Seaview Wastewater Treatment Plant - Waiwhetu Discharge Nitrogen Treatment

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Rev. No.	Date	Description	Prepared By	Checked By	Reviewed By	Approved By
0	4/11/2016	Draft for Client	Michael Tan	CM	CM	AB
1	12/1/2016	Added context to other options	Caroline van Halderen	CM	CM	AB

1 Introduction

MWH has been working closely with Wellington Water and the Hutt City Council investigating the options for discharge of temporary flows to different outfall locations for the Seaview Wastewater Treatment Plant (WWTP).

This report looks to determine a high-level cost estimate associated with upgrading the treatment process at the Seaview WWTP to treat and remove ammonia from the treated wastewater that causes negative environmental and toxicity effects within freshwater and coastal-marine environments. Ammonia removal is being considered to mitigate environmental impacts on receiving waters caused by planned pipe maintenance or emergency repairs.

This short report will discuss:

- Assumption and limitations for the investigation.
- Discussion on the upgrade to achieve nitrogen removal.
- An analysis of the price involved with the upgrade.
- Impacts on the treated discharge.
- Conclusions.

1.1 Information Sources

Information from the following reports/sources has been used:

- Seaview WWTP Temporary Outfall Options: A preliminary assessment of effects on the aquatic ecology of Waiwhetu Stream, Hutt Estuary & Wellington Harbour (MWH, June 2016).
- Ammonia reduction options for Main Outfall Pipeline AEE (MWH, October 2011).
- Seaview WWTP Bypass and Overflows (Wellington Water, 2016).
- Seaview WWTP BioWin Model package (Beca 2015).
- Influent Flow and Load data provided by Seaview WWTP Operations Staff (2016).

2 Assumptions and Limitations

The scope of this report is limited to investigating the addition of a Moving Bed Bioreactor (MBBR) process to nitrify ammonia in the treated wastewater from the WWTP.

During the site visit it was discussed that, during periods where the sludge age in the contact stabilisation process has increased (sometimes causing nitrification) the biomass in the tanks has become susceptible to poor settling and filamentous bacteria. This has resulted in settleability issues in the clarifier. By adding the MBBR to nitrify the treated wastewater after the contact stabilisation and clarifiers (rather than a modification of the contact stabilisation process itself) there will be no disruption to the existing process.

There is an UV/vis spectrolyser provided by DCM Process Control Ltd. located on-site but this data was not available for use during this project.

2.1 Seaview WWTP Influent Characteristics

Daily values for flow, Biochemical Oxygen Demand (BOD) concentration and Total Suspended Solids (TSS) were supplied for the raw influent wastewater. Chemical Oxygen Demand (COD) and ammonia concentrations (at a frequency of 1-2 days per week typical) from the primary sedimentation tank treated effluent were also supplied[1]. Figures Figure 2-1, Figure 2-2, Figure 2-3, Figure 2-4, and Figure 2-5 show profiles for these values with the different colours indicating percentile distribution bands.

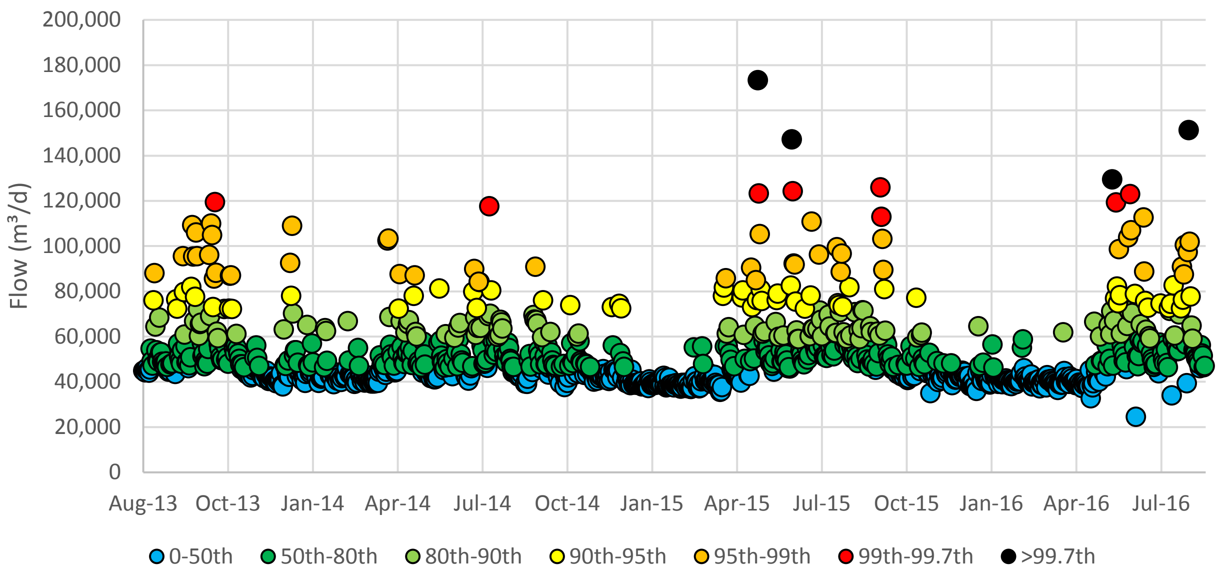

Figure 2-1 Influent Flow Profile with Percentiles

[1] Date range for this data was from 1/8/2013 through to 31/8/2016

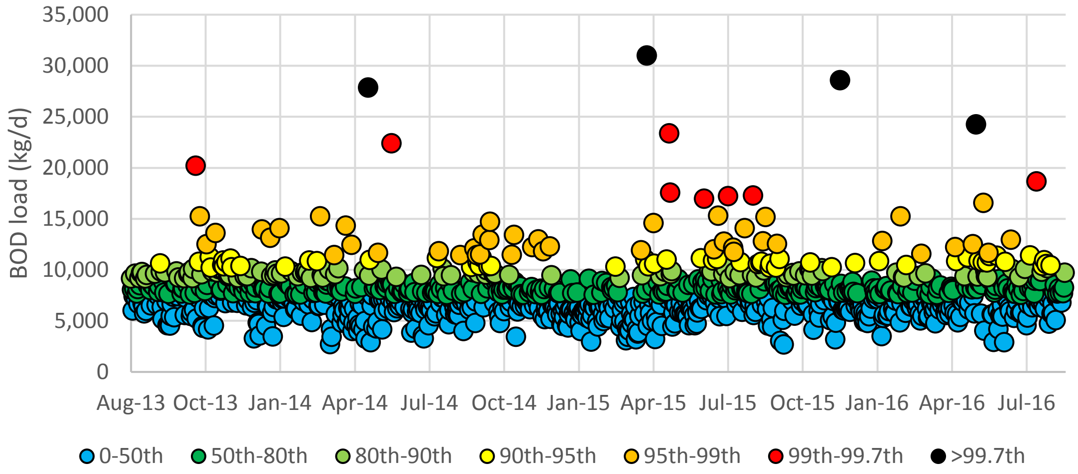

Figure 2-2 Influent BOD Load Profile with Percentiles

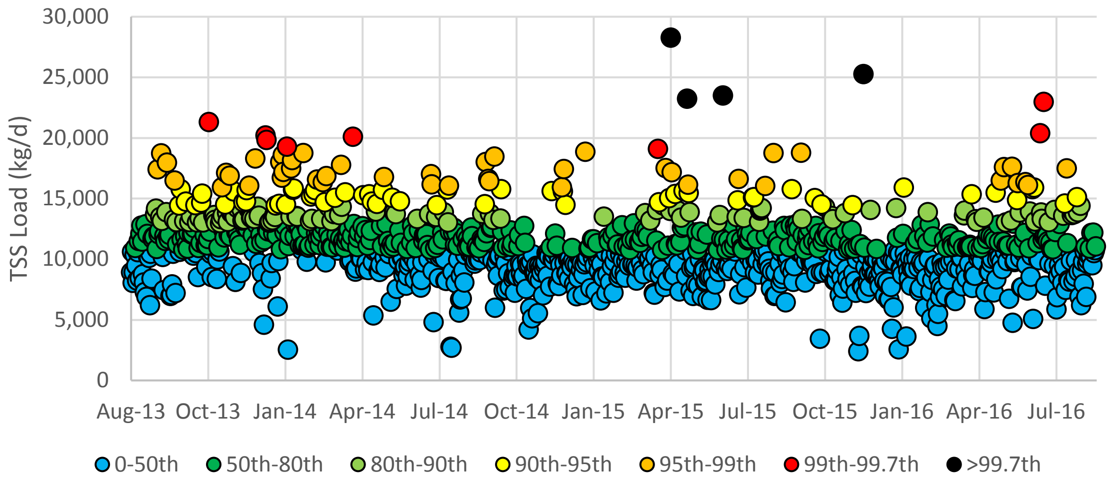

Figure 2-3 Influent TSS Load Profile with Percentiles

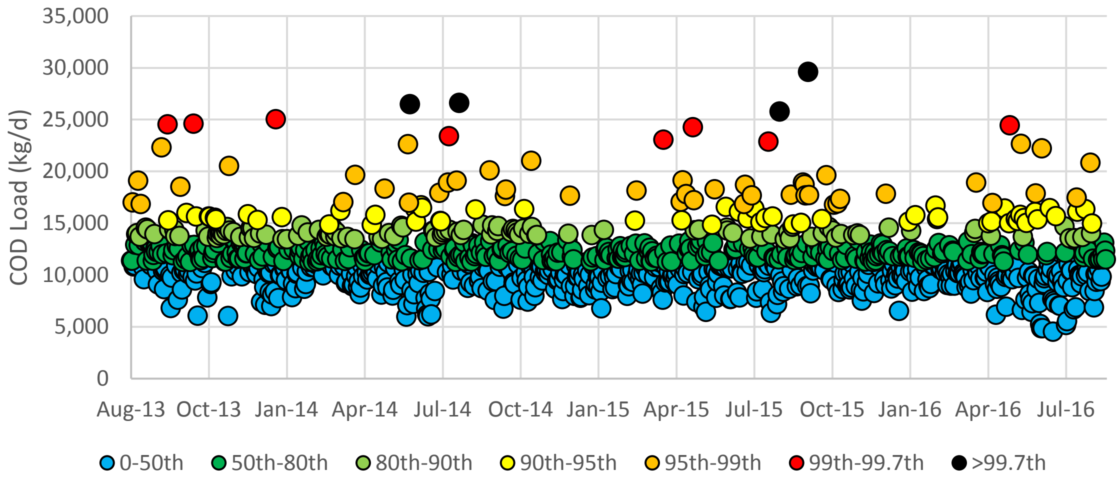

Figure 2-4 Primary Effluent COD Load Profile with Percentiles

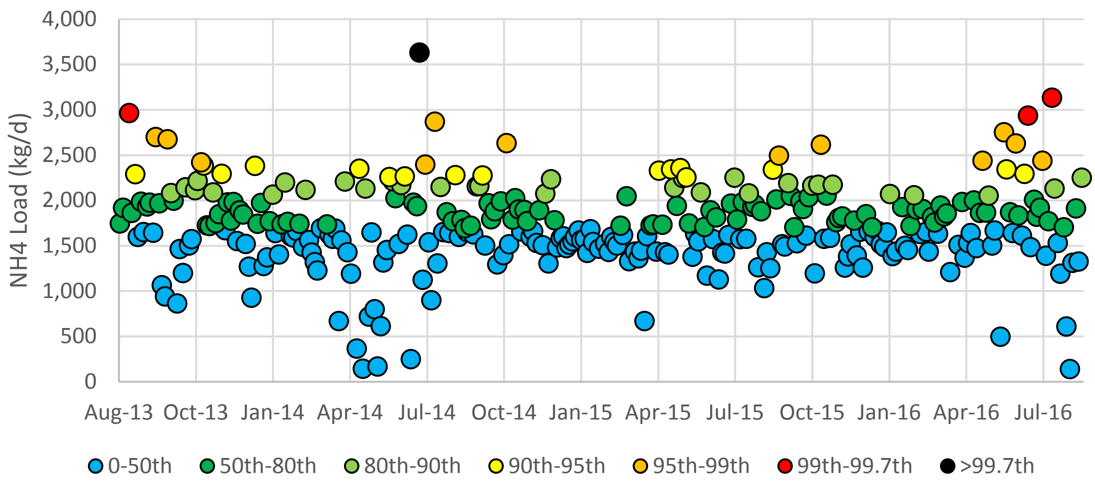

Figure 2-5 Primary Effluent Ammonia Load Profile with Percentiles

Table 2-1 summarises the loads calculated based on the above historical WWTP data. The Total Kjeldahl Nitrogen (TKN)[2] load is based on the assumption that the influent ammonia load is the same as the (measured) primary effluent ammonia load and a typical ammonia:TKN ratio of 0.66 mgNH4/mgTKN.

Table 2-1 Influent and Primary Effluent Wastewater Flow and Loads

Parameter	Units	Influent Median value	Influent 90th Percentile	Primary Effluent Median	Primary Effluent 90th Percentile
Flow	m^3/d	46,300	72,200		
BOD Load	kg/d	7,500	10,200		
COD Load	kg/d			11,300	14,900
TSS Load	kg/d	10,800	14,400		
NH4 Load	kg/d			1,700	2,300
TKN Load (Estimated)	kg/d	2,600	3,500		

2.1.1 Comparison with BioWin™ Model

BioWin™ models produced by Beca in 2015 were provided to MWH to simulate the existing WWTP. This model had flow and loads of:

- Flow 46,608 m^3/d
- BOD load 7,524 kgBOD/d
- TSS load 10,425 kgTSS/d
- TKN load 1,400 kgN/d.

Flow, BOD and TSS loads from the model all agree with sampling data. The model TKN load is significantly lower than that calculated based on the ammonia measured in the primary effluent. Compared to typical ratios for raw wastewater, the estimated 2,600 kgN/d load is high and the modelled 1,400 kgN/d is low. The Seaview WWTP catchment contains a number of industrial/commercial contributors some of whom use pre-treatment of their wastewater before it is released to the network and the WWTP, others that have high strength wastewaters that are significantly different from typical domestic wastewater. These tradewaste contributors could be the source of the atypical characteristics of the wastewater however no data on the nitrogen-based loadings is currently available.

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[2] TKN is the organic nitrogen and ammonia-based nitrogen.

Further sampling of the raw wastewater is needed to determine the TKN load to the process.

2.2 General Assumptions

The following is a list of general assumptions carried out during the course of this assessment:

- No hydraulic flow analysis has been carried out it has been assumed that flows through the clarifiers to the MBBR will require a new pumping stage this has been estimated at $4M.
- No allowance has been made to upgrade existing available power supply and space in switchboard area for additional equipment is available.
- No allowances have been made for additional/extensions to the blower building.
- Costs have been based on scaling from historic/recent quotes. Suppliers have not been approached for Seaview WWTP specific estimates. This includes an allowance of $2,500/m^3 of MBBR media.
- The influent has sufficient alkalinity to allow nitrification.
- Costs associated with temporary works and plant operation during the upgrade of approx. $300,000 have been included.
- A provisional sum for electrical upgrades (new transformer, cabling, switchboard extension) has been estimated at $500,000.

3 Effects on Discharge Environment

The location for discharge from the Seaview WWTP has been assumed to be the Option 2 location from the Waiwhetu Options Assessment report[3]. This location (Figure 3-1 Assumed new discharge location from Seaview WWTP) is at the end of the Waiwhetu Stream near where it joins the Hutt River. The area is exposed to both freshwater and saline environments and experiences conditions influenced by both.

Figure 3-1 Assumed new discharge location from Seaview WWTP

The Australia and New Zealand Conservation Council (ANZECC) has a limit for the maximum ammonia concentration at the discharge location (post-dilution with background) of 900 µgN/L[4] for freshwater and 910 µgN/L for marine environments based on a temperature of 20°C and a pH of 8 as shown in Figure 3-2. This is based on toxicity of ammonia in the environment, as both the temperature and pH decrease, the toxicity limit increases to a higher threshold. This is due to the speciation of ammonia, at lower pH and lower temperature there tends to be less un-ionised ammonia (NH_3) which is the more toxic form of ammonia for aquatic life-forms.

The Waiwhetu and Hutt Rivers were found to have the range of conditions shown in Table 3-1 Waiwhetu and Hutt River Temperature and pH This shows that, even though the median values for both temperature and pH are below 20°C and 8.0 respectively (allowing the threshold limit to be increased) conservatism requires that

[3] Option 2 at the Hutt River/Waiwhetu Stream confluence with additional treatment to remove nitrogen is one of a number of options that is being considered. A number of discharge options are being presented to stakeholders as part of the consultation process to seek input and feedback. An initial long list of options was considered by Hutt City Council and Wellington Water and through an assessment process a "shorter", more manageable list has been drawn up. The long list of options was assessed against five main criteria – natural environment effects, cultural effects, social effects, affordability within current budgets and flexibility to integrate with future changes to the wastewater treatment plant and Main Outfall Pipeline upgrades. The selection of the shortlist also took into account the alternative "types" set out in the conditions of the existing consent, i.e. alternative locations, alternative storage and alternative treatment.

Refer to:

- Seaview WWTP Temporary Outfall Options: A preliminary assessment of effects on the aquatic ecology of Waiwhetu Stream, Hutt Estuary & Wellington Harbour (MWH, June 2016)
- Seaview WWTP Alternative Outfall and Storage Options Study (MWH, June 2016)

[4] 1000 µg/L is equal to 1 mg/L

900 µgN/L be set as the treatment limit. Figure 3-2 shows the trigger values associated with a temperature of 20°C and pH of 8.0.

Table 3-1 Waiwhetu and Hutt River Temperature and pH

Location	Parameter	Minimum	Median	Maximum
Waiwhetu River	Temperature (°C)	9.4	13.9	21.5
	pH	6.8	7.4	8.0
Hutt River	Temperature (°C)	8.3	14.2	21.5
	pH	6.6	7.3	8.2

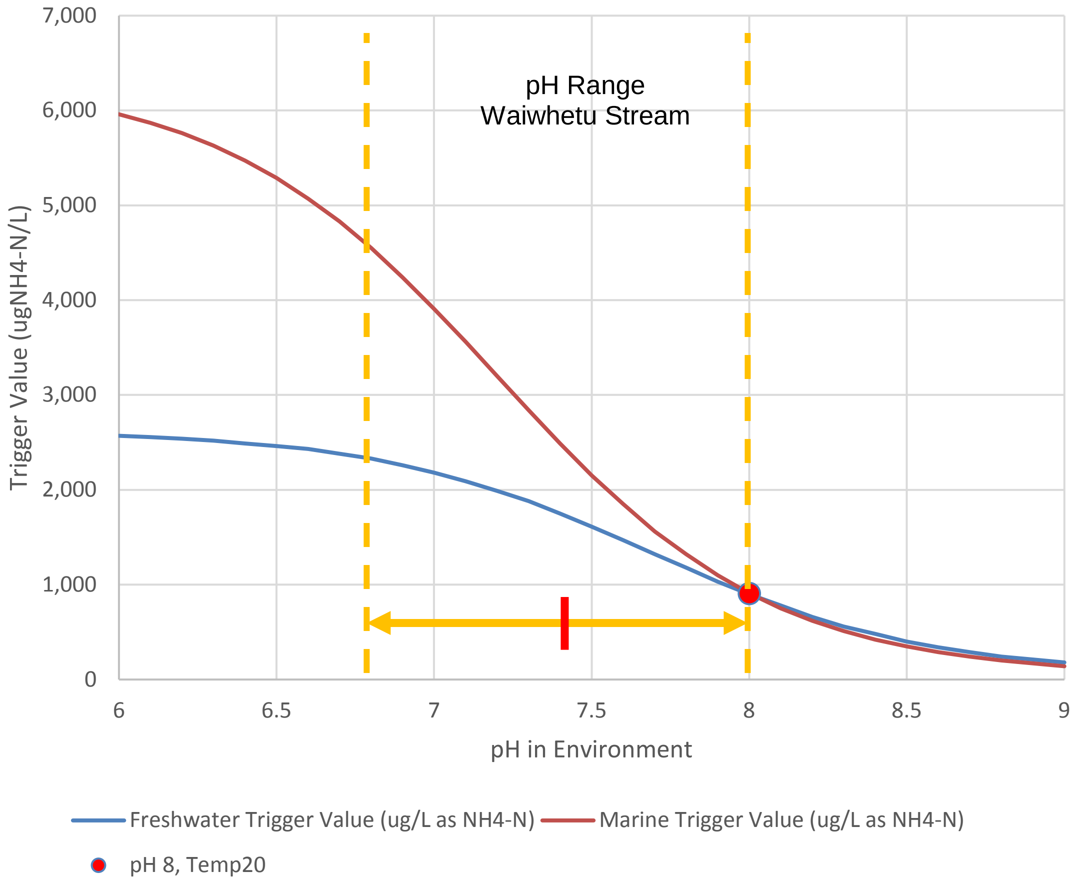

Figure 3-2 Maximum Trigger Values for Ammonia (T= 20°C) in Freshwater and Marine Environments

4 Nitrogen Treatment Solution

4.1 Existing Process

The existing process is a contact stabilisation process:

- Four Aeration Basins Trains
- Four Secondary Clarifiers.

The process is focussed on removal of carbonaceous compounds, suspended solids and pathogens. The plant is not capable of nitrifying ammonia. Nutrient removal is not necessary as part of the existing consent for normal outfall operation.

The solids stream at the Seaview WWTP consists of:

- Primary sedimentation
- Dissolved Air Flotation (DAF) thickening
- Centrifuges
- Dryer

No upgrades to the existing process has been anticipated.

4.2 Upgrade

It is proposed that, an additional process be constructed that will receive the treated flow from the secondary clarifiers to nitrify ammonia, that would otherwise be discharged, into nitrate.

This new process would be a tank filled with synthetic plastic MBBR media. Microorganisms on this media will treat/convert the incoming ammonia without requiring changes to existing treatment trains.

New blowers will be required to supply air to this system distributed through new aeration pipework that will suspend the media within the MBBR and satisfy the oxygen demand required to nitrify the ammonia.

4.3 BioWin™ Model

The BioWin™ model provided was used to simulate the existing process. An MBBR unit was added following the secondary clarifier units to nitrify the treated wastewater stream.

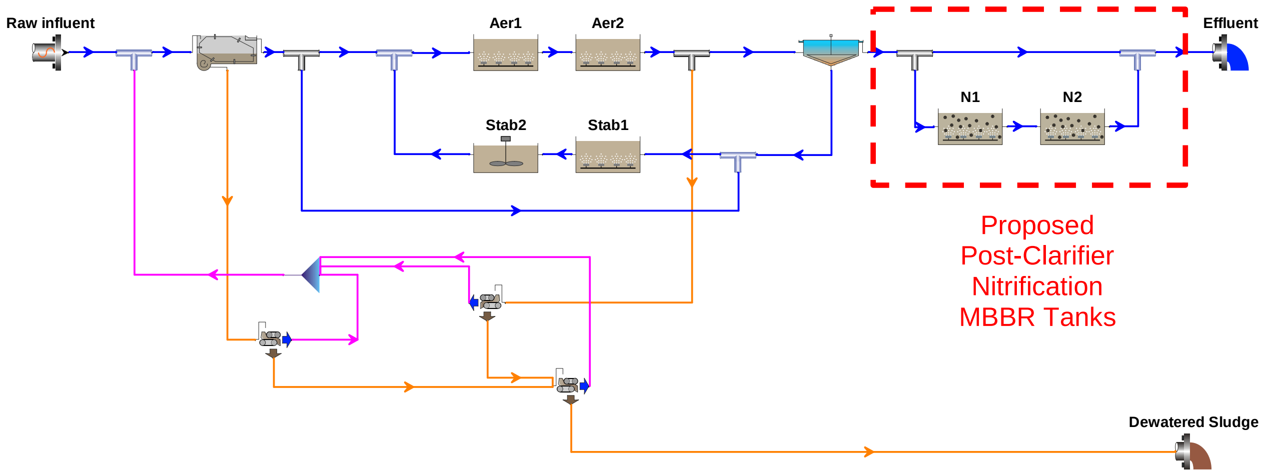

Figure 4-1 Seaview WWTP – BioWin® Model Layout

The actual sizing of the MBBR unit was based on the ability of the process to produce a final effluent quality of less than 1mgN/L to meet the ammonia discharge limit. Only treating a portion of the flow was also considered but due to the high concentration of ammonia in the discharge relative to the discharge limit the non-bypassed flow would be small (5% or less).

Further upgrades to denitrify the nitrate (conversion of nitrate into nitrogen gas) were not included in this model.

5 Price Determination

The prices outlined in this section are based on quotes provided to MWH on previous projects, as insufficient information was available for suppliers to be approached to confirm unit prices. It is recommended that, if this upgrade is favourably selected, prices from suppliers should be obtained and compared with these estimates. As more information becomes available the requirements for the upgrade can be developed to a higher level of detail.

Table 5-1 Nitrifying MBBR Costs for Seaview WWTP

Item	Description	Sub-Totals ($)
1	**Civil**	
1.1	Process Pipework	
1.2	Air Header Pipework	
1.3	Modifications to Blower Building	
1.4	Temporary Works	
		$ 1,000,000
2	**Mechanical**	
2.1	MBBR	
2.2	Blower (7,500Nm³/h)	
2.5	Media	
2.6	Media installation	
2.7	Installation	
2.8	Commissioning	
		$ 5,000,000
3	**Electrical**	
3.1	Switchboard (extension)	
3.2	PLC Control System (excl. programming)	
3.3	Power Supply Upgrade	
		$ 500,000
4	**Instrumentation**	
4.1	Programming	
4.2	Equipment: Air flow meters	
4.3	Equipment: DO Probes	
4.4	Equipment: Recycle Flow Meter	
		$ 100,000
5	**Inter-stage Pump Station**	
5.1	Lifting pump station and Ancillary Items	$ 4,000,000
	UPGRADE	**$ 10,600,000**
	Contingency Allowance	$ 2,000,000
	Engineering Design (based on Design & Construct procurement)	$ 2,000,000
	TOTAL	**$ 14,600,000**

The assumptions made in this report regarding the nitrogen load entering the plant impacts the cost estimate to achieve nitrification of ammonia. The volume of media required to nitrify ammonia is proportional to the actual ammonia load that has to be nitrified and the discrepancy in the assumed load may translate into a shortfall in capital required to meet the project outcome. Media volume estimated to nitrify 2,600kgN/d has been assumed compared to 1,400 kgN/d that was used in the model. This includes allowance for removal of ammonia to required levels during periods when the TKN load is above the median.

The $14.6M cost estimate is based on the providing a system to meet with the higher nitrogen loads calculated from the WWTP sampling data. Such a system would require two 1,250 m^3 tanks each with a footprint of 280 m^2 (total area 600 m^2 approx.) and this would need to be situated near to the existing clarifier tanks.[5]

It also assumes that two additional blowers will be provided to supply air to the MBBR tanks. These blowers would require some modification to the existing blower building but it has been assumed no additional structure will be required.

5.1 Additional Operational Costs

The upgrade would include an increase in the operational costs at the WWTP:

- Aeration requirements would increase requiring up to an additional 10,000 m^3/h of air (1.5 extra blowers in operation).
- Media replacement – this will vary depending on the replacement frequency, at 10-20% replacement this could be between $400,000 to $800,000. The cycle of replacement is based on the operation of the tertiary treatment.
- Chemical dosing – neither alkalinity nor carbon dosing have been included in this assessment but, depending on the influent characteristics, may be required.

6 Conclusions

If the Temporary Outfall Pipeline is to discharge into the Waiwhetu River near to the Hutt River (Option 2 location) then the WWTP will need to nitrify ammonia to meet with the ammonia ANZECC limit of no more than 0.9 mg/L.

A nitrifying MBBR process to treat ammonia in the final clarified effluent could be used to convert ammoniacal nitrogen and reduce the potential for adverse effects on the river ecosystems. Based on the supplied influent information and the supplied BioWin™ model the MBBR has been sized as two 1,250 m^3 tanks each with a 50% media fill. Two new blowers will supply oxygen and mixing to these tanks which will convert ammonia to nitrate.

A price of $14.6M was determined for the treatment aspect of this upgrade. It does not include any costs associated with the upgrade or shift of the Temporary Outfall Pipeline to the proposed location.

[5] Consideration could be made for conversion of the existing emergency storage tank.