# Snowy Monaro Regional Council

## Options Assessment Report - Delegate Water Supply

July 2020

# Executive summary

## Conclusions

The main conclusions from this assessment covering of demand, surface water supply systems, surface water quality and treatment and groundwater alterative are:

Demand; Design peak day demand for the new WTP has some uncertainty due to

- lack of long-term reliable records for supply from the raw water pump station
- uncertain effect of switch from non-potable supply to potable supply

In response it is considered the best cost-effective solution is a 0.5ML/d capacity WTP combined with a large 800kL treated water tank to allow draw/fill of the tank to achieve reliable supply for a peak day demand of up to 750kL/day and average dally demand up to 450 kL/day over the peak week

Raw Water supply system: the existing raw water pumps achieve performance well below design duty point. It is assumed they will be replaced for the new WTP. The existing weir pool, intake structure and rising main are now 70 yrs old. They need replacement/upgrade work. The assessment of what is needed and cost is not included in this project.

Raw Water Quality and Treatment; the Delegate river source has relatively high E.coli levels and is from an inhabited catchment with livestock and farm houses with septic tanks. It is a run of river supply with variable turbidity and colour and a wide temperature range. It is a soft water source that needs alkali addition to stabilise the treated water, especially after chlorine gas is added. Effective Treatment requires a 2- stage process of clarification (Lamella plate clarifier or Dissolved Air Floatation) then filtration (Gravity dual media filters or Microfiltration). UV then chlorine disinfection is also needed to achieve Health Based Targets.

Groundwater alternative: preliminary drilling reveals that this groundwater alternative is not a viable option

Other matters; Council does not own the land where the existing storage tank is located, which is also the site for the new WTP

Comparison of Cost and advantages/disadvantages is summarised in **Table 1**below.

**Table 1: Comparative costs advantages and MCA Scoring for each option**

| Item | Option 1 DAF then MF | Option 2 Lamella Plates Clarifier then MF | Option3 Lamella Plates Clarifier then gravity filters | Option 4 DAF then gravity filters |
|---|---|---|---|---|
| CAPEX* | $5.55 m | $5.52 m | $5.32 m | $5.35 m |
| Land acquisition for WTP** | $0.25-0.3 m | $0.25-0.3 m | $0.25-0.3 m | $0.25-0.3 m |
| OPEX* | $0.142 m/yr | $0.139 m/yr | $0.134 m/yr | $0.138 m/yr |
| NPC 6%pa for 25 yrs | $7.62-7.67 m | $7.55- 7.60 m | $7.29-7.34 m | $7.37 -7.42 m |
| Advantages | Easy to manage barrier for achieving LRV for protozoa risk ( eg | Easy to manage barrier for achieving LRV for protozoa risk ( eg | No de-rating for low water temperature<br>Least complexity for automatic controls | No de-rating for low water temperature<br>Low complexity for automatic |

| | | | | | |
|---|---|---|---|---|---|
| | | Cryptosporidium)<br>Least sensitivity to rapid change in raw water turbidity/ colour/water temp<br>Council operates MF at nearby Dalgety<br>Raw water used in backwash<br>DAF best for algae removal | Cryptosporidium)<br>Low complexity for automated control for Lamella plate clarifier<br>Council operates MF at nearby Dalgety<br>Raw water used in backwash | | control of gravity filters<br>Good for algae removal |
| Disadvantages | | De-rating plant capacity progressively required when water temp is <15 oC<br>Most complex automatic control<br>Expensive Proprietary membranes that have to be replaced every 7 to 8 yrs<br>Higher backwash volume compared to gratify filters<br>Limitation on future PAC dose( if required) | De-rating plant capacity progressively required when water temp is <15 oC<br>Expensive Proprietary membranes that have to be replaced every 7 to 8 yrs<br>Higher backwash volume compared to gravity filters | More sensitive to rapid change in raw water turbidity/colour<br>Careful control of coagulation, clarification and filtration processes required to always achieve LRV for protozoa risk<br>Treated water used in backwash reducing volume in treated water tank for drawdown | More sensitive to rapid change in raw water turbidity/colour<br>careful control of coagulation, DAF an filtration processes required to always achieve LRV for protozoa risk<br>Treated water used in backwash reducing volume in treated water tank for drawdown<br>Limitation on future PAC dose( if required) |
| Relative score against MCA | Barrier to chlorine resistant protozoan | ✓✓✓✓ | ✓✓✓✓ | ✓✓✓ | ✓✓✓ |
| | Low attendance for operation | ✓✓✓✓ | ✓✓✓✓ | ✓✓ | ✓✓✓ |
| | Easy to maintain | ✓✓ | ✓✓✓ | ✓✓✓✓ | ✓✓✓ |
| | Environment | ✓✓✓ | ✓✓✓ | ✓✓✓✓ | ✓✓✓ |
| | OHS | ✓✓✓✓ | ✓✓✓✓ | ✓✓✓✓ | ✓✓✓✓ |
| | Easy procurement/construction | ✓✓✓ | ✓✓✓ | ✓✓✓✓ | ✓✓✓✓ |

| | | | | |
|---|---|---|---|---|
| (preferred Option=1, Less preferred=2) | 1 or 2 | 1 or 2 | 3 | 4 |

*The above costs do not include Fluoridation and other possible future chemical dosing systems. However costs for these items are include in the detailed breakdown for information only purposes

**Nominal land acquisition cost for WTP at existing tank site

## Recommendations

The preferred 0.5ML/d capacity treatment process for the Delegate WTP is the following:

Option 2: Lamella Plate Clarification then MF

The main common works are;

- New raw water pumps
- Repurpose the existing 283 kL tank as a raw water storage to balance out changes in raw water quality and provide some security of supply capability
- UV disinfection then chlorination
- New 800 kL usable volume treated water storage
- Sludge treatment by sludge drying beds
- The main treatment processes located inside a new colour-bond type building
- Allowance in floor area within the treatment plant building for future addition of PAC, potassium permanganate and ammonia dosing

The key benefit of this MF based option is the presence of a physical membrane, which allows occasional suboptimal performance of the coagulation and settling or floatation process to be tolerated. This is important for a run of the river raw water supply system where raw water quality can change rapidly. In addition, Council has experience with MF technology at nearby Dalgety WTP. Also, usually a MF based process requires less operator attendance at site compared to gravity filters based process, as it is more automatic process.

The main benefit of lamella plates clarification is it can handle higher solids loading due to high dose of coagulant for events of high turbidity plus colour.

This treatment process also has a small footprint.

It is also recommended that;

- Land at the existing water tank site be acquired for the new WTP and associated works
- No further groundwater investigations be considered
- assessment of the weir pool, intake structure and raw water pipeline be completed and necessary upgrade works be defined

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# Appendices

# 1. Introduction

## 1.1 Project need

GHD has been engaged by Snowy Monaro Regional Council (SMRC) to carry out an Options Assessment and Concept Design for upgrade to the water supply system for the towns of Bombala and Delegate in southeast  New South Wales. This report covers the town of Delegate.

Water supplied to Delegate Township is designated as non-potable and residents are on a Boil Water Notice. Water is from a weir on the Delegate River. The weir is located upstream of the Delegate Township. The water is chlorinated and pumped to a reservoir on top of a hill overlooking the town. From the tank, the disinfected water flows by gravity into the town reticulation system.

Residents of Delegate have expressed a significant dissatisfaction regarding water quality and in response, the NSW Government has allowed substantial funding for upgrade works.

## 1.2 Project scope

This report outlines the results of a brief visual audit of existing water supply assets and an Options Assessment for a new Delegate Water Treatment Plant (WTP). Specifically, the aims of this report were to:

- Review information supplied by council, including the analysis of the water quality and demand data
- Assess the existing raw water pump station and balancing tank  for capacity and integration with a new Water Treatment Plant(WTP) located next to the existing balance tank
- Confirm capacity of the new WTP and develop options for the treatment process for the new WTP, including advantages, disadvantages and cost estimate
- Recommend a preferred upgrade option for the raw water supply and new WTP
- Address alternate water supply opportunities – Ground water – bore drilling and results
- Overview of existing weir
- Overview of intake structure and depth of the intake pool in the river

## 1.3 Purpose of report

The purpose of this report is to develop upgrade options for a new Delegate WTP and recommend a preferred WTP treatment option to SMRC.

## 1.4 Scope and limitations

*This report: has been prepared by GHD for Snowy Monaro Regional Council* and *may only be used and relied on by Snowy Monaro Regional Council for the purpose agreed between GHD and the Snowy Monaro Regional Council as set out in section 1.3 of this report.*

*GHD otherwise disclaims responsibility to any person other than Snowy Monaro Regional Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.*

*The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.*

*The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.*

*The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report section 1.5. GHD disclaims liability arising from any of the assumptions being incorrect.*

*GHD has prepared this report on the basis of information provided by Snowy Monaro Regional Council and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work.*

*GHD has prepared the preliminary cost estimate set out in section 7 of this report ("Cost Estimate") using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD.*

*The Cost Estimate has been prepared for the purpose of comparison of options and must not be used for any other purpose.*

*The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the Cost Estimate.*

*Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.*

## 1.5 Assumptions

*The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this section of this report). GHD disclaims liability arising from any of the assumptions being incorrect.*

The assumptions for this report are

- Drawings provided by Council represent as constructed details
- Demand and water quality data provided by Council are reasonable representation of history for this site
- Council projection of the rate of increase in demand of 0.05% pa is correct
- Changes to the weir in the river and the associated intake structure and pipework to the raw water pumps and land acquisition at the proposed WTP site has not been considered, commentary on this is provided in section 5
- The existing raw water pipeline and balance tank are assumed to be adequate for reuse as part of the new WTP system , no assessment of condition or cost to upgrade these works has been carried out in this report
- Replacement of the raw water pumps is required and the replacement is sized to suit the future requirements. (refer section 3 )
- GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information

# 2. Performance Objectives

## 2.1 Introduction

This section outlines a number of water supply performance objectives used to develop the new Water Treatment Plant (WTP) process design;

- Meet current and future water demand
- Meet treated water quality requirements – Australia Drinking Water Guidelines (ADWG)
- Achieve asset life, environmental and Occupational Health and Safety (OH&S) requirements and reliable operation targets
- Minimise whole-of-life cost

These objectives are further developed below.

## 2.2 Water quantity

The water quantity objective is to provide adequate WTP capacity to meet expected peak day demand once treated water is available. It is assumed there is no increase in the number of properties supplied by the new WTP will occur for the planning horizon of 25 years.

## 2.3 Treated Water Quality Requirements

The key guidance documents for treated water quality are:

- Australian Drinking Water Quality Guidelines (ADWG)
- Health Based Targets (HBT) framework for Raw Water Quality conditions

Note that the ADWG provides water quality limits measured at customer taps. Consequently, the treated water quality targets at the WTP are more stringent.

Table 2 sets out the normal treated water quality requirements that the Water Treatment Plant (WTP) needs to be designed for to achieve the requirements of ADWG and HBT.

**Table 2 Treated water quality targets**

| Parameter | Units | ADWG or "Good Practise" Target | Monitoring Location |
|---|---|---|---|
| E. Coli | org / 100 mL | Not detected | CWT outlet |
| Total Coliforms | org / 100 mL | Not detected | CWT outlet |
| pH | | Set point* ± 0.2 | CWT outlet |
| Filtered turbidity | NTU | <0.3 @95%, max ≤0.5 | Each Filter outlet |
| True Colour | Hazen or Hu | <5 @95%, max ≤10 | CWT outlet |
| Aluminium | mg/L | <0.1 @ 95%, max ≤0.2 | CWT outlet |
| Iron, total | mg/L | <0.1 @ 95%. max ≤0.3 | CWT outlet |
| Manganese, total | mg/L | <0.02 @ 95%. max ≤0.05 | CWT outlet |
| THMs | mg/L | Max <0.25 | Reticulation Network |
| Taste & Odour<br>Geosmin<br>MIB | <br>ng/ L<br>ng/L | <br><5<br><5 | For good T&O at customer taps |
| Free Chlorine Residual (FCR) | mg/L | Set point* ± 0.2 | At CWT inlet |
| Treated Water Stabilisation | mg/L | -6 to 0 | CWT outlet |

| | | | |
|---|---|---|---|
| CCPP<br>LSI | | -1 to 0 | |
| Health Based targets (HBT) | | LRVs for category 4 unprotected catchment | CWT outlet |

* Set point for pH normally =7.5 to 7.8. Set point for FCR = 1 to 2 mg/L.

### 2.3.1 Health Based Targets (HBTs)

The National Health and Medical Research Council (NHMRC) current draft of the Health Based Targets (HBT) document (2018) sets out required Log Reduction Value (LRV) for pathogens based on various Source Water Categories. The HBT document also defines the LRVs achieved by various treatment processes. Refer *Manual for Application of Health-Based Treated Targets, WSAA (2005*) and *ADWG: Revised Chapter 5 Microbial Quality of Drinking Water incorporating a microbial health based target, NHMRC (2018)* for further information.

Assessment of the source water risk category for Delegate WTP is set out in section 3.3 of this report.

## 2.4 Asset life, environmental and OH&S requirements and reliable operation

### 2.4.1 Asset Life

Asset life decisions need to include consideration of:

- Innovation; for example SCADA hardware and control software continue to reduce in cost and increase in capacity/capability, but have limited support life (now about 15 to 20 yrs).
- Corrosion; correct protection systems are essential for achieving design asset life.
- Design and maintenance/planned replacement; for example correct materials of construction, catholic protection systems, timely replacement of old assets and allowance/prevention of settlement of structures are essential for achieving design asset life.

### 2.4.1 Reliable Operation

It is required that each treatment system is “fit for purpose” in terms of minimum dependence on proprietary equipment, easy to operate and perform well under design raw water conditions and have adequate asset life.

Reliability in operation needs to be in accordance with good industry practice, for example:

- Automation: Adequate online monitoring equipment, alarms and telemetry to allow automatic response to process or equipment failure and efficient operation.
- Reliability: Duty/standby with automatic standby unit start-up upon fault of the duty unit, for process critical equipment
- OH&S: Minimisation of manual handling, automation of processes
- Storage: Sufficient balancing storages to minimise start/stop operation, allow for system failures/power outages and pressure surge risks, and sufficient bulk storage of treatment chemicals.

### 2.4.2 Contingency Management

Contingency management is required to ensure continuous treated water supply to customers by considering risks and actions to minimise to “acceptable” including:

- Equipment failure and associated redundancy
- Local or regional power failure
- Poor raw water quality events

2.4.4 Legislative compliance

### 2.4.3 Regulations

The WTP must comply with statutory requirements including:

- Chemical storage and handling – Dangerous Goods regulations including the Dangerous Goods Act (DGA)
- Occupational health and safety (OH&S) requirements

### 2.4.4 Environmental management

Environmental considerations for operation of the WTP include:

- Compliance with waste disposal and noise requirements (EPA)
- Minimisation of energy consumption
- Sludge disposal including backwash supernatant recovery – EPA requirements

## 2.5 Value for Money

The capital cost together with operating and maintenance costs, needs to be minimised over the adopted planning horizon

# 3. Current Performance of Existing System

## 3.1 Overview of Existing System

Raw water is pumped from the Delegate river to a 283 kL Reinforced Concrete Tank located at the top of a nearby hill. Gaseous chlorine is added at the suction side of the existing raw water pump station. Delegate township is gravity-fed from this Tank

## 3.2 Water demand and number of properties connected to the Delegate water supply system

Water supply data for Delegate River Pump Station for the period 2013/20 was provided to GHD in the format of operator record sheets showing daily pump run times and daily total volume pumped. The data had significant periods where no daily flow or pump run time was recorded.

The current number of property connections to the Delegate water supply is 898 and the number of unique water meters is 651. This compares with Bombala, which has 1531 property connections.

For the 2018/2020 period the peak daily flow recorded was 728 kL/d (refer Figure 1).

The average demand during the peak week for 2018, 2019 and 2020 is shown in Table 5. For years with high peak day demand a relatively low ratio for ave daily demand for peak 7 days /peak day demand of 0.6 to 0.64 occurred.

In 2014 a high average daily flow for the peak month of 514.3kL/d was recorded (refer Table 4).

Over the 2013/20 period, annual volume of water pumped to Delegate has ranged between 56 to 77.8 Ml/yr.

Demand also correlates with water temperature. This is important to understand for main water treatment process selection and sizing (refer section 6).The following table 2 and figure 1 show that it is unlikely that peak period demand will occur when water temperature is less than 15 oC,

**Table 3: Demand versus water temperature**

| Months( inclusive) | Demand range (kL/day) | Water temperature range (oC) |
|---|---|---|
| June to July | 37 – 230 | 2.5 – 7.2 |
| August to September | 42 – 251 | 3.8 – 9.8 |
| October to November | 72 - 453 | 10.1 – 18.5 |
| December to January | 59 – 728 | 16.2 – 24.4 |
| February to March | 62 – 359 | 12.4 – 21.8 |
| April to May | 38 – 210 | 6.5 – 17.0 |

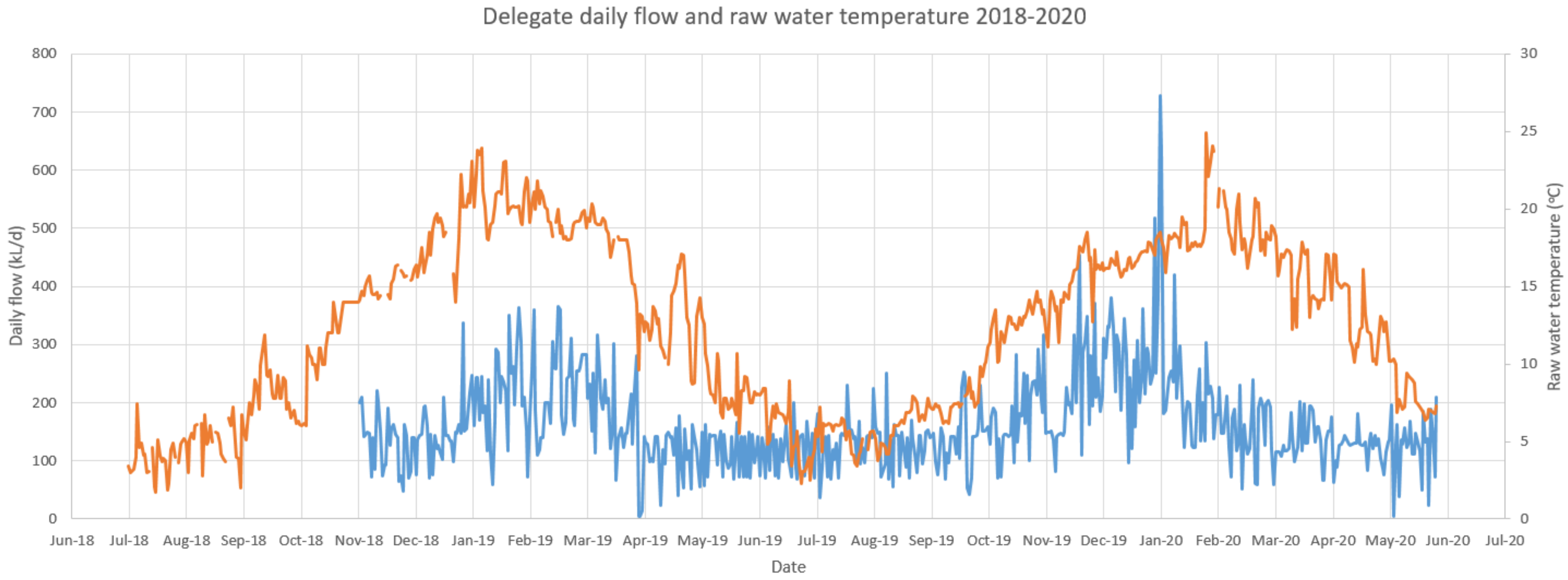


**Figure 1: Daily flow from raw water pumps and raw water temperature in RC reservoir**

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### Table 4: Summary of peak day, peak week, peak month and annual data

| Year | Peak day demand | Peak week demand | Peak month demand | Annual ave daily (kL/day) | 1st Oct to 31st Jan meter reading ( 4 months) |
|---|---|---|---|---|---|
| 2013/14 | NA | NA | Feb – 14,400 kL/month (514.3 kL/d) | 213 | NA |
| 2014/15 | NA | NA | Mar – 9698 kL/month (312.8 kL/d) | 213? | NA |
| 2015/16 | Dec 11th – 555 kL/d (only have sporadic daily data) | NA | Jan – 9248 kL/month (298 kL/d) | NA | NA |
| 2016/17 | Feb 6th – 640 kL/d | Jan 31st – Feb 6th - 2879 kL/week (411.3 kL/d) | Jan 8th – Feb 6th – 10,579 kL ~ 353 kL/d | 195.3 | NA |
| 2017/18 | Feb 24th – 515 kL/d | 18th - 24th of Feb – 2171 kL/week (310 kL/d) | Feb 17th – March 18th– 7152 kL ~238.4 kL/d | 160.5 | 154.3 |
| 2018/19 | Feb 16th- 366 kL/d | 21st- 27th of Jan – 2022 kL/week (289 kL/d) | Feb 13th to March 14th – 7150 kL ~238.3 kL/d | 172.0 | 96.9 |
| 2019/20 (to date) | Jan 4th – 728 kL/d | Dec 31st 2019 - 5th of Jan 2020 – 2993 kL/week (427.6 kL/d) | 7-Dec 2019 to 5th of Jan – 9061 kl ~254 kL/d | NA | 156.2 |

### Table 5: Daily flows for peak week from 2016-2020

| Suspected Peak week | 2016/2017 – 31st Jan – 6th of Feb 2017 | 2017/2018 – 18th to 24th Feb 2018 | 2018/2019- 21st to 27th of Jan 2019 | 2019/2020 – 31st of Dec to 5th of Jan 2020 |
|---|---|---|---|---|
| Day 1 | 400 | 302 | 351 | 233 |
| 2 | 351 | 441 | 251 | 247 |
| 3 | 410 | 228 | 263 | 518 |
| 4 | 413 | 194 | 196 | 251 |
| 5 | 332.5 | 211 | 293 | 378 |
| 6 | 332.5 | 280 | 363 | 728 |
| 7 | 640 | 515 | 305 | 638 |
| Peak week Total | 2879 kL/week 411.3 kl/d | 2171 kL/week 310 kL/d | 2022 kL/week 289 kL/d | 2993 kL/week 428 kL/d |

## 3.3 Assessment of Raw Water quality and Health risk

### 3.3.1 Raw water quality

Results for important raw water quality parameters is summarised in Table 6. The results are for monthly NSW Health data over January 2019 to May 2019, daily data collected by SMRC operator and one recent ALS result.

A subset of a period when turbidity was high in the water quality routinely measured by Snowy Mountains Regional Council (SMRC) is included in Appendix A. Generally, this water supply has low hardness, is relatively soft and has variability in iron, turbidity, colour and pH. It is low in manganese. It is uncertain as to organic content (eg DOC and TOC), algae, and T&O levels as there is very limited data for these parameters.

**Table 6 Raw Water Quality results**

| Water Quality Parameter | NSW Health Jan/Dec 2019 twelve results | SMRC 2017/20 daily results | ALS testing 19/5/2020 single result | 5%ile for Delegate historical data for retic 2001-2019 (1) | 95%ile for Delegate historical data for retic 2001-2019 (1) |
|---|---|---|---|---|---|
| pH | 6.5 – 7.3 | 6.07 to 7.73 | 7.35 | 5.4 (4.6) | 7.61 |
| Alkalinity mg/L (as CaCO3) | | 8 to 75 | 26 | | |
| Hardness (mg/L as CaCO3) | 10.4 – 26.1 | | | 10.3 | 26 |
| TDS (mg/L) | 7 – 220 | | 57 | 24 | 60 |
| Calcium (mg/L) | 1.3 – 3.8 | | | 1.57 | 5.2 |
| Copper (mg/L) | | | | 0.038 | 1.35 |
| Turbidity (NTU) | 0.6 – 9.7 | 3.5 to 20.7 | 5.4 | 1.03 | 20.5 (28.7) |
| True Colour (HU) | 7 – 42 | | 26 | 2 | 22 (32) |
| Apparent Colour (Hu)i | | 37 to 237 | | | |
| Iron ( mg/L) | 0.33 – 0.71 | | 0.36 | 0.29 | 0.91 (1.03) |
| Manganese (mg/L) | 0.009 – 0.042 | | 0.012 | 0.0025 | 0.028 ( 0.13) |
| herbicides | Not detected | | | | |
| DOC (mg/L) | | | 2 | | |
| TOC (mg/L) | | | 2 | | |
| Total blue green algae | | | 200 (Cyanophyta) | | |
| Total Algae | | | 1720 | | |
| Water Temperature( oC) | | 2 to 25 | | | |
| Taste & Odour<br>Geosmin<br>MIB | No data | | <br>5<br><1 | | |

NOTE (1); in retic WQ for example; 95%ile for turbidity = 20.5 and max for turbidity = (28.7)

### 3.3.2 Health Based Targets & Log Removal Values (LRVs)

The HBTs set out required Log Reduction Value (LRV) for pathogens based on various Source Water Categories. As per the HBT guidelines (2018), "*the source water category should be determined by combining the vulnerability assessment with the E. coli band allocated according to results of the microbial indicator assessment*".

The matrix in Figure 2 below defines how this works.

**Table 5.4. Confirmed source water category based on comparison of *E. coli* concentration with vulnerability assessment**

| Preliminary source water category based on vulnerability assessment | Microbial indicator concentration category<br>Maximum *E. coli* result per 100 mL | | |
|---|---|---|---|
| | <20<br>(*E. coli* band 1) | 20 to 2000<br>(*E. coli* band 2) | 2001 to 20,000<br>(*E. coli* band 3) |
| Vulnerability category 1 | Category 1 (/) | Category 2 (*) | Anomalous (x) |
| Vulnerability category 2 | Category 2 (*) | Category 2 (/) | Anomalous (x) |
| Vulnerability category 3 | Anomalous (x) | Category 3 (/) | Category 4 (*) |
| Vulnerability category 4 | Anomalous (x) | Category 4 (*) | Category 4 (/) |

Combining the results of the *E. coli* data and vulnerability assessment will result in one of the following outcomes:

/ The two assessments are consistent and support each other

* The result is feasible, but has a lower degree of confidence. Both the *E. coli* data and vulnerability assessment should be re-examined to better understand the reasons for the misalignment. For example, if the *E. coli* results indicates a higher level of microbial risk than inferred by the vulnerability assessment, then the vulnerability assessment of the catchment should be repeated to determine if there are sources of microbial risk that were not previously identified.

**X-** This result should not be accepted. The results should be critically reviewed to understand the discrepancy. In the interim, the most conservative source water category option under consideration should be adopted**.** These results should be discussed with the relevant party (e.g. a health authority or other regulator).

**Figure 2 Vulnerability versus Microbial indicator concentration category in HBT document (2018)**

#### *Vulnerability assessment*

A vulnerability assessment uses a risk assessment process based on identified sources of, and barriers to, pathogen contamination within the water supply catchment. The results are used to allocate the source water into one of four source water vulnerability categories.

Figure 3 shows a photo of the Delegate water supply pump station and weir on Delegate River. The photo show there is easy access to the watercourse for livestock.

**Figure 3 Photo of Delegate water supply Pump station and weir on Delegate River from GHD site visit (16 April 2019)**

Figure 4 shows the approximate catchment boundary above the Delegate raw water pump station. The catchment area is mainly farmland, with some forested areas along high areas and a number of rural properties presumably with septic tanks.

There is no exclusion zone around the river which has a frontage of 30 kms and would not change the Vulnerability Category of this catchment even if it was fenced as animal faecal matter would still contaminate the river as it flows into the river with run off during wet weather. Farmland goes up to the edge of the river. Based on this desktop assessment the source water is Vulnerability Category 4.

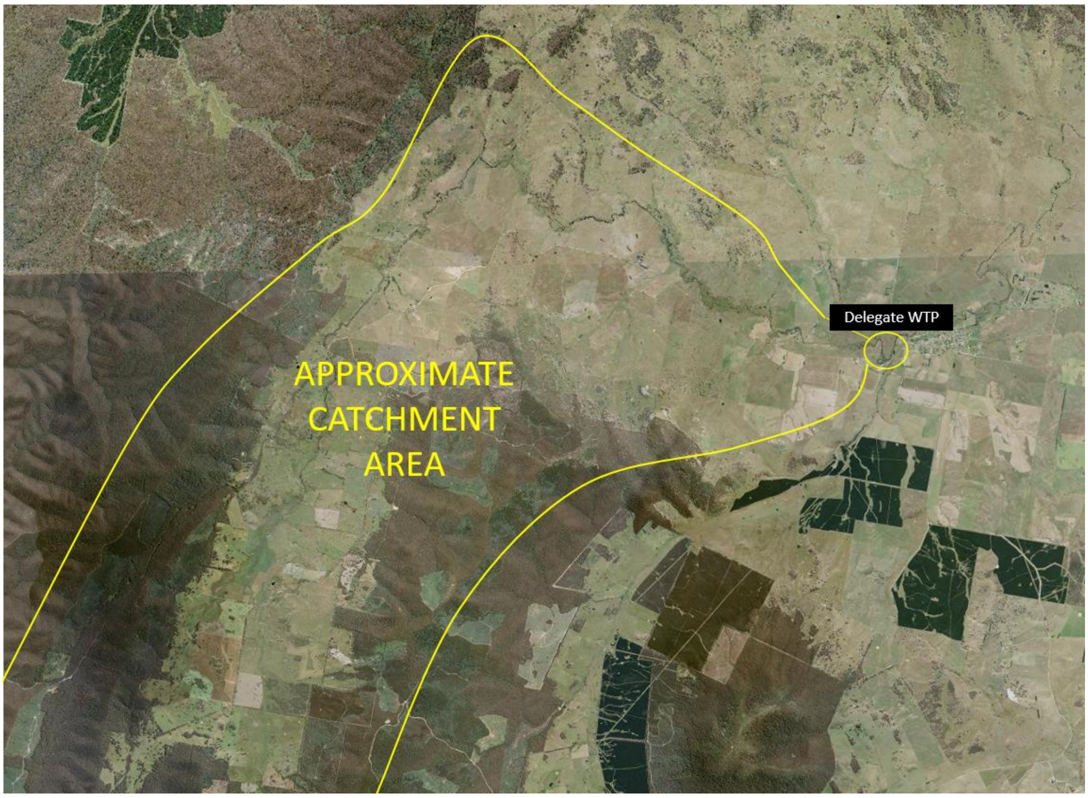

**Figure 4 Approximate catchment area for Delegate's water supply**

### *E.coli testing*

The Health Based Targets (HBTs) concept also requires measurements of the E.coli concentration in the untreated water source. Table 4 shows monthly E.coli results in 2019 for this raw water supply.

Most E. Coli results were >20 cfu/100mL and some were >200cfu/100ml which indicates the source water is E.coli band 3 (refer Figure 2)

**Table 7 Results for coliforms in raw water (MPN/100mL, as assessed by SMRC)**

| Date | E.coli (MPN/100mL) |
|---|---|
| 30/01/2019 | >200 |
| 19/02/2019 | >200 |
| 18/03/2019 | >200 |
| 15/04/2019 | 200 |
| 21/05/2019 | 74 |
| 18/06/2019 | 53 |
| 16/07/2019 | 120 |
| 21/08/2019 | 11 |
| 18/09/2019 | 59 |
| 15/10/2019 | 62 |
| 13/11/2019 | 130 |
| 19/05/2020 * | 74 |

** Data from ALS testing single result, the rest are from DHHS monitoring*

### *Source Water category*

The source water category is therefore determined using the table provided in Figure 2 as follows:

- Vulnerability category 4 + E.Coli band 3 = **Source water category 4**

### *Required LRVs*

Table 8 shows the required Log Removal Values (LRVs) that must be achieved to comply with the HBT for a Source Water Category 4. It also shows the existing Delegate water supply is estimated to currently achieve.

The existing treatment process does not achieve the required pathogen Log Removal Values (LRVs) for protozoa, bacteria or viruses.

**Table 8 Delegate Water Supply Log Removal Values (LRVs) under HBT guidelines**

| Process | Bacteria | Virus | Protozoa | Comment |
|---|---|---|---|---|
| LRV Required | **6** | **6** | **5.5** | based on source water at **Category=4** |
| **EXISTING TREATMENT PROCESS** | | | | |
| Chlorination | 0 | 0 | 0 | Turbidity is not <1NTU and therefore LRV is less than 4 and for design purposes is assumed to be 0 |
| ***Additional LRVs required to meet HBT*** | ***6*** | ***6*** | ***5.5*** | |

Table 9 below summaries the performance achieved for each of the proposed treatment process options discussed in section 6.

**Table 9 Log Removal Values (LRVs) for Future Treatment Options**

| | | | | |
|---|---|---|---|---|
| **NEW PROPOSED PROCESS** | | | | |
| **Option 1** | Bacteria | Virus | Protozoa | Comments |
| Lamella Plate or DAF+<br>MF+<br>UV+<br>Chlorination<br>**TOTAL** | 1<br>3<br>0<br>4<br>8 | 1<br>1<br>0<br>4<br>6 | 0.5<br>3<br>2<br>0<br>5.5 | LRV for MF based on individual filters at 95% <0.1 NTU and max 0.15NTU plus routine membrane Integrity testing<br>LRV for UV based on 5.8mJ/cm2<br>LRV for Chlorination based on CT>15mg/L-min, pH<8.5 & turbidity <1NTU |
| **Option 2**<br>Lamella Plate or DAF+<br>Gravity Filters+<br>UV+<br>Chlorination<br>TOTAL | <br>1<br>1<br>0<br>4<br>6 | <br>1<br>1<br>0<br>4<br>6 | <br>0.5<br>2.5<br>3<br>0<br>6 | LRV for gravity filtration based on individual filters at 95% <0.3NTU and max 0.5NTU<br>LRV for UV based on 12mJ/cm2<br>Chlorine CT>15mg/L-min, pH<8.5 & turbidity <1NTU |

## 3.1 Reliable Operation: Assessment of existing system

### 3.1.1 Asset Condition and Life

A recent NSW Public Works Advisory report (2017) noted that the existing weir and external CICL and AC pipework were installed in 1949. Based on normal asset life criteria the pipeline is approaching end of asset life. The 283 kL Reinforced Concrete tank to which the water is pumped prior to distribution to Delegate customers was built in 1958 and has areas of exposed reinforcement.

The manual duty only gas chlorination system (1kg/hr capacity) was reported to show signs of gas leak in pipework. At the site visit by GHD it is evident works had been done to rectify this risk. The integrator type flow meter appear to be less than 25 years old and in reasonable condition.

Currently, chlorine is dosed to the suction side of the existing duty/standby grunfos type pump. This is likely to have shorten the life of the pumps due to corrosion. The pH of the chlorinated water can, based on operational data 2018/20, to as low as 5.

The measured flow from one of the raw water pumps appears to be around 7 to 14L/s (refer Appendix B) compared to design duty point of 30L/s. A tank fill test completed by the NSW Public Advisory and recently by Council showed the other pump runs at an even lower rate of 6 to 7.2L/s respectively.

Based on the above findings replacement of both existing pumps is recommended to achieve reliable operation over the planned life of the new WTP.

### 3.1.2 Reliable Operation

Operational water quality results indicate the existing manual and duty only chlorinator is undersized for the existing water supply. For example, during recent poor raw water quality conditions in February 2020 (refer appendix A) it was dosing at up to 0.6 to 0.7 kg/hr but this was not sufficient to maintain a chlorine residual in water going to town. Based on operator log sheets the chlorine dose concentrations appear to range between 5 to 12 mg/L, which is high, and suggest the organics content of this raw water supply can at times be quite high. It also is dosing to a water supply with turbidity up to 20 to 25 NTU which is well in excess of the ADWG recommendation of turbidity <1 NTU at the point of chlorination.

The existing tank feeding treated water to Delegate Township has a total volume of 283 kL. (Refer NSW Public Works Advisory report-2107) This is small given the historical peak day demand, which ranges between 450 to 720 kL/d. Normal operational requirement is to provide an operational volume of at least one peak day demand.

### 3.1.3 Contingency management

The duty/standby-raw water pumps provide a reasonable supply security. However, the existing manual adjustment and duty only gas chlorinator is a serious current limitation in relation to contingency management, especially given the relatively high raw water E.coli levels and unprotected catchment classification.

### 3.1.4 Regulations

#### *Compliance with EPA, OHS and WHS regulations*

Current chlorination system has a windsock and safety shower and a chlorine gas detector but does not have a chlorguard or similar automatic gas shutoff system linked to high chlorine gas alarm. Hence, it would not comply with modern OHS requirements. In addition, access to the flowmeter is via a pit with step irons, which is an OHS risk.

#### *Chemical storage and handling*

Access for changing 70kg gas bottles is reasonable

### 3.1.5 Environmental management

The only concern at present is the apparent low flowrate of the raw water pumps compared to design duty point. This results in greater energy consumption than expected.

# 4. Groundwater Investigation

GHD advised Council to undertake a field drilling investigation program to investigate the quality and bore yield potential of the groundwater resources in the vicinity of the townships of Delegate.

A groundwater investigation drilling program was therefore undertaken at the township of Delegate. The objective of this drilling program was to investigate potential groundwater resources in close proximity to the current water reticulation infrastructure at this township.

Two pilot investigation bores were drilled. At Delegate, the drilling focussed on the fractured basement rock aquifer.

The pilot bores drilled at the Delegate Reservoir site and Pumping station site to approximately 120 m depth produced a maximum yield in the order of 1 L/sec. Although the groundwater salinity was suitable for potable use, at around 300 mg/L TDS, there was insufficient yields to warrant the construction of a test bores or any further groundwater investigates.

**Based on these results, there was insufficient yield for ground water to be a reliable future source of supply or to warrant the construction of any test bores or any further groundwater investigations. It is recommended that other potable supply options are pursued.**

**The Groundwater Investigation Report has been issued to SMRC separately to this report.**

# 5. Existing Delegate River weir, intake structure and raw water pipeline

Potential upgrades of the weir on the Delegate River, the raw water intake structure and pipeline from the raw water pump station have not been addressed in this report. GHD understands that SMRC plans to undertake an Integrated Water Cycle Management Study (IWCMS) that will address the weir.

## 5.1 Weir across Delegate River

Raw water for Delegate is sourced from a pool in the Delegate River, upstream of the town. This pool is semi-formalised by the placement of reclaimed concrete blocks across the river to form a permeable weir. The raw water intake consists of a rudimentary timber platform, with manually operated winch assembly for raising and lowering the intake pipe in the pool. Refer to photographs in Figure 3.

The existing water intake and access do not meet current OH&S standards, as reported to Council by NSW Public Works Advisory in June 2017.

GHD has been advised that the existing weir was not formally designed or approved, but has received some level of recognition by the Department of Primary Industries in its report from 2006 addressing seven weirs across rivers in the area of responsibility of the Southern Rivers Catchment Management Authority (as it then existed). That report addresses the informal weir at Delegate in the same manner as the larger weir on the Snowy River at Dalgety. This does not constitute formal approval of this weir, but does acknowledge that it has existed since the 1950s. That report focussed on environmental considerations and recommended either the removal of the weir or upgrading the weir to include a partial width rock fishway, with the weir upgraded to a solid (non-permeable) structure directing normal flows through the proposed fishway.

There has been some recent discussion by Council around the potential to undertake some works on the weir at Delegate for the purpose of improving water security. GHD is not aware of a formal proposal for this weir. GHD understands that the weir will be considered as part of the planned IWCMS for Delegate.

The existing weir arrangement is currently serving to maintain a pool of water around the raw water intake.

The existing informal weir currently provides a workable pool at the raw water intake. This Options Study has assumed that this existing weir will remain in its current configuration and will be addressed in the upcoming IWCMS that SMRC is undertaking.

The following matters would need to be addressed in any proposal for changes to the existing weir arrangement, following from the IWCMS.

- Water security
- Fishway
- Storage capacity
- Investigation and design of ugraded weir
- Upstream and downstream flora and fauna habitats
- Formal approvals and environmental approvals from statutory bodies

# 6. Options for New Water Treatment Plant (WTP)

## 6.1 Capacity of new WTP and treated water storage

For the purposes of the new WTP options, the following capacity related aspects apply;

- Council Strategic Planner advice for Delegate is a 0.05% pa growth rate in population
- It is assumed there will be up to 10% increase in demand due to shift from a non-potable to a potable supply
- Based on ratio of Delegate to Bombala number of property connections and Bombala peak day demand for treated water of 1350 to 1450 kL/d, then on properties connected ratio the peak day demand for treated water at Delegate would be about 790 to 850 kL/day. This is significantly higher than seen in pump station records
- Historical peak day demand at Delegate is in the range 640 to 728 Kl/day and average demand over the peak 7 days has been up to 410 kL/day

Based on the above assessment the design basis is as follows;

- A 0.5ML/d capacity WTP combined with anew 800kL usable volume treated water storage. This arrangement
  - Allows reliable treated water supply via draw/fill of the 800 kl tank based on a design peak day demand up to 750 kL/day and average daily demand over the peak week up to 450 kL/d.
  - Provides security of supply for contingencies (eg extended power failure or raw water pump station unavailable).
- Annual demand of 200 kL/day or 73 ML/yr.

## 6.2 Development of suitable Water treatment process trains

### 6.2.1 Introduction

The key treatment challenges associated with the raw water source for a new Delegate WTP are;

- Achieve Log Removal Values ( LRVs) for bacteria, virus and protozoans based on Source Water Category=4  under Health Based Targets
- Moderate level of Iron, probably in oxidised state, and generally low levels of Manganese. Allowance for pre-oxidation using potassium permanganate is recommended
- A single measurement shows low Geosmin level at 5 ng/L and no detection of MIB. As this is a river source it is unlikely to have high levels of algae generated MIB or Geosmin, but it remains an uncertain but probably low risk. No specific treatment process is proposed, however the repurposing of the existing tank as a raw water balance tank would be suitable for future PAC dosing in the future, if required.
- Low alkalinity, pH and calcium levels and therefore relatively corrosive to cement lined and AC pipes
- cold water in winter down to 2oC and summer temperature up to 25oC  and apparent day to day variations up to about 2 to 5oC

- True colour levels up to 42Hu indicate significant level of Dissolved Organic Carbon (DOC) occur. However, a special organics removal process such as GAC is not required to avoid excessive THM formation. In addition, the relatively compact Delegate retic system means detention time in the retic is relatively short which further reduces the risk of excessive levels of THMs. However the following contingencies are adopted;
  - allowance in the new 800 kL treated water tank design ( i.e. about 600 mm headspace) for future, if required, retrofitting of a PAX type THM stripping system is recommended
  - room allowance in the WTP building for future ammonia and trim chlorine dosing for monochloramine based final disinfection

The WTP also needs to achieve the following design requirements;

- "Fit for Purpose" treatment barriers to achieve treated water targets based on the raw water quality envelope and HBT for the unprotected catchment conditions
- Sized for net peak day production of 0.5 ML/d and an annual output of 70 ML/yr and has integrated automatic operation with a new treated water tank of operating capacity of 800 kL
- Achieve asset life, environmental and OH&S requirements and reliable operation objectives (e.g. adequate automatic, duty/standby for critical equipment )

### 6.2.2 Treatment process options

#### Overview

A brief survey and assessment of various treatment technologies for the delegate raw water quality conditions is summarised in Appendix C. The preferred treatment processes, based on the raw water quality conditions and the treated water targets, are highlighted and are discussed below.

#### Raw Water balance tank

The raw water source is from a river and there is evidence from dally operational readings of relatively rapid changes in raw water quality (e.g. water temperature, turbidity, alkalinity, pH and colour). In addition, the raw water pumps are relatively remote. A raw water balance tank will mitigate these risks. It would have a bypass for direct pumping to the WTP for emergency conditions.

Repurposing use of the existing 283 kL tank as the raw water balance tank is recommended as it;

- Enables simple control of both the raw water pump station and the WTP ( i.e. start/stop on level)
- Protects the WTP from water hammer related pressure surge from the raw water pump
- Enables blending out short-term variations in water quality
- Provides reaction time for oxidation of iron and manganese
- Provides reaction time for future PAC dosing (if required).
- Provides some raw storage for WTP operation during unexpected events, eg extended power failure, flood damage

### Pre-oxidation and/or treatment for Taste/odour

Analysis of water quality data (table 5) indicates relatively low levels of manganese, moderate levels of iron and very little data on MIB/Geosmin/algae. However, as the raw water source is a relatively fast moving river with only small pools, it is unlikely that peroxidation for manganese or iron will be needed. It is possible that algae related taste/odour would occasionally occur in hot summers. Consequently, space allowance in the WTP building for future retrofitting of PAC and potassium permanganate systems is recommended. In addition, a pre-chlorine system would be provided now at this new WTP to dose chlorine to the raw water balance tank. This will be needed during commissioning and is a suitable contingency allowance for these water quality risks.

### Coagulation and pH control

Based on the jar test work for Bombala, alum based coagulation is recommended. Alum dosing at low pH of 5.8 to 6.2 maximises organics removal to minimise disinfection by-product production (eg Tri-Halo-Methanes (THMs) - which has a limit in ADWG )

pH control by caustic soda or soda ash is recommended. Lime dosing would be mean a lower chemical dose but for a small plant the difference in chemical cost is not big. However, a lime system has a significantly higher CAPEX and operational costs due to its handling difficulties.

### Clarification options; Dissolved Air Floatation (DAF) or lamella plate clarifier

The low turbidity and moderate colour plus the variable and at times very low water temperature conditions are well suited to a Dissolved Air Floatation (DAF) type clarification process. It is also best for algae removal, but this appears to be a relatively low risk in the raw water. It also has a small footprint and for this size plant can be fabricated off site in FRP or coated steel or stainless steel and then transported to site. However, it has a relatively high power requirement of about 80 to 120 kWhr/ML. In addition, if future dosing of PAC is required there is an upper limit for PAC dose at around 80mg/L for the DAF process

The alternative of a lamella plate based settling process is marginally more sensitive to water temperature variation but this effect will be minimised by use or the balance tank. It has a small footprint and for this size plant can be fabricated off site. It also has a low relative power requirement of about 10 to 15 kWhr/ML and has less automatic equipment and pressure vessels to maintain. The clarifier process can also accept very high doses of PAC if required in the future and has a greater capacity to treat high turbidity events.

Further discussion regarding the alternatives of a Dissolved Air Floatation (DAF) versus a suitable settling process is also included in Appendix D.

Finally, for this size plant DAF and lamella plate clarifier have about the same CAPEX.

### Filtration options; MF or gravity filters

The very low water temperature conditions in winter would require de-rating of a Microfiltration (MF) process. For a 0.5MLD capacity plant the maximum flowrate through the membranes would be around 7L/s. The effect of water temperature on this maximum flow rate is estimated as follows ;

**Table 10: Water temperature effect on maximum flow rate**

| Water Temperature | Relative maximum flow rate (L./s) | Net production capacity(MLD) |
|---|---|---|
| 20ºC | 7 | 0.5 |
| 15ºC | 6.2 | 0.44 |
| 10ºC | 5.4 | 0.39 |
| 5ºC | 4.6 | 2.3 |

Based on findings from the relationship between demand and water temperature it is proposed that the MF process be designed for maximum production at a water temperature down to 15oC.

The relative benefits of MF technology compared to gravity filtration are;

- Council has this MF process the nearby 0.24 ML/d capacity plant at Dalgety
- Easier to run remotely mainly because the process deals well with non- optimum coagulation/clarification conditions due to rapidly varying raw water turbidity/colour as it has a membrane barrier with pores that are smaller than bacteria and protozoan microbes
- backwash is by air and raw water reducing loss of treated water in backwashing
- Log Removal Value (LRV) for protozoa is higher for MF compared to gravity filters.
- The MF process has an extra energy requirement of about 80 to 90 kWhr/ML compared to a gravity filtration process

However, gravity filtration has the benefit of not requiring plant de-rating in cold-water conditions. It also has less automated systems and valves and hence a lower specialist maintenance requirement.

### Organics and MIB/Geosmin removal options

Special treatment process options for additional organics removal to control THMs or MIB/Geosmin removal to control taste/odour (eg Ozone/GAC or GAC or Nanofiltration etc.) is not included. That is, the single measurement of TOC/DOC and MIB/Geosmin showed low levels when colour reading was near the average value. Relatively low TOC/DOC and MIB/Geosmin levels are relatively common for river sources in this area.

However, contingency allowance for future powdered Activated Carbon (PAC) dosing for possible intermittent MIB/Geosmin risk is recommended.

### Fluoridation

For this small size plant, the recommendation is a sodium fluoride saturator based system installed within a separate purpose built air-conditioned room within the new WTP. A decision on fluoridation of this water supply requires community and Department of Health consultation, which has not yet occurred and is not within the scope of this project.

### Ultra-Violet (UV) disinfection

UV disinfection is required for protozoa removal to achieve LRV target. A higher dose is required for the process with clarification/filtration compared to clarification/MF but the difference is small in terms of power consumption and costs.

### Disinfection: chlorination and allowance for chloramination

Chlorination based on dosing chlorine gas from new duty/standby 72 kg cylinders via duty + standby chlorinators that are automated to adjust dose based on flow pace and trim to a free chlorine residual control as well as automatic changeover on fault. Chlorine would be added to the inflow to the treated water tank. Based on;

- Tank minimum operating volume of 100 kL
- chlorine residual at 1mg/L in water leaving the tank
- peak flow of 7.5L/s and
- shortcircuiting factor of 0.1 ( assumes worst case of USEPA allocation for tank with no baffling)

Then the calculated Concentration(C) x detention time (T) at the tank outlet is 22mg/L-min compared to ADWG minimum recommendation of 15mg/L-min.

In addition, allowance is recommended for trim chlorine dosing plus dosing of ammonia to create monchloramine disinfection residual in the treated water leaving the treated water tank is proposed to minimise THM exceedance risk and maintain a stable disinfectant residual in the town. This requirement may not be required if jar test work during detail design stage shows the THM formation potential is less than the target of <0.25mg/L

### Washwater and sludge management

Washwater and sludge would be discharged to a washwater tank and then slowly pumped to a thickener to produce a sludge suitable for dewatering by 2 No. sludge drying beds. Polymer is added to the flow going to the thickener. The clay-lined sludge drying beds with underdrains in a bottom sand bed, would be located as shown in figure 5. Design is based on an average suspended solids production of 15-20 mg/L and treated water production of 73 ML/yr. Two drying beds are proposed sized for a sludge drying capacity of 30 kg DS/m2/yr for this comparison of options stage. Supernatant from the thickener plus occasional subnatant flow from the drying beds will be stored in a separate small tank. The combined supernatant/subnatant would be pumped back to the raw water balance tank at a controlled rate of <10% of the flowrate of raw water inflow from the pump station at the river. This approach minimises water losses for sludge dewatering. Dried sludge would be removed approximately 1 to 2 times per year from each bed.

The alternative to the sludge drying beds of a mixed thickened sludge tank (approximately 10 to 20 kL) that is emptied every few weeks/monthly will be assessed during concept design stage.

### Summary of Future Treatment Process Options

Based on the above assessment it was determined that suitable alternative treatment process trains for treatment of this raw water are;

- **Option 1 or 2:** Raw water balance tank + Lamella Plate Clarifier or DAF + MF/UF +UV + Chlorination and the chloramination
- **Option 3 or 4:** Raw water balance tank + Lamella Plate Clarifier or DAF + Gravity Filters +UV + Chlorination AND then chloramination

## 6.2.3 New Water Treatment Plant (WTP) Building

To achieve good security and long asset life the new WTP would be located in a lined Colorbond building, containing the main process units, chemical systems, control room and electrics. The figure below shows photos for a similar size plant inside such a building. The building dimensions and nominal internal layout of equipment is included in Appendix E.

**Figure 5 0.6 ML/d Balmoral DAFF main building (left) & Lined sludge drying bed for 23 MLD Hamilton WTP (right)**

### 6.2.4 Proposed WTP and Treated Water Tank location

The proposed location is between the existing access road to the existing 283 kL tank and the southwest boundary of the property. (Refer figure 6) The new WTP location is to the west of the existing raw water pipe to enable easy access to this pipeline. New road works and a small “farm dam” structure (to contain overflows) are proposed. A concrete chemical delivery bund with associated underground spill tank is also included. (Refer figure 7).

The new Treated water tank location minimises extra pipe work while allowing easy access.

### 6.2.5 Land acquisition

We understand that Council does not own the site at Delegate where the existing 283 kl tank is located and the new WTP infrastructure is to be located. This is lot 1 DP 348134 as shown below in figure 6.

The current CAPEX for this project does not include the cost for Council to acquire the land.

While Council does not need to acquire the whole area of the existing lot, the UCV used for rating purposes for the whole site would allow a margin for subdivision and acquisition costs over the land value of the area that does need to be acquired.

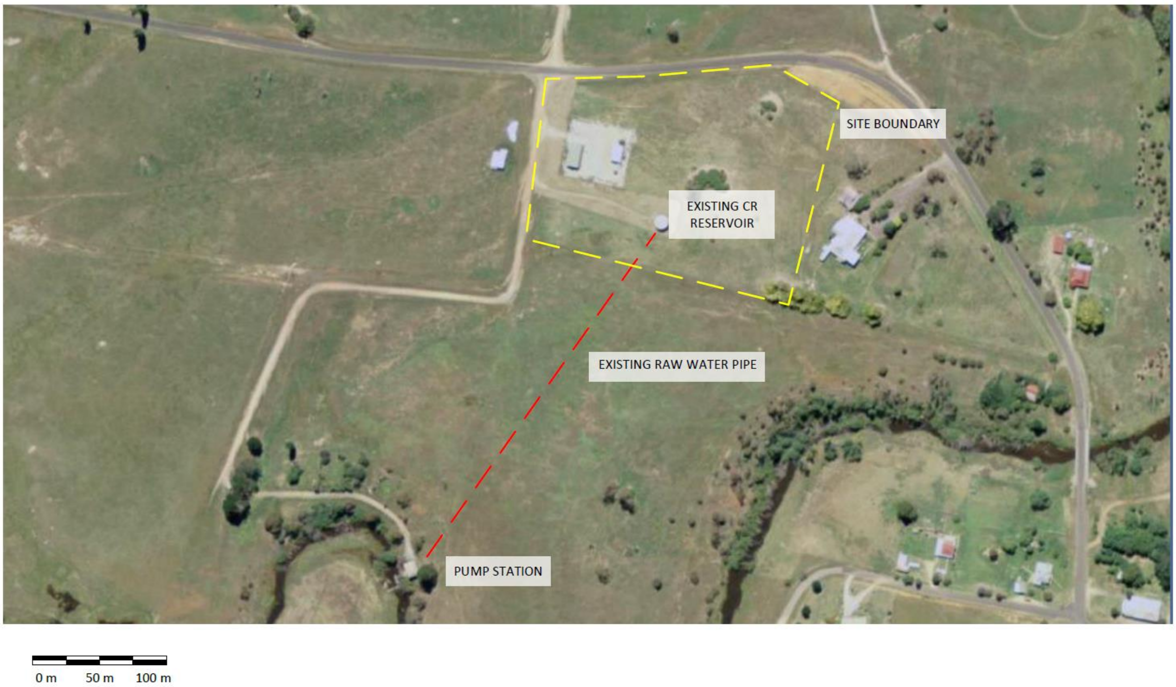


**Figure 6: Aerial view of key site features**

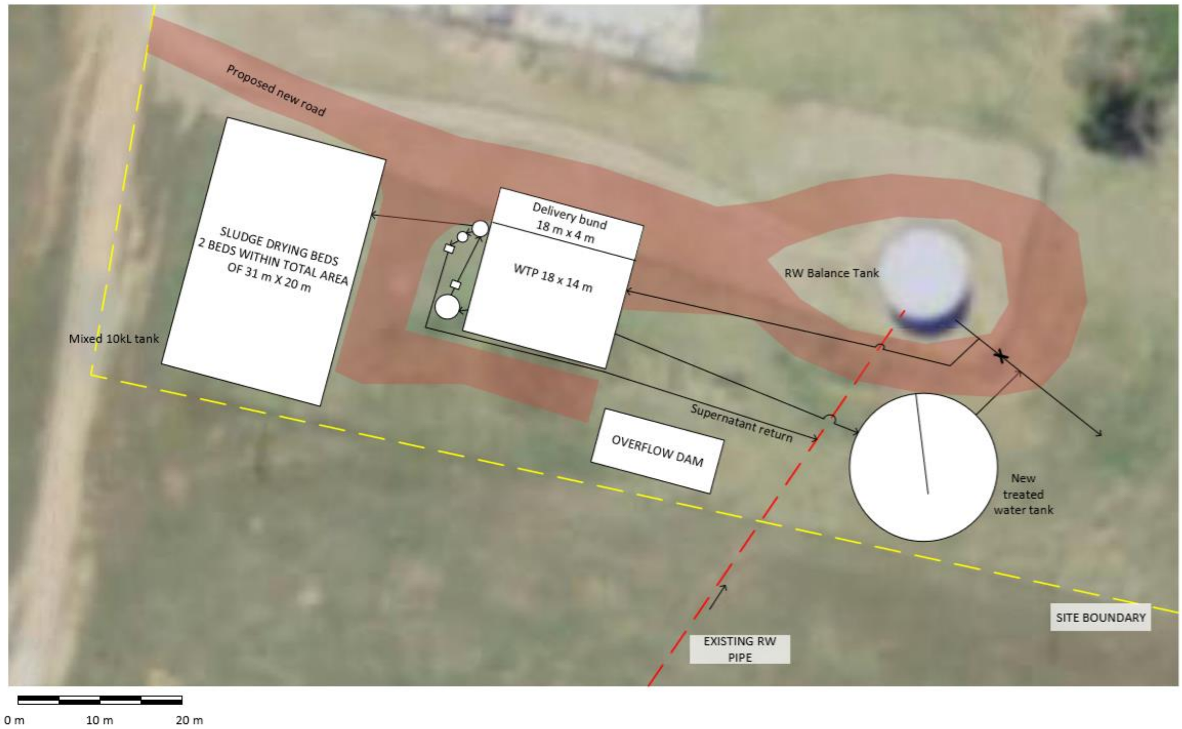


**Figure 7: Proposed site location and layout for Option 1 &2**

## 6.3 Raw water pump station and raw water main

Existing raw water pumps are 18.5 kW and design duty point is 30 L/s at 42.6 m head. At the site visit, the duty pump was drawing 30 amps at 410v, which is consistent with this power rating.

However, investigations of the raw water pump hours, flow integrator readings (provided by SMRC from 2017-2020) plus site tests  indicate pump 1 runs at a flow rate between 4.8 – 7.2 L/s while Pump 2 runs at a flow rate between 13-13.6 L/s.

To achieve asset life and reliably of operation requirements it is assumed both pumps are replaced for the new WTP project. Based on design peak day demand of 750kL/d, a pump capacity of 12L/s is required. The new pumps need to be duty/standby with auto changeover on fault. Fixed speed pumps that start/stop on Low/high water level in the raw water balance tank is all that is needed.

It is assumed that no changes to the raw water main is required.

## 6.4 Common Works for this WTP project

Works that are common to Option 1 and Option 2 include:

- General road/site works and civils
- Replacement of both raw water pumps at raw water pump station
- No upgrade of the existing Raw Water main
- Pre- alkali and potassium permanganate or pre-chlorine dosing
- Existing 283 kL tank repurposed for a Raw water balance tank
- New soda ash, polymer, alkali and coagulant systems
- UV disinfection
- Chlorination
- Treated Water Stabilisation by addition of alkali and carbon dioxide
- Mixed washwater tank, pumps and pipeline to thickener
- Polymer dosing to feed to thickener
- Sludge handling via thickener and sludge drying beds
- Supernatant return tank and pipeline to raw water tank
- New treated water tank (800 kL)
- Overflow “farm dam” of about 100 kL capacity
- Concrete delivery bund  and chemical spill tank
- Service water, compressed air , telemetry link and new power supply and transformer

## 6.5 Option 1 or 2: New DAF or lamella Plate clarifier then Membrane Filtration

This treatment solution includes:

- Dissolved Air Floatation (DAF) or Lamella plate clarifier to produce settled water
- Settled water balance tank and MF feed pumps on VSD control
- Low pressure High Output type Microfiltration (MF) skid backwashed by raw water plus air scour
- CIP system

Figure 8 shows the Process Flow Diagram and the approximate building layout is shown in Figure 7

## 6.6 Option 3 or 4:  Lamella Plate or DAF then Gravity Filtration

This treatment solution includes:

- Dissolved Air Floatation (DAF) or Lamella plate clarifier to produce settled water
- Gravity filters with dual media
- Backwash operation using air scour then high rate filtered water backwash from the existing treated water tank
- Filtered water balance tank and associated level controlled pumps on VSD delivering treated water to the existing RC tank

Figure 8 shows the Process Flow Diagram and the approximate building layout is shown in Appendix E.

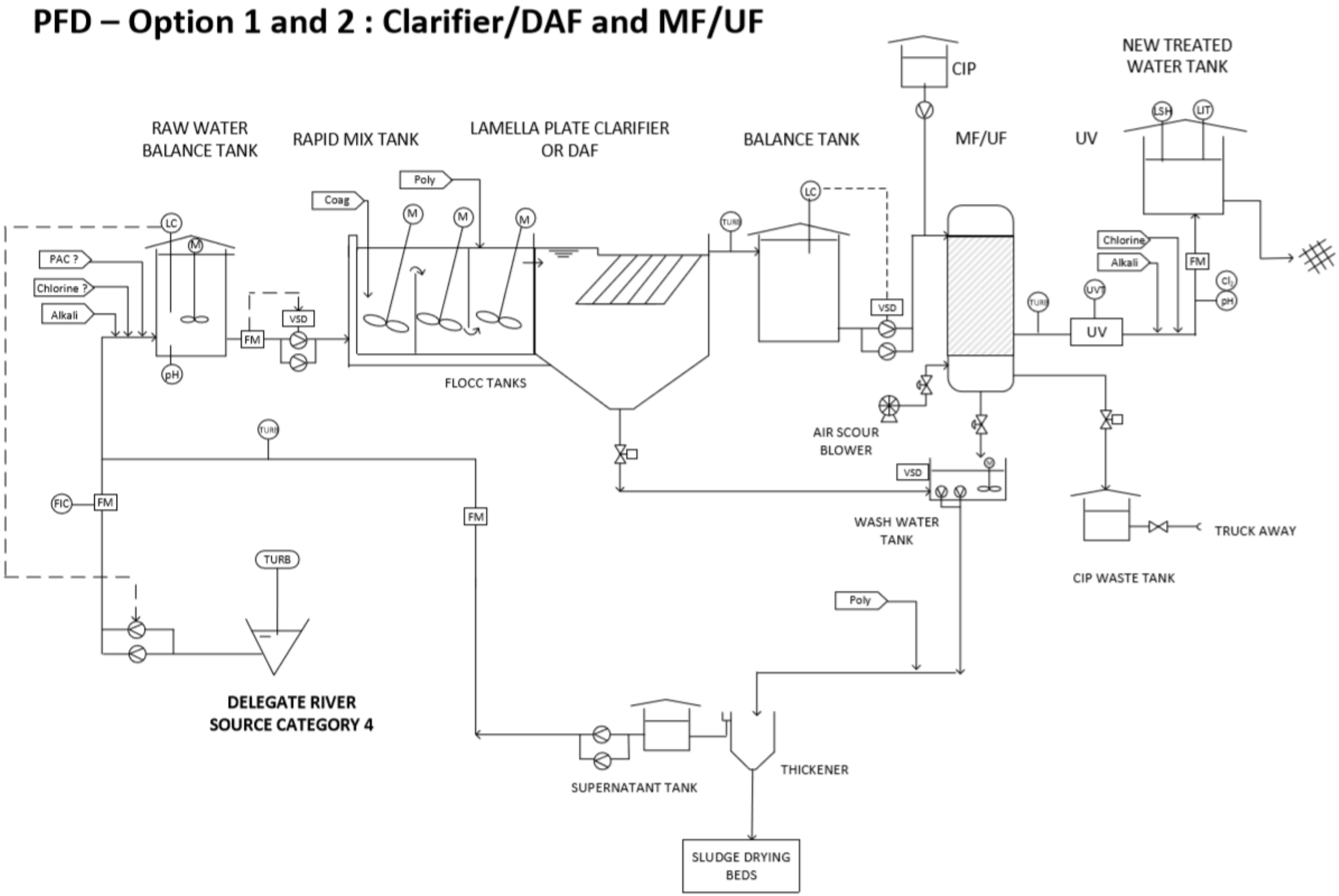


**Figure 8 Process flow diagram of new WTP to treat water from Delegate River (Source Category 4)**

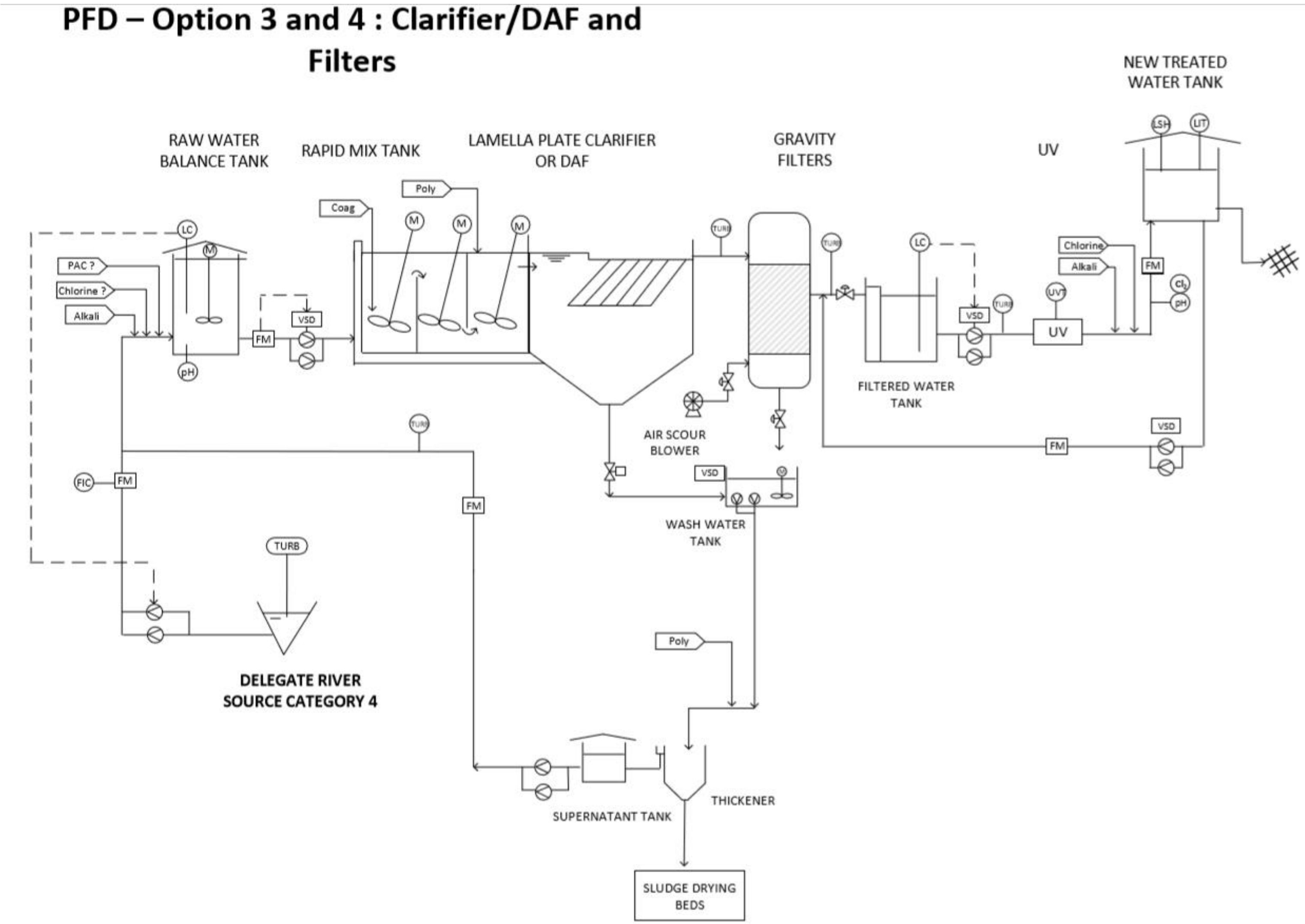


Figure 9: Process flow diagram of new WTP to treat water from Delegate River (Source Category 4)

# 7. Comparison of options

## 7.1 Introduction

The relative CAPEX, OPEX, Net Present Cost (NPC) and non-cost related advantages and disadvantages for each option are discussed in this section of the report.

Refer to Appendix F for breakdown of costing of CAPEX, OPEX and NPC.

## 7.2 Comparison of Options for new WTP

The comparison of options is summarized in Table 11 below.

It is notes that the accuracy of the relative cost estimates is estimated at 30%. Based on this accuracy both options are comparable in terms of CAPEX and NPC.

PAC dosing has not been included in the costing presented in Table 11 as it is a relatively unknown risk and can be retrofit later. A preliminary cost for PAC dosing has been provided in the cost breakdown in Appendix F for information however not added to the final total

Potassium permanganate for manganese oxidation is not included in the cost estimate shown in table 7 as again it is a relatively unknown but probably low risk and can be retrofit later.

Cost for fluoridation is also not included in the cost estimate shown in table 7.

The important features of the comparison of options are;

- The relative differences in energy cost are quite small for the process options;
    - Clarifier/gravity filtration: 30 to 40 kWhr/ML or about $500 to $700pa
    - DAF/filtration: 80 to 100 kWhr/ML or about $1400 to $1800pa
    - DAF/MF: 160 to 200 kWhr/ML or about $2500 to $3000pa
- The MF option has the benefit of low operator attendance requirement as it has the most robust treatment process due to the presence of a physical membrane barrier that prevents passage of protozoans and bacteria. Suboptimal coagulant dosing can be better tolerated compared to DAF or lamella plate clarification
- DAF is well best suited to variable cold water temperature conditions. MF has to be de-rated for water temperature <15oC and the clarification process operates best where water temperature variation rate is < 2oC/hr
- All processes can be fabricated offsite and brought to site on a truck for skid type installation, however the MF system is usually the most suitable for this approach as it comes with its own PLC controller and all automated valves set in place
- All these treatment processes are fabricated locally so procurement of the main process is relatively easy eg;
    - DuPont for Memcor MF structures and controls but note that membrane modules are usually imported
    - Water Treatment Australia and Aquatec Maxcon for DAF and Lamella plate clarifiers structures but lamella plate casettes are often imported

### Table 11: Comparative costs advantages and MCA Scoring for each option

| | | Option 1 DAF then MF | Option 2 Lamella Plates Clarifier then MF | Option3 Lamella Plates Clarifier then gravity filters | Option 4 DAF then gravity filters |
|---|---|---|---|---|---|
| CAPEX* | | $5.55 m | $5.52 m | $5.32 m | $5.35 m |
| Land acquisition for WTP** | | $0.25-0.3 m | $0.25-0.3 m | $0.25-0.3 m | $0.25-0.3 m |
| OPEX* | | $0.142 m/yr | $0.139 m/yr | $0.134 m/yr | $0.138 m/yr |
| NPC 6%pa for 25 yrs | | $7.62-7.67 m | $7.55- 7.60 m | $7.29-7.34 m | $7.37 -7.42 m |
| Advantages | | Easy to manage barrier for achieving LRV for protozoa risk ( eg Cryptosporidium)<br>Least sensitivity to rapid change in raw water turbidity/ colour/water temp<br>Council operates MF at nearby Dalgety<br>Raw water used in backwash<br>DAF best for algae removal | Easy to manage barrier for achieving LRV for protozoa risk ( eg Cryptosporidium)<br>Low complexity for automated control for Lamella plate clarifier<br>Council operates MF at nearby Dalgety<br>Raw water used in backwash | No de-rating for low water temperature<br>Least complexity for automatic controls | No de-rating for low water temperature<br>Low complexity for automatic control of gravity filters<br>Good for algae removal |
| Relative Disadvantages | | De-rating plant capacity progressively required when water temp is <15 ºC<br>Most complex automatic control<br>Expensive Proprietary membranes that have to be replaced every 7 to 8 yrs<br>Higher backwash volume compared to gratify filters<br>Limitation on future PAC dose( if required) | De-rating plant capacity progressively required when water temp is <15 ºC<br>Expensive Proprietary membranes that have to be replaced every 7 to 8 yrs<br>Higher backwash volume compared to gravity filters | More sensitive to rapid change in raw water turbidity/colour<br>Careful control of coagulation, clarification and filtration processes required to always achieve LRV for protozoa risk<br>Treated water used in backwash reducing volume in treated water tank for drawdown | More sensitive to rapid change in raw water turbidity/colour<br>careful control of coagulation, DAF an filtration processes required to always achieve LRV for protozoa risk<br>Treated water used in backwash reducing volume in treated water tank for drawdown<br>Limitation on future PAC dose( if required) |
| Relative score against MCA | Barrier to chlorine resistant protozoan | ✓✓✓✓ | ✓✓✓✓ | ✓✓✓ | ✓✓✓ |
| | Low attendance for operation | ✓✓✓✓ | ✓✓✓✓ | ✓✓ | ✓✓✓ |
| | Easy to maintain | ✓✓ | ✓✓✓ | ✓✓✓✓ | ✓✓✓ |
| | Environment | ✓✓✓ | ✓✓✓ | ✓✓✓✓ | ✓✓✓ |
| | OHS | ✓✓✓✓ | ✓✓✓✓ | ✓✓✓✓ | ✓✓✓✓ |
| | Easy procurement/construction | ✓✓✓ | ✓✓✓ | ✓✓✓✓ | ✓✓✓✓ |
| (preferred Option=1, Less preferred=2) | | 1 or 2 | 1 or 2 | 3 | 4 |

*The above costs do not include Fluoridation or other possible future chemical dosing systems. However costs for these items are include in the detailed breakdown for information only purposes

**Nominal land acquisition cost for WTP at existing tank site

# 8. Conclusions & Recommendations

## 8.1 Conclusions

The main conclusions from this assessment covering of demand, surface water supply systems, surface water quality and treatment and groundwater alterative are:

Demand; Design peak day demand for the new WTP has some uncertainty due to

- lack of long-term reliable records for supply from the raw water pump station
- uncertain effect of switch from non-potable supply to potable supply

In response it is considered the best cost-effective solution is a 0.5ML/d capacity WTP combined with a large 800kL treated water tank to allow draw/fill of the tank to achieve reliable supply for a peak day demand of up to 750kL/day and average dally demand up to 450 kL/day over the peak week

Raw Water supply system: the existing raw water pumps achieve performance well below design duty point. It is assumed they will be replaced for the new WTP. The existing weir pool, intake structure and rising main are now 70 yrs old. They need replacement/upgrade work. The assessment of what is needed and cost is not included in this project.

Raw Water Quality and Treatment; the Delegate river source has relatively high E.coli levels and is from an inhabited catchment with livestock and farm houses with septic tanks. It is a run of river supply with variable turbidity and colour and a wide temperature range. It is a soft water source that needs alkali addition to stabilise the treated water, especially after chlorine gas is added. Effective Treatment requires a 2- stage process of clarification (Lamella plate clarifier or Dissolved Air Floatation) then filtration (Gravity dual media filters or Microfiltration). UV then chlorine disinfection is also needed to achieve Health Based Targets.

Groundwater alternative: preliminary drilling reveals that this groundwater alternative is not a viable option

Other matters; Council does not own the land where the existing storage tank is located, which is also the site for the new WTP

## 8.2 Recommendations

The preferred 0.5ML/d capacity treatment process for the Delegate WTP is:

Option 2: Lamella Plate Clarification then MF

The main common works are;

- New raw water pumps
- Repurpose the existing 283 kL tank as a raw water storage to balance out changes in raw water quality and provide some security of supply capability
- UV disinfection then chlorination
- New 800 kL usable volume treated water storage
- Sludge treatment by sludge drying beds
- The main treatment processes located inside a new colour-bond type building
- Allowance in floor area within the treatment plant building for future addition of PAC, potassium permanganate and ammonia dosing

The key benefit of this MF based option is the presence of a physical membrane, which allows occasional suboptimal performance of the coagulation and settling or floatation process to be tolerated. This is important for a run of the river raw water supply system where raw water quality can change rapidly. In addition, Council has experience with MF technology at nearby Dalgety WTP. Also, usually a MF based process requires less operator attendance at site compared to gravity filters based process, as it is more automatic process.

The main benefit of lamella plates clarification is it can handle higher solids loading due to high dose of coagulant for events of high turbidity plus colour.

This treatment process also has a small footprint.

It is also recommended that;

- Land at the existing water tank site be acquired for the new WTP and associated works
- No further groundwater investigations be considered
- assessment of the weir pool, intake structure and raw water pipeline be completed and necessary upgrade works be defined

# Appendices

# **Appendix A** – SMRC Delegate Operational Data for storm event period

## Delegate WTF - Operational data.

| Process | | Raw Water | Raw Water | Raw Water | Raw Water | Raw Water | Reservoir | Reservoir | Reservoir | Reservoir | Reservoir | Bombala Street - Hydrant at end of main | Bombala Street - Hydrant at end of main | Bombala Street - Hydrant at end of main | Bombala Street - Hydrant at end of main | Hospital - Craigie Street | Hospital - Craigie Street | Hospital - Craigie Street | Hospital - Craigie Street | Orr Street - Hydrant at end of main | Orr Street - Hydrant at end of main | Orr Street - Hydrant at end of main | Orr Street - Hydrant at end of main | Chlorine | Chlorine | Pump hours (calculated from chlorine dose) | Pump hours (from log sheets) | Plant flow | Plant Flow (calculated) | Chlorine dose (calculated) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Critical Control Points | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Parameter | | Colour | Turbidity | pH | emperatu | Alkalinity | Colour | Turbidity | pH | Cl2 | Alkalinity | Colour | Turbidity | pH | Cl2 | Colour | Turbidity | pH | Cl2 | Colour | Turbidity | pH | Cl2 | Pre | Pre | hours | hours | kL/d | L/s | mg/L |
| Units | | Hu | NTU | | °C | mg/l | Hu | NTU | | mg/L | mg/l | Hu | NTU | | mg/L | Hu | NTU | | mg/L | Hu | NTU | | mg/L | kg/hr | kg/d | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Average: 13.2 | Average: 8.87 |
| 22/01/2020 | | 109 | 10.4 | 6.72 | 17.6 | 25 | 91 | 8.01 | 5.97 | 0.32 | 21 | 77 | 6.91 | 6.15 | 0.17 | 97 | 7.61 | 6.3 | 0.01 | 87 | 7.91 | 7.11 | 0.03 | 0.4 | 1.11 | 2.775 | 2.79 | #VALUE! | | #VALUE! |
| 23/01/2020 | | 127 | 11.7 | 6.79 | 17.9 | 25 | 124 | 9.91 | 5.9 | 0.08 | 24 | 102 | 6.99 | 6.17 | 0.11 | 96 | 7.79 | 6.31 | 0.06 | 90 | 7.4 | 7.1 | 0.05 | 0.4 | 1 | 2.5 | 2.5 | #VALUE! | | #VALUE! |
| 24/01/2020 | | 120 | 11.1 | 6.72 | 17.6 | 23 | 113 | 9.81 | 5.92 | 0.17 | 27 | 100 | 6.91 | 6.16 | 0.21 | 91 | 7.7 | 6.3 | 0.08 | 92 | 7.24 | 7.11 | 0.05 | 0.4 | 1.95 | 4.875 | 4.88 | 214 | 12.19 | 9.11 |
| 25/01/2020 | | 121 | 11.4 | 6.74 | 17.7 | 29 | 111 | 9.54 | 5.91 | 0.21 | 22 | 101 | 6.92 | 6.19 | 0.29 | 91 | 7.79 | 6.37 | 0.05 | 91 | 7.26 | 7.17 | 0.05 | 0.4 | 2.37 | 5.925 | 5.83 | 259 | 12.14 | 9.15 |
| 26/01/2020 | | 127 | 11.1 | 6.73 | 17.6 | 30 | 121 | 9.87 | 5.99 | 0.37 | 29 | 107 | 6.99 | 6.12 | 0.28 | 93 | 7.77 | 6.32 | 0.05 | 92 | 7.22 | 7.12 | 0.05 | 0.4 | 1.17 | 2.925 | 2.93 | 135 | 12.82 | 8.67 |
| 27/01/2020 | | 120 | 10.2 | 6.72 | 17.9 | 30 | 127 | 9.8 | 5.91 | 0.38 | 29 | 102 | 6.83 | 6.19 | 0.21 | 92 | 7.81 | 6.37 | 0.06 | 94 | 7.23 | 7.17 | 0.06 | 0.4 | 1.74 | 4.35 | 4.35 | 201 | 12.84 | 8.66 |
| 28/01/2020 | | 127 | 11.4 | 6.71 | 18.7 | 31 | 121 | 9.91 | 5.93 | 0.2 | 27 | 119 | 6.91 | 6.03 | 0.14 | 121 | 7.92 | 6.24 | 0.12 | 100 | 7.91 | 7.11 | 0.1 | 0.4 | 1.18 | 2.95 | 2.93 | 134 | 12.62 | 8.81 |
| 29/01/2020 | | 148 | 8.87 | 7.09 | 24.9 | 30 | 118 | 10.2 | 5.99 | 0.04 | 21 | 153 | 12.2 | 5.96 | 0.15 | 133 | 10.9 | 6.18 | 0.06 | 121 | 7.9 | 7.11 | 0.09 | 0.3 | 2.76 | 9.2 | 6.9 | 303 | 9.15 | 9.11 |
| 30/01/2020 | | 134 | 8.84 | 7.05 | 22.1 | 31 | 116 | 9.81 | 6.06 | 0.17 | 22 | 101 | 8.71 | 6.09 | 0.07 | 99 | 9.92 | 6.16 | 0.05 | 97 | 7.21 | 7.07 | 0.06 | 0.3 | | 0 | 4.82 | 215 | | 0.00 |
| 31/01/2020 | | 132 | 8.7 | 7.12 | 23 | 32 | 110 | 9.73 | 6.12 | 0.12 | 24 | 106 | 9.01 | 6.11 | 0.05 | 106 | 9.91 | 6.2 | low | 90 | 7.05 | 7 | low | 0.3 | 1.14 | 3.8 | 2.85 | 329 | 24.05 | 3.47 |
| 1/02/2020 | | 128 | 8.76 | 7.1 | 24.1 | 23 | 108 | 9.25 | 6.24 | 0.3 | 20 | 101 | 9 | 6.23 | 0.2 | 107 | 9.88 | 6.23 | 0.01 | 92 | 7.13 | 6.81 | 0.01 | 0.4 | 1.71 | 4.275 | 4.29 | 7 | 0.45 | 244.29 |
| 2/02/2020 | | 164 | 10.5 | 6.68 | 23.7 | 22 | 123 | 10.8 | 6.03 | 0.5 | 27 | 107 | 8.92 | 6.18 | 0.1 | 109 | 9.41 | 6.23 | 0.01 | 98 | 7.93 | 6.75 | 0.01 | 0.5 | 2.59 | 5.18 | 5.18 | 239 | 12.82 | 10.84 |
| 3/02/2020 | | | | | | | | | | | | | | | | | | | | | | | | | | | | #VALUE! | | #VALUE! |
| 4/02/2020 | | 127 | 10.2 | 6.62 | 20.1 | 24 | 108 | 9.72 | 5.71 | 0.8 | 21 | 101 | 8.97 | 6.15 | 0.23 | 92 | 8.81 | 6.21 | 0.02 | 91 | 7.92 | 6.11 | 0.01 | 0.5 | 2.51 | 5.02 | | #VALUE! | | #VALUE! |
| 5/02/2020 | | 130 | 9.71 | 6.86 | 21.3 | 30 | 123 | 11.1 | 5.5 | 0.89 | 25 | 110 | 11.5 | 6.25 | 0.04 | 110 | 11 | 6.09 | 0.01 | 73 | 7.37 | 6.18 | 0.01 | 0.5 | 2.5 | 5 | 5.02 | 227 | 12.61 | 11.01 |
| 6/02/2020 | | | | | | | | | | | | | | | | | | | | | | | | | | | | #VALUE! | | #VALUE! |
| 7/02/2020 | | 127 | 9.11 | 6.81 | 21.2 | 30 | 114 | 10.9 | 5.51 | 1.2 | 22 | 120 | 10.2 | 6.21 | 0.1 | 100 | 10.1 | 6.07 | 0.08 | 79 | 7.32 | 6.11 | 0.05 | 0.5 | | 0 | | #VALUE! | | #VALUE! |
| 8/02/2020 | | 129 | 10.4 | 6.81 | 20.1 | 30 | 131 | 10.2 | 5.91 | 1.21 | 21 | 111 | 10.2 | 6.24 | 0.6 | 101 | 10.1 | 6.02 | 0.09 | 77 | 8.81 | 6.1 | 0.05 | 0.5 | 2.43 | 4.86 | 4.87 | 189 | 10.80 | 12.8571429 |
| 9/02/2020 | | 137 | 11.8 | 6.82 | 20 | 29 | 130 | 10.7 | 6.08 | 0.69 | 22 | 110 | 9.92 | 6.19 | 0.62 | 107 | 10.4 | 6.09 | 0.05 | 76 | 8.71 | 6.12 | 0.03 | 0.5 | 2 | 4 | 4 | 212 | 14.72 | 9.43 |
| 10/02/2020 | | 142 | 11.4 | 6.87 | 18.5 | 27 | 134 | 11.1 | 6.06 | 0.62 | 25 | 121 | 9.91 | 6 | 0.19 | 100 | 9.91 | 6.021 | 0.02 | 77 | 8.74 | 6.17 | 0.02 | 0.5 | 1.21 | 2.42 | 2.43 | 124 | 14.23 | 9.76 |
| 11/02/2020 | | 150 | 11.7 | 6.81 | 18.1 | 22 | 131 | 10.1 | 5.91 | 0.43 | 22 | 111 | 8.92 | 5.99 | 0.1 | 92 | 9.81 | 6.24 | 0.02 | 71 | 8.11 | 6.12 | 0.01 | 0.5 | 1.4 | 2.8 | 2.8 | 73 | 7.24 | 19.18 |
| 12/02/2020 | | 157 | 11.9 | 6.82 | 17.4 | 21 | 127 | 10.2 | 5.88 | 0.32 | 21 | 112 | 8.9 | 6.04 | 0.11 | 99 | 9.81 | 6.2 | 0.02 | 77 | 8.14 | 6.17 | 0.01 | 0.5 | 1.4 | 2.8 | 2.81 | 174 | 17.26 | 8.05 |
| 13/02/2020 | | 250 | 21.2 | 6.81 | 17.1 | 27 | 124 | 15.7 | 5.87 | 0.12 | 20 | 124 | 9.91 | 5.98 | 0.17 | 100 | 10.7 | 6.21 | 0.01 | 97 | 9.11 | 6.19 | 0.01 | 0.5 | 2.02 | 4.04 | 4.04 | 188 | 12.93 | 10.74 |
| 14/02/2020 | | 352 | 26.7 | 6.84 | 20 | 26 | 191 | 17.6 | 5.99 | 0.2 | 25 | 149 | 9.26 | 6 | 0.1 | 110 | 9.87 | 6.28 | 0.01 | 92 | 9.16 | 6.15 | 0.01 | 0.4 | 1.12 | 2.8 | 2.8 | 118 | 11.71 | 9.49 |
| 15/02/2020 | | 261 | 16 | 6.62 | 21 | 27 | 246 | 22.7 | 5.93 | 0.2 | 27 | 226 | 20.1 | 5.75 | 0.01 | 136 | 12.6 | 6.24 | 0.01 | 127 | 12 | 6.2 | 0.01 | 0.6 | 1.47 | 2.45 | 2.45 | 134 | 15.19 | 10.97 |
| 16/02/2020 | | 221 | 13 | 6.57 | 19.1 | 11 | 239 | 18.4 | 5.5 | 0.47 | 12 | 207 | 20.4 | 5.73 | 0.1 | 117 | 10.4 | 6.35 | 0.01 | 118 | 10.4 | 6.32 | 0.1 | 0.6 | 2.15 | 3.58 | 3.59 | 230 | 17.83 | 9.35 |
| 17/02/2020 | | 180 | 12.1 | 6.74 | 17.4 | 21 | 223 | 14.2 | 5.27 | 0.42 | 20 | 190 | 19.5 | 5.71 | 0.11 | 121 | 11.9 | 6.11 | 0.03 | 120 | 10.4 | 6.31 | 0.01 | 0.6 | 2.2 | 3.67 | 3.67 | 52 | 3.94 | 42.31 |
| 18/02/2020 | | 127 | 12.2 | 6.7 | 18.1 | 22 | 199 | 12.7 | 5.23 | 0.18 | 21 | 180 | 19.1 | 5.09 | 0.12 | 187 | 12.2 | 6.05 | 0.04 | 124 | 11.1 | 6.37 | 0.01 | 0.6 | 1.5 | 2.50 | 2.5 | 162 | 18.00 | 9.26 |
| 19/02/2020 | | 130 | 13.1 | 6.72 | 17.7 | 20 | 195 | 12.9 | 5.5 | 0.13 | 22 | 167 | 19 | 5.76 | 0.02 | 242 | 14.4 | 6.01 | 0.02 | 121 | 10.2 | 6.3 | 0.01 | 0.6 | 1.85 | 3.08 | 3.09 | 139 | 12.52 | 13.31 |
| 20/02/2020 | | 141 | 13.4 | 6.77 | 16.2 | 21 | 180 | 11.2 | 5.62 | 0.18 | 21 | 152 | 13.1 | 5.72 | 0.07 | 132 | 12.2 | 6.07 | 0.01 | 120 | 9.91 | 6.32 | 0.01 | 0.6 | 1.36 | 2.27 | 2.26 | 112 | 13.73 | 12.14 |
| 21/02/2020 | | 149 | 13.1 | 6.74 | 17.1 | 22 | 172 | 10.9 | 5.64 | 0.21 | 22 | 151 | 15.7 | 5.71 | 0.2 | 121 | 11.1 | 6.21 | 0.02 | 200 | 11.2 | 6.3 | 0.03 | 0.6 | 1.67 | 2.78 | 2.79 | 121 | 12.08 | 13.80 |
| 22/02/2020 | | 120 | 14.4 | 6.71 | 18 | 21 | 156 | 10.1 | 5.62 | 0.27 | 29 | 127 | 15.4 | 5.74 | 0.31 | 107 | 10.1 | 6.4 | 0.05 | 176 | 10.9 | 6.37 | 0.02 | 0.6 | 1.71 | 2.85 | 2.86 | 191 | 18.62 | 8.95 |
| 23/02/2020 | | 222 | 14.2 | 6.72 | 18.2 | 22 | 160 | 9.9 | 5.69 | 0.32 | 25 | 131 | 13.2 | 5.71 | 0.37 | 109 | 9.8 | 6.23 | 0.04 | 150 | 9.7 | 6.31 | 0.02 | 0.6 | 3.02 | 5.03 | 5.03 | 239 | 13.19 | 12.64 |
| 24/02/2020 | | 192 | 11.4 | 6.7 | 20.7 | 20 | 140 | 13.9 | 5.05 | 1.41 | 12 | 151 | 12.4 | 5.17 | 0.18 | 170 | 13.5 | 5.82 | 0.08 | 161 | 13.3 | 5.8 | 0.02 | 0.6 | 1.72 | 2.87 | 2.87 | 62 | 6.01 | 27.74 |
| 25/02/2020 | | 140 | 10.9 | 6.72 | 20.1 | 19 | 156 | 11.1 | 4.66 | 0.39 | 19 | 128 | 10.2 | 5.29 | 0.19 | 121 | 10.2 | 5.87 | 0.05 | 155 | 10.2 | 5.7 | 0.04 | 0.6 | 0.7 | 1.17 | 1.17 | 60 | 14.29 | 11.67 |
| 26/02/2020 | | 130 | 9.71 | 6.74 | 20.4 | 22 | 138 | 11.4 | 4.79 | 0.45 | 20 | 183 | 12.1 | 5.33 | 0.12 | 191 | 12.7 | 5.82 | 0.04 | 170 | 11.4 | 5.72 | 0.03 | 0.6 | 2.47 | 4.12 | 4.03 | 190 | 12.82 | 13.00 |
| 27/02/2020 | | 195 | 14.6 | 6.21 | 17.3 | 20 | 142 | 14.9 | 4.53 | 0.37 | 30 | 190 | 17.2 | 4.85 | 0.06 | 162 | 14.3 | 5.9 | 0.03 | 103 | 9.08 | 5.97 | 0.02 | 0.7 | 3.3 | 4.71 | 4.72 | 208 | 12.26 | 15.87 |
| 28/02/2020 | | 187 | 13.2 | 6.65 | 18 | 21 | 172 | 14.2 | 4.72 | 1.27 | 25 | 183 | 16.2 | 5.02 | 0.1 | 165 | 13.8 | 5.99 | 0.01 | 100 | 9.16 | 5.91 | 0.01 | 0.7 | 2.44 | 3.49 | 4.2 | 195 | 15.54 | 12.51 |
| 29/02/2020 | | 205 | 14.3 | 6.66 | 17 | 53 | 161 | 16 | 4.31 | 0.47 | 13 | 140 | 11.6 | 4.72 | 0.2 | 130 | 12.7 | 5.61 | 0.05 | 125 | 8.57 | 5.82 | 0.02 | 0.7 | 1.98 | 2.83 | 2.83 | 127 | 12.47 | 15.59 |
| 1/03/2020 | | 188 | 13.2 | 6.65 | 18.5 | 12 | 133 | 14.3 | 4.32 | 0.75 | 10 | 188 | 11.3 | 4.61 | 0.05 | 113 | 12.4 | 5.52 | 0.01 | 115 | 9.02 | 5.87 | 0.01 | 0.7 | | 0 | 4.19 | 198 | | 0 |
| 2/03/2020 | | 170 | 12.4 | 6.6 | 18.1 | 22 | 122 | 13.1 | 4.18 | 1 | 20 | 110 | 10.2 | 4.69 | 0.08 | 200 | 13.7 | 5.85 | 0.06 | 109 | 9.11 | 5.87 | 0.01 | 0.7 | | 0 | 4.27 | 204 | | 0 |
| 3/03/2020 | | 160 | 12.1 | 6.62 | 18 | 24 | 133 | 13.7 | 4.26 | 1.43 | 22 | 105 | 10.1 | 4.84 | 0.06 | 150 | 12.1 | 5.87 | 0.05 | 100 | 9.01 | 5.82 | 0.05 | 0.7 | | 0 | 4.54 | 192 | | 0 |
| 4/03/2020 | | 164 | 12.1 | 6.69 | 18.9 | 22 | 125 | 12.1 | 4.22 | 0.66 | 21 | 104 | 9.11 | 4.74 | 0.05 | 122 | 11.1 | 5.82 | 0.05 | 101 | 9.21 | 5.87 | 0.02 | 0.7 | | 0 | 2.37 | 119 | | 0 |
| 5/03/2020 | | 150 | 12.1 | 6.62 | 18.7 | 21 | 123 | 13.1 | 4.16 | 0.63 | 20 | 105 | 9.21 | 4.3 | 0.07 | 120 | 10.2 | 5.84 | 0.04 | 107 | 9.21 | 5.82 | 0.03 | 0.6 | | 0 | 1.59 | 60 | | 0 |
| 6/03/2020 | | 161 | 13.1 | 6.6 | 18.2 | 20 | 121 | 11.2 | 4.19 | 1.01 | 22 | 103 | 5.27 | 4.67 | 0.18 | 129 | 11.4 | 5.7 | 0.06 | 115 | 10.1 | 5.71 | 0.05 | 0.6 | | 0 | 2.31 | 115 | | 0 |
| 7/03/2020 | | 182 | 19.2 | 6.69 | 15.7 | 30 | 132 | 12.5 | 4.06 | 0.75 | 17 | 105 | 6.12 | 4.51 | 0.1 | 167 | 13.9 | 6.03 | 0.04 | 121 | 10.31 | 5.8 | 0.02 | 0.6 | | 0 | 2.72 | 115 | | 0 |
| 8/03/2020 | Exceedance | 124 | 15.1 | 6.81 | 16 | 51 | 101 | 12 | 4.19 | 1.61 | 13 | 123 | 12.8 | 4.58 | 0.08 | 106 | 11.4 | 5.9 | 0.03 | 24 | 2.53 | 5.82 | 0.07 | 0.4 | | 0 | 2 | 116 | | 0 |
| 9/03/2020 | Exceedance | 130 | 14.1 | 6.62 | 17.1 | 29 | 112 | 10.4 | 4.25 | 1.94 | 20 | 85 | 10 | 4.67 | 0.26 | 120 | 12.1 | 5.91 | 0.07 | 100 | 9.11 | 5.8 | 0.08 | 0.4 | | 0 | 3.04 | 108 | | 0 |
| 10/03/2020 | Exceedance | 122 | 13.1 | 6.04 | 16.9 | 27 | 112 | 12.8 | 4.28 | 1.99 | 21 | 82 | 10.6 | 5.01 | 0.45 | 85 | 12.4 | 5.99 | 0.09 | 82 | 7.77 | 5.8 | 0.09 | 0.5 | 1.39 | 2.78 | 2.32 | 127 | 12.69 | 10.94 |

# Appendix B – Plant flows and Chlorine Dose

Refer to following page.

| Date | | Delegate Pump Station Data Jan 2019 | | | | Chlorine dosage (Based on Jan 2020 doses) | |
|---|---|---|---|---|---|---|---|
| | Hours | Run time | Flow meter | kL/d | L/s | kg/hr | mg/L |
| Average | | 4.4 | | 213 | 14 | | 8.3 |
| Maximum | | 6.9 | | 451 | 26 | | 36 |
| 1/01/2019 | 3111.32 | | 734375 | | | | |
| 2/01/2019 | 3114.5 | 3.18 | 734536 | 161 | 14.06 | | 0.00 |
| 3/01/2019 | 3119.52 | 5.02 | 734780 | 244 | 13.50 | 0.25 | 5.14 |
| 4/01/2019 | 3124.43 | 4.91 | 735023 | 243 | 13.75 | 0.25 | 5.05 |
| 5/01/2019 | 3128.27 | 3.84 | 735194 | 171 | 12.37 | 0.2 | 4.49 |
| 6/01/2019 | 3133.23 | 4.96 | 735439 | 245 | 13.72 | 0.2 | 4.05 |
| 7/01/2019 | 3137.08 | 3.85 | 735622 | 183 | 13.20 | 0.3 | 6.31 |
| 8/01/2019 | 3141.08 | 4 | 735817 | 195 | 13.54 | 0.3 | 6.15 |
| 9/01/2019 | 3143.33 | 2.25 | 736173 | 178 | 21.98 | 0.3 | 3.79 |
| 10/01/2019 | 3148.31 | 4.98 | 736173 | 178 | 9.93 | 0.3 | 8.39 |
| 11/01/2019 | 3150.49 | 2.18 | 736287 | 114 | 14.53 | 0.3 | 5.74 |
| 12/01/2019 | 3153.69 | 3.2 | 736346 | 59 | 5.12 | 0.3 | 16.27 |
| 13/01/2019 | 3157.27 | 3.58 | 736512 | 166 | 12.88 | 0.3 | 6.47 |
| 14/01/2019 | 3161.26 | 3.99 | 736805 | 293 | 20.40 | 0.3 | 4.09 |
| 15/01/2019 | 3167.15 | 5.89 | 737091 | 286 | 13.49 | 0.3 | 6.18 |
| 16/01/2019 | 3171.24 | 4.09 | 737292 | 201 | 13.65 | 0.3 | 6.10 |
| 17/01/2019 | 3176.28 | 5.04 | 737538 | 246 | 13.56 | 0.3 | 6.15 |
| 18/01/2019 | 3181.2 | 4.92 | 737873 | 335 | 18.91 | 0.30 | 4.41 |
| 19/01/2019 | 3184.46 | 3.26 | 737943 | 70 | 5.96 | 0.4 | 18.63 |
| 20/01/2019 | 3189.56 | 5.1 | 738190 | 247 | 13.45 | 0.4 | 8.26 |
| 21/01/2019 | 3195.62 | 6.06 | 738461 | 271 | 12.42 | 0.4 | 8.94 |
| 22/01/2019 | 3200.44 | 4.82 | 738912 | 451 | 25.99 | 0.4 | 4.27 |
| 23/01/2019 | 3206.11 | 5.67 | 738975 | 63 | 3.09 | 0.4 | 36.00 |
| 24/01/2019 | 3212.41 | 6.3 | 739171 | 196 | 8.64 | 0.4 | 12.86 |
| 25/01/2019 | 3218.79 | 6.38 | 739614 | 443 | 19.29 | 0.4 | 5.76 |
| 26/01/2019 | 3225.71 | 6.92 | 739827 | 213 | 8.55 | 0.4 | 13.00 |
| 27/01/2019 | 3230.13 | 4.42 | 740132 | 305 | 19.17 | 0.4 | 5.80 |
| 28/01/2019 | 3234.15 | 4.02 | 740327 | 195 | 13.47 | 0.4 | 8.25 |
| 29/01/2019 | 3238.49 | 4.34 | 740537 | 210 | 13.44 | 0.3 | 6.20 |
| 30/01/2019 | 3241.46 | 2.97 | 740690 | 153 | 14.31 | 0.3 | 5.82 |
| 31/01/2019 | 3243.16 | 1.7 | 740763 | 73 | 11.93 | 0.3 | 6.99 |

# **Appendix C** – Comparison of treatment processes

Refer to following page

### Table 12 Comparison of treatment processes based on treatment of contaminants in raw water from Delegate river

**LEGEND**

- preferred process
- optional process
- Additional process if shown later to be required

| Contaminant Removed | Iron & Manganese | Turbidity and flocc particles | Colour | pH control | Dissolved Organic Carbon | Pesticide chemicals | MIB& Geosmin | Virus | Bacteria | Protozoans | THMs | Algae | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Treatment Process** | | | | | | | | | | | | | |
| Potassium Permanganate | ✓✓✓✓ | | | | | | | | | | | | Best at pH >7.5 – 8.5 in high DOC water as if prevents overdose risk |
| Powder activate carbon | | | | | ✓ | | ✓✓✓ | | | | | | Best if MIB/Geosmin is intermittent |
| Alchlor (ACH) | | ✓✓✓✓ | ✓✓ | ✓ | ✓ | | | | | | | | Preferred for high turbidity/low colour(DOC) water and where high coagulation pH is preferred |
| Alum | | ✓✓✓✓ | ✓✓✓✓ | | ✓✓ | | | | | | | | Preferred for high colour(DOC)/ low to high turbidity water and where low coagulation pH 5.8-6.2 is preferred for maximum DOC removal |
| Dissolved Air Floatation (DAF) | | ✓✓ | ✓✓✓✓ | | | | | | | | | ✓✓✓✓ | Best for high colour/low turbidity water and good for confined site |
| Sedimentation by Lamella Plates | | ✓✓✓✓ | ✓✓✓ | | | | | | | | | ✓✓ | Good for confined site and best for high turbidity /low to moderate colour conditions |
| Sedimentation by Reactivator | | ✓✓✓✓ | ✓✓ | | | | | | | | | | Best for high turbidity low colour water and less confined site |
| Gravity Dual Media Filtration | ✓✓ (greensand) | ✓✓✓ | | | | | | | | ✓ | | | Requires polymer dosing & air scour + water backwash & filter to waste |
| Microfiltration (MF) | | ✓✓✓✓ | ✓ | | | | | | | ✓✓✓ | | | Pore size 0.3 – 0.5 µm, lower power and raw water plus air scour backwash |
| Ultrafiltration (UF) | | ✓✓✓✓ | ✓✓ | | | | | | | ✓✓✓ | | | Pore size 0.1 – 0.2 µm, higher power and raw water plus air scour backwash |
| Nano Filtration (NF) | | | | | ✓✓✓ | | ✓? | | | ✓✓ ✓(if no bypass) | | | Get about 50% DOC removal and recovery 85-90% |
| Nanofiltration (SW) | | | | | ✓✓✓✓✓ | | ✓? | | | ✓✓ ✓(if no bypass) | | | Get about 90% DOC removal and recovery 80% |
| MIEX | | | | | ✓✓✓✓ | | | | | | | | Proprietary design & high OPEX risk |
| Ozone/GAC | | | | | ✓✓ | ✓✓✓ | ✓✓✓✓ | | | ✓✓ (if CT correct) | | | ozone mainly for MIB/geosmin present most of the time |
| GAC/BAC | | | | | ✓✓ | ✓✓ | ✓✓ | | | | | | DOC removal drops from 50% to 20-30% over 1 year then drops to 15-25% over 10 year |
| Chlorine | ✓✓✓ | | | | | | | ✓✓✓✓ | ✓✓✓✓ | | | | Need to have treated water DOC < 4 to 6 mg/L to avoid THMs >250 µg/L |
| Chloramine | | | | | | | | ✓ | ✓✓ | | ✓✓✓ | | Stops further THMs production |
| Caustic Soda | | | | ✓✓✓✓ | | | | | | | | | Dangerous good but lower dose required compared to soda ash |
| Soda Ash | | | | ✓✓✓✓ | | | | | | | | | Not a dangerous good |
| UV Disinfection | | | | | | | | | | ✓✓✓✓ | | | Installed power increases a lot as UVT in filtered water reduces from >90% to < 80% |
| PAX type aeration in Treated water tank | | | | | | | | | | | ✓✓✓ | | Removes > 35% of THM's when water temp <15oC |

# **Appendix D** – Comparison of DAF and Settling

The following Figure 10.1, based on International Water Treatment experience, shows the normal operating range for a Dissolved Air Floatation (DAF) process. The TOC is related to colour and in turn alum dosage, which adds to the solids load. This figures show that, for water that has a high TOC (or DOC or true colour) and a low turbidity, the preferred treatment process is DAF then filtration. At Delegate the true colour (from NSW Health results) can reach 40Huin the water canurDOC can be up to about 24mg/L and the turbidity is almost all the time <10NTU in all raw water data.

Settling processes, such as the existing reactivator clarifier or lamella Plate clarifier, are not preferred until the raw water turbidity exceeds about 40 NTU (Degremont-Suez). This is consistent with experience by GHD at several plants such as Hamilton in Victoria, where only the combination of high turbidity with high colour caused de-rating of the DAFF process.

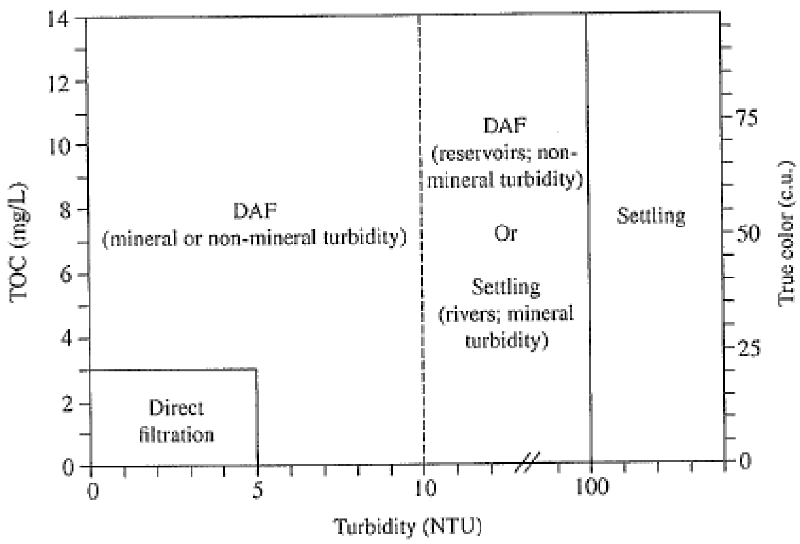


**FIGURE 10-1** Process selection diagram based on average raw water quality conditions (*Source: reprinted from Valade et al. (2009), Journal of Water Supply: Research and Technology AQUA, 58 (6), 424–432, with permission from the copyright holder, IWA Publishing).*

# **Appendix E** – Proposed Building Layout

Refer following page..

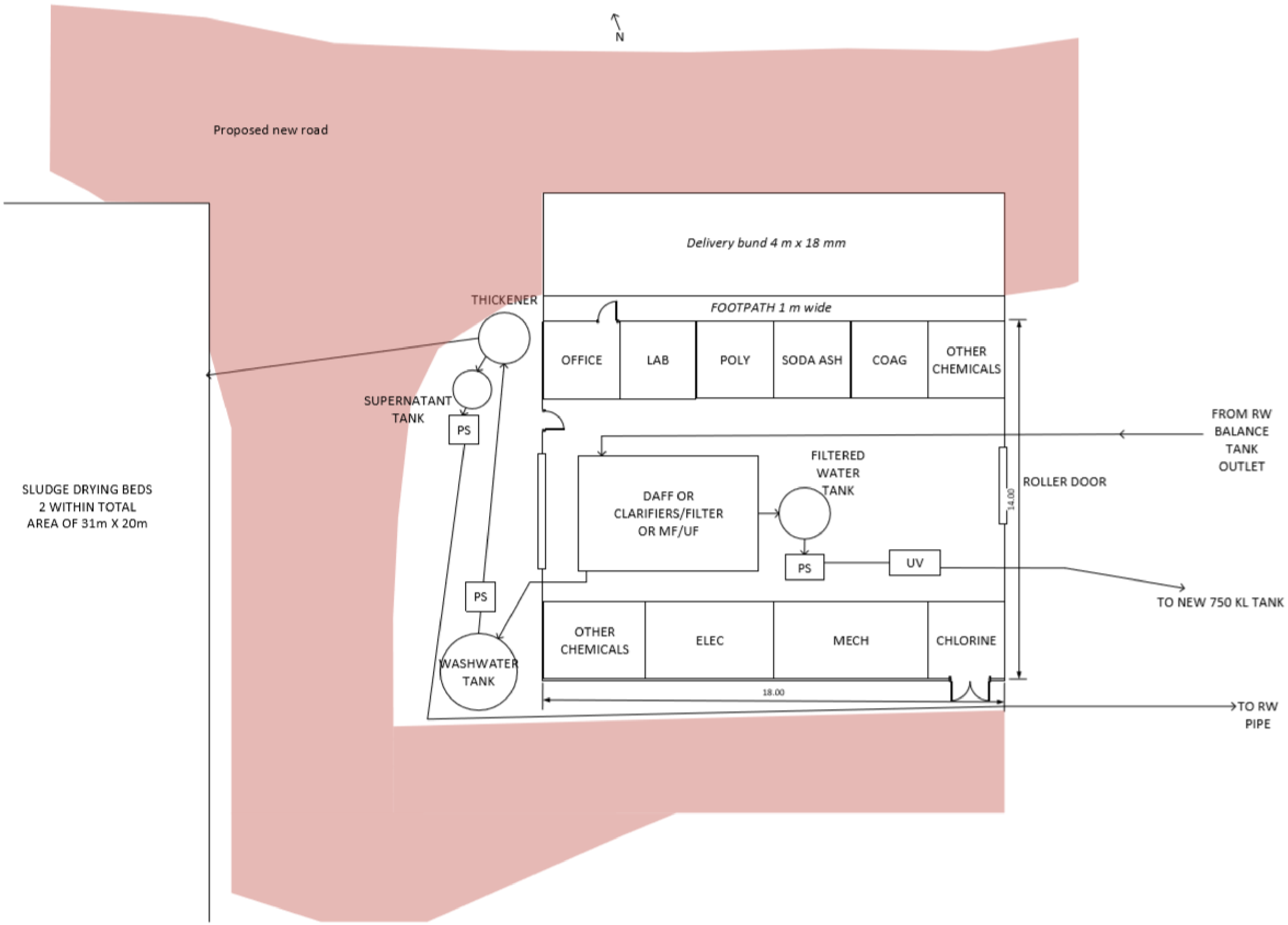


**Figure 10: Proposed building layout**

# **Appendix F** – Cost Estimates, CAPEX, OPEX, NPC

**Delegate WTP Cost Estimate** 29/07/2020

**Options Assessment**

| | | | | | Option 1 DAF+MF/UF+UV | | Option 2 Lamella Plates+MF/UF+UV | | Option 3 Lamella Plate+Gravity Filters+UV | | Option 4 DAF+Gravity Filters+UV | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No.** | **ITEM** | **Detail** | **Rate** | **Unit** | **Qty** | **Cost** | **Qty** | **Cost** | **Qty** | **Cost** | **Qty** | **Cost** | **Comment** |
| **0.0** | **Site Establishment / Preliminaries (10%)** | | | ***Subtotal*** | | **$ 624,000** | | **$ 624,000** | | **$ 600,000** | | **$ 600,000** | |
| 0.1 | Mobilisation and demobilisation | Allow 9% of total cost | $ 200,000 | No. | 1.87 | $ 374,000 | 1.87 | $ 374,000 | 1.8 | $ 360,000 | 1.8 | $ 360,000 | *From Myrniong/Lancefield, ~5% total cost.* |
| 0.2 | Design and documentation | Allow 6% of total cost | $ 250,000 | No. | 1 | $ 250,000 | 1 | $ 250,000 | 0.96 | $ 240,000 | 0.96 | $ 240,000 | *From Myrniong/Lancefield, ~5% total cost.* |
| 0.3 | Planning and approvals | | | No. | 0 | $ - | 0 | $ - | 0 | $ - | 0 | $ - | *To be undertaken by SMRC* |
| **1.0** | **Site Civil Works** | | | ***Subtotal*** | | **$ 259,500** | | **$ 259,500** | | **$ 259,500** | | **$ 259,500** | |
| 1.1 | Earth Works at Site | Assumes relativitely flat site with minimal rock | $ 30,000 | No. | 1 | $ 30,000 | 1 | $ 30,000 | 1 | $ 30,000 | 1 | $ 30,000 | *Based on Small Tassie Plant Tenders* |
| 1.2 | Stormwater drainage works | Gutters and pipes | $ 20,000 | No. | 1 | $ 20,000 | 1 | $ 20,000 | 1 | $ 20,000 | 1 | $ 20,000 | *Based on Small Tassie Plant Tenders* |
| 1.3 | New gravel road | New compacted hardstand to WTP site and around CWS | $ 225 | linear m | 200 | $ 45,000 | 200 | $ 45,000 | 200 | $ 45,000 | 200 | $ 45,000 | *Brogo estimate at $48/sqm for all weather combacted gravel road* |
| 1.4 | Footpaths | 1 m wide footpath around 3 sides of 18 x 14 WTP building | $ 150 | per sq m | 50 | $ 7,500 | 50 | $ 7,500 | 50 | $ 7,500 | 50 | $ 7,500 | |
| 1.5 | Chemical Delivery bund | 18 m x 4 m delivery bund | $ 40,000 | No. | 1 | $ 40,000 | 1 | $ 40,000 | 1 | $ 40,000 | 1 | $ 40,000 | *Based on small Tassie Plant Tenders* |
| 1.6 | Sludge drying beds | 2 No. clay-lined sludge drying beds, total area of 31 m x 20 m | $ 60,000 | No. | 1 | $ 60,000 | 1 | $ 60,000 | 1 | $ 60,000 | 1 | $ 60,000 | *Based on Numerka WTP (2014)* |
| 1.7 | Overflow dam | Base area of dam 5 m x 15 m | $ 5,000 | No. | 1 | $ 5,000 | 1 | $ 5,000 | 1 | $ 5,000 | 1 | $ 5,000 | |
| 1.8 | New site security fence and access | | $ 200 | linear m | 260 | $ 52,000 | 260 | $ 52,000 | 260 | $ 52,000 | 260 | $ 52,000 | *Brogo cost estimate for chain mesh fence and gates (2020)* |
| **2.0** | **External Pipelines** | | | ***Subtotal*** | | **$ 89,350** | | **$ 89,350** | | **$ 89,350** | | **$ 89,350** | |
| 2.1 | Sludge pipeline | Sludge pipeline from thickener to geobags, DN 75 | $ 230 | linear m | 10 | $ 2,300 | 10 | $ 2,300 | 10 | $ 2,300 | 10 | $ 2,300 | *Based on Brogo cost estimates (2020) and small Tassie Plant tenders* |
| 2.2 | Connection from existing raw water tank outlet to new WFP | DN 150 | $ 300 | linear m | 45 | $ 13,500 | 45 | $ 13,500 | 45 | $ 13,500 | 45 | $ 13,500 | *since short distance, higher rate /m* |
| 2.3 | Treated Water connection to new treated water tank RC reservoir | DN 150 | $ 300 | linear m | 35 | $ 10,500 | 35 | $ 10,500 | 35 | $ 10,500 | 35 | $ 10,500 | *since very short distance, $/m escalated by x3.0* |
| 2.4 | Extra valves | 3 No. DN 150 valves | $ 3,000 | No. | 3 | $ 9,000 | 3 | $ 9,000 | 3 | $ 9,000 | 3 | $ 9,000 | |
| 2.5 | Wash water to thickener pipeline | DN 75 Between supernatant tank, pump station and raw water inlet | $ 230 | linear m | 5 | $ 1,150 | 5 | $ 1,150 | 5 | $ 1,150 | 5 | $ 1,150 | |
| 2.6 | Supernatant return pipeline | Between wash water pump station and raw water main DN 75 | $ 190 | linear m | 60 | $ 11,400 | 60 | $ 11,400 | 60 | $ 11,400 | 60 | $ 11,400 | *Based on Brogo cost esitmates (2020) and Liverpool (2016)* |
| 2.7 | Overflow pipeline from new treated water storage to overflow dam | DN 150 | $ 300 | linear m | 65 | $ 19,500 | 65 | $ 19,500 | 65 | $ 19,500 | 65 | $ 19,500 | |
| 2.8 | Overflow pipeline from WTP to washwater tank | DN 150 | $ 600 | linear m | 10 | $ 6,000 | 10 | $ 6,000 | 10 | $ 6,000 | 10 | $ 6,000 | |
| 2.9 | Overflow pipeline from washwater tank to overflow dam | DN 150 includes pit at overflow dam | $ 600 | linear m | 10 | $ 6,000 | 10 | $ 6,000 | 10 | $ 6,000 | 10 | $ 6,000 | |
| 2.10 | Isolation valve on existing raw water balance tank outlet | DN 150 Isolation of raw water balance tank outlet pipeline for the RC reservoir, includes pit | $ 5,000 | No. | 1 | $ 5,000 | 1 | $ 5,000 | 1 | $ 5,000 | 1 | $ 5,000 | |
| 2.11 | Stormwater discharge pipeline | DN100 from building to overflow dam | $ 5,000 | No. | 1 | $ 5,000 | 1 | $ 5,000 | 1 | $ 5,000 | 1 | $ 5,000 | |
| **3.0** | **Process Equipment, Tanks and associated pipework in building** | | | ***Subtotal*** | | **$ 763,500** | | **$ 747,500** | | **$ 639,100** | | **$ 659,000** | |
| 3.1 | Lamella plate clarifier | Sized for 0.5 ML/d | $ 230,000 | No. | 0 | $ - | 1 | $ 230,000 | 1 | $ 230,000 | 0 | $ - | *Based on crescent head and Casterton lamella plate clarifiers and tassie plant tenders* |
| 3.2 | DAF tank and recycle system | Sized for 0.5 ML/d | $ 240,000 | No. | 1 | $ 240,000 | 0 | $ - | 0 | $ - | 1 | $ 240,000 | *Based on Lancefield, Mirani, Myrniong, Alexandria, Apollo Bay (2013)* |
| 3.3 | MF/UF and associated equipment/tanks | MF/UF process - feed pumps, pipework, membrane and housing, local controls | $ 250,000 | No. | 1 | $ 250,000 | 1 | $ 250,000 | 0 | $ - | 0 | $ - | *Based on Crescent Head and small tassie plant tenders, Mole Creek (2015), Rosebury (2014), Apollo Bay (2013)* |
| 3.4 | Access walkways to main clarifier/filter systems | Applies to Option 1 and Option 2 | $ 17,000 | No. | 1 | $ 17,000 | 1 | $ 17,000 | 1 | $ 17,000 | 1 | $ 17,000 | *Based on Balmoral (2006), and Mole Creek (2015) and Lady Baron (2014)* |
| 3.5 | Air scour blower for MF/UF and gravity filters | Applies to Option 1 and Option 2 | $ 25,000 | No. | 1 | $ 25,000 | 1 | $ 25,000 | 1 | $ 25,000 | 1 | $ 25,000 | *Rosebury* |
| 3.6 | Gravity Filters | Sized for 0.5 ML/d | $ 140,000 | No. | 0 | $ - | 0 | $ - | 1 | $ 140,000 | 1 | $ 140,000 | *Based on small tassie plant tender (Lady Baron, 2014) and GAC filters Ringarooma (2014) & Balmoral (2006)* |
| 3.7 | UV | 0.5 ML/d | $ 100,000 | No. | 1 | $ 100,000 | 1 | $ 100,000 | 1 | $ 100,000 | 1 | $ 100,000 | *Bridgewater, Lanacoorie, Heathcote* |
| 3.8 | Analysers & sampling system | Raw pH ($15k)<br>Settled turbidity ($10k)<br>Filtered turbidity ($10k, N/A)<br>Final treated water turbidity, pH, & total chlorine ($30k) | $ 65,000 | No. | 1 | $ 65,000 | 1 | $ 65,000 | 1 | $ 65,000 | 1 | $ 65,000 | *GHD estimate & Heathcote tender, Cohuna* |
| 3.9 | Flow meters | Raw water flowmeter DN 150 ($5k)<br>Post raw water balance tank flowmeter DN 150 ($5k)<br>Washwater return flowmeter DN 75 ($3k)<br>Filtered water flowmeter DN 150 ($5k)<br>Treated water flowmeter DN 200 ($10k) | $ 28,000 | No | 1 | $ 28,000 | 1 | $ 28,000 | 1 | $ 28,000 | 1 | $ 28,000 | *Based on Brogo cost estimate (2020) $4k/flowmeter ~DN 150, Cohuna $10k DN 200* |
| 3.10 | Backwash flowmeter from CWS | DN 200 | $ 4,000 | No | 0 | $ - | 0 | $ - | 1 | $ 4,000 | 1 | $ 4,000 | *Based on Miranie tender (2006) and Forsyth tender (2018)* |
| 3.11 | Level control on filtered water tank | | $ 1,500 | No | 0 | $ - | 0 | $ - | 1 | $ 1,500 | 1 | $ 1,500 | *Based on Apollo Bay (2013)* |
| 3.12 | Level control on raw water balance tank | | $ 1,500 | No | 1 | $ 1,500 | 1 | $ 1,500 | 1 | $ 1,500 | 1 | $ 1,500 | *Based on Apollo Bay (2013)* |
| 3.13 | Service Water system | New service water systems | $ 7,000 | No. | 1 | $ 7,000 | 1 | $ 7,000 | 1 | $ 7,000 | 1 | $ 7,000 | |
| 3.14 | Compressed air system | New compressor and pipework and controls from plant for service water. | $ 30,000 | No. | 1 | $ 30,000 | 0.8 | $ 24,000 | 0.67 | $ 20,100 | 1 | $ 30,000 | *Based on Romsey and small tassie plant tenders* |
| **4.0** | **Building** | | | ***Subtotal*** | | **$ 504,000** | | **$ 504,000** | | **$ 504,000** | | **$ 504,000** | |
| 4.1 | WTP Building | ColourBond; covers all of main WTP process units, chemical storage, control room and electrics | $ 2,000 | per sq m | 252 | $ 504,000 | 252 | $ 504,000 | 252 | $ 504,000 | 252 | $ 504,000 | *Based on Balmoral, Lancefield and Myrniong tenders and small tassie plant tenders* |
| **5.0** | **Electrical and Control (E&C)** | | | ***Subtotal*** | | **$ 625,000** | | **$ 625,000** | | **$ 585,000** | | **$ 585,000** | |
| 5.1 | WTP Electrical, instrumentation and control (EI&C) (15%) | Allow 15% of total cost, excluding all items for Raw Wtaer pump station as the EIC for this is considered separately (below) | | % | 0.6 | $ 600,000 | 0.6 | $ 600,000 | 0.57 | $ 570,000 | 0.57 | $ 570,000 | *Around 15% of contract value based Laanacoorie, BridgewaterCrescent Heathcote, and Tassie plants* |
| 5.2 | New power supply to site | Require 25-50 kVa transformer | $ 25,000.00 | No. | 1 | $ 25,000 | 1 | $ 25,000 | 0.6 | $ 15,000 | 0.6 | $ 15,000 | *Estimate significant uncertainty* |
| **6.0** | **Chemical Systems** | | | ***Subtotal*** | | **$ 235,000** | | **$ 235,000** | | **$ 220,000** | | **$ 220,000** | |
| 6.1 | Coagulant | New Alum dosing system and bulk storage | $ 40,000 | No. | 1 | $ 40,000 | 1 | $ 40,000 | 1 | $ 40,000 | 1 | $ 40,000 | *Based on Crescent Head, Casterton, and Tassie (small plants)* |
| 6.2 | Polymer | Liquid Poly in bulk storage in separate bund | $ 30,000 | No. | 1 | $ 30,000 | 1 | $ 30,000 | 1 | $ 30,000 | 1 | $ 30,000 | *Based on Charters Towers & Balmoral (2006)* |
| 6.3 | Caustic soda | | $ 45,000 | No. | 0 | $ - | 0 | $ - | 0 | $ - | 0 | $ - | *Based on Tassie (small plants)* |
| 6.4 | Soda Ash | 25 kg bag automated batching system. Including batching and dosing system & pumps | $ 55,000 | No. | 1 | $ 55,000 | 1 | $ 55,000 | 1 | $ 55,000 | 1 | $ 55,000 | *Based on Crescent Head* |
| 6.5 | Chlorine gas | New D/S Gas chlorinator with 2x 72kg cylinders | $ 95,000 | No. | 1 | $ 95,000 | 1 | $ 95,000 | 1 | $ 95,000 | 1 | $ 95,000 | *Based on Crescent Head* |
| 6.6 | PAC dosing system | Needed if taste and odour problems occur in supply | $ 40,000 | No. | 0 | $ - | 0 | $ - | 0 | $ - | 0 | $ - | |
| 6.7 | CIP systems for MF/UF | Includes pipework and CIP preparation tanks, controls, dosing system, bunds | $ 15,000 | No. | 1 | $ 15,000 | 1 | $ 15,000 | 0 | $ - | 0 | $ - | *Based on Tassie (small plants)* |
| 6.8 | Future Potassium Permanagate dosing and storage | | $ 40,000 | No. | 0 | $ - | 0 | $ - | 0 | $ - | 0 | $ - | *Cresent Head and small tassie plants* |
| 6.10 | Future ammonia dosing and storage | | $ 30,000 | No. | 0 | $ - | 0 | $ - | 0 | $ - | 0 | $ - | |
| 6.11 | Future Trim gas chlorination | | $ 25,000 | No. | 0 | $ - | 0 | $ - | 0 | $ - | 0 | $ - | |
| **7.0** | **Pumps and pipework** | | | ***Subtotal*** | | **$ 147,000** | | **$ 147,000** | | **$ 140,000** | | **$ 140,000** | |
| 7.1 | New raw water pumps | 18.5kW pumps, replace both raw water pumps with a like for like replacement, Mech pumps $25k + $10k EI&C | $ 35,000 | No. | 1 | $ 35,000 | 1 | $ 35,000 | 1 | $ 35,000 | 1 | $ 35,000 | *Cresent Head, small tassie plants (2014)* |
| 7.1 | Raw water balance tank pumps | 7L/s Flow controled pumps at outlet of raw water balance tank. Includes VSD control | $ 20,000 | No. | 1 | $ 20,000 | 1 | $ 20,000 | 1 | $ 20,000 | 1 | $ 20,000 | *Based on Mole Creek (2015)* |
| 7.2 | Filtered water tank relift pumps to CWS | 7L/s Outlet of filtered water tank via level control, includes VSD control | $ 20,000 | No. | 0 | $ - | 0 | $ - | 1 | $ 20,000 | 1 | $ 20,000 | |
| 7.3 | MF/UF balance tank pumps | 7L/s Inlcudes VSD control | $ 22,000 | No. | 1 | $ 22,000 | 1 | $ 22,000 | 0 | $ - | 0 | $ - | |
| 7.4 | Self cleaning strainers | Duty/standby | $ 30,000 | No. | 1 | $ 30,000 | 1 | $ 30,000 | 0 | $ - | 0 | $ - | *Based on Mole Creek (2015)* |
| 7.5 | Backwash pumps from CWS | 35L/s from CWS, includes VSD control | $ 25,000 | No. | 0 | $ - | 0 | $ - | 1 | $ 25,000 | 1 | $ 25,000 | *Based on Balmoral (2006)* |
| 7.6 | Washwater pumps to thickener | 1 L/s | $ 15,000 | No. | 1 | $ 15,000 | 1 | $ 15,000 | 1 | $ 15,000 | 1 | $ 15,000 | |
| 7.7 | Supernatant return pumps (from supernatant tank) | 2 L/s includes VSD control | $ 25,000 | No. | 1 | $ 25,000 | 1 | $ 25,000 | 1 | $ 25,000 | 1 | $ 25,000 | *Based on Mole Creek (2015), Heathcote ($32-36k), Brogo (2020)* |
| **8.0** | **Other Tanks** | | | ***Subtotal*** | | **$ 776,000** | | **$ 776,000** | | **$ 768,000** | | **$ 768,000** | |
| 8.2 | MF/UF feed pump balance tank | Between clarifier / daf and MF/UF - 10 kL, includes connecting pipework. Pumps on VSD | $ 15,000 | No. | 1 | $ 15,000 | 1 | $ 15,000 | 0 | $ - | 0 | $ - | *Based on Tassie (small plants)* |
| 8.3 | CIP waste tank for MF/UF | 5kL Tank has connection for pump out by contractor to waste tank on truck. | $ 8,000 | No. | 1 | $ 8,000 | 1 | $ 8,000 | 0 | $ - | 0 | $ - | *Based on Tassie (small plants)* |
| 8.4 | Filtered Water relift pump station tank | 10 kL tank | $ 15,000 | No. | 0 | $ - | 0 | $ - | 1 | $ 15,000 | 1 | $ 15,000 | *Based on small Tassie plant tender (Mole Creek (2015) ) & Balmoral (2006)* |
| 8.5 | Washwater tank | 20 kL tank, includes $8k for mixer | $ 28,000 | No. | 1 | $ 28,000 | 1 | $ 28,000 | 1 | $ 28,000 | 1 | $ 28,000 | *Based on Crescent Head and Rosebury and Heathcote ($67-85k)* |
| 8.6 | Supernatant tank | 5kL tank | $ 15,000 | No. | 1 | $ 15,000 | 1 | $ 15,000 | 1 | $ 15,000 | 1 | $ 15,000 | *Based on Myrniong* |
| 8.7 | Thickener | 2L/s sludge from lamella plate clarifier/DAF, 2.5 m diameter | $ 45,000 | No. | 1 | $ 45,000 | 1 | $ 45,000 | 1 | $ 45,000 | 1 | $ 45,000 | *Based on Forsyth, and Heathcote (5.6L/s at $140-288k in 2016) & Balmoral (2006)* |
| 8.8 | New Treated Water Storage | 800 kL tank | $ 650,000 | No. | 1 | $ 650,000 | 1 | $ 650,000 | 1 | $ 650,000 | 1 | $ 650,000 | *Romsey (2002) & Numerka (2011)* |
| 8.9 | Chemical spill tank | 9kL (minimum) volume | $ 15,000 | No. | 1 | $ 15,000 | 1 | $ 15,000 | 1 | $ 15,000 | 1 | $ 15,000 | |
| **9.0** | **Other Requirements for BAU: upgrade Existing plant** | | | ***Subtotal*** | | **$ 7,000** | | **$ 7,000** | | **$ 7,000** | | **$ 7,000** | |
| 9.1 | New Safety shower | 2 No. new showers | $ 3,500 | No. | 2 | $ 7,000 | 2 | $ 7,000 | 2 | $ 7,000 | 2 | $ 7,000 | *based on Charters Towers* |
| **10.0** | **Commissiong & Proof of performance** | | | ***Subtotal*** | | **$ 165,000** | | **$ 165,000** | | **$ 210,000** | | **$ 210,000** | |
| 10.1 | | Allow 4% of total cost | $ 300,000 | No. | 0.55 | $ 165,000 | 0.55 | $ 165,000 | 0.7 | $ 210,000 | 0.7 | $ 210,000 | *~4% at Lancefield, Myrniong, Balmoral* |
| | ***Sub-total*** | | | | | **$ 4,196,000** | | **$ 4,180,000** | | **$ 4,022,000** | | **$ 4,042,000** | |
| | Remote location factor | (% based on subtotal) | 10% | | | $ 419,600 | | $ 418,000 | | $ 402,200 | | $ 404,200 | *Rawlinsons* |
| | Contingency | % based on subtotal & location factor) | 20% | | 1 | $923,120.00 | 1 | $919,600.00 | 1.0 | $884,840.00 | 1.0 | $889,240.00 | |
| | ***Sub-total (Indirect Job Costs)*** | | | | | **$ 1,350,000** | | **$ 1,340,000** | | **$ 1,290,000** | | **$ 1,300,000** | |
| | **TOTAL** | | | | | **$ 5,550,000** | | **$ 5,520,000** | | **$ 5,320,000** | | **$ 5,350,000** | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **11.0** | **Fluoride System** | | | ***Subtotal*** | | **$ 630,000** | | **$ 630,000** | | **$ 630,000** | | **$ 630,000** | |
| 11.1 | Fluoride | Sodium Fluoride saturator on load cell and day tank etc. $200k EI&C, $180k separate building at plant, $150k additional Prelim+ Comissioning $100k package SF system. | $ 630,000 | No. | 1 | $ 630,000 | 1 | $ 630,000 | 1 | $ 630,000 | 1 | $ 630,000 | *Cost based on Camperdown, Cahoona and independent estimates for Brogo.* |

Cost Estimates have been developed based on supplier budget quotes and a concept design for the purposes of comparing options . These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. It should be noted that at this level of design, the scope and quality of the works has not yet been fully identified and some items may not be included. Therefore the estimates are not warranted by GHD and the accuracy of the estimates is typically not expected to be better than about ± 40%.

# Operating Cost Estimates - Delegate WTP Options Assessment

## Base Assumptions

| | | | |
|---|---|---|---|
| Electricity Price | $ 0.23 | per kWhr | *From SW Rocks estimate* |
| Annual treated water production | 70.0 | ML/yr | *Based on treated Water demand - WTP flows in 2019, 0.5 ML/d* |
| Max flowrate | 7 | L/s | *7L/s for the Clarifier Filters or DAFF but 7.5L/s for the Clarifier+MF/UF* |

## Chemicals (as supplied)

| | Cost | | % concentration | | SG | |
|---|---|---|---|---|---|---|
| Coagulant (ACH) | $1.1 | per kg supplied | 24% | w/w as Al2O3 | 1.34 | *$1.37/L for Coliban Water at Bendigo (Megapac 23)* |
| Coagulant (Alum) | $0.45 | per kg as pure Alum | | | 1 | Dose as pure alum (which is 16% Al2O3) |
| pH adjustment (Caustic) | $1.2 | per kg pure caustic | | | 1 | |
| pH adjustment (Soda Ash) | $0.8 | per kg | | | 1 | |
| Pre Chlorine gas as 100% Cl2 | $4.5 | per kg | 100% | w/w (as pure cl2) | 1 | *Updated to gas with new cost* |
| Post Chlorine gas as 100% Cl2 | $4.5 | per kg | 200% | w/w (as pure cl2) | 1 | |
| Polymer - settled water | $8.0 | per kg | 100% | w/w (powder) | 1 | |
| CIP for MF/UF | $4,000 | per year | | | *UP CIP every month. Based on Romsey CIP and Upper Yarra CIP. Hypo, citirc acid, SMBM, Caustic Soda* | |

## UV replacement items

| | | | |
|---|---|---|---|
| UV lamps | $4,000 | per year | *2 lamps at $1000 each, twice a year* |
| UV Ballast | $200 | per year | *$500 * 2, replaced every 5 years* |
| UV sleeves | $200 | per year | *2 UV sleeves replaced every 5 years* |
| UV wiper | $200 | per year | *$750 each, replaced every 5 years* |
| UVI sensors | $1,100 | per year | *2 at $5400 each, replaced every 10 years* |

## Membrane Replacement

| | | | |
|---|---|---|---|
| UF Membrane cost | $2,500 | per element | *From TasWater plants - Laurie Curran tenders. Replace every 5 years* |
| UF Membrane elements | 20 | elements | *64 units at Ringarooma (20.8 L/s), $2100 per element, 5 year life, quote from 2015* |
| UF Membrane life | 8 | years | *According to tenders* |

| | | | |
|---|---|---|---|
| Annual treated water production | 70 | 70 | ML/year |
| Raw water for dosing | 74 | 74 | ML/yr |

## Operating cost estimate

### Chemical Doses (mg/L)

| | Option 1 DAF+MF/UF+UV | Option 2 Lamella Plate +MF/UF+UV | Option 3 Lamella Plate+Gravity Filters+UV | Option 4 DAF+Gravity Filters+UV | basis of dose | |
|---|---|---|---|---|---|---|
| Coagulant (Alum) | 0 | 0 | 25 | 25 | raw water | *as pure Alum* |
| ACH | 15 | 15 | 0 | 0 | raw water | |
| pre pH adjustment (caustic) | 0 | 0 | 0 | 0 | raw water | *Assumes no pre-oxidation required for most of the year* |
| pre pH adjustment (soda) | 0 | 0 | 0 | 0 | raw water | |
| Pre Chlorine gas as 100% Cl2 | 0 | 0 | 0 | 0 | raw water | *Assumes no pre-oxidation required for most of the year* |
| Post Chlorine gas as 100% Cl2 | 3 | 3 | 3 | 3 | treated | |
| Polymer - settled water | 0.05 | 0 | 0.05 | 0 | raw water | *polymer only for Clarifier* |
| post pH adjustment (caustic soda) | 17 | 17 | 23 | 23 | treated | |
| Polymer dose to washwater | 0.1 | 0.1 | 0.1 | 0.1 | raw water | dose for 5% of raw water (options 1-3) and 20% of raw water for option 4 |

### Variable Costs ($/yr)

**Chemicals ($/year)**

| | Option 1 | Option 2 | Option 3 | Option 4 | | |
|---|---|---|---|---|---|---|
| Coagulant (Alum) | $ - | $ - | $ 827 | $ 827 | raw water | |
| ACH | $ 1,181 | $ 1,181 | | | raw water | |
| pre pH adjustment (caustic) | | | | | raw water | |
| pre pH adjustment (soda) | $ - | $ - | $ - | $ - | raw water | |
| Pre Chlorine gas as 100% Cl2 | | | | | raw water | |
| Post Chlorine gas as 100% Cl2 | $ 945 | $ 945 | $ 945 | $ 945 | treated | |
| Polymer - settled water | $ 29 | $ - | $ 29 | $ - | raw water | |
| post pH adjustment (caustic soda) | $ 952 | $ 952 | $ 1,288 | $ 1,288 | treated | |
| Polymer dose to washwater | $ 2 | $ 2 | $ 2 | $ 2 | | dose for 5% of raw water |
| CIP for MF/UF | $ 1,000 | $ 1,000 | | | | |
| Sludge Removal | $ 2,000 | $ 2,000 | $ 2,000 | $ 2,000 | | *Each geobag sutable for 1.2 m3 of sludge $150/bag + removal costs twice a year at $500/removeal* |
| **TOTAL CHEMICALS** | **$6,110** | **$6,080** | **$5,091** | **$5,062** | | |

**Energy ($/year)**

| | | | | | |
|---|---|---|---|---|---|
| **TOTAL ENERGY** | **$13,144** | **$11,206** | **$9,923** | **$11,862** | *See calculations below* |

| | | | | |
|---|---|---|---|---|
| Total Variable Costs ($/yr) | $ 19,254 | $ 17,286 | $ 15,015 | $ 16,924 |
| Total Variable Costs ($ / ML) | $ 275 | $ 247 | $ 214 | $ 242 |

### Fixed Costs ($/yr)

| | Option 1 DAF+MF/UF+UV | Option 2 Lamella Plate +MF/UF+UV | Option 3 Lamella Plate+Gravity Filters+UV | Option 4 DAF+Gravity Filters+UV | |
|---|---|---|---|---|---|
| Operations labour | $ 60,000 | $ 60,000 | $ 70,000 | $ 70,000 | *Assumed 3 hour/day x 5 days/week for MF/UF options, and 3.5 hours/day x 5 days/week for gravity filters at $80/hr. Based on other plants of similar size and complexity, the operations labour and associated transport and wq testing costs is set at $60,000/yr, based on Lockington, Pyamid Hill, Gornong and Letchvile (2014)* |
| Maintance (Labour & equipment) | $ 35,410 | $ 35,090 | $ 31,682 | $ 32,080 | *2% of M&E CAPEX cost - linked to CAPEX calculation page* |
| UV total | $ 5,700 | $ 5,700 | $ 5,700 | $ 5,700 | |
| UF Membrane replacement cost | $ 6,250 | $ 6,250 | | | *Annualised cost* |
| CIP waste removal for MF | $ 2,000 | $ 2,000 | | | *2 x 10kL removals by truck each year, 0.2 kL per ML, 20kL waste removeal, $500/waste removal. Tyers WTP AQM estimate* |
| Total Fixed Costs ($/yr) | $ 109,360 | $ 109,040 | $ 107,382 | $ 107,780 | |

### Totals

| | | | | | |
|---|---|---|---|---|---|
| Total Operating Costs | $ 129,000 | $ 126,000 | $ 122,000 | $ 125,000 | |
| Contingency (10%) | $ 12,900 | $ 12,600 | $ 12,200 | $ 12,500 | 10 % contingency |
| **TOTAL OPEX ($/year)** | **$ 141,900** | **$ 138,600** | **$ 134,200** | **$ 137,500** | |
| **TOTAL OPEX ($/year)** | **$ 142,000** | **$ 139,000** | **$ 134,000** | **$ 138,000** | |

### Electricity estimates

| Type of operation | Power (kW) | Hours per day | Option 1: DAF +MF/UF+UV | kWh/day | Option 2: Lamella Plate+MF/UF+UV | kWh/day | Option 3; Lamella Plate +Gravity Filters+UV | kWh/day | Option 4; DAF +Gravity Filters+UV | kWh/day |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw water pumps | 7.5 | 20 | 1 | 150.0 | 1 | 150.0 | 1 | 150 | 1 | 150 |
| Raw Water feed pump to lamella plate or DAF | 0.75 | 22 | 1 | 16.5 | 1 | 16.5 | 1 | 16.5 | 1 | 16.5 |
| Flash mixer | 0.25 | 22 | 1 | 5.5 | 1 | 5.5 | 1 | 5.5 | 1 | 5.5 |
| Flocc mixers | 0.15 | 24 | 1 | 3.6 | 1 | 3.6 | 1 | 3.6 | 1 | 3.6 |
| DAF & sludge roller | 1.6 | 22 | 1 | 35.2 | 0 | 0.0 | 0 | 0 | 1 | 35.2 |
| Air compressors - Clarifier | 2.5 | 8 | 0 | 0.0 | 1 | 20.0 | 1 | 20 | 0 | 0 |
| Air compressors - DAF | 3 | 15 | 1 | 45.0 | 0 | 0.0 | 0 | 0 | 1 | 45 |
| MF/UF feed pump | 3.2 | 22 | 1 | 70.4 | 1 | 70.4 | 0 | 0 | 0 | 0 |
| Air Scour Blower for MF/UF | 2.2 | 1.5 | 1 | 3.3 | 1 | 3.3 | 0 | 0 | 0 | 0 |
| Air Scour Blower for Gravity Filters | 2.2 | 0.15 | 0 | 0.0 | 0 | 0.0 | 1 | 0.33 | 1 | 0.33 |
| Filtered water pump | 1.5 | 22 | 0 | 0.0 | 0 | 0.0 | 1 | 33 | 1 | 33 |
| Backwash pump for Gravity Filters | 5.5 | 0.1 | 0 | 0.0 | 0 | 0.0 | 1 | 0.55 | 1 | 0.55 |
| UV | 0.5 | 22 | 1 | 11.0 | 1 | 11.0 | 1 | 11 | 1 | 11 |
| Supernatant return pumps | 1.3 | 22 | 1 | 28.6 | 1 | 28.6 | 1 | 28.6 | 1 | 28.6 |
| Washwater tank mixer | 0.25 | 22 | 1 | 5.5 | 1 | 5.5 | 1 | 5.5 | 1 | 5.5 |
| Washwater pump to thickener | 1.3 | 12 | 1 | 15.6 | 1 | 15.6 | 1 | 15.6 | 1 | 15.6 |
| Miscellaneous (WTP) | 1.5 | 12 | 1 | 18.0 | 1 | 18.0 | 1 | 18 | 1 | 18 |
| | | | | 408.2 kWh/day | | 348.0 kWh/day | | 308.2 kWh/day | | 368.4 kWh/day |
| | | | | 816 kWh/ML treated wat | | 696 kWh/ML treated water | | 616 kWh/ML trea | | 737 kWh/ML treated water |
| | | | | 13144 $/year | | 11206 $/year | | 9923 $/year | | 11862 $/year |

| Growth rate | Discount rate |
|---|---|
| 0% | 6% |

| Year | 0 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Annual treated water demand (ML) | | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |

| Year | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| Annual treated water demand (ML) | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |

## Option 1 DAF+MF/UF+UV

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAPEX | $ 5,550,000 | | | | | | | | | | | | |
| OPEX | | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 |
| Cash flow | $ 5,550,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 |
| **Cash flow NPV** | | $ 133,962 | $ 126,379 | $ 119,226 | $ 112,477 | $ 106,111 | $ 100,104 | $ 94,438 | $ 89,093 | $ 84,050 | $ 79,292 | $ 74,804 | $ 70,570 |
| **Cumulative Cash flow NPV** | **$ 5,550,000** | $ 5,683,962 | $ 5,810,342 | $ 5,929,568 | $ 6,042,045 | $ 6,148,156 | $ 6,248,260 | $ 6,342,698 | $ 6,431,791 | $ 6,515,840 | $ 6,595,132 | $ 6,669,936 | $ 6,740,506 |

| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OPEX | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 |
| Cash flow | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 | $ 142,000 |
| **Cash flow NPV** | $ 66,575 | $ 62,807 | $ 59,252 | $ 55,898 | $ 52,734 | $ 49,749 | $ 46,933 | $ 44,276 | $ 41,770 | $ 39,406 | $ 37,175 | $ 35,071 | $ 33,086 |
| **Cumulative Cash flow NPV** | $ 6,807,081 | $ 6,869,888 | $ 6,929,139 | $ 6,985,037 | $ 7,037,771 | $ 7,087,520 | $ 7,134,453 | $ 7,178,729 | $ 7,220,499 | $ 7,259,905 | $ 7,297,080 | $ 7,332,151 | $ 7,365,237 |

| | | | |
|---|---|---|---|
| CAPEX | $ | 5,550,000 | |
| OPEX | $ | 142,000 | per year |
| **NPC (25 years)** | **$** | **7,365,000** | |

## Option 2 Lamella Plate+MF/UF+UV

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAPEX | $ 5,520,000 | | | | | | | | | | | | |
| OPEX | | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 |
| Cash flow | $ 5,520,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 |
| **Cash flow NPV** | | $ 131,132 | $ 123,710 | $ 116,707 | $ 110,101 | $ 103,869 | $ 97,990 | $ 92,443 | $ 87,210 | $ 82,274 | $ 77,617 | $ 73,223 | $ 69,079 |
| **Cumulative Cash flow NPV** | **$ 5,520,000** | $ 5,651,132 | $ 5,774,842 | $ 5,891,549 | $ 6,001,650 | $ 6,105,519 | $ 6,203,508 | $ 6,295,951 | $ 6,383,161 | $ 6,465,435 | $ 6,543,052 | $ 6,616,276 | $ 6,685,354 |

| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OPEX | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 |
| Cash flow | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 | $ 139,000 |
| **Cash flow NPV** | $ 65,169 | $ 61,480 | $ 58,000 | $ 54,717 | $ 51,620 | $ 48,698 | $ 45,941 | $ 43,341 | $ 40,888 | $ 38,573 | $ 36,390 | $ 34,330 | $ 32,387 |
| **Cumulative Cash flow NPV** | $ 6,750,523 | $ 6,812,003 | $ 6,870,003 | $ 6,924,719 | $ 6,976,339 | $ 7,025,037 | $ 7,070,978 | $ 7,114,319 | $ 7,155,207 | $ 7,193,780 | $ 7,230,170 | $ 7,264,500 | $ 7,296,887 |

| | | | |
|---|---|---|---|
| CAPEX | $ | 5,520,000 | |
| OPEX - fixed | $ | 139,000 | per year |
| **NPC (25 years)** | **$** | **7,295,000** | |

## Option 3 Lamella Plate+Gravity Filters+UV

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAPEX | $ 5,320,000 | | | | | | | | | | | | |
| OPEX | | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 |
| Cash flow | $ 5,320,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 |
| **Cash flow NPV** | | $ 126,415 | $ 119,260 | $ 112,509 | $ 106,141 | $ 100,133 | $ 94,465 | $ 89,118 | $ 84,073 | $ 79,314 | $ 74,825 | $ 70,590 | $ 66,594 |
| **Cumulative Cash flow NPV** | **$ 5,320,000** | $ 5,446,415 | $ 5,565,675 | $ 5,678,184 | $ 5,784,324 | $ 5,884,457 | $ 5,978,921 | $ 6,068,039 | $ 6,152,112 | $ 6,231,427 | $ 6,306,252 | $ 6,376,841 | $ 6,443,435 |

| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OPEX | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 |
| Cash flow | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 | $ 134,000 |
| **Cash flow NPV** | $ 62,824 | $ 59,268 | $ 55,914 | $ 52,749 | $ 49,763 | $ 46,946 | $ 44,289 | $ 41,782 | $ 39,417 | $ 37,186 | $ 35,081 | $ 33,095 | $ 31,222 |
| **Cumulative Cash flow NPV** | $ 6,506,260 | $ 6,565,528 | $ 6,621,441 | $ 6,674,190 | $ 6,723,953 | $ 6,770,899 | $ 6,815,188 | $ 6,856,969 | $ 6,896,386 | $ 6,933,572 | $ 6,968,653 | $ 7,001,748 | $ 7,032,970 |

| | | | |
|---|---|---|---|
| CAPEX | $ | 5,320,000 | |
| OPEX - fixed | $ | 134,000 | per year |
| **NPC (25 years)** | **$** | **7,035,000** | |

## Option 4 DAF+Gravity Filters+UV

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAPEX | $ 5,350,000 | | | | | | | | | | | | |
| OPEX | | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 |
| Cash flow | $ 5,350,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 |
| **Cash flow NPV** | | $ 130,189 | $ 122,820 | $ 115,867 | $ 109,309 | $ 103,122 | $ 97,285 | $ 91,778 | $ 86,583 | $ 81,682 | $ 77,058 | $ 72,697 | $ 68,582 |
| **Cumulative Cash flow NPV** | **$ 5,350,000** | $ 5,480,189 | $ 5,603,008 | $ 5,718,876 | $ 5,828,185 | $ 5,931,306 | $ 6,028,591 | $ 6,120,369 | $ 6,206,952 | $ 6,288,634 | $ 6,365,692 | $ 6,438,389 | $ 6,506,970 |

| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OPEX | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 |
| Cash flow | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 | $ 138,000 |
| **Cash flow NPV** | $ 64,700 | $ 61,038 | $ 57,583 | $ 54,323 | $ 51,248 | $ 48,347 | $ 45,611 | $ 43,029 | $ 40,593 | $ 38,296 | $ 36,128 | $ 34,083 | $ 32,154 |
| **Cumulative Cash flow NPV** | $ 6,571,670 | $ 6,632,708 | $ 6,690,290 | $ 6,744,614 | $ 6,795,862 | $ 6,844,209 | $ 6,889,820 | $ 6,932,849 | $ 6,973,443 | $ 7,011,738 | $ 7,047,866 | $ 7,081,949 | $ 7,114,103 |

| | | | |
|---|---|---|---|
| CAPEX | $ | 5,350,000 | |
| OPEX - fixed | $ | 138,000 | per year |
| **NPC (25 years)** | **$** | **7,115,000** | |

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