cwt WATER TREATMENT SPECIALISTS

Mendooran WTP Upgrades Concept Design

For Warrumbungle Shire Council

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Mendooran WTP Upgrades Concept Design

For Warrumbungle Shire Council

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Definitions

ADWG	**Australian Drinking Water Guidelines**
BF	Baffle Factor
CCP	Critical Control Point
Contractor	Term used interchangeably with *successful tenderer* to refer to the organisation responsible for delivery all components of work described in this document
CWT	City Water Technology
DBP	Disinfection By-Products
DOC	Dissolved Organic Carbon
DWMS	Drinking Water Management System
'Good Practice Guide'	Refers to *Good Practice Guide to the Operation of Drinking Water Supply Systems for the Management of Microbial Risk* (WSAA/WRA, 2015)
'Guidelines'	Refers to the *Australian Drinking Water Guidelines* (NHMRC, 2011)
HBT	Health Based Target
HBT Manual	Abbreviation for *Manual for the Application of Health-Based Treatment Targets* (WSAA, 2015).
$KMnO_4$	Potassium Permanganate
LRV	Log Reduction Value
'Manual'	Refers to the *Manual for the Application of Health-Based Treatment Targets* (WSAA, 2015)
Mn	Chemical symbol for manganese
NaOCl	Sodium Hypochlorite
NTU	Nephelometric Turbidity Unit
PACl	Polyaluminium Chloride
PHA	Preliminary Hazard Assessment
PFD	Process Flow Diagram
RTU	Remote Terminal Unit
Sedimentation Lagoon	Existing sedimentation lagoons No.1 and 2
Wastewater Lagoon	Existing sedimentation lagoons No.1 and 2 repurposed into wastewater lagoons. This is associated with installation of a clarifier.

Tenderer	Organisation presenting a bid for the Design and Construct Contract for Mendooran WTP upgrades
THM	Trihalomethanes
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
T&O	Tastes & Odours; often due to the presence of algae
UPS	Uninterruptable Power Supply
UVT	UV Transmissivity (units: %)
VSD	Variable Speed Drive
WHS	Work Health and Safety (previously OHS Occupational Health and Safety)
WSAA	Water Services Association of Australia; authors of the *Manual for the Application of Health-Based Treatment Targets* (2015) and co-author of *Good Practice Guide to the Operation of Drinking Water Supply Systems for the Management of Microbial Risk* (2015)
WRA	Water Research Australia; co-author of *Good Practice Guide to the Operation of Drinking Water Supply Systems for the Management of Microbial Risk* (2015)
WSC	Warrumbungle Shire Council
WSS	Water Supply System/ Scheme
WTP	Water Treatment Plant
WQ	Water Quality

1 Introduction

1.1 Background

CWT were engaged by Warrumbungle Shire Council (WSC) to assess options and design upgrades for the Mendooran Water Treatment Plant (WTP) and reticulation.

The existing Mendooran WTP supplies treated water to the Mendooran and Coolabah areas. Mendooran WTP was constructed in 2009 and has a capacity of ~1.0 ML/day.

In 2015, City Water Technology (CWT) was engaged by NSW Health to offer support to numerous utilities for WTP process review. CWT visited Mendooran WTP and in May 2015 submitted an audit report. Several recommendations were provided in the *WSC742-02-A Mendooran WTP Audit Report*, of which many issues remain unresolved.

Up until 2019, several other incident investigations and site inspections were performed, noting several process deficiencies, water quality issues and work health and safety concerns. Between April 2017 and June 2017 *E. Coli* was also detected in the reticulation and led to a boil water notice being issued to the Mendooran and Coolabah customers.

Water security in the region is also an issue for concern; in November 2019 Mendooran was placed on Level 2 restrictions, Level 3 in December 2018, then Level 5 and 6 in Jan 2019.

In May 2020 CWT (Jess Circosta, Christina Saxvik) facilitated a preliminary hazard assessment (PHA) by teleconference with WSC (Cornelia Wiebels, Andrew Milford and Stephen Drew). The purpose of the PHA was to ensure that packages of works identified in Council's Brief were sufficient to mitigate known process deficiencies, water quality issues and work health and safety concerns. However, from the PHA, CWT's recent site visit and other investigations (see Section 1.2), CWT identified the need for additional works.

These works, together with those described in Council's Brief shall be address further by this concept design.

1.2 Reference Documents and Supporting Evidence

Previous projects have been facilitated by Council in an effort to identify and mitigate issues to operability and safety, treatability, current and future water quality.

Table 1-1 provides a summary of reference documents and supporting evidence used for the development of this concept design.

Table 1-1: Documentation References

Report Title	Author	Year	Description
Mendooran Water Treatment Plant – Operation of Equipment Manual	Water Treatment Australia	2010	Operations manual and control philosophy of the Mendooran WTP. WTA's scope of works included the "Filtration Plant" and "Chemical Dosing". This document was intended as a guide for YORECON to develop their detailed functional description.
Mendooran WTP Audit Report	Hunter Water Australia/ Lower Macquarie Water Utilities Alliance	2014	This report documented several WTP deficiencies, including the information systems for the WTP, the overall process, safety and security.

Report Title	Author	Year	Description
ASAM Project Management System Report	ASAM RT	2014	Several reservoir integrity issues were highlighted in this report. This report mainly highlighted issues with entry hatches and reservoir sealing.
WSC742-02-A Mendooran WTP Audit Report	City Water Technology (CWT)	2015	CWT was engaged by NSW Health to offer support to numerous utilities in the areas of water treatment process review, assistance with plant optimisation and development of operator procedures. CWT visited Mendooran WTP on March 4, 2015 to evaluate the plant and take note of any issues as seen by operators and supervisory staff.
Mendooran Site Inspection and DWQMP Implementation Update	Hunter H_2O	2017	The purpose of the report was the following: 1. Discuss Hunter H_2O's site visit findings and recommendations. 2. Document findings regarding the treated water turbidity issue and chlorine dosing system issues. 3. Discuss the feasibility, benefits, and issues of taking the existing standpipe reservoir offline. 4. Assess status of the WTP against the DWQMP implementation action plan. 5. Document the training and advice provided to operational staff during the site visit. 6. Provide Standard Operating Procedures (SOPs) for turbidity, pH and chlorine measurements and daily monitoring.
Water Quality Incident Review	Hunter H_2O	2017	Hunter H_2O (HH2O) was engaged by NSW Health, on the 11th of August 2017, to assist in responding to biological contamination of a section of the Mendooran area drinking water supply. This report includes the incident investigation and debrief workshop details, collected data, event timeline and documentation of recommend actions to reduce the likelihood of this type of incident occurring again in the future.
WEARS Reservoir Inspection Report	WEARS	2017-18	After a request by Council to investigate and inspect the reservoir at Cobra Street Mendooran, WEARS reservoir specialist attended site and conducted an internal and external inspection. Further inspection and cleans were carried out at Coolabah 1, 2 & 3 Reservoir. Similar issues, as the Mendooran Standpipe, were observed at Coolabah Reservoirs.
Mendooran WTP Filter Inspection Report	Hunter H_2O	2018	NSW Health engaged Hunter H_2O, on behalf of WSC, to perform a filter inspection to assess the existing condition and performance of the Mendooran WTP filters. The project evaluated current filtration operations, backwash flow rate and backwash water quality, considering the need to replace filter media.

Report Title	Author	Year	Description
Mendooran WTP Remote Alarming Report	Hunter H_2O	2018	Warrumbungle Shire Council (WSC) via NSW Health engaged Hunter H_2O to inspect the WTP control system and provide further advice and recommendations on the required alarm dialler system, as there was no remote alarming at the WTP.
Mendooran Reservoir Upgrade Report 2019	WEARS	2019	Several reservoir integrity issues were addressed in this report, mainly on entry hatches and reservoir sealing. Additional issues were highlighted in this report, including access structures and reservoir mixing.
WIS – Mendooran – Cobra Street – Visual Inspection	Water Infrastructure Services	2019	This report highlighted any defects and inherent risks associated with the operations and maintenance of the Mendooran Standpipe Reservoir.
Mendooran WTP Emergency Ops Support Report April 2019	Hunter H_2O	2019	Hunter H_2O was engaged by NSW Health and WSC to provide emergency operational support to Mendooran WTP. The purpose of the operational support visit was to identify possible solutions to algae issues and determine if it is possible to increase the current operational capacity. Representatives from WSC, Hunter H_2O, Department of Industry Water and NSW Health attended the site and discussed the current situation and identify pathways to removing water restrictions while preventing algal blooms in the sedimentation lagoons.
Mendooran WTP Site Constraint and Hazard Review Report	City Water Technology (CWT)	2019	CWT was engaged by Warrumbungle Shire Council (WSC) to assess options for upgrades at Mendooran Water Treatment Plant (WTP) and to develop a concept design and technical specification for several upgrade packages. The purpose of this report was to summarise the process issues identified during the site visit conducted by City Water Technology (CWT) on November 14th, 2019. This report provides the background information needed to develop the proposed upgrade options for the WTP, which will be described in the WMA1334-03-REP Mendooran Design Basis and Options Assessment Report.
Mendooran WTP Design Basis and Options Assessment Report	City Water Technology (CWT)	2019	CWT was engaged by Warrumbungle Shire Council (WSC) to assess options for upgrades at Mendooran Water Treatment Plant (WTP) and to develop a concept design and technical specification for several upgrade packages. The purpose of this report was to help address process issues identified in the WMA1334-02-REP Mendooran WTP Site Constraint and Preliminary Hazard Review Report by listing the upgrade options available. This report also provides a design basis that will be used in the development of the WTP upgrade concept designs.
Mendooran WTP	City Water Technology (CWT)	2020	CWT was engaged by Warrumbungle Shire Council (WSC) to assess options for upgrades at Mendooran Water Treatment

Report Title	Author	Year	Description
Project Risk Management Plan			Plant (WTP) and to develop a concept design and technical specification for several upgrade packages. The purpose of the Project Risk Management Plan (PRMP) was to document findings captured in the Preliminary Hazard Analysis (PHA) and set out a road map to address known and newly identified issues.
Warrumbungle Shire Council WTP Automation and Process Instrumentation Audit	HunterH_2O	2020	HunterH_2O was engaged by WSC to undertake a WTP automation and process instrumentation audit scoping study. The objective of the study was to identify key requirements to improve WTP instrumentation, monitoring and automation at four conventional WTPs and four bore WTPs in the Warrumbungle Shire Council area.

1.3 Objectives

The purpose of this report is to provide a Concept Design for upgrades for the Mendooran WTP and reticulation. The recommended upgrades have been identified, rationalised, and supported by:

- Council's Project Brief
- An extensive review of previous investigations (summarised in Table 1-1)
- WMA1334-04-REP Mendooran WTP Design Basis and Options Assessment Report (CWT, 2019)
- WMA1334-02-REP Mendooran WTP Site Constraint and Hazard Review Report (CWT, 2019).
- WMA1334-08-REP Mendooran WTP Project Risk Management Plan (CWT, 2020).

The scope of works is defined in Section 3 of this report.

The objectives of this Concept Design are to:

- Define the scope of works, provisions and limits and design considerations for the preferred options.
- Ensure the Concept Design makes provisions for:
  - Adopting a multi-barrier treatment approach;
  - Meeting water quality objectives in accordance with the:
    - Australian Drinking Water Guidelines (the 'Guidelines'; NHMRC, 2011); and
    - Manual for the Application of Health-Based Treatment Targets (the 'HBT Manual'; WSAA, 2015).
  - Meeting operational objectives in accordance with the:
    - Good Practice Guide to the Operation of Drinking Water Supply Systems for the Management of Microbial Risk, Second Edition ('Good Practice Guide'; WSAA/WRA, 2020).
- Design for ease of operability with reasonable levels of automation to reduce reliance on operator/manual intervention.

1.4 Further Investigation

This Concept Design has been established based on data made available as of December 2019.

Additional data is recommended to further support this concept design and to be made available prior to the tendering phase.

This includes but is not limited to:

- Ongoing raw water quality monitoring from the various raw water sources to provide confidence in the selection and sizing of chemical dosing systems.
- Jar testing of raw water quality to provide confidence for the selection of dosed chemicals and their dose ranges.
- Geotechnical surveying for the purposes of an installation of a new Clarifier and/or extension of existing Sludge Lagoons etc.
- Condition assessments and/or pressure testing of reticulation pipework extending from the Mendooran Standpipe. Integration of the Mendooran Standpipe booster pumps would increase reticulation supply pressure. Testing should be performed to help prevent future pipe ruptures.

2 Existing System

The township of Mendooran forms part of the Warrumbungle Shire Council (WSC) local government area. Mendooran is a town located approximately 71 km south of Coonabarabran and 66 km north east of Dubbo in the central western area of New South Wales. Mendooran WTP was constructed in 2009. The WTP uses conventional treatment processes including coagulation, flocculation and sedimentation, followed by filtration and chlorine disinfection.

2.1 Demand

Mendooran WTP was designed with a maximum design flowrate of ~1 ML/d. The maximum design instantaneous flow rate is 14.5 L/s based on a 22-hour operational day.

Actual demand is much lower than 1 ML/d; according to the treated water demand data supplied by WSC, the maximum monthly water demand was recorded in January 2018 with a value of 9,283 kL corresponding to a daily average of ~300 kL/day. The maximum daily demand was recorded on December 28, 2017 with a value of 707 kL/day.

A more detailed discussion on WTP design capacity for the upgrade works is provided in Section 4.2.2.

2.2 Catchment

Major uses of the land surrounding Mendooran WTP are agricultural, with considerable farming activities, fertiliser application, and possible cattle access to the waterway. In the past, concerns were raised over possible septic contamination of the backup bores and aquifer from irresponsible septic waste disposal. It was also reported that the water level in the backup river bore increased by 2 m during heavy rainfall and is impacted when irrigators use ground water in the area.

This means that the sources supplying the WTP could be connected to surface hydrology and could be at risk of contamination from human and agriculture activity. According to the HBT Manual (2015), raw water sources as such belong to a Category 4 catchment. Category 4 catchments are characterised as unprotected catchments with no exclusion zone, public access to the inner catchment and waterbody, the presence of septic or sewage treatment plants and/or intensive stock, dairy or feedlots.

2.3 Start/ Stop Control of Plant and Flow Balancing

The start/ stop operation of the plant operates in a cascade arrangement as follows:

- A low level setpoint signal from any of the reservoirs calls the treated water pumps to start.
- A low level setpoint signal from the Clear Water Tank calls the Filter Feed Pumps (also known as the Low Lift Pumps) to start.
- A low level in the Filter Feed pumping station calls the raw water pumps to start pumping.
- Raw water pumps will start and stop based on the 'start' and 'stop' level setpoints in the Filter Feed pumping station.
- Similarly, the Filter Feed Pumps will start and stop based on the 'start' and 'stop' level setpoints in the Clear Water Tank (HunterH$_2$o, 2020).

The raw water pumps and Filter Feed Pumps are both fixed speed and flow balancing can be problematic. The plant operates in a batch type operation unless flowrates are aligned via the use of manual valve adjustments (HunterH$_2$o, 2020).

Plant raw water flowrate and settled water flowrate (filtered water flowrate) is set via manual valves (HunterH₂o, 2020).

Treated water is preferentially supplied to the Mendooran Standpipe until the high level setpoint is reached, upon which a control valve closes and thus directs treated water to the Coolabah reservoirs. A high level in the Coolabah reservoirs triggers the treated water pumps to stop (HunterH₂o, 2020).

2.4 Raw Water Extraction

Mendooran WTP can draw water from several sources, which include the following:

- *Castlereagh Riverbed*: Two submersible pumps (duty/standby) located in a pump well, supplied by intake screens located underneath the Castlereagh Riverbed.
  - These pumps feed a DN150 rising main, pumping water to the WTP approximately 850 m away.
  - Based on the results of the site visit, the ground surface water appeared stagnant with minimal river water flow at the extraction point. However, there is reportedly an under-river drift channel that continues to supply water to the raw water pumps.
  - According to the "Conceptual Hydraulic Profile (Work as Executed)" drawing #0700910-04, the raw water pumps operate at 14.5 L/s.
  - Based on review of the provided P&IDs, it is assumed that these pumps are not VSD controlled.
- *Backup bore*: A 25 m deep back-up bore reportedly 20 m from the riverbed. The backup bore pipework is connected to the WTP rising main.
  - Based on review of the provided P&IDs, it is been assumed that their design flow rate is 4 L/s. WSC has indicated that they expect that this flowrate is higher than 4 L/s, therefore the flowrate is to be reported as '>4 L/s' further in this report. Although the P&IDs indicate VSD control, Council has reported that this supply operates at fixed flow and does not contain VSDs.
- *Emergency onsite bore*: An onsite WTP bore, which is intended for use in emergency.
  - It was reported by Council that this bore can only provide a fixed raw water flow rate of 0.8 L/s to the WTP. For a 22-hour operational day, this equates to 0.06 ML/d.
  - This water is pumped directly to the inlet of the cascade aerator and is not connected to the WTP main.
- *Old river pump station*: This pump station was the previous raw water supply for the town but was taken offline once the WTP was built. Council applied for funding to install a pipeline between the pump station and the existing rising main into the WTP. This work has now been completed and there are reportedly two operable 6" submersible pumps with VSDs in the riverbank well. This supply is missing process control implementation; however, this is soon to be commissioned by another contractor.

Table 2-1 summarises data on the available raw water sources.

Table 2-1: Mendooran WTP Raw Water Storages

Raw water Source	Pump configuration	Duty (L/s, kL/h)	Fixed or Variable flow
Castlereagh Riverbed	2 × duty/standby	14.5, 52.2	Fixed
Backup Bore	1 × duty	>4.0, >14.4	Fixed
Emergency Onsite Bore	1 × duty	0.8, 2.88	Fixed

Raw water Source	Pump configuration	Duty (L/s, kL/h)	Fixed or Variable flow
Old River Pump Station	2 × duty/standby	12-14.5, 43.2-52.2	Variable Flow

2.5 Water Treatment Plant and Reticulation

Table 2-2 provides a process description of the existing Mendooran WTP and reticulations.

Table 2-2: Mendooran WTP Process Description

Process	Process Description
General	• The township of Mendooran forms part of the Warrumbungle Shire Council (WSC) local government area. Mendooran is located approximately 71 km south of Coonabarabran and 66 km north east of Dubbo, NSW. • Mendooran WTP was constructed in 2009. • The WTP uses conventional treatment processes including coagulation, flocculation and sedimentation, followed by filtration and chlorine disinfection. • Mendooran WTP was designed with a maximum design flowrate of ~1 ML/d. • Major uses of the land surrounding Mendooran WTP are agricultural, with considerable farming activities, fertiliser application, and possible cattle access to the waterway. There are septic systems located within the catchment site. Therefore, the catchment is characteristic of a catchment category 4 – unprotected catchment.
Water Treatment Plant Process	The current treatment process is as follows: • Raw water enters the Mendooran WTP site and is received at a Cascade Aerator. • Potassium permanganate ($KMnO_4$) is dosed at the top of the Cascade Aerator stairway to promote manganese and iron oxidation. • Polyaluminium chloride (PACl) is also dosed at the top of the Cascade Aerator stairway for coagulation. • The Cascade Aerator promotes mechanical oxidation of manganese and iron. • A baffled Flocculation Tank is located at the base of the Cascade Aerator to promote mixing. • Water flows by gravity to the Sedimentation Lagoons (duty/standby arrangement) which offer some hydraulic retention time and sedimentation. • Water flows by gravity to the Low Lift Pump wells, where water is then pumped to the Filters by the Low Lift Pumps (duty/standby). • Water is filtered using 2 dual media (coal/sand) open gravity Filters. • Disinfection is achieved by dosing sodium hypochlorite (NaOCl). • Clear water is stored at the Clear Water Tank which supplies the demands of the reticulation via duty/standby High Lift Pumps. • Offline systems include:

Process	Process Description
	○ Soda Ash Dosing System for pH control and Fluoride Dosing System. They are present but these systems are not in use. The Soda Ash Dosing System has been used for spare parts. The Fluoride Dosing System requires redesign and recommissioning. A separate contractor is engaged by Council to re-design the Fluoride Dosing System.
Reservoirs and Reticulation	• Treated water from the Clear Water Tank is transferred via the High Lift Pumps to a dedicated pipe feeding the reservoir system. ○ The reticulation contains 4 reservoirs with a combined capacity of 1.06 ML. ○ The Mendooran Standpipe Reservoir is located on the corner of Brambil St and Cobra St and has a capacity of 0.55 ML. ○ There are 3 reservoirs located in the Coolabah reticulation zone on Manusu Drive, which are Coolabah Reservoirs No. 1, 2 and 3. These have a capacity of 0.09, 0.09 and 0.33 ML respectively. ○ The Coolabah Reservoirs have a top water level elevation higher than the Mendooran Standpipe Reservoir. • The Coolabah Reservoir site has a sodium hypochlorite Booster Chlorination System on the common inlet/outlet water main.

2.6 Water Quality Statistical Analysis

2.6.1 Raw Water Quality Data

As reported in the HunterH₂o *Mendooran WTP Filter Service "15 Point Check" Report*, the plant data prior to June 2017 does not appear to be reliable due to inconsistencies with recorded filtered turbidity data and the poor condition of the WTP. To enable meaningful data analysis, only the data after June 2017 has been considered.

Based on discussion with operations staff and the provided plant monitoring data, the following assumptions have been made for the *river water pumps* and *backup bore* data sets:

- All raw water data before 21/12/2018 corresponds to water from the river water pump station. This is assumed as the monitoring data does not provide comment as to whether "bore" or "river" water is used.
- Monitoring data from 21/12/2018 until 29/08/19 indicates which raw water source, between the river water pump station and the backup river bore, was used.
- Monitoring data after 29/08/19 does not indicate which source is used. The operations team has indicated that the backup river bore was in use until 22/10/19. Council has commented that the backup bore has continued to be the primary source beyond this date.

The data for the *Emergency Onsite Bore* was analysed by an external laboratory and reported in the *Warrumbungle Shire Council Water Quality Database* spreadsheet. Three samples were dated between 23/08/2017 and 25/08/2017, and a fourth sample was dated 26/11/2019.

- The data for the *Old River Pump Station* is a combination of NSW Health recorded data, and on-site testing performed by Hunter H_2O and operational monitoring undertaken by Council.

- Table 2-3 provides a statistical summary of the raw water quality data provided to date. The data has been summarised using the Mendooran daily operational monitoring data, unless otherwise stated in the commentary.

Table 2-3: Mendooran WTP operating data

Source	Parameter (unit)	Min	5th%ile	Average	95th%ile	Max	Count	Source
River Water Pumps	Temperature (°C)	14	14	17	19	19	10	[1]
	pH	6.1	6.7	7.3	7.8	8.4	614	[1]
	Turbidity (NTU)	0.2	0.7	7.3	19.5	61.5	613	[1]
	Total iron (mg/L)	0.04	0.09	4.30	12.26	14.50	44	[1]
	Total manganese (mg/L)	0.16	0.17	1.68	3.62	6.01	56	[1]
	Total phosphorus (mg/L)	0.027	0.027	0.027	0.027	0.027	1	[1]
Back-Up Bore	Temperature (°C)	0	1	3	11	32	197	[1]
	pH	6.5	6.6	6.9	7.6	8.0	197	[1]
	Turbidity (NTU)	0.20	0.76	3.42	10.50	32.10	197	[1]
	True colour (HU)	1	1	3	5	5	2	[1]
	Total iron (mg/L)	0.03	0.03	0.06	0.14	0.16	7	[1]
	Total manganese (mg/L)	0.53	0.58	0.78	1.20	1.39	7	[1]
	Total aluminium (mg/L)	0.01	0.01	0.01	0.01	0.01	1	[1]
	Total phosphorus (mg/L)	0.15	0.15	0.19	0.23	0.23	2	[2]
	Total hardness (mg/L)	117	125	199	272	280	2	[1]
Emergency Bore	pH	6.9	6.9	6.9	7.1	7.0	4	[3]
	Conductivity (µS/cm)	677	724	919	1009	1010	4	[3]
	Turbidity (NTU)	2.3	2.5	4.0	5.4	5.6	2	[3]
	True colour (HU)	1	1	3	4	4	2	[3]
	Total alkalinity (mg/L)	397	404	462	507	508	4	[3]
	Total iron (mg/L)	0.66	0.87	2.73	4.59	4.80	2	[3]
	Total manganese (mg/L)	0.05	0.06	0.16	0.26	0.27	2	[3]
	Total aluminium (mg/L)	0.01	0.01	0.02	0.03	0.03	2	[3]
	Total hardness (mg/L)	96	96	101	105	105	2	[3]
	E.Coli (MPN/100 mL)	1	1	1	1	1	1	[3]
	Total coliforms (MPN/100 mL)	1	1	1	1	1	1	[3]
O – τ	Calcium (mg/L)	80.7	80.7	80.7	80.7	80.7	1	[4]

Source	Parameter (unit)	Min	5th%ile	Average	95th%ile	Max	Count	Source
	Chloride (mg/L)	353	353	353	353	353	1	[4]
	DOC (mg/L)	91.8	91.8	91.8	91.8	91.8	1	[4]
	Iron (mg/L)	0.01	0.04	0.27	0.50	0.53	2	[4]
	Magnesium (mg/L)	62.60	62.60	62.60	62.60	62.60	1	[4]
	Manganese (mg/L)	0.280	0.282	0.304	0.326	0.328	2	[4]
	Phosphorus (mg/L)	0.20	0.20	0.20	0.20	0.20	1	[4]
	Sodium (mg/L)	388	388	388	388	388	1	[4]
	TDS (mg/L)	1,336	1,336.0	1336.0	1336.0	1336.0	1	[4]
	Total Hardness (mg/L)	459.30	459.30	459.30	459.30	459.30	1	[4]
	True Colour (HU)	1	1	1	1	1	1	[4]
	Uranium (mg/L)	0.017	0.017	0.017	0.017	0.017	1	[4]

References:

[1] *Mendooran operational monitoring v2.0* Spreadsheet (01/06/2017 to 10/10/2019)

[2] Hunter H_2O *Mendooran WTP Emergency Ops Support Report* (April 2019) (19/02/2019 to 20/02/2019).

[3] External Laboratory, recorded in *Warrumbungle Shire Council Water Quality Database* spreadsheet (23/8/2017 to 25/08/2017, and 26/11/2019)

[4] Combined data from the Hunter H_2O *Mendooran WTP Emergency Ops Support Report* (April 2019), which includes an NSW Health data summary (19/02/2019 to 20/02/2019), and *Mendooran Operational Monitoring* (01/06/2017 to 10/10/2019)

2.6.2 Settled and Filtered Water Quality

Table 2-4 provides a summary on several water quality parameters measured at various WTP stages by WSC operations staff. This includes samples taken from the raw, settled, filtered, and treated (clear water tank) water.

Table 2-4: Statistical Summary of Inter-Process Water Quality Data (Jun 2017 – Oct 2019)

	Location of Monitoring	Min	5th%ile	Average	95th%ile	Max	Count
Turbidity (NTU)	Raw Water	0.2	0.7	6.4	18.8	61.5	810
	Settled Water	0.11	0.34	1.03	2.23	9.93	836
	Filter 1	0.09	0.12	0.22	0.37	0.83	663
	Filter 2	0.07	0.12	0.21	0.36	0.68	655
	Combined Filtered Water	0.09	0.14	0.28	0.42	6.87	834
	Filtered Water - Online	0.03	0.04	0.15	0.36	0.69	667
	Treated Water	0.03	0.13	0.31	0.47	8.60	840
pH	Raw Water	6.1	6.7	7.2	7.8	8.4	811
	Settled Water	6.7	7.4	7.8	8.3	8.5	841

	Location of Monitoring	Min	5th%ile	Average	95th%ile	Max	Count
	Filtered Water	6.9	7.5	7.9	8.3	8.8	838
	Treated Water	6.4	7.6	8.0	8.4	8.5	845
Mn (mg/L)	Raw Water	0.2	0.2	1.6	3.5	6.0	63
	Settled Water	0.01	0.07	0.35	0.73	1.49	38
	Treated Water	0.001	0.003	0.038	0.200	0.222	48
Iron (mg/L)	Raw Water	0.03	0.04	3.72	11.70	14.50	51
	Settled Water	0.001	0.001	0.005	0.012	0.013	4
	Treated Water	0.001	0.003	0.099	0.298	0.610	34

2.6.3 Sedimentation Lagoon Performance

- On 09/05/2019, a sample taken from the Sedimentation Lagoons and analysed by Sydney Water Laboratory Services. The results showed a total microcystin-LR (mainly intracellular) reading of 11 µg/L. The ADWG limit is 1.32 µg/L for total microcystin-LR, which means that the level of microcystin-LR in the Mendooran Sedimentation Lagoons was nearly 750% greater than the AWDG health limit.
- Microcystins can cause damage to the liver and are possibly carcinogenic. Microcystins are extremely stable chemically and remain potent even after boiling.

2.7 Process Flow Diagram

A process flow diagram of the existing Mendooran WTP and reticulations is given in Figure 2-1.

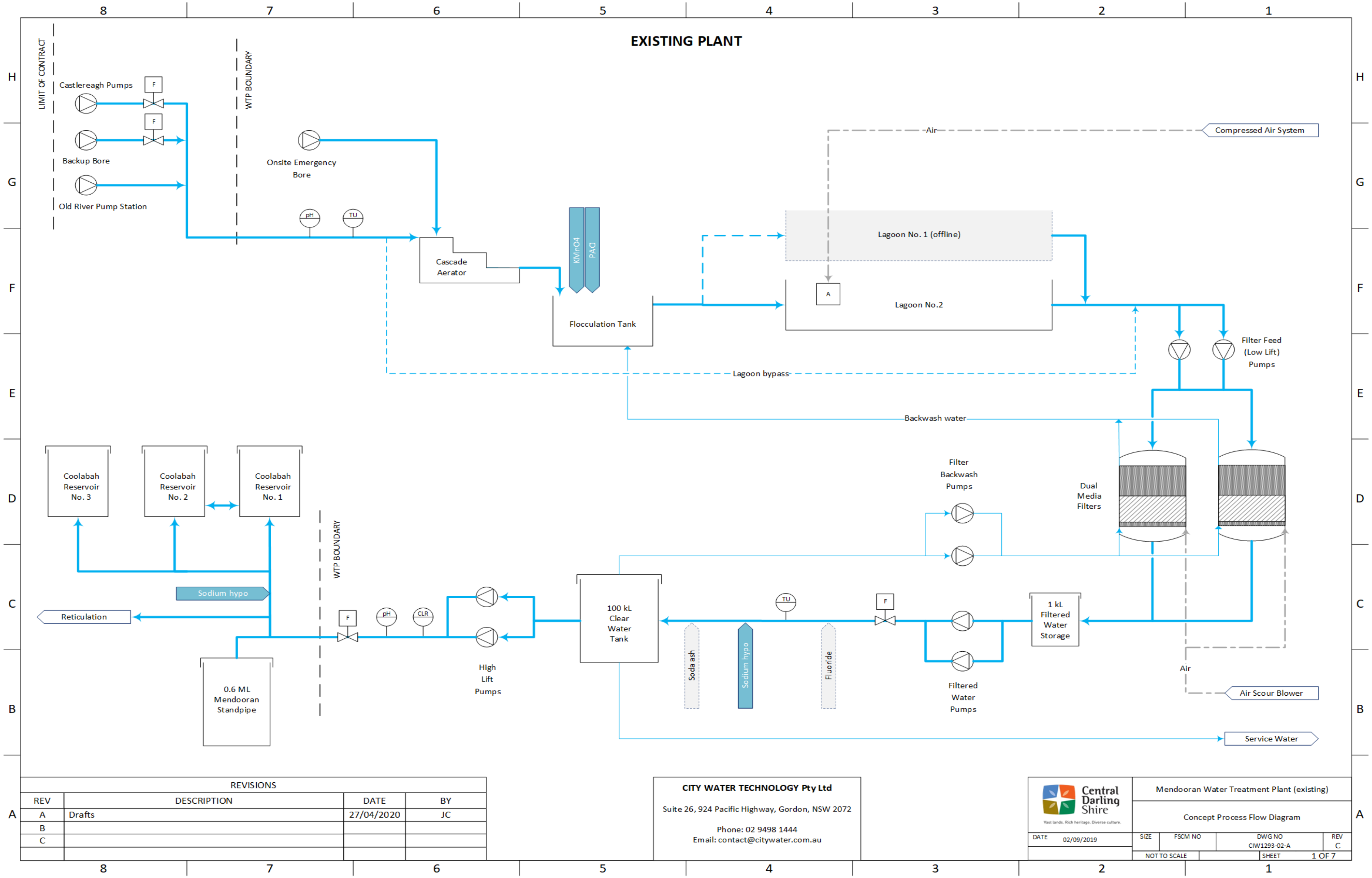

Figure 2-1 Existing Mendooran WTP and Reticulation

3 Project Scope

3.1 Scope of Works Overview

The scope of works for upgrades for the Mendooran WTP and reticulation have been identified, rationalised and supported by:

- Council's Project Brief
- An extensive review of previous investigations (summarised in Table 1-1)
- WMA1334-04-REP Mendooran WTP Design Basis and Options Assessment Report (CWT, 2019)
- WMA1334-02-REP Mendooran WTP Site Constraint and Hazard Review Report (CWT, 2019)
- WMA1334-08-REP Mendooran WTP Project Risk Management Plan (CWT, 2020).

3.1.1 Project Timing

- The scope of works is divided into two categories and are likely to be carried out at different stages:
    1. Small Works Packages (immediately – 2.0 years)
    2. Additional Work Packages (2 years+).

3.1.2 Small Works Packages

The Small Works Packages have primarily been rationalised by CWT from Warrumbungle Shire Council's project brief and include:

- WP1: Raw Water Supply and Blending
- WP2: WTP Chemical Dosing Upgrades:
    - WP2.1 Potassium Permanganate ($KMnO_4$) Dosing System
    - WP2.2 Polyaluminium Chloride (PACl) Dosing System
    - WP2.3 Chlorine Gas (Cl_2) Dosing System
- WP3: WTP Online Instrumentation and Process Control
- WP4: Mendooran Standpipe Installation of Booster Pumps
- WP5: Coolabah Reservoirs Management of Water Age:
    - WP5.1 Recirculation Line
    - WP5.2 Chlorine Gas (Cl_2) Booster System, with dosing and residual monitoring.

3.1.3 Additional Work Packages

Based on CWT's recent site visit and an extensive review of previous projects and their findings (as referenced in Table 1-1), CWT have identified additional works which were not included in Council's project brief but which are highly recommended. These additional works are recommended to address issues, hazardous events and/or process deficiencies that cannot be mitigated by the project brief's work packages or those mitigation strategies and/or control measures identified in the PHA.

The Additional Work Packages include:

- WP2.4 Soda ash dosing system
- WP2.5 Polymer dosing system
- WP7 Replacement of Sedimentation Lagoons with Clarifier
- WP8 Installation of UV disinfection unit.

3.1.4 Scope of Works' Activities

CWT have included all work packages in this Concept Design. However, in keeping consistent with Council's brief, work packages WP7 and WP8 will not be included in the development of the Technical Specification.

Summarised, these packages include:

- WP1: Raw Water Supply and Blending
- WP2: WTP Chemical Dosing Upgrades:
  - WP2.1 Potassium Permanganate ($KMnO_4$) Dosing System
  - WP2.2 Polyaluminium Chloride (PACl) Dosing System
  - WP2.3 Chlorine Gas (Cl_2) Dosing System
  - WP2.4 Soda ash dosing system
  - WP2.5 Polymer dosing system
- WP3: WTP Online Instrumentation and Process Control
- WP4: Mendooran Standpipe Installation of Booster Pumps
- WP5: Coolabah Reservoirs Management of Water Age:
  - WP5.1 Recirculation Line
  - WP5.2 Chlorine Gas (Cl_2) Booster System, with dosing and residual monitoring.
- WP6 Replacement of Sedimentation Lagoons with Clarifier
  - WP6.1 Replacement of Sedimentation Lagoons with Clarifier
  - WP6.1 Reconfiguration of Sedimentation Lagoons to Sludge Lagoons
  - WP6.1 Installation of supernatant return facilities
- WP7 Installation of UV disinfection unit.

Table 3-1 summaries the activities associated with each work package.

Table 3-1: Scope of Works and Activities

No.	Work packages	Activities
WP1	Raw water supply and blending	• Concept design and description of: ○ Connection of Emergency Onsite Bore to common inlet main ○ Raw water blending philosophy (subject to water quality data availability) ○ Installation of a new Blending Tank

No.	Work packages	Activities
WP2	Chemical dosing facilities upgrades	• Concept design and description for each chemical dosing systems (soda ash, potassium permanganate, polyaluminium chloride, polymer LT22S and chlorine gas) with consideration for: o Delivery (to site) and loading o Batching, mixing and storage o Delivery (to process) o Dosing location o WHS incl. PPE and safety equipment o Relevant standards. • Installation of an inline mixer • Upgrade of service water pumps • Installation of a Wastewater Holding Tank
WP3	Online instrumentation and process control	• Identification for all required instrumentation including: o Analytical: turbidimeters, pH, free chlorine, UVI o Flow switches, flow meters and level sensors o Variable speed drives at: ▪ Castlereagh Riverbed Pumps ▪ Backup Bore Pumps ▪ Low level/filter feed pumps • Describe process control philosophy (alarm setpoints and feedback control) for: o All chemical dosing systems listed in WP2 o Filtration forward and backwash control o Analytical instrumentation in accordance with CWT and Hunter H_2O recommendations
WP4	Mendooran standpipe booster pump installation	• Concept design and description of: o Mendooran Standpipe Booster Pumps (subject to reticulation condition assessment and/or pressure testing – out of scope) o Mitigation of reservoir integrity and WHS issues
WP5	Management of Coolabah Reservoir water age	• Concept Design and description of: o Piping and hydraulic connections between the Coolabah Reservoirs o Installation of a recirculation line and pump o Installation of a chlorine gas dosing system o Chlorine residual monitoring • Mitigation of reservoir integrity and WHS issues
WP6	Replacement of Sludge Lagoons with Clarifier	• Concept design for: o Replacement of Sedimentation Lagoons with Clarifier o Reconfiguration of Sedimentation Lagoons to Sludge Lagoons o Reconfiguration of filter backwash waste to Lagoons o Implementation of filter-to-waste line o Installation of supernatant return facilities
WP7	Installation of UV Disinfection Unit	• Concept design for:

No.	Work packages	Activities
		○ UV Disinfection Unit

Section 3.2 summarises the treatment process configuration in relation to these work packages.

3.2 Preferred Treatment Process

This Concept Design is based on the following preferred treatment process configuration:

- Raw water delivery to a raw water Blending Tank (this project)
- Primary pH and alkalinity adjustment by soda ash at inlet to Blending Tank and before $KMnO_4$ dosing to optimise oxidation process (this project)
- Chemical oxidation by $KMnO_4$ dosing for iron and manganese removal at Blending Tank (this project)
- Secondary pH and alkalinity adjustment (alternate dose point) by soda ash at the outlet of the Blending Tank (this project)
- Coagulation with polyaluminium chloride (PACl) dosing at an in-line mixer after soda ash dosing (this project)
- Polymer dosing to enhance flocculation at inlet to flocculation tank (this project)
- Clarification with a new lamella plate or tube settler clarifier (by others)
- Chlorine dosing at inlet to dual media filters to promote a manganese oxide coating at filter media to facilitate secondary oxidation for removal of manganese and iron (this project)
- Dual media filtration (existing)
- UV disinfection (by others)
- Chlorine disinfection via chlorine gas (this project)
- Tertiary pH and alkalinity adjustment by soda ash (alternate dose point) at inlet to Clear Water Tank (this project)
- Treated water storage and supply (this project), with the following:
  - Recirculation and booster chlorination at Coolabah reservoirs to reduce water age
  - Booster pumps at the Mendooran Standpipe to increase supply pressure for mains cleaning and for consumer supply.
- Wastewater management (clarifier blowdown and filter backwash water) received at lagoons for sedimentation. Supernatant drawn off and returned to Blending Tank.

3.3 Process Equipment Status and Requirements

The following table summarises the status and capacity of all major process components either installed or to be installed at Mendooran WTP and reticulation assets.

Table 3-2: Process Equipment Status and Requirements

Process	Equipment		Existing Equipment Details	Scope of Works
	Existing	New		
Raw Water Supply & Blending				
Castlereagh Riverbed Pumps	✓		2 × 14.5 L/s duty/standby pumps (fixed flow)	Included in WP1 scope of works for modification with VSDs.
Back-up Bore Pump	✓		1 × >4.0 L/s duty pump (fixed flow)	Included in WP1 scope of works for modification with VSDs.
Emergency Onsite Bore Pump	✓		1 × 0.8 L/s duty pump (fixed flow)	Included in WP1 scope of works: discharge end of pipe to be reconfigured to connect to main
Old River Pump Station Pumps	✓		2 × 12-14.5 L/s duty/standby pumps (variable flow)	
Blending Tank		✓		Included in WP1 scope of works
Chemical Dosing				
Potassium permanganate		✓		Included in WP2 and WP3 scope of works
Polyaluminium chloride		✓		
Chlorine gas		✓		
Soda ash		✓		
Polymer		✓		
Fluoride	✓		Existing system offline	Other contractor engaged to re-design the fluoride dosing system.
Service Water Pumps	✓	✓	2 × 3.8 L/s duty/standby pumps	Included in WP2: Service water system to be replaced.
Equipment				
Flocculation Tank		✓	3 baffled chambers (each chamber volume approx. 1.6 x 2.5 x 2.4 m)[1]	
Cascade Aerator		✓	6 x SS angles (Grade 316); 150 x 150 x 10 mm and equally spaced; fixed to concrete with SS chemical anchors.	
Clarifier		✓		Included as WP6 scope of works
Low Lift Pumps	✓		2 × 12.6 L/s duty/standby pumps	Included in WP3: Modify with VSDs.
Dual Media Filters	✓		2 x gravity filters; diameter = 2.5 m; filter area = 4.91 m^2/filter; design filtration rate = 4.6 m/hr.	
Filtered Water Tank	✓		1 x 1,000 L tank	
Filtered Water Pumps	✓		2 × 12.6 L/s duty/standby pumps with VSDs	

Filter Backwash Pumps	✓		2 x 68.2 kL/h duty/standby pumps	
UV System		✓		Included in WP7 scope of works
Clear Water Tank	✓		1 x 100 kL tank installed.	
High Lift Pumps	✓		1 x 21 L/s duty pump to Standpipe **1** x 8 L/s duty pump to Coolabah Reservoirs	
Mendooran Standpipe	✓		1 x 0.6 ML tank	Included in WP4 scope of works: Installation of booster pumps
Mendooran Standpipe Booster Pumps		✓		
Coolabah Estate Reservoirs	✓		3 x tanks of 0.09, 0.09- and 0.33-ML	Included in WP5 scope of works: installation of recirculation line, pumps, chlorine dosing and monitoring.
Wastewater Handling System / Lagoons		✓		Included in WP6 scope of works
Wastewater Holding Tank		✓		Included in WP2 scope of works: to receive chemical spills and wastes for offsite disposal
Laboratory	✓			
Control Room	✓			

Note 1: Normal operating level is 1.8 m.

3.4 Project Limits

For the work packages and their activities described in Table 3-1, the Concept Design project limits are as follows:

- For works relating to raw water supply and blending and water treatment plant upgrades (i.e. WP1, WP2, WP6, WP7):
  - The upstream limit of the works is at each raw water offtake point including:
    - Castlereagh River Pumps
    - Backup Bore
    - Emergency Onsite Bore
  - The downstream limit of the works is at the plant boundary at the treated water line
- For works relating to online instrumentation and process control (i.e. WP3):
  - The upstream limit of the works is at each raw water offtake point including:
    - Castlereagh River Pumps
    - Backup Bore

- Emergency Onsite Bore
- The downstream limit of the works is at:
  - Common inlet/outlet treated water line to/from the Mendooran Standpipe at the Mendooran Standpipe site boundary.
  - Common inlet/outlet treated water line to/from the Coolabah Reservoirs at the Coolabah Reservoir site boundary.

- For works relating to the management of the Coolabah Reservoir water age (i.e. WP4):
  - The upstream and downstream limit of the works is at common inlet/outlet treated water line to/from the Coolabah Reservoirs at the Coolabah Reservoir site boundary.
  - Works are to be carried out within the boundaries of the Coolabah Reservoir site lot (Lot DP 717238)
- For works relating to the installation of booster pumps at the Mendooran Standpipe (i.e. WP5)
  - The upstream and downstream limit of the works is at common inlet/outlet treated water line to/from the Mendooran Standpipe at the Mendooran Standpipe site boundary.
  - Works are to be carried out within the boundaries of the Mendooran Standpipe site boundary lot (Lot # N/A – corner of Brambil and Cobra Street, Mendooran).

All activities described in Table 3-1 are to be connected to or interface with existing utilities within the boundaries of the work site including:

- Power
- Communications and telemetry
- Wastewater management including Sedimentation/ Sludge Lagoons and a Wastewater Holding Tank.

3.5 Project Exclusions

The following items are outside the scope of this concept design and will be the responsibility of WSC:

- Jar testing and raw water quality monitoring to provide confidence for the selection of chemicals and their dose ranges
- Geotechnical surveying for any civil works including those related to a new clarifier or extension of Sludge Lagoons
- Asset condition assessments and/or pressure testing of any components (particularly those relating to the reticulation extending from Mendooran Standpipe)
- Upgrades or replacement of any raw water pumps and associated electrical, communications and telemetry and other ancillaries
- Upgrades to any of the following utilities *inside* the boundaries of the work sites:
  - Installation or connection to septics and/or sewer
  - Stormwater management
  - New buildings
  - Fencing and security
- Upgrades to any utilities *outside* the boundaries of the work sites including:
  - Power

- Communications and telemetry
- Connection to sewer

- Land acquisition.

3.6 Process Flow Diagram for Concept Design Scope of Works

Figure 3-1 is process flow diagram illustrates in red all work packages that will be considered in the Concept Design.

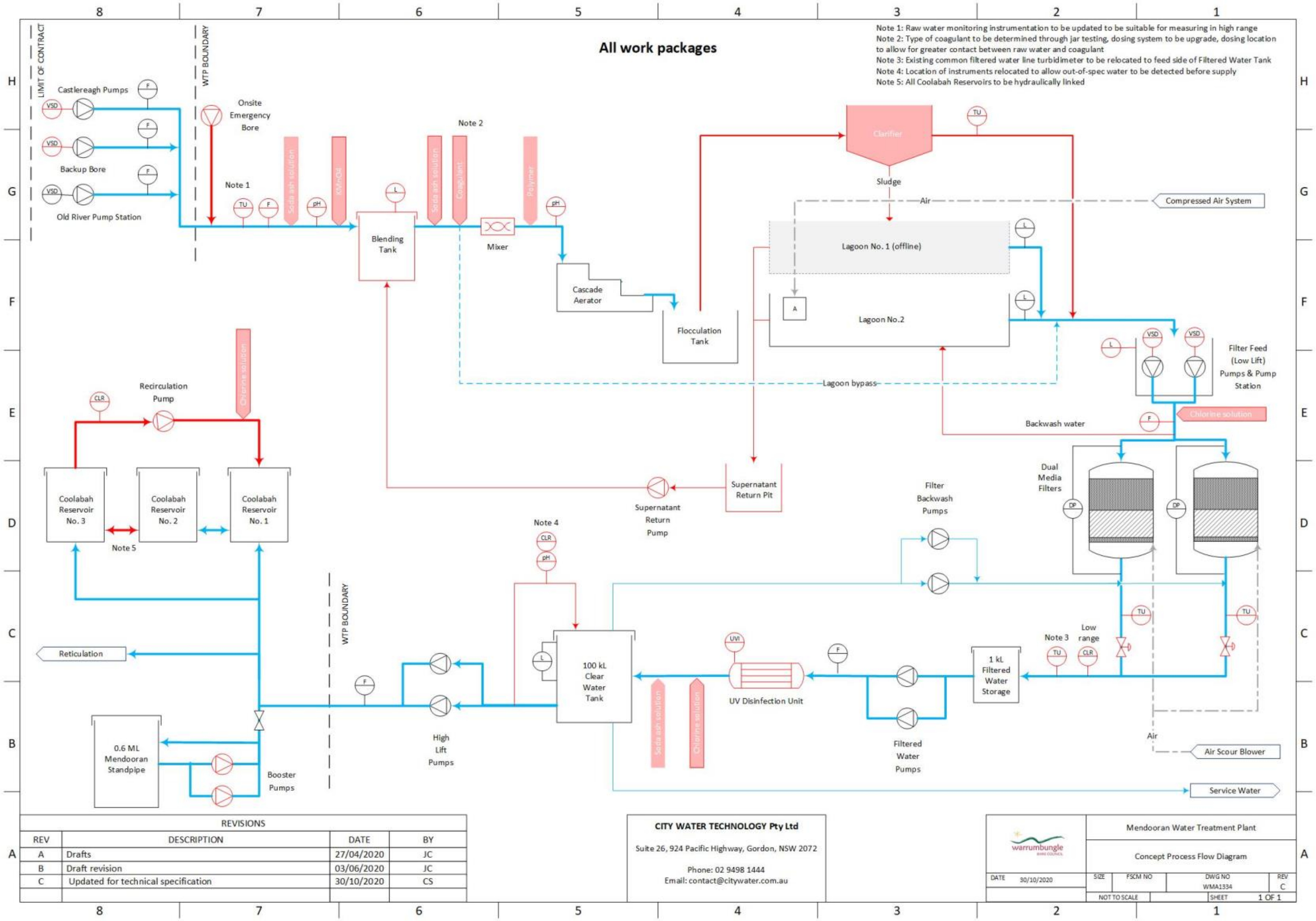

Figure 3-1 Proposed Scope of Works (in red) for new Mendooran WTP Concept Design

4 Design Requirements

To provide a water treatment plant that is robust, effective, reliable, and with a low WHS risk, the following design considerations shall be addressed in the concept design and/or technical specifications.

4.1 General Considerations

- The concept design acknowledges that the inlet hydraulics of the upgraded WTP must complement the existing raw water supply hydraulics and pumps.
- The existing WTP is run at a fixed rate in start/ stop mode with some flow reduction via valve throttling. The concept design shall allow the plant to be downrated and chemical dosing systems to be flow-paced.
- The concept design must allow the WTP to be fully automated and remotely operated based on Supervisory Control and Data Acquisition (SCADA). Where economic feasibility does not permit such automation, the designer must make provisions for operator intervention e.g. sample taps, operator adjusted dose rates and laboratory testing facilities.
- A risk and hazard assessment (HAZOP) of the design is required, with WSC involvement.
- A hazard and critical control point assessment of the design is required, with WSC involvement.
- Existing services or assets to be retained, connected to or refurbished on site are to be taken into consideration when configuring new process components.
- The existing Mendooran WTP must be operable throughout construction and commissioning.
- It is the Contractor's responsibility to ensure that provisions are made to ensure new infrastructure is appropriately secured from public access during construction.
- Chemical delivery access roads and turnaround bays to be constructed should be suitable for the delivery of IBC chemical dosing systems and equipment and materials replacements as required. WSC would need to liaise with local suppliers regarding vehicle delivery tonnage.
- Flexibility and redundancy in the design is included, for example multiple chemical dosing points, duty/ standby dosing pumps with automatic duty changeover, and the ability to take units off-line for maintenance whilst continuing to operate.

4.2 Process Requirements

4.2.1 Preferred Treatment Process

- Refer to Section 3.2 of this report.

4.2.2 Design Capacities

The existing Mendooran WTP was designed for ~1 ML/d with the Castlereagh Riverbed pumps (main supply) delivering raw water at an instantaneously flowrate of 14.5 L/s (i.e. 1.15 ML/d extraction for 22 hours of operation).

The plant is oversized with respect to water licencing limits (150 ML/pa from Castlereagh River) as well peak demands. Oversizing the plant has several disadvantages including, but not limited to:

- Higher capital and operational costs associated with implementation of new equipment sized to 1 ML/d.
- Short plant run times (due to high instantaneous flowrates) leading to more frequent start/stop operation and consequently, greater opportunity for turbidity spikes.

At present, the higher instantaneous rate through the plant (~14.5 L/s) is favoured by Council as it allows the Mendooran Standpipe to maintain a sufficient volume/head pressure to mitigate low pressure issues in parts of the reticulation. However, with the implementation of booster pumps at the Standpipe, this requirement will be redundant.

Table 37 of the Integrated Water Cycle Management Plan (IWCMP; Hydrosphere, 2019) projects no population growth for Mendooran and marginal growth for Coolah. Therefore, it is not likely that new plant facilities will need to be sized to meet higher demands in the future.

The following table has been derived from data provided in the IWCMP and estimates the portion of the plant that is oversized with respect to the metrics provided in the Plan.

Table 4-1: Capacity Metrics from IWCMP

Metric	Per annum (ML)	Average daily (ML)	% Oversized
Average annual demand (2018)	70	0.19	+81%
Water licence extraction limit	150	0.41	+59%
Peak demand (maximum)		0.71	+29%

For sizing new equipment and chemical dosing systems, CWT recommends sizing the equipment to be able to treat production range that corresponds to the 50th percentile of the available flow data (June 2017 – November 2019) to the design capacity of 1 ML/d over 22 hours/day. While it is unlikely that the plant will be operated up to 1 ML/d, CWT recognises that if new process components are sized for less, there would be insufficient treatment in the event that raw water pumps are operated at their maximum rate. Furthermore, in the event of bushfires, sufficiently treated water for fire-fighting can be made available as soon as possible.

The instantaneous flows are based on 22 hours of operation per day. In the event of planned maintenance and shutdown, Council have the option to increase the instantaneous flowrate prior to shutdown to meet expected demands during the non-production period.

When the plant is producing less than the nominal flowrate (i.e. 50th percentile), the plant shall operate for less than 22 hours a day to meet the demand. This avoids the requirement for designing for very low instantaneous flowrates which can be impractical and can have implications for process control and feasible turndown ratios.

To back calculate the expected raw water extraction flowrates, a conservative estimate is applied that assumes 15% water losses associated with filter backwashing and future clarifier sludge blowdown. However, it is expected that realistic water losses will represent <10%, especially with the design for supernatant returns to the head of the plant.

Table 4-2 provides a summary of the design capacities for new equipment and chemical dosing systems in this Concept Design.

Table 4-2: Design Capacities for Concept Design

Parameter (unit)	Design Capacity Range		
	50th-%ile	95th-%ile	Design
Clear water pump daily flow (kL/d)	170	361	~1,000
Plant losses (%)	15	15	-
Raw water pump flow (kL/d)	200	424	1,148
Hours of operation (h/d)	22	22	22

Parameter (unit)	Design Capacity Range		
	50^{th}-%ile	95^{th}-%ile	Design
Instantaneous flowrate (kL/h)	**9.1**	**19.3**	**52.5**
Instantaneous flowrate (L/s)	**2.5**	**5.4**	**14.5**

4.2.3 Multi-Barrier Approach

The multi-barrier approach is a risk minimisation strategy and best practice design approach. Using this approach, a specific hazard can be minimised by two or more successive treatment stages, such that should one be ineffective or unavailable, sufficient protection is still provided.

The following treatment barriers were identified against key hazards of concern (Table 4-3).

Table 4-3: Treatment Barriers Against Key Hazards

Barrier	Soluble metals	Turbidity & particulate	DBPs, T&Os	Bacteria	Viruses	Protozoa
Potassium permanganate oxidation	✓✓		✓			
Coagulation, flocculation & clarification		✓✓		✓	✓	✓
Media filtration with MnO_2-coated media	✓✓	✓✓		✓✓	✓✓	✓✓
UV disinfection		✓✓		✓✓	✓	✓✓
Chlorine disinfection				✓✓	✓✓	

Key: ✓ Offers *some* barrier protection when operated within specified operating limits

✓✓ Offers *relatively good* barrier protection when operated within specified operating limits

4.1 Treated Water Quality Targets

4.1.1 ADWG (2011) Treated Water Quality Targets

Treated water quality produced by the new Mendooran WTP should comply with the ADWG (2011) targets. This concept design has been developed in line with adherence to meeting the ADWG key water quality parameters summarised in Table 4-4.

Table 4-4: ADWG Recommended Treated Water Quality Targets

Parameter (unit)	ADWG Limits		Best-Practice Limits		Trigger Level
	Health	Aesthetic	95^{th}%ile	Absolute	
Turbidity (NTU)	≤ 1	≤ 5	≤ 0.2 ex filter	≤ 0.3 ex filter	> 0.5 for 15 minutes
True Colour (HU)		≤ 15	≤ 5	≤ 10	> 10
pH		6.5 – 8.5	7.6 ± 0.4[1]	7.0 – 8.2	Outside range for 1 hour
Chlorine (mg/L)	≤ 5		Setpoint ± 0.1	Setpoint ± 0.3	Outside range for 1 hour
Total Aluminium (mg/L)	≤ 0.2		≤ 0.1	≤ 0.2	> 0.2

Parameter (unit)	ADWG Limits		Best-Practice Limits		Trigger Level
	Health	Aesthetic	95^{th}%ile	Absolute	
Total Manganese (mg/L)	≤ 0.5	≤ 0.1	≤ 0.02	≤ 0.05	> 0.05
Total Iron (mg/L)		≤ 0.3	≤ 0.08	≤ 0.1	> 0.1
Total Alkalinity (mg/L $CaCO_3$)			≥ 30	≥ 40	N/A
CCPP				-5 to 0	If required
Total Dissolved Solids (TDS; mg/L)					> 500
***E. coli* or thermotolerant coliforms (CFU/100 mL)**	<1			<1	≥ 1
Pathogens	≥ 3-log inactivation of *Crypto.* across entire process				≥ 1
Total trihalomethanes (mg/L)	≤ 0.25		≤ 0.15	≤ 0.25	> 0.25
Nitrates (mg/L)	≤ 50			≤ 10	> 10
Hardness (mg/L)		200		150	
Hydrogen Sulphide (mg/L)		≤ 0.05	≤ 0.02	≤ 0.05	
Taste and odour	Acceptable to most people				
Pesticides	Refer to ADWG (2011)				

Note 1: Achievable with pH correction only (e.g. soda ash)

4.1.2 WSAA (2015) Health-Based Pathogen Log Removal Targets

Treated water quality produced by the new Mendooran WTP should at a minimum meet the WSAA health-based targets as given in Table 4-5.

Table 4-5: WSAA Recommended Health-Based Treated Water Quality Targets

Pathogen Group	Log10 Removal Target
Bacteria	6.0
Viruses	6.0
Protozoa	5.5

WSAA's HBT Manual (2015) provides default microbial log removal values (LRV) for common drinking water treatment barriers. These default LRVs can be applied if the effectiveness of the treatment process is monitored in real-time and if critical limits are applied in accordance with industry practice.

Membrane and UV manufacturers often validate their processes to greater than the LRV values given in Table 4-6. These values are acceptable to use in place of those prescribed by the WSAA HBT Manual if independent validation and certification is provided.

4.1.2.1 Potential LRVs for Stage 1: Small Works Packages

Table 4-6 is a summary of theoretical default LRVs that the Mendooran WTP may achieve upon completion of Stage 1: Small Works Packages.

Table 4-6: Theoretical Log Reduction Capacity of Stage 1 Mendooran WTP

Treatment Barrier	Default LRV			Manual Critical Limits
	Bacteria	Virus	Protozoa	
Conventional Treatment (coagulation, flocculation, sedimentation and granular filtration)	2.0	2.0	3.0	Individual treated water turbidity ≤0.3 NTU for 95% of the month and not >0.5 NTU for ≥15 consecutive minutes.
Chlorine Disinfection	4.0	4.0	0	C.t. will vary depending on the log removal required and the temperature, turbidity and pH of the water. Typically, the C.t. will be greater than 15 mg.min/L.
Total LRV capacity	**6.0**	**6.0**	**3.0**	
Health-Based Target	**6.0**	**6.0**	**5.5**	
LRV credit or deficit	**+0**	**+0**	**-2.5**	Assuming critical limits (above) are not exceeded

Even if the Stage 1 upgraded Mendooran WTP meets the water quality objectives for their treatment processes defined in Table 4-6, the WTP would not meet its HBT for protozoa.

4.1.2.2 Potential LRVs for Stage 2: Additional Work Packages

Table 4-6 is a summary of theoretical default LRVs that the Mendooran WTP may achieve upon completion of stage 2: Additional Work Packages.

Table 4-7: Theoretical Log Reduction Capacity of Stage 2 Mendooran WTP

Treatment Barrier	Default LRV			Manual Critical Limits
	Bacteria	Virus	Protozoa	
Conventional Treatment (coagulation, flocculation, sedimentation and granular filtration)	2.0	2.0	3.0	Individual filter turbidity ≤ 0.3 NTU for 95% of month and not > 0.5 NTU for ≥ 15 consecutive minutes.
Chlorine Disinfection	4.0	4.0	0	C.t. will vary depending on the log removal required and the temperature, turbidity and pH of the water. Typically, the C.t. will be greater than 16 mg.min/L.
UV Disinfection	4.0	0.5	4.0	UV dose > 40 mJ/cm^2 Feed water <1 NTU UVT% > manufacturer's specifications
Total LRV capacity	**10.0**	**6.5**	**7.0**	
Health-Based Target	**6.0**	**6.0**	**5.5**	
LRV credit or deficit	**+4.0**	**+0.5**	**+1.5**	Assuming critical limits (above) are not exceeded

If Stage 2 upgraded Mendooran WTP meets the water quality objectives for their treatment processes defined in Table 4-7, the WTP could theoretically meets its HBTs.

4.2 Buildings

- New chlorine gas rooms are to be built in accordance with AS/NZS 2927: *The Storage and Handling of Liquefied Chlorine Gas* at two (2) sites:
  - Mendooran WTP site located on Lot DP 1076077
  - Coolabah Reservoir site located on Lot DP 717238.
- No other new buildings are included in the scope of works.
- However, consideration is made for WHS and safety equipment and modifications to existing infrastructure will be included as required e.g. modifications to bunds.

4.3 Power Supply

- Power is available at each of the three sites: WTP site at Lot DP 1076077, Mendooran Standpipe site at Lot #N/A and Coolabah Reservoir site at Lot DP 717238.
- Additional power supply requirements are to be determined by WSC. WSC will be responsible for providing sufficient power for connection by the Contractor.

4.4 Telemetry and Control Systems

- The control system is to be linked to the raw water supply pumps to enable automatic start-up where possible.
- The control system may incorporate:
  - A hot backup computer control system
  - Continuous monitoring
  - Remote access and control
  - Automatic adjustment of all dosing rates based on monitoring (parameters and feedback loops to be determined)
  - Flow pacing, with no hunting or rapid changes to dosing or flowrates
  - Calibration testing ability
  - A manual override facility.
- Telemetry and communications are available at site. The Contractor is to connect and/or interface with the existing telemetry and communications utilities available at site. The Contractor shall make an assessment for any necessary augmentations to the existing system.
- Any additional telemetry and communication requirements are to be determined by WSC.

4.5 Documentation

The following documentation should be provided by the Contractor:

- Operation and maintenance manuals
- Functional description
- Equipment supplier manuals
- As built drawings

- Piping and instrument diagram
- Calibration certificates
- Commissioning checklists (FAT / SAT)
- Proof of Performance (PoP) Test Plan
- PoP outcomes report and supporting evidence
- Safe work method statements
- Standard operating procedures
- Equipment schedules
- I/O list
- PLC code
- Alarm list.

4.6 Training

Upon commissioning each Stage of works, the Contractor shall provide training to ensure operators are appropriately trained to operate and maintain the installations.

Operator training should include:

- Operating principles
- Routine operation
- Routine maintenance (calibration, cleaning, etc.)
- Jar testing
- Troubleshooting
- Safety considerations
- Environment considerations.

It is Council's preference that training is carried after commissioning of each stage of works for a minimum of one (1) working day.

5 Site Layout

5.1 Castlereagh River Pumps Site

The Castlereagh River Pumps are situated beneath the Castlereagh Riverbed near River and Daglish Streets in the town of Mendooran, NSW. The Back-up Bore is also situated on the Castlereagh River Pumps site.

5.2 Old Raw Water Pump Station Site

The Old Raw Water Pump Station is situated upstream from the Castlereagh River Pump station in the town of Mendooran, NSW.

5.3 Mendooran WTP Site Layout

The Mendooran WTP site is situated at and can be accessed from Danglish Street, Mendooran, NSW 2842.

The property is located on Lot DP 1076077 as shown in Figure 5-1.

Figure 5-1 Mendooran WTP Site Layout (SixMaps 2020)

5.4 Mendooran Standpipe Site Layout

The Mendooran Standpipe site is situated at the corner of Cobra and Brambil Streets, Mendooran, NSW 2842 and can be accessed via Brambil Street.

The property is located on an unnumbered lot as shown in Figure 5-1.

Figure 5-2 Mendooran Standpipe Site Layout (SixMaps 2020)

5.5 Coolabah Reservoirs Site Layout

The Coolabah Reservoir site is situated at 59 Manusu Drive, Mendooran, NSW 2842 and can be accessed off an unsealed road.

The property is located on Lot DP 717238 as shown in Figure 5-3.

Figure 5-3 Coolabah Reservoirs Site Layout (SixMaps 2020)

6 Work Package 1: Raw Water Supply and Blending

6.1 Description of works

6.1.1 Overview

The following table is an excerpt of Table 3-1, and summarises the activities to be addressed in this Section of the Report.

Table 6-1: Work Package 1 - Scope of Works and Activities

No.	Work packages	Activities
WP1	Raw water supply and blending	• Concept design and description of: o Connection of Emergency Onsite Bore to common inlet main o Raw water blending philosophy (subject to water quality data availability) o Installation of a new Blending Tank

6.1.2 Process Description

The raw water source to Mendooran WTP shall be selected by the operator in the PLC. Raw water is primarily sourced from the Castlereagh River Pumps. A Backup Bore is also available adjacent to the Castlereagh River Pumps. The Old Raw Water Pump Station designated as an alternate water supply during periods of low flow. Each supply line is equipped with a flowmeter before connecting to the raw water main which extends to the Mendooran WTP.

Within the WTP site boundary, a newly configured T-connection shall provide supply from the Onsite Emergency Bore if elected to run.

The Castlereagh River Pumps, Backup Bore, Old River Pump Station and Emergency Onsite Bore can be operated concurrently to improve raw water availability. However, the total combined raw water flowrate received at the plant shall not exceed 14.5 L/s to prevent over-pressurising the main and/or overwhelming the plant treatment processes.

Each raw water pump, except for the Onsite Emergency Bore Pump is to be equipped with variable speed drives to allow the plant to be downrated to extend run-times while meeting treated water demands. Downrating the plant will have significant impact on improved water quality.

After the T-section, the raw water pH and turbidity shall be measured online before passing through a common raw water flow meter.

Prior to being received at a newly installed Blending Tank, soda ash for pH and alkalinity adjustment (optional), and potassium permanganate for soluble metals oxidation, shall be flow-paced to the raw water flowrate as measured by the common raw water flowmeter.

The Blending Tank shall facilitate blending of raw water received from alternating sources and supernatant returns (future) as well as sufficient contact time for potassium permanganate dosing. In the future (stage 2), a supernatant return pump shall return supernatant from converted Sedimentation Lagoons (to Sludge Lagoons) to the Blending Tank, to allow dilution of supernatant with raw water and enable contact with the downstream coagulation process.

The Blending Tank shall be fitted with a level transmitter for the stop/ start signals of the selected Raw Water Pump(s).

Figure 6-1 is a schematic showing those components relating to Work Package 1. Components in black and blue are existing, and components shown in red are to be installed/ augmented/ incorporated as part of the Work Package 1 scope of works.

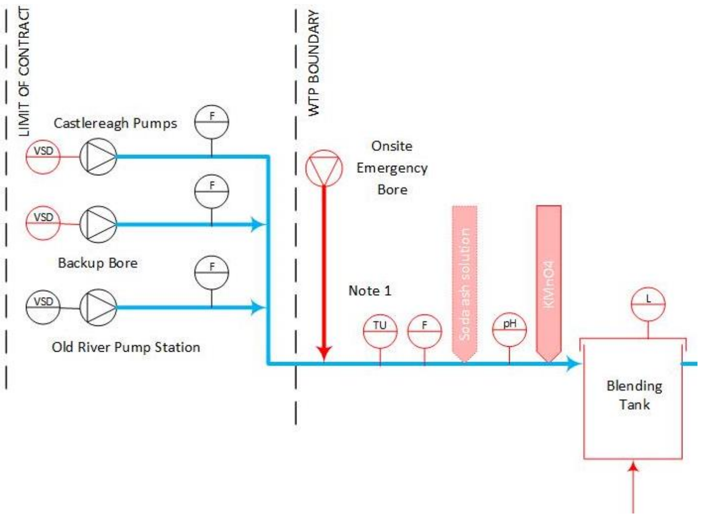

Figure 6-1 Schematic of Work Package 1

6.1.3 Location of Works

The following table summarises the location of works.

Table 6-2: Work Package 1 – Location of Works

Process/ Equipment	Location
Connection of Emergency Onsite Bore to inlet main	Emergency Onsite Bore supply pipework shall be reconnected at the inlet main within the WTP lot boundary, downstream of the other raw water sources and upstream of analysers, the flowmeter or chemical dosing points.
Installation of a new Blending Tank	The Blending Tank shall be located downstream of the inlet main $KMnO_4$ dosing point, and upstream of the coagulant dosing point. On site, the Blending Tank shall be located near the chemical dosing systems and the Cascade Aerator.

6.2 Assumptions

The assumptions associated with raw water supply are as follows:

- The Castlereagh River Pumps, the Backup Bore and the Old River Pump station are currently connected to the inlet main. This excludes the Emergency Onsite Bore.
- The Castlereagh River Pumps, the Backup Bore and the Old River Pump Station shall operate with dedicated flow meters, which are to be or have been installed by another contractor.
- It is assumed the Castlereagh River Pumps, the Backup Bore and the Old River Pump Station shall operate with Variable Speed Drives (VSDs). See Section 8 for more details.
- The Emergency Onsite Bore is assumed to currently operate without a dedicated flow meter and shall continue to operate at a low fixed flow.

- The Castlereagh River Pumps, Backup Bore, Old River Pump Station and Emergency Onsite Bore can be operated concurrently to improve raw water availability. However, the total combined raw water flowrate received at the plant shall not exceed 14.5 L/s to prevent over-pressurising the main and/or overwhelming the plant treatment processes.

6.3 Design Requirements

6.3.1 Raw Water Supply

The design requirements for raw water supply are as follows:

- To match raw water flow and treated water demand, all pumps except the Emergency Onsite Bore require VSDs. The Emergency Onsite Bore is an exception as it does not provide enough flow to validate the use of a VSD. The details of the VSD instrumentation are listed in Section 8.
- The raw water sources and the flow rates, within the capacity range outlined in Section 4.2.2, shall be operator selectable.
- The Castlereagh River Pumps, Backup Bore, Old River Pump Station and Emergency Onsite Bore can be operated concurrently but must not exceed a combined raw water flowrate of 14.5 L/s as measured by the combined raw water flowmeter.
- The Emergency Onsite Bore pipework shall be modified to connect to the common inlet main upstream of instruments and chemical dose points. See assumptions below.
- Flow and analytic instrumentation will be provided, with details outlined in Section 8.
- The inlet works shall be designed to accommodate the inline dosing of potassium permanganate and soda ash. The details of the chemical dosing systems are listed in Section 7.
- The dosing point for potassium permanganate shall be located downstream of the mains intersection from any raw water pumps or raw water quality instrumentation.
- The dosing point for soda ash shall be located downstream of the mains intersection from any raw water pumps or raw water quality instrumentation and shall be located upstream of the potassium permanganate dosing point.
- The raw water main shall be connected to the new Blending Tank.

6.3.2 Blending Tank

The design requirements for Blending Tank are as follows:

- Existing plant hydraulics i.e. sized for the maximum flow of 1.148 ML/d over 22 hours.
- 5-15 minutes contact time for oxidation of soluble metals by upstream dosing of potassium permanganate
- An appropriately designed inlet, outlet and/or baffles to prevent short-circuiting so that the effective contact time is achieved i.e. baffle factor of 0.3
- The Blending Tank is to be sized with respect to:
  - Hydraulic requirements
  - 5 - 10% supernatant returns
- Suitable materials of construction to be compliant with potassium permanganate dosing
- Level sensors for the stop/ start of the WTP.

- The Blending Tank shall have the following connections:
  - Connection to upstream raw water inlet line
  - Connection to downstream Inline Mixer
  - Scour line for maintenance flush
  - Future connection for supernatant returns from the Sludge Lagoons via a future Supernatant Return Well.
- Materials of construction must be compliant with potassium permanganate and soda ash contact near the dosing location.

6.4 Concept Design Calculations

Table 6-3 summarises the design basis, assumptions and calculations for the Blending Tank.

Table 6-3: Blending Tank Design Basis, Assumptions and Calculations

Parameter (unit)	Value	Assumption/ Reference
Raw water pump stop/start signals (%)	85, 95	Assumed; 5% allowance for supernatant returns (future)
Baffle factor	0.3	USEPA (1999); Single or multiple unbaffled inlets and outlets
L:D ratio	3.0	Typical design value
Design oxidation contact time (min)[1]	5	Design contact time for oxidation of soluble metals with $KMnO_4$
Volume required for oxidation (kL)	14.5	Volume at 85% fill level
Volume at 95% fill level	16.1	Volume at 95% fill level
Volume of Blending Tank (kL)	17.1	Volume at 100% fill level
Design diameter (m)	1.9	L:D = 3.0
Design height (m)	5.8	

Note 1: this tank is sized for the design capacity of 1 ML/d but typically operated at a much lower rate, therefore, the lower range of the design oxidation time for oxidation of soluble metals with $KMnO_4$ has been elected.

7 Work Package 2: Chemical Dosing Facilities

7.1 Description of works

7.1.1 Overview

The following table is an excerpt of Table 3-1 is summarises the activities to be addressed in this Section of the Report.

Table 7-1: Scope of Works and Activities

No.	Work packages	Activities
WP2	Chemical dosing facilities upgrades	• Concept design and description for each chemical dosing systems (soda ash, potassium permanganate, polyaluminium chloride, polymer LT22S and chlorine gas) with consideration for: o Delivery (to site) and loading o Batching, mixing and storage o Delivery (to process) o Dosing location o WHS incl. PPE and safety equipment o Relevant standards. • Installation of an inline mixer • Upgrade of service water pumps • Installation of a Wastewater Holding Tank

7.1.2 Process Description

The following table summarises the purpose for each work activity which is addressed in this Section of the report.

Table 7-2: Chemicals and Purpose

Chemical	Dosing Location	Purpose
Soda Ash	Primary dose point (optional): On the combined raw water line at the inlet to the Blending Tank and prior to potassium permanganate dosing.	To raise pH to meet target pH setpoint for optimal oxidation with potassium permanganate. Potassium permanganate is most effective at pH 8.5.
	Secondary dose point (optional): At the outlet of the Blending Tank prior to coagulant dosing.	If required, to adjust pH to meet a target pH setpoint for optimal coagulation; typically 7.0 – 8.0. However, PACl coagulant is not highly pH dependant.
	Tertiary dose point (optional): Downstream of chlorine dosing point for disinfection and prior to the Clear Water Tank	If required, to adjust pH to meet a target pH setpoint for optimal corrosion control; typically 7.6 to 7.8.
Potassium Permanganate ($KMnO_4$)	On the combined raw water line at the inlet to the Blending Tank and after primary soda ash dosing.	For the oxidation of soluble metals; particularly manganese and iron.
Poly-Aluminium Chloride (PACl)	At the outlet of the Blending Tank, after the secondary soda ash dosing point and prior to the inline mixer.	To form floc for the removal of dissolved organic matter and colloidal particles through sedimentation.

Chemical	Dosing Location	Purpose
Cationic Polymer LT22S	At the juncture between the existing Cascade Aerator and prior to the Flocculation Tank	To act as a flocculation aid and facilitate in the coagulation of floc.
Chlorine Gas	Oxidation: At the inlet to the Media Filters on the common filter feed line	To catalyse the formation of manganese oxide-coated media within the filter media bed for secondary oxidation of soluble metals; manganese and iron. Also establishes an oxidation barrier for manganese removal in the event of $KMnO_4$ overdosing or destratification in the Sedimentation Lagoons leading to leaching of metals.
	Disinfection: After UV Disinfection Unit and prior to soda ash dosing and Clear Water Tank.	Disinfection for inactivation of chlorine-sensitive pathogens; particularly bacteria and viruses
	Booster chlorination: At the Coolabah Reservoir Recirculation Line	Booster chlorination to booster chlorination to replace any chlorine lost due to water age to meet chlorine residual setpoint as required.
Inline Mixer		To ensure sufficient chemical dispersion, mixing and contact with volume of water.
Service Water Pumps	-	To provide sufficient service water for chemical dosing batching, dilution and/or carrier water as well as services for hose-down etc.
Waste Holding Tank	-	For the collection chemicals not suitable for disposal to the environment or for recycle to the head of works such as chemical spills.

7.1.3 Location of works

The following table summarises the location of works.

Table 7-3: Location of Works

Work Packages	Location of Works
Soda Ash Dosing Facility	To be installed within the existing Chemical Storage Building with dosing lines extending to the appropriate dose points in the process as described in Table 7-2 above.
$KMnO_4$ Dosing Facility	
PACl Dosing Facility	
Polymer LT22S Dosing Facility	
Chlorine Gas Dosing Facility	Mendooran WTP site: To be installed in separate and potentially adjoining Chlorine Gas Dosing Room
	Coolabah Reservoirs' site: To be installed in a newly construction Chlorine Gas Dosing Room
Inline Mixer	To be installed in proximity to the chemical dosing systems, Blending Tank and Cascade Aerator.

Work Packages	Location of Works
Service Water Pumps	To be installed on the service water supply line extending from existing Clear Water Tank and supplying each chemical dosing facility (except the chlorine gas dosing facility) and Service Water taps and hoses.
Waste Holding Tank	To be installed at a location to be determined by the Contractor

7.2 Design Requirements

7.2.1 Design Basis

A number of design bases have been applied to determine the chemical dosing and storage requirements for the upgraded Mendooran WTP:

- The coagulant dosing system shall have at least 30 days' storage volume at average dose and average flowrate
- Sufficient capacity of all systems will allow at least three days unattended operation
- The soda ash dosing system shall include a softener to prevent scaling
- Liquid dosing systems will be fitted with pulsation dampeners and local calibration tubes
- Relevant chemical systems and unloading areas will be suitably bunded to contain the chemical in the event of spillage
- All chemical dosing lines with be laid in chemical trenches or trays where appropriate. The trenches will be covered with removable covers
- All chemical dosing lines will be appropriately labelled identifying the chemical in the line, the direction of flow and marked with appropriate colours (in accordance with WSC's elected standards)
- All equipment (including injection equipment and dosing lines) will allow for easy and safe isolation, to facilitate quick repairs without necessitating shutdown of the plant
- Service water pumps shall be sized to permit all chemicals to be adequately diluted prior to dosing to improve mixing:
  - Soda ash shall be:
    - Batched as a 10% w/v solution
    - Delivered at a 10:1 ratio of carrier water to soda ash solution
  - Potassium permanganate shall be:
    - Batched as a 2% w/v solution. Note: this is an estimate based on previous experience. Solubility can vary depending on mixing efficacy and temperature.
    - Delivered at a 10:1 ratio of carrier water to potassium permanganate slurry
  - Polymer LT22S shall be:
    - Batched as a 0.2% w/v solution (typically 0.15-0.3%)
    - Delivered at a 10:1 ratio of carrier water to polymer solution
  - Coagulant PACl shall be delivered as at a 20:1 ratio of carrier water to coagulant

- All chemical dose rates in this section of the report are approximate only and should be verified by the Contractor during the design and acceptance phase.

7.2.2 Design Chemical Dose Rates

Chemical storage and dosing facilities have been sized on the basis of the expected minimum, nominal and maximum dose rates nominated in

Table 7-4 below.

The selected chemicals and values are intended as a guide only and are subject to change in line with new raw water quality and jar testing results. Prior to tendering Council shall carry out or engage a contractor to conduct jar testing to confirm the chemical selection and their nominated dose ranges.

Table 7-4: Chemical Dose Rates

Chemical	Units	Target dose rate (mg/L)			Assumptions, Basis and Comments
		Min	Avg	Max	
Soda ash (Na_2CO_3) for pH & alkalinity adjustment at:					Product purity assumed to be 99.2%.
- Primary dose point	mg Na_2CO_3/L	10	20	100	Dose ranges approximated from similar projects and the ADWG typical dose range of 5 – 500 mg/L.
- Secondary dose point	mg Na_2CO_3/L	10	20	100	
- Tertiary dose point	mg Na_2CO_3/L	10	20	100	Insufficient data available for modelling.
Potassium permanganate	mg/L $KMnO_4$	0.3	1	5	Based on ADWG (2011) typical dose range
Polyaluminium chloride	mg Al_2O_3/L	5	30	50	Based on ADWG (2011) typical dose range
	mg product/L	50	300	500	Based on PACl containing 10% w/w of Al_2O_3 and specific gravity of 1.21 kg/L
Polymer LT22S	mg/L	0.01	0.08	0.2	Based on previous experience.
Chlorine gas for:					
- Oxidation	mg Cl_2/L	2	3	5	Typical
- Disinfection	mg Cl_2/L	2	3	5	Typical
- Booster	mg Cl_2/L	1	2	3	Typical

7.3 Concept Design Calculations for Chemical Dosing Facilities

7.3.1 Soda Ash

7.3.1.1 General

Soda ash is to be employed for pH and alkalinity correction.

7.3.1.2 Dosing Points

The dose points are illustrated by annotations in Figure 3-1 and are located:

1. *Primary dose point:* On the combined raw water line at the inlet to the Blending Tank and prior to potassium permanganate dosing.
2. *Secondary dose point (alternate dose point):* At the outlet of the Blending Tank prior to coagulant dosing.

3. *Tertiary dose point (alternate dose point):* Downstream of chlorine dosing point for disinfection and prior to the Clear Water Tank

The soda ash dosing system has been sized to dose at two of the three dose points.

The dosing points shall be designed to evenly disperse the solution to the whole water flow, for example using a dosing sparge.

7.3.1.3 System Details

The proposed dosing system will consist of the following components:

- Chemical Storage/Solution Batching Tank with mixer
- 3 × duty/ duty/ standby Soda Ash Solution Dosing Pumps
- Pipework, valves, inline strainers and bunding; and
- Dilution system.
- Vacuum transfer/loading equipment can be offered.

7.3.1.4 Dose Range, Consumption and Turndown Ratio

Table 7-5 provides a summary of the typical dose rates, daily consumption, turndown ratio and 30 day's consumption based on the expected nominal dose rate.

Table 7-5: Chemical Dose Rates and Product Consumption

Dose range in mg/L of Na_2CO_3	Flow Range (ML/d)			Units	Comments/ Units
	Nominal – 0.200	95th-%ile - 0.424	Design - 1.148		
10	2.0	4.3	11.6	kg/d of product	Assumes product purity of 99.2% w/v
20	4.0	8.6	23.1	kg/d of product	
100	20.2	42.8	115.7	kg/d of product	
Dosing Pumps					
10	0.9	1.9	5.3	L/h of product	Assumes solution concentration of 10% w/v
20	1.8	3.9	10.5	L/h of product	
100	9.2	19.4	52.6	L/h of product	
Turndown ratio			57		
30 days' consumption (at nom. flow & avg dose)[1]			121	kg/30d product	

Note 1: Assumes dosing is only occurring at one of the three available dose points.

7.3.2 Potassium Permanganate

7.3.2.1 General

Potassium permanganate is to be employed for the oxidation of soluble metals, particularly manganese and iron.

7.3.2.2 Dosing Points

The dose point is illustrated by annotations in Figure 3-1 and is located:

1. On the combined raw water line at the inlet to the Blending Tank and after primary soda ash dosing.

The dosing point shall be designed to evenly disperse the solution to the whole water flow, for example using a dosing sparge.

7.3.2.3 System Details

The proposed dosing system will consist of the following components:

- 1 x batching tank with mixer and 1x storage/dosing tank;
- 2 × duty/ standby Potassium Permanganate Dosing Pumps;
- Pipework, valves, inline strainers and bunding; and
- Dilution system.
- Vacuum transfer/loading equipment can be offered.

7.3.2.4 Dose Range, Consumption and Turndown Ratio

Table 7-6 provides a summary of the typical dose rates, daily consumption, turndown ratio and 30 day's consumption based on the expected nominal dose rate.

Table 7-6: Chemical Dose Rates and Product Consumption

Dose range in mg/L of $KMnO_4$	Flow Range (ML/d)			Units	Comments/ Units
	Nominal – 0.200	95th-%ile - 0.424	Design - 1.148		
0.3	0.06	0.13	0.35	kg/d of product	Assumes product purity of 98% w/v
1.0	0.20	0.43	1.17	kg/d of product	
5.0	1.02	2.16	5.86	kg/d of product	
Dosing Pumps					
0.3	0.14	0.29	0.80	L/h of product	Assumes solution concentration of 2% w/v.
1.0	0.46	0.98	2.66	L/h of product	
5.0	2.32	4.92	13.31	L/h of product	
Turndown ratio			96		
30 days' consumption (at nom. flow & avg dose)			6	kg/30d product	

7.3.3 Polyaluminium Chloride

7.3.3.1 General

The coagulation process is achieved by controlled doses of coagulant. The coagulation process involves the addition and mixing of chemical coagulant to water to create conditions which agglomerate suspended and dissolved contaminants in the water into floc particles.

The type of coagulant to be used shall be confirmed by Council. Polyaluminium chloride has been elected for the development of this concept design only and its use should be confirmed through jar testing.

7.3.3.2 Dosing Points

The dose point is illustrated by annotations in Figure 3-1 and is located:

1. At the outlet of the Blending Tank, after the secondary soda ash dosing point and prior to the inline mixer.

The dosing point shall be designed to evenly disperse the coagulant to the whole water flow, for example using a dosing sparge or needle.

7.3.3.3 System Details

The proposed dosing system will consist of the following components:

- 2 × duty/ standby Chemical Storage (bulk delivery to one of two 1,500 L tank or whichever is appropriate so as not to exceed manufacturer's recommended shelf-life)
- 2 × duty/ standby PACl Dosing Pumps
- Pipework, valves, inline strainers and bunding; and
- Dilution system.

7.3.3.4 Dose Range and Turndown Ratio

The selected dose rates are based on previous CWT experience. The dose range has been elected for the development of this concept design only and should be confirmed through jar testing.

Table 7-7 provides a summary of the typical dose rates, daily consumption, turndown ratio and 30 day's consumption based on the expected nominal dose rate.

Table 7-7: Chemical Dose Rates and Product Consumption

Dose range in mg/L of Al_2O_3	Flow Range (ML/d)			Units	Comments/ Units
	Nominal – 0.200	95th-%ile - 0.424	Design - 1.148		
3	5.0	10.5	28.5	L/d of product	Assumes product concentration of 10% Al_2O_3 and specific gravity of 1.21 kg/L
30	49.6	105.1	284.6	L/d of product	
50	82.6	175.2	474.4	L/d of product	
Dosing Pumps					
3	0.23	0.48	1.29	L/h of product	Assumes dilution ratio of 20:1 service water to coagulant
30	2.25	4.78	12.94	L/h of product	
50	3.76	7.96	21.56	L/h of product	
Turndown ratio			96		
30 days' consumption (at nom. flow & avg dose)			1,488	L/30d product	

PACl will be dosed immediately upstream of rapid mixing, which is designed to disperse the coagulant into the raw water quickly and evenly.

7.3.4 Cationic Polymer LT22SS

7.3.4.1 General

Cationic polymer LT 22SS may be employed as a flocculation and/or settling aid.

The type of polymer to be used shall be confirmed by Council. Cationic polymer LT22SS has been elected for the development of this concept design only and its use should be confirmed through jar testing.

7.3.4.2 Dosing Point

The dose point is illustrated by annotations in Figure 3-1 and is located:

1. Upstream of the Cascade Aerator and downstream of the Inline Mixer.

The dosing point shall be designed to evenly disperse the polymer to the whole water flow, for example using a dosing sparge or needle.

7.3.4.3 System Details

The proposed dosing system will consist of the following components:

- Duty/standby Solution/ Batching Tank with mixer
- 2 × duty/ standby Polymer Dosing Pumps
- Pipework, valves and bunding; and
- Dilution system.
- Vacuum transfer/loading equipment can be offered.

7.3.4.4 Dose Range and Turndown Ratio

The selected dose rates are based on previous CWT experience. The dose range has been elected for the development of this concept design only and should be confirmed through jar testing.

Table 7-8 provides a summary of the typical dose rates, daily consumption, turndown ratio and 30 day's consumption based on the expected nominal dose rate.

Table 7-8: Chemical Dose Rates and Product Consumption

Dose range in mg/L of polymer	Flow Range (ML/d)			Units	Comments/ Units
	Nominal – 0.200	95th-%ile - 0.424	Design - 1.148		
0.01	0.002	0.004	0.011	kg/d of product	Assumes product purity of 100% w/v
0.08	0.02	0.03	0.09	kg/d of product	
0.2	0.04	0.08	0.23	kg/d of product	
Dosing Pumps					
0.01	0.05	0.10	0.26	L/h of product	Assumes solution concentration of 0.2% w/v
0.08	0.36	0.77	2.09	L/h of product	
0.2	0.91	1.93	5.22	L/h of product	
Turndown ratio			115		
30 days' consumption (at nom. flow & avg dose)			0.48	kg/d of product	

7.3.5 Chlorine Gas

7.3.5.1 General

Chlorine gas is to be employed for the processes of oxidation and disinfection at the Mendooran WTP.

Chlorine gas is to be employed for the process of booster chlorination at the Coolabah Reservoirs.

7.3.5.2 Dosing Points

The dose points are illustrated by annotations in Figure 3-1 and are located:

1. *Oxidation*: At the inlet to the Media Filters on the common filter feed line
2. *Disinfection*: After UV Disinfection Unit and prior to soda ash dosing and Clear Water Tank.
3. *Booster chlorination*: On the recirculation line at the Coolabah Reservoirs.

7.3.5.3 System Details

The chlorine gas systems are is to be installed in accordance with AS NZS 2927 (2001) – *The Storage and Handling of Liquefied Chlorine Gas*.

Two (2) chlorine gas dosing systems are to be installed; one at the Mendooran WTP (shared between the chlorine oxidation and disinfection points) and one at Coolabah Reservoir site.

Mendooran WTP Chlorination System

The chlorine gas dosing system at Mendooran WTP consists of the following components:

- 2 × duty/standby 70 kg chlorine gas drums on weigh scales with auto-changeover
- 1 × cold standby 70 kg chlorine gas drum
- 2 × vacuum regulators, rate valves and ejectors
- 2 × control valves
- 2 × electrical auto cylinder shutdown systems
- 2 × duty/ standby chlorine booster pumps for pre- and post-dosing
- 2 × chlorinators (duty/ duty)
- 1 × Leak detection with auto gas generator

Coolabah Reservoir Site Chlorination System

The chlorine gas dosing system at Coolabah Reservoir site consists of the following components:

- 2 × duty/standby 70 kg chlorine gas drums on weigh scales with auto-changeover
- 2 × vacuum regulators, rate valves and ejectors
- 2 × control valves
- 2 × electrical auto cylinder shutdown systems
- 2 × duty/ standby chlorine booster pumps
- 1 × chlorinator (duty)
- 1 × Leak detection with auto gas generator.

7.3.5.4 Dose Range and Turndown Ratio

Mendooran WTP Site

Table 7-9 provides a summary of the typical dose rates, daily consumption, turndown ratio and 30 day's consumption based on the expected nominal dose rate at the Mendooran WTP site.

Note: the flowrate at the oxidation point accounts for 7.5% of process water losses and the flow rate at the disinfection dose point accounts for 15% of process water losses.

Table 7-9: Chemical Dose Rates and Product Consumption

Dose range in mg/L of Cl_2	Flow Range (ML/d)			Units	Comments/ Units
	Nominal – 0.185	95th-%ile - 0.392	Design - 1.062		
Oxidation					
2.0	0.37	0.78	2.12	kg/d of product	Assumes product purity of 100% w/v
3.0	0.56	1.18	3.19	kg/d of product	
5.0	0.93	1.96	5.31	kg/d of product	
Turndown ratio			14		
30 days' consumption (at nom. flow & avg dose)			17	kg/d of product	
Dose range in mg/L of Cl_2	**Flow Range (ML/d)**			**Units**	**Comments/ Units**
	Nominal - 0.170	**Maximum - 0.360**	**Design – 0.976**		
Disinfection					
2.0	0.34	0.72	1.95	kg/d of product	Assumes product purity of 100% w/v
3.0	0.51	1.08	2.93	kg/d of product	
5.0	0.85	1.80	4.88	kg/d of product	
Turndown ratio			14		
30 days' consumption (at nom. flow & avg dose)			15	kg/d of product	
Total 30 days' consumption (at nom. flow & avg dose) – oxidation + disinfection			32	kg/d of product	

Coolabah Reservoir Site

Table 7-10 provides a summary of the typical dose rates, daily consumption, turndown ratio and 30 day's consumption based on the expected nominal dose rate at the Coolabah Reservoir site.

Note: the flowrate is based on as assumed instantaneously recirculation flowrate of 12 L/s for 1, 4 or 8 hours per day (i.e. total flow of 43.2 kL/d, 86.4 kL/d, 345.6 kL/d, respectively).

Table 7-10: Chemical Dose Rates and Product Consumption

Dose range in mg/L of Cl_2	Flow Range (kL/d)			Units	Comments/ Units
	Nominal – 0.043	95th-%ile - 0.086	Design – 0.346		
1.0	0.04	0.09	0.35	kg/d of product	Assumes product purity of 100% w/v
2.0	0.09	0.17	0.69	kg/d of product	
3.0	0.13	0.26	1.04	kg/d of product	
Turndown ratio			24		
30 days' consumption (at nom. flow & avg dose)			5	kg/d of product	

7.4 Concept Design for Inline Mixer

7.4.1 General

Good coagulation requires that all coagulant chemicals be mixed very quickly and thoroughly with the water and with sufficient energy so that the particles and the coagulant molecules collide rapidly and often. This is particularly important for the metal coagulants where the initial chemical reactions of adsorption-destabilisation occur in less than 1 second.

The Inline Mixer will be used to mix coagulant downstream of the Blending Tank, with the outlet of the Inlet Mixer connected with the existing Cascade Aerator.

7.4.2 Design Requirements

The design requirements for Inline Mixer are as follows:

- The Inline Mixer will be of static or mechanical type.
- Monitoring instrumentation will be provided in the pipework between the Blending Tank and Inline Mixer. These details are outlined in Section 8.
- The works shall be designed to accommodate the inline dosing of coagulant and soda ash. The details of the chemical dosing systems are listed in Section 7.
- The dosing point for coagulant shall be located downstream of the soda ash dosing point and monitoring equipment, and upstream of the mixer.
- The dosing point for soda ash shall be located downstream of the Blending Tank and upstream of the monitoring equipment, coagulant dosing and Inline Mixer.
- Materials of construction must be compliant with the chemicals dosed.
- The outlet of the Inline Mixer shall be connected to the inlet of the Cascade Aerator.

The rapid mixing stage should provide at least 2 seconds' detention time for in-line mixing. The mixing gradient (i.e. G value) for the rapid mixing stage should be at least 750 s^{-1}.

Table 7-11: Coagulation System Options Design

Item	Details	Value	Comments
In-line mixer	Mixing gradient (s^{-1})	750	Mechanical mixing
	Coefficient of Variance	0.05	Static mixer

After inline mixing, the coagulated water will flow on to the existing Cascade Aerator where coagulated water will gravitate towards the Flocculation Tank.

7.5 Concept Design for Service Water Pumps

7.5.1 General

Two (2) new duty/ standby Service Water Pumps connected to a pressure accumulator shall be made available at the outlet of the Clear Water Tank to provide service water for:

- Chemical batching, dilution, carrier and flushing requirements
- Service water to an onsite hose reel for chemical area washdown inside chemical dosing room
- Other

7.5.2 Design Requirements

The design requirements for the service water pumps is as follows:

- The service water pumps shall be sized to:
  - Provide sufficient dilution water for chemical makeup/ batching and delivery as follows:
    - Soda ash shall be:
      - Batched as a 10% w/v solution
      - Delivered at a 10:1 ratio of carrier water to soda ash solution
    - Potassium permanganate shall be:
      - Batched as a 2% w/v solution (without heating). Note: this is an estimate based on previous experience. Solubility can vary depending on mixing efficacy and temperature.
      - Delivered at a 10:1 ratio of carrier water to potassium permanganate slurry
    - Polymer LT22S shall be:
      - Batched as a 0.2% w/v solution (typically 0.15-0.3%)
      - Delivered at a 10:1 ratio of carrier water to polymer solution
    - Coagulant PACl shall be delivered as at a 20:1 ratio of carrier water to coagulant
    - Chlorine solution shall be delivered at 10 L/min (Chlorine Handbook)
  - Provide service water to one (1) standard hose rated to deliver 65 L/min
  - Include contingency of +25%

The system will comprise two (2) duty/ standby Service Water Pumps connected to a pressure accumulator to maintain a constant pressure throughout the service water reticulation and deliver up to approximately 130 L/min.

7.5.3 Concept Design Calculations

The following calculations were used to determine the Service Water Pump sizing requirements and turndown ratio for the three design capacities i.e. 0.200, 0.424 and 1.148 ML/d (which correspond to nominal, 95^{th}%ile and design flow rates).

Contractor

Table 7-12 Service Water Pumps Design Calculations

Service water requirements	Nominal WTP flow	95^{th}%ile WTP flow	Design Flow	Comments
Number of pumps		2		
Configuration		Duty/standby		
1 × standard hose for chemical washdown area (L/min)	65.00	65.00	65.00	Assumes standard hose delivers 65 L/min

Service water requirements	Nominal WTP flow	95th%ile WTP flow	Design Flow	Comments
Soda ash batching and carrier water (L/min)	1.53	3.24	8.77	Based on 10% w/v solution, 10:1 dilution
$KMnO_4$ batching and carrier water (L/min)	0.39	0.82	2.22	Based on 2% w/v solution, 10:1 dilution
Coagulant carrier water (L/min)	1.25	2.65	7.19	Based on 20:1 dilution
Polymer batching and carrier water (L/min)	0.15	0.32	0.87	Based on 0.2% solution, 10:1 dilution
Chlorine carrier water (L/min)	20	20	20	Based on Chlorine Handbook data
Contingency +/- 25%	22.08	23.01	26.01	
Turndown ratio	To be determined by contractor			
Total estimation (L/min)	**110.4**	**115.0**	**130.1**	
Total estimation (L/s)	**1.8**	**1.9**	**2.2**	

7.6 Concept Design for Wastewater Holding Tank

7.6.1 General

- A Wastewater Holding Tank of approximately 6 kL is to be installed at site for transfer of chemical waste in the event of a chemical spill.
- The Wastewater Holding Tank will not be plumbed in by rather be fed by temporary 25 mm flexible hose connected to an uninstalled chemical transfer pump.

7.6.2 Design Requirements

The design requirements are as follows:

- Wastewater Holding Tank sized to contain 110% of liquid chemical stored at site or 6 kL; whichever is larger
- Tank materials of construction to be suitable for contact with corrosive liquids
- Uninstalled chemical transfer pump to transfer contained spills to tank via an inlet value situated below eye level).
- Camlock fitting at tank for transfer of waste offsite
- Pressure relief valve
- Access hatch for inspection and maintenance
- Scour valve for maintenance cleans
- Level sensor affixed to top of tank to alert operators when tank is approaching its maximum limit.

7.7 Safety in Design Considerations

The following safety equipment will be available:

- Chemical bunds around liquid chemical dosing systems sized to contain 110% of chemical storage volumes with entry and exit ladders as required.

- Note that the existing chemical bunds are 0.5 m in height and have the following dimensions:
  - Soda ash dosing system: 2,375 mm x 4,150 mm x 500 mm.
  - Potassium permanganate dosing system: 2375 mm x 4150 mm x 500 mm.
  - Sodium hypochlorite dosing system: 4000 mm x 4150 mm x 500 mm.
  - PACl dosing system: 4000 mm x 4150 mm x 500 mm.
- If the existing chemical bunding is to be re-used for the upgraded systems, the Contractor will be required to provide a condition assessment to determine if any remediation works are required.
  - Figure 7-1 below shows the existing bunding in the chemical dosing system room.

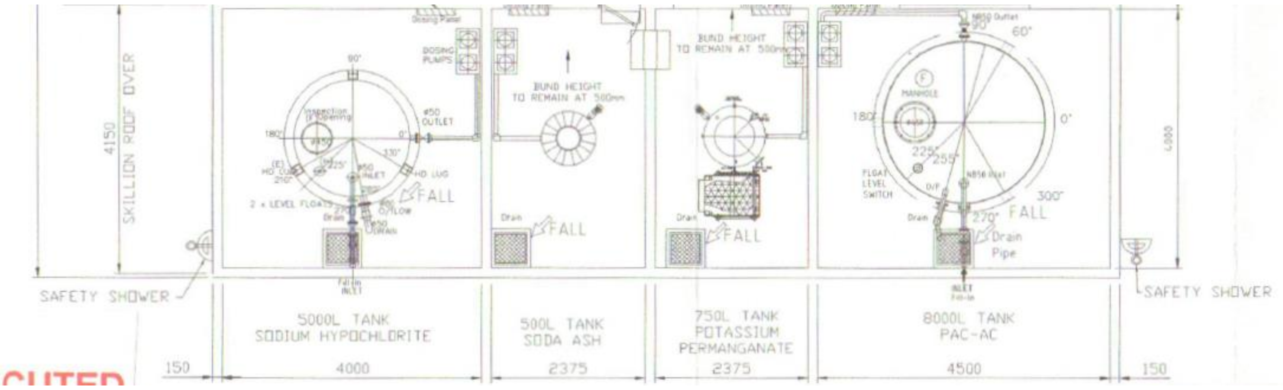

Figure 7-1: Existing bunding in chemical dosing system area

- The Contractor will be required to install the chemical dosing systems with minimal downtime to ensure near-continuous operation and treatment. This may require that the new chemical dosing systems be installed and brought online in sequence. For example, once the new chlorine gas room has been installed, the existing sodium hypochlorite system can be decommissioned, which will provide space for another system to be installed. The existing non-operational soda ash system can also be decommissioned at any stage. The Contractor will be required to provide a project schedule for such works.
- Deluge-type safety shower/ plunge bath and eyewash facilities complying with AS 4775-2007 *Emergency Eyewash and Shower Equipment* within close proximately to chemical dosing facilities
- A hose (25 mm diameter minimum) of suitable length to reach all parts of the unloading area and permanently connected to a water tap. The water tap must be fitted with a backflow prevention device complaint with AS 2845.1-2010 *Water Supply – Backflow Prevention Devices*
- Safety Data Sheets (SDSs) for each chemical
- Equipment to allow vacuum transfer of product during loading to minimise dust inhalation
- Personal Protective Equipment (PPE) including chemical suits, googles, face masks and/or face-shield, rubber boots and rubber gloves, as relevant to the advice provided in relevant chemical SDS's.
- Adequate ventilation for all enclosed chemical areas
- Fire extinguishers complying with AS 2444-2001 Potable Fire Extinguishers and Fire Blankets
- 240 L chemical spill kit
- Appropriate safety signage.

- The following standards are applicable to the Mendooran WTP chemical dosing system upgrades and shall be referenced in the technical specification:
  - AS NZS 2927:2001 The storage and handling of liquefied chlorine gas
  - AS 3780: 2008 The storage and handling of corrosive substances
  - AS 4326: 2008 The storage and handling of oxidizing agents
  - AS 2845: 2010 Water supply—Backflow preventions devices
  - AS 4775: 2007 Emergency eyewash and shower equipment
  - AS NZS 3000: 2007 *Wiring rules.*

8 Work Package 3: Online Instrumentation & Process Control

8.1 Description of works

8.1.1 Overview

The following table is an excerpt of Table 3-1 is summarises the activities to be addressed in this Section of the Report.

Table 8-1: Scope of Works and Activities

No.	Work packages	Activities
WP3	Online instrumentation and process control	• Identification for all required instrumentation including: o Analytical: turbidimeters, pH, free chlorine, UVI o Flow switches, flow meters and level sensors o Variable speed drives at: ▪ Castlereagh Riverbed Pumps ▪ Backup Bore Pumps ▪ Low level/filter feed pumps • Describe process control philosophy (alarm setpoints and feedback control) for: o All chemical dosing systems listed in WP2 o Filtration forward and backwash control o Analytical instrumentation in accordance with CWT and Hunter H_2O recommendations (defined in Section 8)

8.1.2 General

The Mendooran WTP shall be upgraded with sufficient automation for remote unmanned operation with periodic on-site input from operators of around 20 man-hours per week at site (excluding travel to/from site).

The control system upgrades to the WTP shall include the following control system components:

- If possible, the control system shall be linked to the raw water supply control systems via a RTU system
- A master Programmable Logic Controller (PLC) system and programming in accordance with Hunter H_2O's recommendations
- Proprietary PLC systems where relevant such as those made available with the UV disinfection systems
- Supervisory Control and Data Acquisition (SCADA) system and programming; including:
  - SCADA information and processes status and alarms
  - SCADA to include time stamped events and alarm logs
- SCADA HMI computer
- All necessary SCADA I/O for remote monitoring and control from WSC's SCADA system
- The option to link new RTU units with WSC's existing ELPRO Automation system
- Local controls for components as applicable

- Communications cable CAT5e.

8.1.3 Performance Requirements

The WTP control system will be upgraded to provide:

- Fully automated, remote operation of WTP system (with periodic site attendance)
- Continuous monitoring
- Remote access and control
- Chemical dosing flow pacing, with no hunting or rapid changes to dosing or flowrates
- Automatic adjustment of some chemical dosing rates based on monitoring feedback loops
- Calibration testing ability
- A manual override facility for operation of WTP sub-systems and individual equipment.

8.1.4 Summary of Instruments and Requirements

In June of 2020, HunterH$_2$O issued their WTP Automation and Process Instrumentation Audit. The purpose of the audit was to review current instrumentation, compare it with WSC's Drinking Water management System (DWMS) and make recommendations for new instrumentation and automation and control requirements.

Except where stated in the Table notes below, CWT's recommendations align with those of HunterH$_2$O.

Table 8-2 is a summary of the recommended instrumentation, their location and requirements.

Table 8-2: Summary of Instrumentation, Location and Requirements

Online Instrument	Location	Requirements		
		Install new	Replace existing	Relocate
Flow and Level Instruments				
Flowmeters	Common combined raw water	✓		
	Pre-filters[2]	✓		
Flow switches	Post-Blending Tank[2]	✓		
Level sensor	Blending Tank	✓		
	Settled Water/Filter Feed Pump Station	✓		
	Coolabah Reservoir No. 1 or No. 2	✓		
Variable speed drives	Castlereagh River Pumps	✓		
	Backup Bore Pump	✓		
	Low Level/Filter Feed Pumps	✓		
Analytical Instruments				
Free chlorine analyser	Common filtered water[2]	✓		
	Treated water pre-CWT[1]	✓		
	Treated water post-CWT[3]		✓	✓
	Recirculation line at Coolabah Reservoirs' site		✓	

Online Instrument	Location	Requirements		
		Install new	Replace existing	Relocate
pH analyser	Raw water		✓	
	Post-Blending Tank	✓		
	Treated water post-CWT3		✓	✓
Turbidimeter	Raw water		✓	
	Settled/ clarified water	✓		
	Filter 1 filtrate	✓		
	Filter 2 filtrate	✓		
	Combined filtered water			✓
UV intensity (future)	At UV unit	✓		
Fluoride analyser	Outside scope of this project			

Note 1: Recommended by HunterH_2O but may be removed as a cost-saving initiative.
Note 2: Not captured by HunterH_2O but recommended by CWT
Note 3: CWT recommends a combined chlorine-pH-T analyser.
Note 4: Alternatively, the Contractor may propose an ORP sensor to monitor chlorine present in the coated media filtrate.

Refer to Hunter H_2O's *WTP Automation and Process Instrumentation Audit* (2020).

Note: Hunter H_2O's report lists a turbidimeter as a requirement on the treated water line. In the Concept Design Workshop held on the 22nd of July, it was agreed that this is not required in addition to other turbidimeters located upstream.

Furthermore, it was noted that Council have already procured a Wallace & Tiernan Depolox 3 chlorine analyser. This should be installed by the Contractor in a suitable location that is representative of the process it is trying to measure and/ or control as follows:

- If this analyser is to be the *common filtered water analyser* it must be located at least 3 minutes from the chlorine dose point and preferably in a location that prevents 'drift' following plant restart and necessitates frequent recalibration. Typically, this is in a location with constant flows.
- If this analyser is to be the treated water analyser, it must also be installed in a location that prevents 'drift' following plant restart and necessitates frequent recalibration. Typically, this is in a location with constant flows.

8.2 Instrument List and Controls

Table 8-3 provides the control function for each instrument identified in Table 8-2.

Table 8-3: Preliminary Instrument List

Online Instrument	Location	Control Function
Flow and Level Instruments		
Flowmeters	Common combined raw water	▪ Continuous online monitoring of combined raw water flows ▪ Secondary verification of upstream flowmeters
	Pre-filters	▪ Continuous online monitoring of settled/clarified water flows ▪ Provides stop/start signals and flow-pacing for pre-filter chlorination

Online Instrument	Location	Control Function
Flow switches	Soda ash dosing system	▪ Alarming and confirmation that soda ash solution is being dosed
	Potassium permanganate dosing system	▪ Alarming and confirmation that potassium permanganate slurry is being dosed
	PACl dosing system	▪ Alarming and confirmation that PACl is being dosed
	Post-Blending Tank	▪ Provides stop/start signals for soda-ash (secondary dose point option) and coagulant dosing
	Post-Cascade Aerator	▪ Provides stop/start signal for polymer dosing
Level sensor	Blending Tank	▪ Raises alarms at HH, H, L, LL level to inform operators of tank level and allow for manual intervention if required ▪ Automatic feedback control for start/stop signal to duty Raw Water Pumps o Starts Raw Water Duty Pump(s) at L level o Stops Raw Water Duty Pump(s) at H signal
	Settled Water/Filter Feed Pump Station	▪ Raises alarms at HH, H, L, LL level to inform operators of tank level and allow for manual intervention if required
	Coolabah Reservoir No. 1 or No. 2	▪ Raises alarms at HH, H, L, LL level to inform operators of tank level and allow for manual intervention if required ▪ Other control settings as per those implemented at Coolabah No. 3 Reservoir.
Variable speed drives	Castlereagh River Pumps	▪ Adjusts pump rate with respect to operator selectable plant flowrate
	Backup Bore Pump	▪ Adjusts pump rate with respect to operator selectable plant flowrate
	Low Level/Filter Feed Pumps	▪ Automatically adjusts pump rate to raw water flowrate and/or adjusts pump rate with respect to operator selectable flowrate (e.g. in the event of poor water conditions)
Analytical Instruments		
Free chlorine analyser	Common filtered water	▪ Continuous online confirmation that post-filtration chlorine residual setpoint is being met. ▪ If TRIM is selected in the PLC, provides 4-20 mA signal feedback for pre-chlorination (pre-Filters) trim dosing ▪ Raises alarm at HH, H, L, LL level to inform operators to manually adjust pre-chlorination (pre-Filters) dose setpoint.
	Treated water pre-CWT	▪ Disinfection CCP (MDN2) verification monitoring point ▪ Continuous online confirmation that post-chlorination (for disinfection) and the chlorine dose setpoint is being met. ▪ Raises alarm at HH, H, L, LL level to inform operators to manually adjust pre-chlorination (pre-Filters) dose setpoint.
	Treated water post-CWT	▪ Distribution CCP (MDN4) verification monitoring point ▪ Continuous online confirmation that chlorine residual (for disinfection) setpoint is being met to achieve C.t target. ▪ Provide WTP and Treated Water Pumps shutdown signals if treated water chlorine residual is outside the allowable range to prevent supply to customers

Online Instrument	Location	Control Function
		▪ Raises alarm at HH, H, L, LL level to inform operators to manually adjust post-chlorination dose setpoint.
		▪ Continuous online confirmation (accurate when recirculation pump is running only) that chlorine residual setpoint is being met. ▪ If TRIM is selected in the PLC, provides 4-20 mA signal feedback for booster chlorination trim dosing ▪ Raises alarm at HH, H, L, LL level to inform operators of requirement to manually adjust dose setpoint.
pH analyser	Raw water	▪ Continuously online monitoring of raw water pH ▪ Provides duty Raw Water Pump shutdown signal if raw water pH is outside allowable range ▪ Raises alarm at HH, H, L, LL level to provide early-warning and allow operators to select alternate raw water sources if required or manually adjust soda ash dose setpoint
	Post-Blending Tank	▪ Continuously online monitoring of blending water pH ▪ If TRIM is selected in the PLC, provides 4-20 mA signal feedback for soda ash automatic feedback control trim dosing (at primary or secondary dose point) ▪ Raises alarm at HH, H, L, LL level to inform operators to manually adjust soda ash dose setpoint (at primary or secondary dose point)
	Treated water post-CWT	▪ Final pH CCP (MDN5) verification monitoring point ▪ Continuously online monitoring of treated water pH ▪ Provide WTP and Treated Water Pumps shutdown signals if treated water pH is outside the allowable range to prevent supply to customers ▪ If TRIM is selected in the PLC, provides 4-20 mA signal feedback for soda ash automatic feedback control trim dosing (at tertiary dose point) ▪ Raises alarm at HH, H, L, LL level to inform operators to manually adjust soda ash dose setpoint (at tertiary dose point)
Turbidimeter	Raw water	▪ Continuously online monitoring of raw water turbidity ▪ Provides duty Raw Water Pump shutdown signal if raw water turbidity is above the allowable limit ▪ Raises alarm at HH, H level to provide early-warning and allow operators to select alternate raw water sources if required or manually adjust coagulant dose setpoint
	Settled/ clarified water	▪ Possible Clarification/ Sedimentation CCP verification monitoring point ▪ Continuous online monitoring of settled/ clarified water turbidity ▪ Signals for Low Level Pumps shutdown if settled/ clarified water turbidity is above the allowable limit ▪ Raises alarm at HH, H level to provide early-warning and allow operators to select alternate raw water sources if required or manually adjust coagulant dose setpoint ▪ Clarification/ Sedimentation CCP verification monitoring point
	Filter 1 filtrate	▪ Continuous online monitoring of filter 1 filtrate turbidity ▪ At a H level signals for WTP shutdown and queue filters for backwash

Online Instrument	Location	Control Function
		▪ Raises alarm at HH, H level to alert operators of high turbidity
	Filter 2 filtrate	▪ Continuous online monitoring of filter 2 filtrate turbidity ▪ At a H level signals for WTP shutdown and queues filter for backwash ▪ Raises alarm at HH, H level to alert operators of high turbidity
	Combined filtered water	▪ Distribution CCP (MDN7) verification monitoring point ▪ Continuous online monitoring of combined filtrate turbidity and verification of individual filter filtrate turbidimeters ▪ At H level signals for WTP shutdown and queues filters for backwash ▪ Raises alarm at HH, H level to alert operators of high turbidity
UV intensity (future)	At UV unit	▪ UV disinfection CCP (future) verification monitoring point ▪ Continuous online monitoring of UV dose ▪ Provides WTP shutdown signals if UV dose is below acceptable limit ▪ Raises alarm at LL, L to alert operators

8.3 Critical Control Points

A Critical Control Point is an activity, procedure or process at which control can be applied in a timely manner, and that is essential to prevent a hazard or reduce it to an acceptable level (ADWG, 2011).

In order to prevent or reduce a hazard, the CCP must be monitored to provide timely feedback of data so corrective action can take place before the hazard can no longer be controlled. This necessitates the use of online instrumentation to provide ongoing output of data regarding the performance of a CCP.

CCPs are assigned parameters which are measured continuously and for which target, adjustment and critical limits are applied.

- The **target** can be a range or setpoint for which values represent normal operation and acceptable mitigation of a hazard.
- An **adjustment/ alert** limit can be an upper or lower range or limit for which values represent a deviation from normal operation and where corrective action may be required to return the process to control.
- A **critical** limit is an upper or lower limit which, if breached, indicates that the process is out of control and the system is no longer mitigating a specific hazard for which it was designed to treat or remove.

The location of analytical instrumentation is critical and should be located such that it can provide process verification of the CCP while eliminating interference by other processes or being situated too far or too close to the process to provide in-time or accurate monitoring.

To meet the above requirements, CWT recommends that WSC revise the Mendooran WTP CCP's to ensure:

- The name of the CCP applies to an activity, procedure or process only – Distribution [MDN4] and Final pH CCP [MDN5] does not meet this requirement
- Analytical instruments which have been elected for CCP verification must provide information in a timely manner to allow intervention and prevent hazards from passing through the system – the current location of the treated water chlorine [for MDN4] and pH analysers [for MDN5] is beyond the point where control can be applied and/or supply to customers can be prevented in the event of a CCP breach.

- Analytical instruments which have been elected for CCP verification should be located such that they provide reliable indication of the performance of the CCP process – treated water turbidity [for MDN7] is a poor indicator of filtration performance or overall plant performance as it is subject to interference by competing processes such as soda ash dosing.
- All critical limits correspond to plant shutdown or divert of water to prevent supply to customers.

Table 8-4: Recommendation for Revised CCPs at Mendooran WTP

No.	CCP	Monitoring Location	Parameter	Target	Alert	Critical
MDN1	**Filtration**	Turbidimeter at common outlet of filters	Turbidity (NTU)	<0.2	>0.3	>0.5
MDN2	**UV Disinfection**	UVI sensor at UV Disinfection Unit (future)	UV dose (mJ/cm^2)	>40		<40
MDN3	**Chlorine Disinfection**	Combined chlorine residual and pH analyser at outlet of Clear Water Tank prior to Treated Water Pumps	Chlorine residual (mg/L)	0.7-2.0	<0.4, >3.0	<0.2, >4.0
			pH	7.5 – 8.3	7.0 – 8.4	6.5 – 8.5

8.4 Alarm Lists

The analytical alarms are listed in Table 8-5. This is not an exhaustive list and does not include all alarms; particularly alarms that may be proposed by manufacturers of proprietary systems.

For more alarming and instrument control information refer to HunterH_2O's *WTP Automation and Process Instrumentation Audit* (2020).

The following alarm list is intended as a guide only and may be modified at the discretion of Council.

- *System alarm* means an alarm is raised in SCADA.
- *Operator callout* means an operator is alerted remotely to their personal communications device and that manual intervention may be required.
- *Plant shutdown* means that breaches of the alarm condition automatically divert or shutdown the plant to prevent delivery of off-specification water to downstream process or the customer.
- The instruments elected for CCP control, in accordance with Table 8-5, are in **blue.**

Table 8-5: Preliminary WTP Alarm List

Online Instrument	Location	Mode, Level	System Alarm	Operator Callout	Plant Shutdown/ Divert
Free chlorine analyser	Common filtered water	HH, LL	✓	✓	✓
		H, L	✓		
	Treated water pre-CWT	HH, LL	✓	✓	
		H, L	✓		
	Treated water post-CWT (CCP MDN3 Chlorine Disinfection)	HH, LL	✓	✓	✓
		H, L	✓		
	Coolabah Reservoirs' Site	HH, LL	✓	✓	

Online Instrument	Location	Mode, Level	System Alarm	Operator Callout	Plant Shutdown/ Divert
		H, L	✓		
pH analyser	Raw water	HH, LL	✓	✓	
		H, L	✓		
	Post-Blending Tank	HH, LL	✓	✓	
		H, L	✓		
	Treated water post-CWT (CCP MDN3 Chlorine Disinfection)	HH, LL	✓	✓	✓
		H, L	✓		
Turbidimeter	Raw water	HH	✓	✓	✓
		H	✓		
	Settled/ clarified water	HH	✓	✓	✓
		H	✓		
	Filter 1 filtrate	HH	✓	✓	✓
		H	✓		
	Filter 2 filtrate	HH	✓	✓	✓
		H	✓		
	Combined filtered water (CCP MDN1 Filtration)	HH	✓	✓	✓
		H	✓		
UV intensity (future)	At UV unit (CCP MDN2 UV Disinfection)	LL	✓	✓	✓
		L	✓		

8.5 Raw Water Supply

There are existing flowmeters on each raw water source with the exception of the onsite emergency bore.

A new common raw water flowmeter is to be installed at the common raw water inlet line to the Blending Tank. An accurate flow meter, such as a magnetic flow meter, is required on the inlet main to provide measurement of flow rates.

The selected flow rate control system should allow operators to select a WTP flow rate anywhere in the range between the minimum and maximum WTP design flow rate, as specified in Section 4.2.2. The control system shall also allow operators to select a single WTP raw water source, with the exception of the Emergency Bore. If multiple raw water sources are selected, appropriate controls and alarms must be in place to maintain the WTP flow rate within the design capacity range, as specified in Section 4.2.2. Flow meters and analysers shall be connected to SCADA to allow for call out alarms and remote monitoring.

The flow control system will include automatic flow ramping and flow-related alarms.

Under normal operations, the WTP flow rate shall be set to maintain the Clear Water Storage level within an operating band. However, low/high levels in the Clear Water Storage may be used to start/stop the SCADA selected raw water pump(s).

8.6 Chemical Dosing Systems

Chemical doses should be able to be selected on the SCADA screen in terms of the "mg/L" dose of active ingredient in a given chemical. The control system will calculate the required dosing pump rate based on the dose setpoint and the WTP flow rate.

All chemical dosing will be flow proportional and adjusted with respect to the first flowmeter upstream of the dose point.

Where there is no flowmeter immediately upstream of the chemical dose point, a flow switch shall be made available to allow the stop/start of the chemical dosing.

Trim dosing shall be made available for the soda ash and chlorine gas dosing systems and will be described further in their relevant Sections.

Where chemical systems dose to several different points and share a common standby dosing pump, the SCADA system will need to allow for checks and alarms so that the standby pump uses the correct flow pacing and/or feedback analyser signals when it is used.

8.6.1 Soda Ash

When soda ash dosing is selected to operate, the required soda ash dose rate set point is entered into SCADA as "mg/L of Na_2CO_3."

The required soda ash dose rate set point shall be entered into SCADA. The dose required shall be determined by the operators and should be adjusted with respect to the incoming raw water pH (as measured online) and alkalinity (as measured in the lab).

The soda ash dosing system will operate when the following conditions are satisfied:

- The Raw Water Pumps are operating i.e. the front-end of the WTP is in operation
- The WTP flow rate as selected by the operator in the PLC is equal to or ±10% as detected at the common raw water flowmeter
- The soda ash dosing system is selected to operate
- The soda ash dosing system is available and online

If the soda ash dosing system is selected to operate but is not available due to any system fault, an alarm will be raised, and the system will not run.

Soda ash dosing can occur at only one of three locations in the plant (as described in Section 7.3.1) and therefore share 2 × duty/ standby dosing pumps. An "Automatic / Manual / off" selection shall be provided on SCADA for the dosing pumps. Automatic transfer to the standby pump is required on detection of a duty pump failure or soda ash solution flow fault.

8.6.2 Potassium Permanganate

The required potassium permanganate dose rate set point shall be entered into SCADA as "mg/L of $KMnO_4$." The dose required shall be determined by the operators and should be proportional to the soluble manganese concentration of the raw water.

The potassium permanganate dosing system will operate when the following conditions are satisfied:

- The Raw Water Pumps are operating i.e. the front-end of the WTP is in operation

- The WTP flow rate as selected by the operator in the PLC is equal to or ±10% as detected at the common raw water flowmeter
- The potassium permanganate dosing system is selected to operate
- The potassium permanganate dosing system is available and online

If the potassium permanganate dosing system is selected to operate but is not available due to any system fault, an alarm will be raised, and the system will not run.

Potassium permanganate dosing occurs at one location in the plant (as described in Section 7.3.2) and therefore has dedicated 2 × duty/ standby dosing pumps. An "Automatic / Manual / off" selection shall be provided on SCADA for the dosing pumps. Automatic transfer to the standby pump is required on detection of a duty pump failure or potassium permanganate slurry flow fault.

8.6.3 Polyaluminium Chloride (PACl)

The required PACl dose rate set point shall be entered into SCADA as "mg/L of Al_2O_3." The dose required shall be determined by the operators and should be adjusted with respect to the incoming raw water turbidity (as measured online) and daily jar tests (as performed in the lab).

The PACl dosing system will operate when the following conditions are satisfied:

- The Raw Water Pumps are operating i.e. the front-end of the WTP is in operation
- The WTP flow rate as selected by the operator in the PLC is equal to or ±10% as detected at a flow switch
- The PACl dosing system is selected to operate
- The PACl dosing system is available and online.

If the PACl dosing system is selected to operate but is not available due to any system fault, an alarm will be raised, and the system will not run.

PACl dosing occurs at one location in the plant (as described in Section 7.3.3) and therefore has dedicated 2 × duty/ standby dosing pumps. An "Automatic / Manual / off" selection will be provided on SCADA for the dosing pumps. Automatic transfer to the standby pump will be required on detection of a duty pump failure or PACl flow fault.

8.6.4 Polymer

When polymer dosing is selected to operate, the required polymer dose rate set point is entered into SCADA as "mg/L of polymer." The dose required shall be determined by the operators and should be adjusted with respect to the incoming raw water turbidity (as measured online) and daily jar tests (as performed in the lab).

The polymer dosing system will operate when the following conditions are satisfied:

- The Raw Water Pumps are operating i.e. the front-end of the WTP is in operation
- The WTP flow rate as selected by the operator in the PLC is equal to or ±10% as detected at a flow switch
- The polymer dosing system is selected to operate
- The polymer dosing system is available and online.

Polymer dosing can occur at one location in the plant (as described in Section 7.3.4) and therefore has dedicated 2 × duty/ standby dosing pumps. An "Automatic / Manual / off" selection will be provided on SCADA for the dosing pumps. Automatic transfer to the standby pump will be required on detection of a duty pump failure or polymer flow fault. An "Automatic / Manual / off" selection will be provided on SCADA for the dosing pumps. Automatic transfer to the standby pump will be required on detection of a duty pump failure or polymer flow fault.

8.6.5 Chlorine Dosing

8.6.5.1 Chlorine Dosing for Oxidation (Pre-Dosing)

The required chlorine dose rate set point shall be entered into SCADA as "mg/L of Cl_2." The dose required for oxidation shall be determined by the operators and should be adjusted to achieve a minimum detectable chlorine residual at the outlet of the filters. The acceptable chlorine dose range does not need to exceed 0.5 mg/L; only a minimal detectable limit (e.g. 0.02 mg/L) is required to ensure that the filter media beds are saturated with chlorine to maintain a manganese-oxide coating for manganese removal.

The chlorine (for oxidation) dosing system will operate when the following conditions are satisfied:

- The Low Lift Pumps are operating i.e. the back-end of the WTP is operating
- The WTP flow rate as selected by the operator in the PLC is equal to or ±10% as detected at a flowmeter prior to the filters
- The chlorine (for oxidation) dosing system is selected to operate
- The chlorine (for oxidation) dosing system is available and online.

If the chlorine (for oxidation) dosing system is selected to operate but is not available due to any system fault, an alarm will be raised, and the system will not run.

Chlorine (for oxidation) dosing occurs at one location in the plant (as described in Section 7.3.5) and therefore has a dedicated chlorinator.

8.6.5.2 Chlorine Dosing for Disinfection (Post-Dosing)

The required chlorine dose rate set point shall be entered into SCADA as "mg/L of Cl_2." The dose required for disinfection shall be determined by the operators and should be adjusted to achieve a sufficient chlorine residual (at the outlet of the Clear Water Tank) that correlates to a C.t value of ≥16 mg.min/L for 4-log removal of bacteria and viruses (assuming water quality is ≤2 NTU, pH ≤8.0 and T ≥ 10°C; WaterVal 2015).

The chlorine (for oxidation) dosing system will operate when the following conditions are satisfied:

- The Low Lift Pumps are operating i.e. the back-end of the WTP is operating
- The WTP flow rate as selected by the operator in the PLC is equal to or ±10% as detected at a flowmeter prior to the filters
- The chlorine (for disinfection) dosing system is selected to operate
- The chlorine (for disinfection) dosing system is available and online.

If the chlorine (for disinfection) dosing system is selected to operate but is not available due to any system fault, an alarm will be raised, and the system will not run.

Chlorine (for disinfection) dosing occurs at one location in the plant (as described in Section 7.3.5) and therefore has a dedicated chlorinator.

8.6.5.3 Chlorine Dosing for Booster Chlorination

The required chlorine dose rate set point shall be entered into SCADA as "mg/L of Cl_2." The dose required for booster chlorination shall be determined by the operators and should be adjusted to achieve a sufficient chlorine concentration to target a minimum chlorine residual of 0.2 mg/L at the extremities of the reticulation.

The chlorine (for booster chlorination) dosing system will operate when the following conditions are satisfied:

- The recirculation line is operation for a minimum period of time (delay period to be set by operators)
- A low level setpoint on SCADA for chlorine residual has been detected after the recirculation pump run time delay has lapsed. This delay shall allow the analyser reading to stabilize before providing automatic feedback to the booster pump system.
- The recirculation rate is equal to or ±10% as detected at a flow switch on the recirculation line
- The chlorine (for booster chlorination) dosing system is available and online.

If the chlorine (for booster chlorination) dosing system is selected to operate but is not available due to any system fault, an alarm will be raised, and the system will not run.

The booster chlorination and recirculation system shall stop once the chlorine residual, as measured by the chlorine residual analyser, reaches a desired setpoint, as input/adjusted by operators in the PLC.

8.6.5.4 Common facilities

Mendooran WTP Site

Liquified gas chlorine shall be housed in the chlorine gas room where two cylinders (duty/standby) shall be connected to the dosing system. The cylinders would be on weight scales to monitor their available capacity and the cylinders should have their temperature maintained by a storage heater.

The chlorine dosing system should deliver accurate doses of chlorine gas to two (2) chlorinators i.e. a chlorinator for chlorine oxidation and a chlorinator for chlorine disinfection. The chlorinators are monitored with flow indicators, pressure switches and speed indicator controllers.

When called to operate, the chlorination system should operate automatically from the PLC. The set point would be entered into SCADA for each chlorine dose point. The required feed rate would be calculated in the WTP PLC based on the set point and the flowrate of the WTP. The chlorinators would then provide this feed rate.

Shared chlorine booster pumps operating in duty/ standby will deliver water to each chlorinator. An "Automatic / Manual / off" selection will be provided on SCADA for the shared booster pumps. Automatic transfer to the standby pump will be required on detection of a duty pump failure or chlorine flow fault.

Coolabah Reservoirs' Site

Liquified gas chlorine shall be housed in the chlorine gas room where two cylinders (duty/standby) shall be connected to the dosing system. The cylinders would be on weight scales to monitor their available capacity and the cylinders should have their temperature maintained by a storage heater.

The chlorine dosing system should deliver accurate doses of chlorine gas to one (1) chlorinator for booster chlorination. The chlorinator is monitored with flow indicators, pressure switches and speed indicator controllers.

When called to operate, the chlorination system should operate automatically from the PLC. The set point would be entered into SCADA for each chlorine dose point. The required feed rate would be calculated in the WTP PLC based on the set point and the flowrate of the recirculation line. The chlorinator would then provide this feed rate.

Chlorine booster pumps operating in duty/ standby will deliver water to the chlorinator. An "Automatic / Manual / off" selection will be provided on SCADA for the shared booster pumps. Automatic transfer to the standby pump will be required on detection of a duty pump failure or chlorine flow fault.

8.7 Filtration and Backwash Control

At present flow through the filters is moderator by manual adjustment of the outlet flow control valves. Backwash is triggered on a timer every 5 hours.

The filtration and backwash control systems are to be upgraded to include:

- Installation of filter-to-waste line to discharge first pass of water after plant start-up or after filter backwash (may form part of works in Work Package 6)
- Installation of automatic flow control valves at the outlet of each filter (to maintain constant flow across filters and minimise turbidity breakthrough at start-up)
- Installation of turbidimeters at the outlet of each filters
- PLC control system to be updated/ upgraded to allow backwash to be triggered by:
    - Automatic timer
    - Differential pressure setpoint across each filter as measured by existing differential pressure indicators; and/or
    - Filtered water turbidity setpoint at outlet of each filter as measured by new turbidimeters.

9 Work Package 4: Mendooran Standpipe Booster Pumps and Standpipe Modifications

9.1 Description of works

9.1.1 Overview

The following table is an excerpt of Table 3-1 is summarises the activities to be addressed in this Section of the Report.

Table 9-1: Work Package 4 - Scope of Works and Activities

No.	Work packages	Activities
WP4	Mendooran standpipe booster pump installation	• Concept design and description of: ○ Mendooran Standpipe Booster Pumps (subject to reticulation condition assessment and/or pressure testing – out of scope) • Mitigation of reservoir integrity and WHS issues

9.1.2 Process Description

When a low level is detected at the Mendooran Standpipe, the High Lift Pumps at the Mendooran WTP will start supplying the Standpipe. Customers can be supplied directly from the main extending from the High Lift Pumps to the Standpipe.

At the Standpipe, water is supplied under gravity to the Mendooran township. When the Mendooran Standpipe approaches its lower limit, and therefore has reduced head pressure, two (2) duty/ standpipe Booster Pump shall boost and maintain pressure to the reticulation for improved distribution mains cleaning purposes.

9.1.3 Location of Works

The following table summarises the location of works.

Table 9-2: Work Package 4 - Location of Works

Process/ Equipment	Location
Mendooran Standpipe Booster Pumps	Located near the base of the Mendooran Standpipe near the inlet and outlet pipes.
Mitigation of reservoir integrity and WHS issues	Items located internally, externally and on the roof of the Mendooran Standpipe, in specifically these areas: • Roof access stairs • Internal access stairs • Internal overflow riser bracket • Safety equipment located on the Mendooran Standpipe roof.

9.2 Design Requirements

The service pressure requirements, as outlined by *AS/NZS 3500.1:2015 Plumbing and Drainage*, are the following:

- The minimum working pressure at the furthermost or most disadvantaged residential fixture or outlet shall not be less than 50 kPa (5 m head). Note, that some household fixtures may require more than 50 kPa supply pressure to function.
- Provision shall be made to ensure that the maximum static pressure at any outlet, other than a fire service outlet, within a building does not exceed 500 kPa.
- The maximum water velocity in piping shall be 3.0 m/s. The velocity limitation shall not apply to piping used exclusively for fire services.
- The pumps shall be controlled to limit the number of starts per hour to within the capacity of the pump.
- The pumps shall contain the following components:
  - Have vibration eliminators at the base of the pump, on the suction side and the delivery side of the pump, to minimise noise along the piping system and to prevent undue stress placed on the pump.
  - Have isolation valves on the delivery side and suction side of the pump.
  - Have a non-return valve on the delivery side of the pump before the isolation valve.
  - Have pressure gauges on the inlet and outlet of the pump.
  - Have unions or flanges to enable the pump's removal.

The suggested service pressure limits within the reticulation system, subject to pressure testing, are listed in the table below.

Table 9-3: Service pressure limit recommendations, subject to pressure testing

Item	Details	Value
Treated Water Supply Pressure	Desirable maximum service pressure	600 kPa (~87 psi, 60 m head)
	Minimum allowable service pressure	150 kPa (~22 psi, 15 m head)
	Desirable minimum service pressure	300 kPa (~44 psi, 30 m head)
	Desirable minimum static pressure	350 kPa (~51 psi, 35 m head)

The Standpipe Booster pumps shall be fully automatic. Pumps will start, change speed (where appropriate) or stop, as directed by the control sequences of the local PLC, with input from district control loops (locally at reservoir or pressure sensor) and from the HMI at the WTP.

Provision is required for connecting emergency standby generation directly into the switchboard.

9.3 Concept Design

9.3.1 Standpipe Booster Pumps

The Contractor will be required to size the booster pumps with a size range and appropriate turndown ratio that will be suitable for incremental changes in reticulation pressure during pressure testing. Care will be required during the supply pressure testing phase due to the age of the reticulation and varying materials of construction.

In the event of a pump failure, change over between the duty and standby booster pumps shall be automatically controlled by the SCADA System. The pumps may have either fixed or variable speed motors, designed to deliver the required flow at the available head. Pump curves will show the appropriateness of the pumps for their application.

The design parameters of the Standpipe Booster Pumps are listed below.

Table 9-4: Mendooran Booster Pumps Design Summary

Item	Details	Value
Mendooran Standpipe	Maximum Capacity (kL)	0.55 ML
	High level height – current (m)	To be confirmed by Council
	Low level height – current (m)	To be confirmed by Council
	High level height – new (m)	Same as existing
	Low level height – new (m)	Minimum suction pressure to be determined by the Contractor
Mendooran Standpipe Booster Pumps	Number of pumps	2
	Configuration	Duty/ standby
	Maximum pump supply pressure	To be determined by Contractor through reticulation pressure testing
	Minimum pump suction pressure	To be determined by Contractor
	Turndown ratio	To be determined by Contractor

9.3.2 Mendooran Standpipe Modifications

A number of reservoir integrity issues were identified in previous audit reports. CWT provided Council with a summary of these issues (*WMA1334-08-REG-B)*, to determine whether they were to be included within the Concept Design scope. The items that were chosen by Council to be included within the scope of the project are listed in the table below. Note that CWT has not performed any detailed reservoir inspections, and that the requirements below are based on previous inspection audit reports.

Table 9-5: Scope of Mendooran Standpipe modifications

Process/ Equipment	Modifications
Roof access stairs	• Replace or cover the existing roof access stair treads with FRP or galvanised tread, as the stairway is very narrow. • Strip and re-paint the existing roof access stairs due to potential contact with lead-based paint. Task not required if the stairs are replaced. • Install a base ladder with a security enclosure for the roof access stairs. No base ladder is present.
Internal access stairs	• Install an internal ladder for safe access or rescue. No internal ladder is present.
Internal overflow riser bracket	• Replace the overflow riser bracket due to corrosion and risk of failure for supply.
Safety equipment on Standpipe roof	• Load testing on the roof access davit. The davit is currently uncertified. • Add handrailing on roof for safe maintenance access.

9.4 Safety in Design

The following standards must be followed by the Contractor during the pressure testing phase of the installation.

- AS 4037 1999 Pressure Equipment – Examination and Testing
- AS4041 2006 Pressure Piping
- AS 4037 Standard Hydrostatic Pressure Test Records

The application of these standard for hydrostatic test states that the test should be undertaken for a minimum of 30 minutes unless otherwise specified in applicable standards.

A test pressure of 4 bar is to be applied in accordance with the standards.

The pressures discussed in these standards are for the design pressure of the fabricated pipe work and defer to the applicable installation standards for installation hydrostatic test pressures and durations.

The following standards must be followed by the Contractor for the design pressure of any fabricated pipe work, which defer to the applicable installation standards for installation hydrostatic test pressures and durations.

- AS/NZS 2033:2008 Installation of polyethylene pipe systems
- AS 4032 2006 Installation of PVC pipe systems
- AS 2566.2-2002 Buried flexible lines

The testing pressure gauge should be of an accuracy of not less than AS-1349.

The requirement for reporting results are

- Date of test
- Identification of the fabrication
- Test pressure
- Certification of compliance with the test requirements – no visible evidence of bulging, distortion or leakage.

10 Work Package 5: Management of Coolabah Reservoirs' Water Age and Reservoir Modifications

10.1 Description of works

10.1.1 Overview

The following table is an excerpt of Table 3-1 is summarises the activities to be addressed in this Section of the Report.

Table 10-1: Scope of Works and Activities

No.	Work packages	Activities
WP5	Management of Coolabah Reservoir water age	• Concept Design and description of: o Piping and hydraulic connections between the Coolabah Reservoirs o Installation of a recirculation line and pump o Installation of a chlorine gas dosing system o Chlorine residual monitoring • Mitigation of reservoir integrity and WHS issues

10.1.2 Process Description

Treated water would be received at the three Coolabah Reservoirs with a combined capacity of 0.51 ML (0.09 ML, 0.09 ML and 0.33 ML). The complex currently consists of three concrete tanks; Coolabah Reservoir No. 1 and 3 are connected to a common inlet-outlet main. Coolabah Reservoir No. 1 and 2 are hydraulically connected through a low-level connection.

To resolve poor circulation and storage dead zone issues, the Coolabah Reservoirs shall be hydraulically linked such that when one tank is filled the other tanks fill at a comparable rate. This requires that a low-level connection be provided between Coolabah Reservoir No. 2 and No. 3 and a recirculation line, fitted with a Recirculation Pump and chlorine analyser to be connected from Reservoir No. 3 to Reservoir No. 1.

Level sensors shall be available at another reservoir. Coolabah No. 3 is currently monitored with a level sensor, while the other two are not. Installing an additional analyser will provide some redundancy. .

After a period of time has lapsed, as set in the PLC, the Recirculation Pump will run allowing water to recirculate from Reservoir No. 3 to 1, then consequently, from No. 1 via No. 2 and back through No. 3. After a delay period, the reading from the chlorine analyser on the recirculation line shall stabilise to provide a representative average chlorine residual reading across the tanks.

If the chlorine residual reading is below a target setpoint chlorine concentration of 1-3 mg/L, a signal from the analyser will provide automatic feedback control to initiate the booster chlorination system. When the chlorine residual reaches the target chlorine concentration setpoint, the booster chlorine system shall turn off, following by the Recirculation Pump.

This purpose of this is to:

- Maintain chlorine residuals towards the end of the distribution network
- Reduce chlorine fluctuation at sites throughout the distribution network

- Increase operational flexibility for maintaining chlorine residuals in the network as usage characteristics change over time

10.1.3 Location of Works and Hydraulic Connections

Table 10-2 summarises the location of works and hydraulic connections.

Table 10-2: Location of Works and Hydraulic Connections

Components	Location of Works and Hydraulic Connections
Coolabah Reservoir No. 1, No. 2, No. 3	• Modifications to be undertaken at respective Reservoirs in accordance with Section 0.
Recirculation Line	• Installation of Recirculation Line to Connect Reservoir No. 3 to Reservoir No. 1; the downstream limit is Reservoir No. 3 and the upstream limit is Reservoir No. 1
Recirculation Utilities	• In the direction of flow, the following are to be installed on the recirculation line: chlorine analyser, Recirculation Pump and chlorine dose point
Chlorine Gas Dosing System	• Adjacent to Reservoirs in newly installed Chlorine Dosing Room
Hydraulic Connection Line	• Installation of Hydraulic Connection Line to Connect Reservoir No. 2 to Reservoir No. 3; the downstream limit is Reservoir No. 2 and the upstream limit is Reservoir No. 3

10.2 Design Requirements

Table 10-3 is summary of the design requirements.

Table 10-3: Work Package 5 - Design Requirements

Components	Design Requirements
Recirculation Line	• To prevent short-circuiting, the connection points of the recirculation line at Reservoirs' No. 3 and No. 1 must not align with any other existing pipe connections, in either height or at a position of 180°. The connection point to be configured in a manner that allows a baffle factor of at least 0.3 to be theoretically achieved • The pipework shall be pressure rated to deliver the maximum flow from the recirculation pump is accordance with AS AS4041 *Pressure Piping*
Hydraulic Connection Line	• To prevent short-circuiting, the connection points of the hydraulic connection line at Reservoirs' No. 2 and No. 3 must not align with any other existing pipe connections, in either height or at a position of 180°. The connection point to be configured in a manner that allows a baffle factor of at least 0.3 to be theoretically achieved.
Free Chlorine Residual Analyser	The chlorine residual analyser shall: • Provide automatic feedback control to the chlorine booster system after an operator input/adjusted delay has lapsed • Raise alarms at HH, H, L, LL levels
Recirculation Pump	• Recirculation flow rate shall be sized to achieve 100% total tank volume turnover over 12 hours. • The recirculation pump shall: ○ Start based on an automatic timer system; the timer duration shall be operator input/adjusted at the PLC. ○ Stop when the free chlorine residual setpoint is reached as signalled by the chlorine residual analyser.

Components	Design Requirements
Booster Chlorination System	• The chlorine dosing facility shall be ○ Designed and installed in accordance with relevant Sections of Section 7.3.5 of this report. ○ Operated and controlled in accordance with relevant Sections in Section 8 of this report.

10.3 Concept Design

10.3.1 Management of Water Age

Table 12-2 lists the Coolabah Reservoir components design, assumptions and calculations for the management of water age

Table 10-4: UV Disinfection Unit Design Basis, Assumptions and Calculations

Parameter (unit)	Value	Assumption/ Reference/ Comments
Total reservoir capacity (kL)	510	
No. of Recirculation Pumps	2	Council is to confirm their preferred level of redundancy
Configuration	Duty/ Standby	
Recirculation Pump Capacity (kL/h, L/d)	42.5, 12	Sized to turnover 100% of maximum volume over 12 hours
Chlorination setpoint range H, L	1, 3	To be confirmed by Council; depends on length of reticulation. WSC should select chlorine residual setpoints that would achieve 0.2 mg/L of free chlorine at extremities of reticulation for protection from contamination and/or ingress (ADWG, 2011).

10.3.2 Chlorine Gas for Booster Chlorination

The concept design for the booster chlorination dosing facility is described in:

- Relevant sections of Section 7.3.5 of this report relating to design and installation
- Relevant sections in Section 8 of this report relating to operation and control.

10.3.3 Coolabah Reservoir Modifications

A number of reservoir integrity and WHS issues were identified in previous audit reports. CWT provided Council with a summary of these issues (*WMA1334-08-REG-B)*, to determine whether they were to be included within the scope of works. The items that were elected by Council to be included within this project are listed in Table 10-5.

Table 10-5: Coolabah Reservoir Modifications

Process/ Equipment	Modifications
Coolabah Reservoir No. 1 and/or No. 2	• Design, manufacture, and construction of an independent access structure which could service both Coolabah Reservoir No. 1 and 2, or individually; access to the roof for sampling and access to level sensors was reportedly not compliant with WHS standards.
Coolabah Reservoir No. 1 and/or No. 3	• Design, manufacture, and construction of a new independent access structure for Coolabah Reservoir No. 3; current ladder does not have a platform.

11 Work Package 6: Replacement of Sludge Lagoons with Clarifier

11.1 Description of works

11.1.1 Overview

The following table is an excerpt of Table 3-1 is summarises the activities to be addressed in this Section of the Report.

Table 11-1: Scope of Works and Activities

No.	Work packages	Activities
WP6	Replacement of Sludge Lagoons with Clarification	• Concept design for: ○ Replacement of Sedimentation Lagoons with Clarifier ○ Reconfiguration of Sedimentation Lagoons to Sludge Lagoons ○ Reconfiguration of filter backwash waste to Lagoons ○ Implementation of filter-to-waste line ○ Installation of supernatant return facilities

A Preliminary Hazard Assessment (PHA) facilitated by CWT (Jess Circosta, Christina Saxvik) on the 14th and 20th of May 2020 found that WSC's proposed upgrades works were not sufficient to mitigate identified risks at the Sludge Lagoons to an acceptable level. Algae and their toxins (see Section 2.6.3), faecal contamination by birds and environmental runoff were identified as key hazards which could not be reduced to an acceptable level by the existing measures, even with improved operation or upgrades to the upstream infrastructure.

It is recommendation that the existing Sludge Lagoons are replaced by a Clarifier to exclude algae-favouring conditions and introduced contaminants from the environment.

11.1.2 Process Description

Flocculated water from the Flocculation Tank would gravitate to a Clarifier.

At the Clarifier, sludge would be drawn out intermittently on timer via duty/ standby Clarifier Sludge Pumps and transferred to Sludge Lagoons. The existing Sedimentation Lagoons may serve as these Sludge Lagoons.

Clarified water would pass into the launders and to the outlet of the Clarifier where it will be collected at the Low Lift Pump Station and pumped to the filters.

The Sludge Lagoons would be operated in duty/standby and alternated every 6 months to 1 year for desludging purposes.

From the Sludge Holding Lagoons, supernatant shall gravitate to a Supernatant Return Well where it can be returned to the Blending Tank at the head of the works via a duty Supernatant Return Pump at a rate not exceeding 10% of the plant's instantaneous flow.

Council may also opt to use supernatant for onsite irrigation purposes.

Figure 11-1 Example of Inclined Plate 200 GPM Clarifier (HydroFlow, 2020)

Backwash water from the filters shall be redirected to the Sludge Lagoons (rather than the Flocculation Tank as per the current configuration). Pipework and valves at the discharge side of the filters shall direct first pass water upon plant start up to a filter-to-waste line. This filter-to-waste line shall extend to the Sludge Lagoons.

11.1.3 Location of Works

Table 11-2 provides a summary of the key process components included in this package of works and their location for instalment.

Table 11-2: Location of Works

Components	Location of Works
Clarifier	Adjacent to existing Sludge Lagoons; downstream of the Flocculation Tank and upstream of the Low Lift Pump Station
Sludge Pump(s)	Adjacent to the Clarifier; downstream of the Clarifier and upstream of the Sludge Lagoons
Sludge Lagoons	At existing Sedimentation Lagoons; existing Sedimentation Lagoons to be repurposed as Sludge Lagoons
Supernatant Return Well	Within a pit at the outlet the Sludge Lagoons; downstream of the Sludge Lagoons and upstream of the Blending Tank
Supernatant Return Pump	Either submerged or adjacent to/in the Supernatant Return Well; downstream of the Sludge Lagoons and upstream of the Blending Tank
Filter Backwash Line	At the feed side of the existing filters and extending to the Sludge Lagoons
Filter-to-Waste Line	At the discharge side of the existing filters and extending to the Sludge Lagoons

11.2 Design Requirements

Table 11-3 is summary of the design requirements.

Table 11-3: Summary of Design Requirements

Components	Design Requirements
Clarifier	• Designed for loading rate of: ○ 5 m/h for circular clarifier ○ 1.5 m/h for tube settler or lamella plate clarifier
Clarifier Sludge Pump	• Duty/ standby arrangement
Sludge Lagoons	• Duty/ standby arrangement alternated every 6-12 months
Supernatant Return Well	• Capacity of pit is sized to contain the volume of: ○ 2 × filter backwash volumes based on backwash pump capacity of 68.2 kL/h and backwash duration of 10 minutes per filter ○ Clarifier sludge production of 10 minutes with flowrate based on 10% of total plant flows ○ Plus 10% for overflows
Supernatant Return Pump	• Duty or duty/ standby arrangement (as per Council's preference) fitted with VSD • Return supernatant folows to head of works to be limited to 10% of incoming raw water flows to the plant as measured by the common raw water flowmeter.

11.3 Concept Design Calculations

The equipment sizing shall depend on the elected design basis. The existing components of the plant, and in particular the raw water pumps are sized to deliver up to 1 ML/d. However, as discussed in Section 4.2.2of this report, the daily demand infrequently exceeds 0.424 ML/d. The following sizing requirements are given for the 0.424 ML/d (over 16 h/day) and 1 ML/d (over 22 h/d).

Table 11-4: Clarifier Design Basis, Assumptions and Calculations

Component/ Option	Parameter (unit)	95-%ile – 0.424 ML/d	Design – 1.00 ML/d	Assumption/ Reference/ Comment
Circular clarifier option	Loading rate (m/h)	1.5	1.5	WIOA (2008) Practical Guide to Coagulation, Flocculation and Clarification; Clarification loading rate of 1.5 m/h is targeted for Circular Clarifiers, a clarification rate of 5 m/h is targeted for lamella plate or tube settler clarifiers.
	Surface area of Clarifier (m^2)	17.7	30.3	
	Diameter of Clarifier (m)	4.7	6.2	
Lamella or inclined plate option	Loading rate (m/h)	5.0	5.0	
	Surface area of Clarifier (m^2)	5.3	7.6	
	Diameter of Clarifier (m)	2.6	3.1	
Clarifier Sludge Pump	No. of pumps	2	2	
	Configuration	Duty/standby	Duty/standby	
	Capacity	As per package specifications		
Supernatant Return Pit	Capacity (kL)	25.5		Sized for 10 minutes of clarifier sludge production at 10% of total plant flows + the volume of 2 × 10- minute filter backwashes at 68.2 kL/h.
Sludge Lagoons	Capacity (kL)	As per existing		Sludge capacity requirements should be confirmed during detailed design
Supernatant Return Pump	No of pumps	1	1	Redundancy requirements to be confirmed by Council
	Configuration	Duty	Duty	
	Capacity (kL/h)	2.7	4.6	10% of instantaneous raw water flows

12 Work Package 8: Installation of UV Disinfection Unit

12.1 Description of Works

12.1.1 Overview

The following table is an excerpt of Table 3-1, and summarises the activities to be addressed in this Section of the Report.

Table 12-1: Scope of Works and Activities

No.	Work packages	Activities
WP7	Installation of UV Disinfection Unit	• Concept design for: ○ UV Disinfection Unit ○ UV transmissivity benchtop analyser

A Preliminary Hazard Assessment (PHA) facilitated by CWT (Jess Circosta, Christina Saxvik) on the 14th and 20th of May 2020 found that WSC's proposed upgrades works were not sufficient to meet the new health-based log removal targets for raw water sourced from a Category 4 catchment. Category 4 catchments are characterised as unprotected catchments with agricultural and human activities in the catchment and the possible presence of septics. These catchments attract health-based targets of 6.0-, 6.0- and 5.5-log reduction of bacteria, viruses and protozoa, respectively.

Even with the proposed upgrades as described in the previous sections of this report, the WTP processes, even optimised, would have a 2.5-log removal deficit for protozoa (see Table 4-6).

Therefore, it is recommended that an inline UV disinfection unit is installed at Mendooran WTP.

12.1.2 Process Description

From the 1 kL Filtered Water Tank, water would be pumped to an inline UV disinfection unit sized to deliver 40 mJ/cm^2 for 4.0-, 0.5- and 4.0-log removal of bacteria, viruses and protozoa, respectively. The UV unit shall continuously monitor UV intensity.

From the UV Disinfection Unit, water is to pass to the Clear Water Tank. En route, UV treated water is to be dosed with chlorine solution for final disinfection and soda ash for pH and alkalinity correction (as required).

The UV transmissivity of filtered water shall be measured daily using a benchtop UVT analyser.

12.2 Design Requirements

The design requirements are as follows:

- The UV unit shall be sized to deliver a validated Reduction Equivalent Dose (RED) of 40 mJ/cm^2 or a dose sufficient to meet to log deficit for protozoa removal, as outlined by the *Health Based Targets*.
- The manufacturer's stated operating envelop for water quality must be consistent with that of the filtered water quality produced by the Mendooran WTP. Typically, this includes water of <1 NTU and with $\geq 85\%$ UV transmissivity.
- A benchtop UVT analyser shall be procured to verify that water being received at the UV unit is within the required water quality envelop as set out in the manufacturer's specifications.

- The UV unit shall be validated to acceptable standards such as those outlined in the following:
  - DVGW (Deutsche Vereinigung des Gas und Wassserfaches)
  - USEPA Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule; and/or
  - NWRI (National Water Research Institute) Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse.
- A bypass shall be provided around the UV system to allow continuity of production during maintenance.
- Components required for redundancy such as additional standby units, UV sleeves and/or lamps shall be at the discretion of Council.

12.3 Concept Design Calculations

Table 12-2 lists the UV disinfection unit design basis, assumptions and calculations.

Table 12-2 :UV Disinfection Unit Design Basis, Assumptions and Calculations

Parameter (unit)	Value	Assumption/ Reference/ Comments
No of units	1	Redundancy requirements to be confirmed by Council
Configuration	Duty	
UV dose (mJ/cm²)	40	HBT manual (2005) for 4.0-, 0.5- and 4.0-log removal of bacteria, viruses and protozoa. Otherwise, the unit shall deliver a dose suitable to meet the overall WTP log reduction deficit for protozoa to meet an overall protozoa removal target of 5.5 log across the plant.
Turndown ratio	2.1	Based on operating range of 200-424 kL/d over 16 hours
	3.6	Based on operating range of 200 kL/d over 16 hours and 1 ML/d over 22 hours.

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