	Short circuiting - inadequate contact time	Pathogens	- Chlorine residual analyser - Offset separate inlet outlet - Minimum service level is 80%	Council	E	1	Low	D	3	Moderate		
45	High level res	Ingress of vermin faecal matter	Bacteria	- Good roofs, well sealed - Common inlet outlet - Annual cleaning and inspection (detailed reporting with WQ inspection)	Council	E	1	Low	D	3	Moderate		
46	High level res	Malicious contamination	Various	- Hatch is locked - Locked stairwell - On private land	Council	E	3	Moderate	E	3	Moderate		
47	High level res	Access to reservoirs by unauthorised personnel	Various	- Hatch is locked - Locked stairwell - On private land	Council	E	1	Low	E	3	Moderate		
48	High level res	Water age	Taste and odour, potentially pathogens	- Good chlorine residual, customer complaints (monitoring)	Council	E	1	Low	E	3	Moderate		
49	Distribution	Mains break or perforation leading to ingress	Pathogens	- Separate tools and sump pumped used on water repairs. - Mains are flushed after repair. - On-the-job training. - Good chlorine residuals	Council	D	2	Low	B	4	Very High		

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
50	Distribution	Backflow/cross connection leading to water contamination events	Various	- Backflow prevention devices on and Council high and medium risk facilities. - All residences have dual check valves. - Maintenance system in place for the sewage works and pump stations. - Currently working on the surveying and administration of other sites which is in the hands of the Councils health section. - Both reservoir fed systems (loss of head unlikely). - Break tank for the poultry farm.	Council - Health and Building	D	1	Low	C	3	High		Council's policy needs to be implemented.
51	Distribution	Dead end in reticulation systems leading to stagnation	Taste and odour	- Flushing programs		E	1	Low	D	2	Low		
52	Distribution	Use of fire hydrants stirring up the system and causing water quality incidents	Sediment	- Only one operator for water tankering. - Flushing program keeps solids low. - Chlorine residual keeps biofilm down		E	1	Low	C	2	Moderate		
53	Whole of Plant	Malicious contamination leading to water contamination	Various	- Security, locked access.	Council	E	5	High	E	5	High	5 is based on manpower to manage the situation and cost to rectify any damage/contamination.	
54	Whole of Plant	Power failure	Various	- 32 kVa generator - proposed to put generator into low level reservoir, plant will not 'run' without power.	Council	C	1	Low	C	1	Low	actions are based on asset preservation rather than water quality	
55	Whole of Plant	Failure of monitoring devices	Various	- Operator verification, calibration program	Council	C	3	High	B	3	High	Depends on which instrument failures	
56	Whole of Plant	Failure of telemetry system	Various	- Daily checks - Battery backup, can be run by a small generator	Council	D	2	Low	C	2	Moderate	Not had major problems	
57	Whole of Plant	Human error	Various	- Operator training and training program, documented procedures	Council	C	2	Moderate	B	5	Very High		
58	Whole of System (all council systems)	Chemical quality contamination	Various e.g. mono-acrylamide in LT20 or other hazard	- Procurement controls through stores system. - LT20 from Orange Council - Batched chemical used in jar tests	Council	E	3	Moderate	D	4	High		Check how this is controlled

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
59	Whole of System (all council systems)	Materials not fit for contact with water	Various	- Procurement controls through stores. - From water industry supplier.	Council	E	2	Low	D	3	Moderate		
60	Whole of System (all council systems)	Loss of trained operators and external services due to sickness or leave or leaving the sector, etc.	Various	- At present there are three trained operators council-wide. - Job satisfaction. - Inspectors from NOW training staff.	Council	C	5	Very High	A	5	Very High	This is an industry issue.	Improve documentation and automation in case of emergency backup operators are needed. Alliances with other operators. Multi-skilling within Council. Improve Council's recognition and value of staff.

APPENDIX B-2. LITTLE BORE RISK ASSESSMENT WORKSHEET.

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
1	Bore	Pathogens from rural residential and agricultural inputs due to surface water ingress	Protozoa Bacteria Viruses	- Bore head is above the flood height and is not flood prone. - Estimated at 70 m deep. - Chlorination downstream.	Council	D	3	Moderate	C	4	Very High	Location is in a rural-residential subdivision. New pump was dropped down in 1993.	Clarify if the source is confined. Clarify if we know the state of the bore casing.
2	Bore	Spills occurring in recharge area on roads or on properties	Chemicals (various)	- Bore head is above the flood height and is not flood prone. - Estimated at 70 m deep.	Council	E	2	Low	E	3	Moderate	No known chemical hazard sources of high significance.	
3	Bore	Elevated suspended solids	Turbidity	- Chlorine will help to precipitate iron	Council	C	2	Moderate	C	2	Moderate		
4	Disinfection	Under-dosing or no dosing	Pathogens	- Weekly inspections. - Duty standby gas with auto-changeover during the past 12 months.	Council	E	2	Low	D	3	Moderate	Stable subsurface water quality reduced the risk	New alarm systems is proposed and will be telemetered to pressure, levels and chlorine
5	Disinfection	Over-dosing	Chlorine	- Weekly inspections.	Council	D	1	Low	D	1	Low	No direct feed to customers. Consider contacting dialysis patients with very high feed	
6	Treated water storage	Ingress of vermin faecal matter	Bacteria	- Good roofs, well sealed - Top in, bottom outlet.	Council	E	1	Low	D	3	Moderate		
7	Treated water storage	Malicious contamination	Various	- Hatch is locked. Would need a ladder to get up to the tank top.	Council	E	3	Moderate	E	3	Moderate	Not routinely inspected.	
8	Treated water storage	Access to reservoirs by unauthorised personnel	Various	- Hatch is locked. Would need a ladder to get up to the tank top.	Council	E	1	Low	E	3	Moderate	Not routinely inspected.	
9	Treated water storage	Short circuiting - inadequate contact time	Pathogens	- Inlet spray nozzle into the reservoir so approximately a week of storage	Council	E	1	Low	D	2	Low		
10	Pressure tank											Not related to water quality - there would be positive pressure regardless of this unit.	
11	Distribution	Mains break or perforation leading to ingress	Pathogens	- Separate tools and sump pumped used on water repairs. - Mains are flushed after repair. - On-the-job training. - Good chlorine residuals - Mains are in road reserves.	Council	D	2	Low	B	4	Very High		

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
12	Distribution	Backflow/cross connection leading to water contamination events	Various	- Currently working on the surveying and administration of other sites which is in the hands of the Councils health section.	Council - Health and Building	C	2	Moderate	B	3	High	Stock troughs may be connected. Pressure loss possible during power loss.	Council's policy need to be implemented.
13	Distribution	Dead end in reticulation systems leading to stagnation	Taste and odour	- Flushing programs	Council	E	1	Low	D	2	Low		
14	Whole of Plant	Human error	Various	- Operator training and training program - Documented procedures	Council	D	2	Low	C	2	Moderate		
15	Whole of Plant	Power failure	Various	- Tanker water. - Could take out backup generator. - Several days of storage in the system.	Council	C	1	Low	C	1	Low		
16	Whole of Plant	Failure of telemetry monitoring devices	Various									- To be scored once the system is in place	