Attachment 7:

Independent Technical Review Reports:

7A:

Technical Review– Matauara Processing Plant Resource Conesnt Applications– Water Quality and Ecology, 4Sight Consulting, May 2020 (4Sight Water Quality and Ecology Review);

4SIGHT CONSULTING

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TECHNICAL REVIEW – MATAURA PROCESSING PLANT RESOURCE CONSENT APPLICATIONS

For: Environment Southland

Water Quality and Ecology

May 2020

REPORT INFORMATION AND QUALITY CONTROL

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1 INTRODUCTION

Alliance owns and operates a Meat Processing Plant ('the Plant') on the riverbank of the Mataura River in the Mataura township, which is approximately 44 km upstream from the Toetoes Estuary.

Alliance is applying for replacement resource consents with a consent term of 35 years for the Plant for the following activities:

- Discharge of up to 8,000 m^3 per day of treated meat works wastewater into the Mataura River;
- Discharge of condenser cooling water into the Mataura River;
- Take up to 21,200 m^3 water per day from the Mataura River for cooling water;
- Take up to 8,000 m^3 water per day from the Mataura River for meat processing and truck washing; and
- Use an existing weir and hydro race structure to dam and divert water.[1]

The purpose of this report is to present a technical review of the Assessment of Environmental Effects and supporting reports to assist Environment Southland with the processing of the application. This report also presents findings from the analysis of the monitoring data supplied by both Alliance and Environment Southland regarding the effects of the discharge from the Plant on the receiving environment.

State of the Environment data collected by Environment Southland have been analysed separately and presented in a letter to Environment Southland.[2] This letter provides a snapshot of water quality up and downstream of the Plant's location in order to put the potential effects of the discharge from the Plant in context. The Mataura River has a large catchment with a wide range of land uses. Consequentially, at times, there are elevated levels of contaminants which degrade the water quality of the Mataura River.

2 WATER QUALITY EFFECTS

This section discusses the potential effects of the discharge from the Plant on the water quality of the Mataura River. The discussion is broken down into each key water quality parameter and the potential dilution of the contaminants in the discharge by the Mataura River.

2.1 Potential for dilution

On first inspection, the levels of contaminants measured in the discharge appear very high, particularly those of *E. coli* and nitrogen. However, measurement of contaminants after reasonable mixing in the Mataura River (estimated at 100 m downstream from the discharge point but monitored at an accessible location approximately 300 m downstream), has shown that most contaminant levels are not substantially altered from upstream levels. The most obvious exceptions to this are *E. coli* and ammonia.

Streamlined Environmental ran a mixing model to determine the mixing area downstream of the discharge point.[3] They found that, based on their model, the discharge was well-mixed with the river within 100 m downstream. The potential level of dilution, however, was not calculated. Without estimating the dilution potential, it is unclear what the likely water quality would be downstream of the discharge for any established limits at the point of discharge. Dilution estimates are useful so that water quality targets set downstream can be converted into consent limits at the discharge.

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[1] Resource consents for land and water permits for this activity were applied for under a separate application to the others titled 'Use of Mataura River weir to dam and divert water'.

[2] Wilson, P. Technical Review – Mataura Processing Plant: SOE Data Analysis. Letter to Environment Southland. 14 October 2019.

[3] Dada, AC (2019) Determination of mixing zone of treated wastewater from Alliance Mataura discharged into the Mataura River: a mixing modelling approach using contaminant tracers. Streamlined Environmental Report AES1803. 18 p. (Appendix 4 of AEE)

2.1.1 Estimating potential dilution

Using the data supplied by Alliance and Environment Southland, potential dilution of the contaminants discharged from the Plant in the Mataura River was estimated using two approaches:

1) Long-term median concentrations were compared between the point of discharge and the downstream monitoring location on the Mataura River; and

2) Samples collected at the point of discharge and downstream of the Plant on the same day were compared pairwise. The average of the daily difference was used to estimate the mean dilution.

Note that neither of these approaches has accounted for the concentration of contaminants upstream of the discharge. The Mataura River has known elevated concentrations of *E. coli* and nutrients, which will influence the dilution capacity of the river for certain contaminants; however, the concentration of contaminants in the discharge is generally multiple orders of magnitude greater than background levels, so in our opinion, this approach is appropriate for a simple estimate.

Not all water quality parameters were monitored both at the point of discharge and downstream of the Plant, which is necessary for this type of assessment. The following parameters were monitored by either Alliance or Environment Southland and allowed for assessing the potential dilution:

- Dissolved reactive phosphorus;
- Ammonia;
- Total phosphorus;
- Total suspended solids; and
- *E. coli*.

Dissolved reactive phosphorus, ammonia, total phosphorus, and total suspended solids were monitored weekly by Alliance upstream, downstream, and the point of discharge. These data were used in both approaches.

E. coli was only routinely measured at the point of discharge (i.e., was not routinely measured downstream) by Alliance so these data were supplemented using state of the environment (SOE) data collected downstream of the plant by Environment Southland. An exception to this is the additional sampling that Alliance conducted between December 2017 to May 2018 to also measure *E. coli* concentrations upstream and downstream of the discharge (18 samples). To increase the number of data points for analysis, downstream *E. coli* concentrations were also included from the Environment Southland State SOE monitoring programme.

For all analyses, data were analysed from January 2012 to January 2019.

2.1.1.1 Dilution estimates using long-term medians

A simple approach to estimate the level of dilution is to compare the median concentration of contaminants measured in the discharge with the median concentration measured after mixing (i.e., at the monitoring location 300 m downstream of the discharge).

The findings from this approach revealed two general levels of dilution: 1) DRP and TSS were diluted around 10–20 times (one order of magnitude); and 2) ammonia, total phosphorus, and *E. coli* were diluted 100–300 times (two orders of magnitude).

Table 1: Median contaminant concentrations measured in the wastewater discharge and 300 m downstream of the discharge. Values are compared to each other to estimate median dilution.

Parameter	Median Concentration (2012–2019)		Median Dilution* (x times)
	Discharge	Downstream	
Dissolved Reactive Phosphorus (g/m^3)	0.21	0.013	20
Ammonia (g/m^3)	15.8	0.05	300
Total Phosphorus (g/m^3)	3.5	0.03	100
Total Suspended Solids (g/m^3)	67	6	10
E. coli (MPN/100 mL)	190,000	1,400	100

* A 1x dilution means that no dilution has taken place. A 10 times dilution means that the concentration has reduced by an order of magnitude.

2.1.1.2 Dilution estimates using pairwise comparisons

Another simple approach to estimate the level of dilution is to compare the concentration of contaminants in the discharge with the concentration of contaminants measured downstream of the Plant on the same day. This provides a pairwise comparison. The range of calculated dilutions and the overall mean of these dilutions are presented in Table 2.

The findings from this approach were similar to those of the first approach. DRP and TSS were diluted by one order of magnitude on average, and the other contaminants were diluted by two orders of magnitude on average. The range of calculated dilutions is wide for each parameter. This is reflective of the complex nature of this environment and the multiple factors that influence the level of dilution, including the flow rates of the Mataura River and the discharge and the existing contaminant concentrations upstream of the Plant.

Table 2: Average dilution of contaminants in the Plant's discharge by the Mataura River estimated using pairwise comparisons from 2012 to 2019.

Parameter	No. Samples	Dilution Range (x times)	Mean Dilution (x times)
Dissolved Reactive Phosphorus (g/m^3)	285	0–430	30
Ammonia (g/m^3)	286	30–1900	300
Total Phosphorus (g/m^3)	285	10–550	100
Total Suspended Solids (g/m^3)	286	0–50	10
E. coli (MPN/100 mL)	34	0–3000	300

* A 1x dilution means that no dilution has taken place. A 10 times dilution means that the concentration has reduced by an order of magnitude.

2.2 *Escherichia coli*

E. coli is measured as an indicator of potential pathogens in the water that could make the water unsuitable for recreational use. It is also the indicator used to determine whether water is suitable for consumption by humans and/or animals.

The Proposed Southland Water and Land Plan (PSWLP) lists Mataura River at Mataura River Bridge as a popular bathing site, which is located approximately 300 m downstream of the discharge point from the Plant. The *E. coli* limit in the PSWLP for a popular bathing site is less than 130 *E. coli* per 100 mL. This limit is more stringent than the water quality standard for the other sections of the river as it relates specifically to human health in a known popular bathing location.

E. coli levels in the discharge ranged from 1,200 CFU/100 mL to at least 17,000,000 CFU/100 mL (Table 3). Concentrations may have been higher than the reported values at times because the laboratory reported more than

50 results as being higher than the upper detection limit for the analytical method. At times, this upper limit was as low as 2,880 CFU/100 mL (i.e., >2,880 CFU/100 mL), which limits the usefulness of these specific data. In general, the concentration of *E. coli* in the wastewater discharge varies greatly (as indicated by the very high standard deviation) and is 1–5 orders of magnitude higher than the limit for popular bathing sites (130 CFU/100 mL). Such concentrations would require substantial dilution to meet the bathing site limit (i.e. 10–100,000 times dilution).

Table 3: Summary statistics for *E. coli* concentrations measured in the Plant's wastewater discharge from November 2012 to February 2019.

Minimum	20th %ile	Median	80th %ile	Maximum*	Mean	Standard Deviation	No. Samples
1,200	28,800	190,000	628,000	17,000,000	510,079	1,231,434	288

* Some values were reported as being higher than the upper laboratory detection limit so may have exceeded this value

Alliance conducted routine monitoring of water quality upstream and downstream of the discharge location to assess the effects of the discharge on the receiving environment; however, this programme did not include *E. coli* measurements. Additional sampling was carried out for about 20 weeks from 21 December 2017 to 8 May 2018 to measure *E. coli* concentration upstream and downstream of the discharge. This sampling period does not cover the full year and, therefore, range of seasons and weather conditions, but does cover the summer bathing season. As a result, these findings may not be entirely reflective of the full range of *E. coli* concentrations in the environment. Notably, this type of sampling was not conducted during winter months, which generally have more frequent and greater volumes of rainfall and consequently, higher levels of *E. coli* in the river. Inclusion of *E. coli* in the weekly monitoring upstream and downstream of the discharge point is highly recommended.

After reasonable mixing (i.e., at the monitoring location 300 m downstream of the discharge), *E. coli* levels were still highly elevated (typically >1000 CFU/100 mL; about seven times greater than upstream; Table 4 and Figure 1). To put these results in context, the PSWLP limit for bathing sites is 130 CFU/100 mL and the recreational water quality guidelines[4] state that water with an *E. coli* concentration >550 CFU/100 mL is highly likely to be unsuitable for contact recreation (e.g. swimming).

The *E. coli* limit of 130 CFU/100 mL is typically exceeded upstream of the processing plant at Gore (median value over the past 5 years, 375 CFU/100 mL) and the Waikaka Stream (median value over the past 5 years, 315 CFU/100 mL). However, the mean concentration of *E. coli* is statistically significantly higher by 2,300 CFU/100 mL downstream (mean = 3,588 CFU/100 mL) than it is upstream (mean = 1,310 CFU/100 mL).[5] This indicates that the discharge from the Plant's wastewater discharge is having a significant adverse effect on the concentration of faecal bacteria in the Mataura River.

Table 4: Summary statistics for *E. coli* concentrations measured upstream and downstream of the Plant's wastewater discharge between December 2017 and May 2018

Site	Minimum	20th %ile	Median	80th %ile	Maximum *	Mean	Standard Deviation	No. samples
Upstream	30	120	355	666	5,500	678	1,309	16
Downstream	390	771	2,600	5,830	50,000	5,871	12,077	16

* Some values were reported as being higher than the upper laboratory detection limit so may have exceeded this value

[4] MfE/MoH (2003) Microbiological water quality guidelines for recreational water

[5] Paired samples t-test carried out on log-transformed and untransformed *E. coli* concentrations. $P < 0.001$

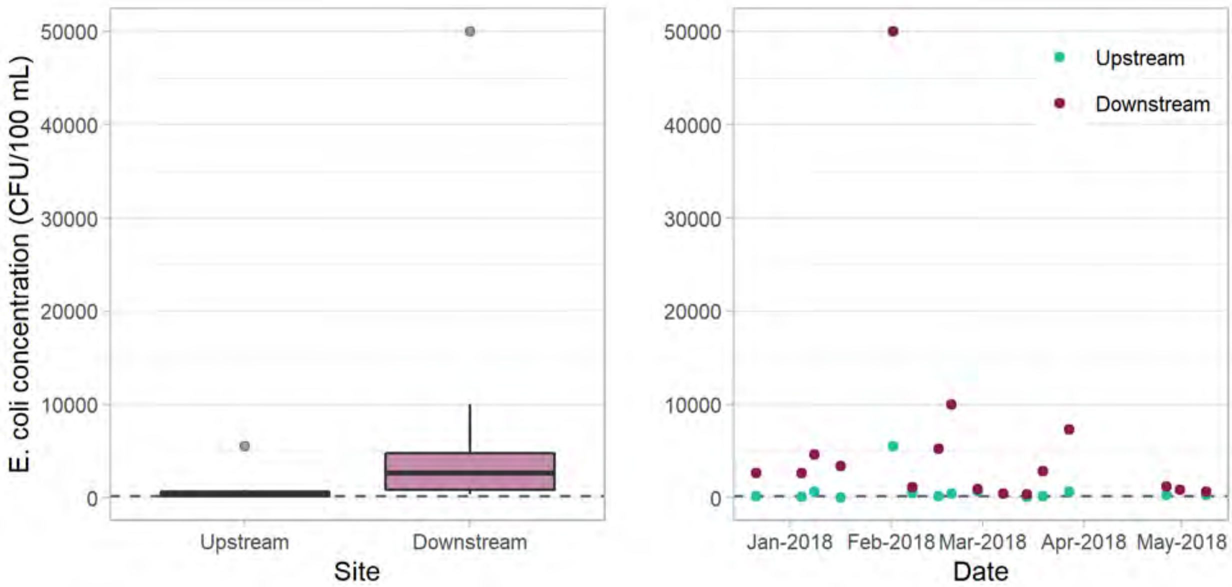

Figure 1: Boxplot and scatterplot of *E. coli* data collected upstream and downstream of the discharge point between December 2017 and May 2018. The range of the boxes shows the lower and upper quartiles of the data and the horizontal line, the median. Black circles above the bars show results that are greater than 1.5 times the interquartile range (the range of the boxes). The dashed horizontal line shows the PSWLP bathing site limit of 130 CFU/100 mL for reference.

Because of the high concentrations of *E. coli* measured in the discharge and after mixing with the Mataura River, the applicant conducted testing of pathogens in the water. A prior study by Environment Southland had identified that the levels of pathogens (specifically, campylobacter) in the Mataura River were lower than concentrations of *E. coli* indicated.[6] Pathogen testing on four occasions resulted in positive detections of one or more of salmonella, campylobacter, *E. coli* 0157, giardia, or cryptosporidium in every sample. Although the Freshwater Solutions report suggests the results were all low, in our opinion, this confirms that there is an elevated health risk to recreational water users as a result of the discharge outside of the mixing zone (i.e., >100 m downstream). The processing water doesn't undergo any treatment that would remove bacteria or viruses from the discharge (e.g. UV treatment) and, therefore, any pathogens that are present in the processing plant will be discharged into the river.

The applicant proposes installing microbiological treatment (UV or equivalent) in five years. The treatment system is estimated to reduce the median *E. coli* concentration in the discharge to no more than 1,000 CFU/100 mL (down from the current median concentration of 190,000 CFU/100 mL) and the 95th percentile to be less than 10,000 CFU/100 mL.[7] Reduction of the median *E. coli* concentration in the discharge by two orders of magnitude will be highly beneficial to the water quality of the Mataura River and will likely reduce the downstream *E. coli* concentrations to be much more similar to ambient/upstream concentrations. Based on the estimated dilution in Section 2.1.1, *E. coli* concentrations are diluted on average by two orders of magnitude. This indicates that the median *E. coli* concentration downstream of the plant could be around 10 CFU/100 mL, plus the contribution from upstream sources. The 95th percentile of results downstream of the Plant could be around 100 CFU/100 mL plus the contributions from upstream sources.

Even with the proposed wastewater treatment upgrades and the resulting improvement in discharge quality (i.e. reduction in the discharge of faecal bacteria), it is unlikely that the water quality at the designated popular bathing site at Mataura River Bridge will be within the limits set out in the PSWLP without also having further reductions in *E. coli* throughout the catchment.

[6] Cressey, P., Hodson, R., Ward, R., & Moriarty, E. (2017). Use of QMRA to Assess the Human Health Risk of the Mataura River, Southland.

[7] AEE p 53.

To help put this in context, if the wastewater treatment upgrades are carried out as they have been proposed, faecal bacteria concentrations downstream of the Plant in the Mataura River would likely be at suitable levels (i.e., compliant with the PSWLP) if this area was not a popular bathing site. This section of the Mataura River, however, is designated as a popular bathing site. Even with all the proposed upgrades, *E. coli* concentrations downstream of the Plant are likely to exceed the water quality standards set out in the PSWLP (130 CFU/100 mL), on occasion, after the installation of all proposed wastewater treatment upgrades due to the Plant's discharge alone (i.e., irrespective of the upstream catchment sources). In part, this is a consequence of the discharge being so close to the popular bathing site.

2.3 Nitrogen

Three forms of nitrogen were measured by the applicant upstream and downstream of the discharge point: nitrate, nitrite, and total ammoniacal nitrogen (herein referred to as ammonia). Each species contributes to the total nitrogen load and, at high concentrations, can be toxic to aquatic species. This section focuses on two species most affected by the discharge, nitrate and ammonia.[8]

Total nitrogen is not currently measured by the applicant; however, they propose to include limits on, and presumably measurements of, the concentration of total nitrogen in the discharge and total annual load after the installation of a biological treatment system in 15 years. Inclusion of total nitrogen in the Plant's routine monitoring is recommended. Reductions in total nitrogen loads will be important for the improvement in water quality in the Mataura River and Toetoes Estuary downstream of the plant. Effects of the discharge from the Plant on the Toetoes Estuary is discussed in Section 2.5 of this report.

2.3.1 Nitrate

Nitrate concentrations are slightly higher downstream from the discharge point than they are upstream (mean concentration 0.02 g/m^3 higher; Figure 2).[9] The concentrations of nitrate upstream of the Plant always exceed the ANZG (2018) ecosystem health guideline value.

With regard to toxicity, concentrations of nitrate both upstream and downstream of the discharge are below the chronic toxicity guideline value of 2.4 g/m^3 for slightly to moderately disturbed systems (95% protection).[10]

The applicant has proposed a biological treatment system upgrade in 15 years that will reduce the levels of nitrate in the discharge. There is no current limit on the concentration of nitrate that can be discharged from the Plant, however, after the upgrade, the applicant proposes a total nitrogen limit (which includes nitrate) whereby the rolling 12-month median of total nitrogen will not exceed 20 g/m^3 and the 95th percentile will be less than 10 g/m^3.[11]

Overall, the discharge from the Plant has a very small effect on the concentrations of nitrate in the Mataura River after mixing.

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[8] Statistical analysis was conducted on nitrite concentrations and there was no statistical difference between upstream and downstream concentrations (paired samples t-test, $p = 0.90$).

[9] Paired samples t-test; $t = 2.52$, $p = 0.012$.

[10] Hickey, C.W. (2013). Updating nitrate toxicity effects on freshwater aquatic species. NIWA Report HAM2013-009 prepared for Ministry of Building, Innovation and Employment: Funded by Envirolink. 31 p.

[11] AEE p 59.

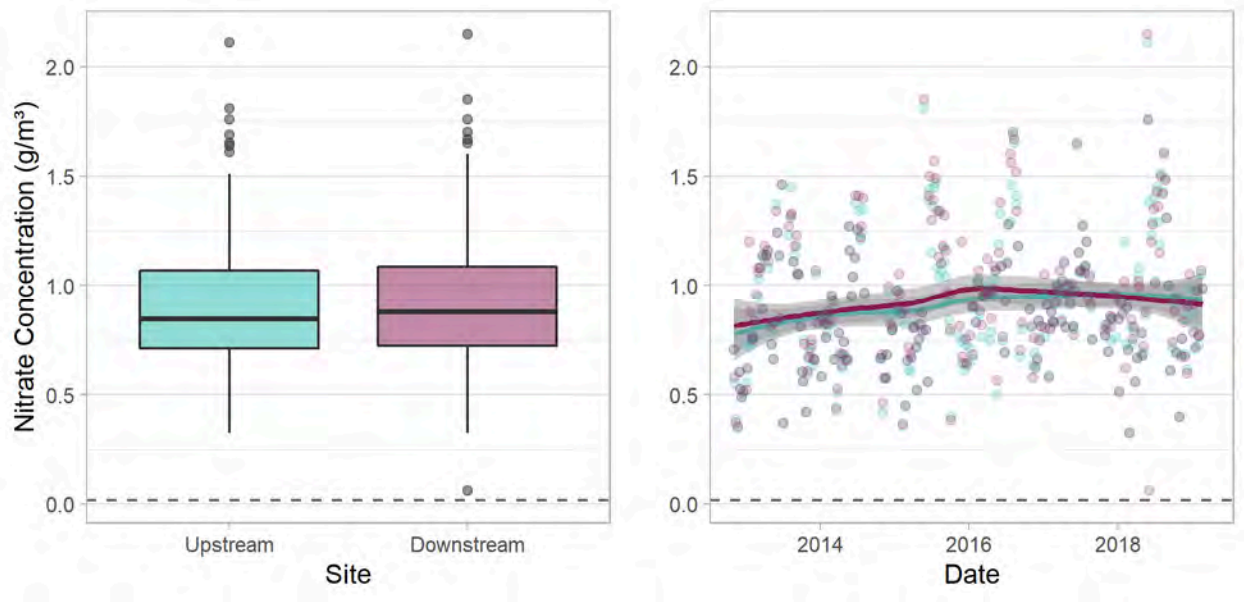

Figure 2: Boxplot and scatterplot of nitrate data collected upstream and downstream of the discharge point between November 2012 and March 2019. The range of the boxes shows the lower and upper quartiles of the data and the horizontal line, the median. Black circles above the bars show results that are greater than 1.5 times the interquartile range (the range of the boxes). The fit through the data of the scatterplot is a loess fit. The dashed horizontal line shows the ANZG (2018) ecosystem health guideline value of 0.018 g/m^3 for reference.

2.3.2 Ammonia

The discharge from the Plant substantially increases the concentration of ammonia in the Mataura River downstream of the discharge.

At high concentrations, ammonia can be toxic to aquatic species. Depending on the concentration, the effects can range from behaviour modification to death. The toxicity of ammonia is a factor primarily of pH, but also water temperature. The reason for this is that the measurement of ammonia includes both NH_3 (ammonia) and NH_4^+ (ammonium) and the associated toxicity is primarily due to NH_3. The ratio of these two components in solution is dependent on pH and temperature.

The PSWLP has ammonia standards for lowland hill surface waterbodies that apply to this section of the Mataura River (Mataura 3). The standards are given for pH ranges from 6.0 to 9.0 and this results in ammonia standards ranging from 2.38 g/m^3 to 0.18 g/m^3, respectively. The standard is lower at higher (more alkaline) pH because a great proportion of ammonia is in the form of NH_3.

A common approach for analysing ammonia data is to standardise the concentrations to pH 8.0, which is the approach that was used for this analysis. At pH 8.0, the PSWLP ammonia standard is 0.9 g/m^3. This value sits within Attribute State band ‘C’ of the NPS-FM, which has the narrative “80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species).”

Ammonia concentrations downstream of the discharge are within the PSWLP standard (Figure 8). This represents a low toxicity risk to most aquatic species. There is, however, a statistically significant increase in the mean ammonia concentration downstream of the discharge (after reasonable mixing) by approximately 0.03 g/m^3 (2.2 times increase) (Figure 4).[12] Ammonia concentrations in the mixing zone (the area up to 100 m downstream from the discharge) will have higher ammonia concentrations, which may pose some risk to aquatic species close to the discharge.

[12] Paired sample t-test; $t = 13.59$, $p < 0.001$.

These potential toxicity effects have been acknowledged in the Freshwater Solutions report: "*the Amm-N concentration in the discharge has the potential to cause adverse effects in the mixing zone through chronic and acute toxicity, as well as result in non-toxic effects such as adversely affecting fish migration in the mixing zone*."[13]

The applicant has proposed a biological treatment system upgrade in 15 years that will reduce the levels of ammonia in the discharge. Once the system is installed, the applicant proposes ammoniacal nitrogen limits in the discharge of 5 g/m^3 for a 12-month rolling mean and 10 g/m^3 for the 95th percentile.[14] This is a marked proposed reduction from their current discharge limits of up to 50 g/m^3 per day (but typically <30 g/m^3). As a result of the proposed treatment system upgrade, concentrations downstream of the Plant should be closer to ambient/upstream concentrations. Reductions in ammonia will be important for reducing the total nutrient load in the Mataura River and downstream Toetoes Estuary. It will also reduce the risk of acute toxicity to aquatic organisms in the mixing zone. There is no current evidence of significant issues occurring to aquatic organisms in the mixing zone due to ammonia, however, this is difficult to assess without targeted studies. This is addressed further in Section 3.

Figure 3: Ammonia concentration (total ammoniacal-N) adjusted to pH 8.0 (note the log scale on the y-axis). The lines of best fit through each location is a Loess fit and the shaded area is the 95% confidence interval of each fit. The dashed line is the ammonia toxicity standard from the PSWLP at pH 8.0.

[13] AEE p 26.

[14] AEE p 58.

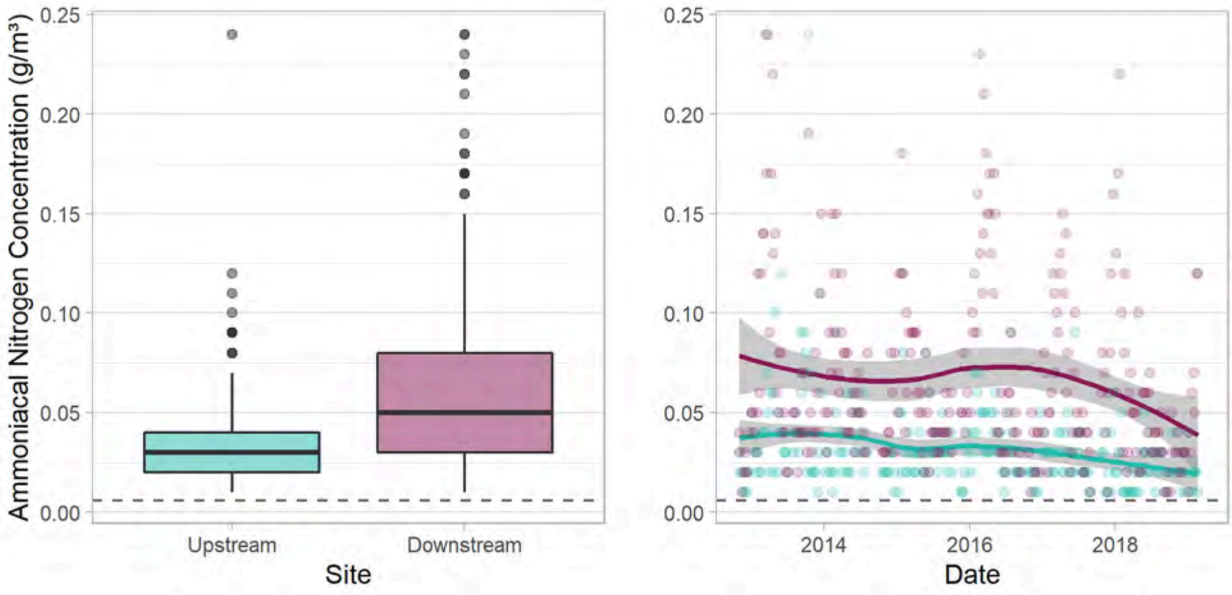

Figure 4: Boxplot and scatterplot of ammoniacal nitrogen data (unadjusted for pH) collected between November 2012 and March 2019 upstream and downstream of the discharge. The range of the boxes (interquartile range) shows the extent of the lower and upper quartiles of the data and the horizontal line, the median. Black circles above the boxes show results that are greater than 1.5 times the interquartile range. The fit through the data of the scatterplot is a loess fit. The dashed horizontal line in both plots shows the ANZG (2018) ecosystem health guideline value for rivers classified as Cool Dry Hill (0.006 g/m^3).

2.4 Phosphorus

Two measurements of phosphorous were carried out by the applicant upstream and downstream of the discharge point: total phosphorus and dissolved reactive phosphorus (DRP). DRP is one component of total phosphorus that is readily bio-available and elevated levels of phosphorus contribute to eutrophication, which may result in nuisance algal growth.

2.4.1 Total phosphorus

Total phosphorus concentrations varied widely and the highest measurement was 47 times greater than the ANZG (2018) ecosystem health guideline value[15] both upstream and downstream of the discharge (Figure 5). Typically, total phosphorus concentrations follow a similar pattern to suspended sediment concentrations because a large proportion of total phosphorus is sediment-bound; that is, following heavy rainfall, both suspended sediment and total phosphorus concentrations are typically elevated.

The average total phosphorus concentration between 2012 and 2019 was 35% higher downstream from the discharge than it was upstream.[16] The applicant proposes installing a biological treatment system, which will slightly reduce the total phosphorus concentration in the discharge from a rolling 12-month median of 5.5 g/m^3 to a rolling 12-month median of 5 g/m^3.[17] Although this is a relatively small decrease, and opportunities for further phosphorus reduction would be supported, we consider that reduction of *E. coli* and nitrogen to be a higher priority over that of total phosphorus. Despite the levels of phosphorus being elevated, there are no obvious signs of nutrient enrichment (eutrophication) such as clear patterns of increased nuisance algal growth downstream from the plant. Reductions of phosphorus to ANZG (2018) guideline levels would, however, be beneficial to improve water quality and overall

[15] ANZG (2018) ecosystem health guideline value for rivers classified as Cold Dry Hill = 0.009 g/m^3.

[16] Upstream mean = 0.041 g/m^3; downstream mean = 0.048 g/m^3; paired sample t-test: f = 5.70, $p < 0.001$.

[17] AEE p 59.

ecosystem health. Furthermore, estuaries such as the Toetoes Estuary are nitrogen limited due to the abundance of phosphorus in oceanic waters such that reductions in phosphorus are likely to provide limited improvement on the quality of the estuary without also reducing nitrogen loading.

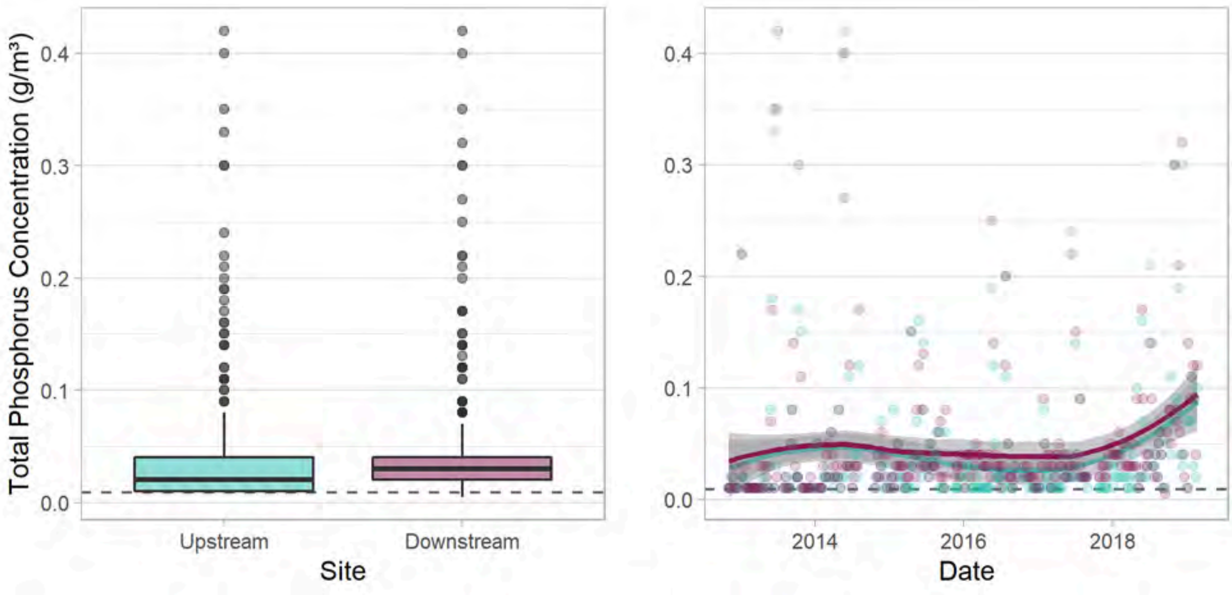

Figure 5: Boxplot and scatterplot of total phosphorus data collected between November 2012 and March 2019 upstream and downstream of the discharge. The range of the boxes (interquartile range) shows the extent of the lower and upper quartiles of the data and the horizontal line, the median. Black circles above the boxes show results that are greater than 1.5 times the interquartile range. The fit through the data of the scatterplot is a loess fit. The dashed horizontal line in both plots shows the ANZG (2018) ecosystem health guideline value for rivers classified as Cool Dry Hill (0.009 g/m^3).

2.4.2 Dissolved reactive phosphorus (DRP)

The results for DRP were similar to those of total phosphorus in that measured concentrations varied widely and were 40% higher downstream than they were upstream of the Plant.[18] The applicant doesn't propose any decrease to limits of DRP even after the proposed installation of a biological treatment system.[19] Further reductions in DRP in the discharge would likely require an additional treatment system or process. In the same manner as total phosphorus, we consider that greater reductions of *E. coli* and nitrogen to be a higher priority over that of DRP, however, opportunities for further DRP reduction would be supported.

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[18] Upstream mean = 0.010 g/m^3; downstream mean = 0.014 g/m^3; paired sample t-test: f = 13.08, p < 0.001.

[19] AEE p 59.

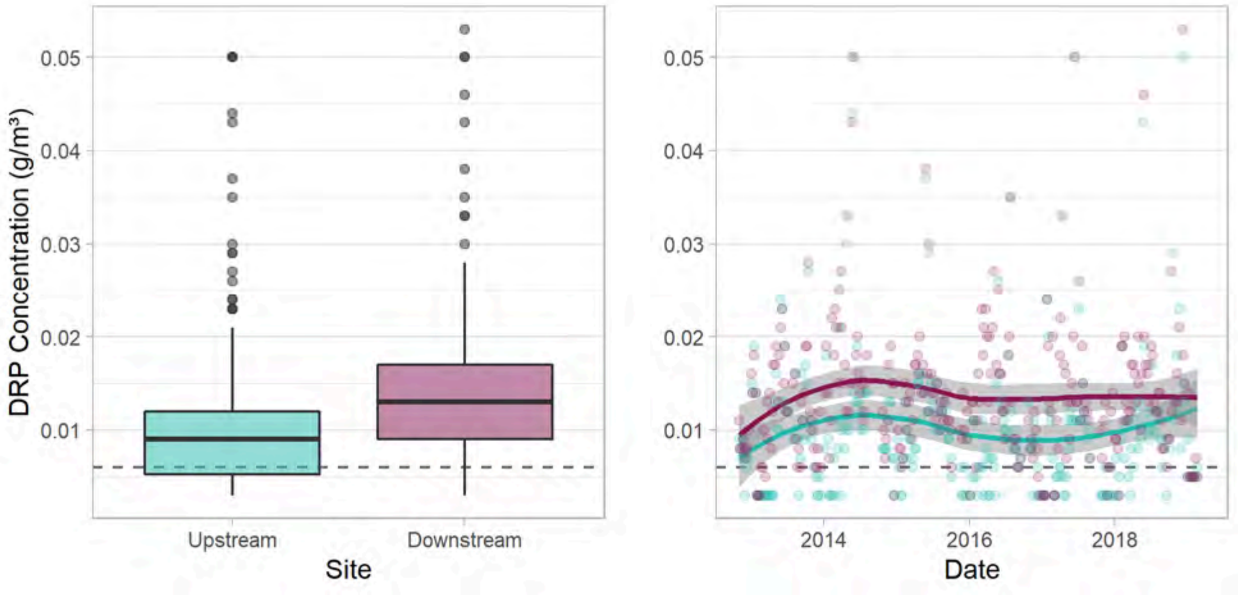

Figure 6: Boxplot and scatterplot of dissolved reactive phosphorus data collected between November 2012 and March 2019 upstream and downstream of the discharge. The range of the boxes (interquartile range) shows the extent of the lower and upper quartiles of the data and the horizontal line, the median. Black circles above the boxes show results that are greater than 1.5 times the interquartile range. The fit through the data of the scatterplot is a loess fit. The dashed horizontal line in both plots shows the ANZG (2018) ecosystem health guideline value for rivers classified as Cool Dry Hill (0.006 g/m^3).

2.5 Nutrient loads to the Toetoes Estuary and cumulative effects

The Toetoes Estuary is approximately 60 km downstream from the Plant. It is a Ramsar site, which means it is recognised internationally as a wetland of high ecological value and importance.[20] The Ramsar site was initially restricted to the Awarua Waituna Lagoon but was increased in 2008 to include other nearby wetland areas and the addition of three major estuaries: Toetoes Harbour, Awarua Bay, and the Invercargill (New River) Estuary.

Nutrient loading to the Toetoes Estuary and cumulative effects are closely linked in the Freshwater Solutions report as the discharge nutrient loads are reported in the context of catchment-wide nutrient loads. The report repeatedly describes the effects of its nutrient discharge as likely to have little effect overall when considering that it contributes around 1% of the nutrient load from the entire catchment (1.1–1.7% TN; 0.7–1.1% TP). The Mataura Catchment, however, has elevated nutrient levels and is strongly influenced by high productivity agriculture, which is the primary land use in the catchment. Therefore, 1% of the overall catchment's nutrient load is still a substantial load and is arguably not negligible as it is described in the executive summary (p. v).

Furthermore, the Freshwater Solutions report also states that "*even a marked reduction of the discharge total nitrogen and total phosphorus loads would have little, if any, detectable effect on the nutrient status of the Toetoes Estuary*."[21] Water quality improvements are only likely to be achieved in the Mataura River if the quality of all discharges to the river are improved. Furthermore, estuaries are nitrogen-limited, that is, there is typically an abundance of phosphorus in estuarine systems and elevations in nitrogen typically result in the growth of nuisance algae and the presentation of other eutrophication-related issues.

Currently, there is no specific removal of nitrogen from the wastewater stream and, therefore, the vast majority of nitrogen generated on-site is discharged to the river. Proposed wastewater treatment upgrades to a biological

[20] https://www.wetlandtrust.org.nz/get-involved/ramsar-wetlands/awarua-waituna-lagoon/

[21] AEE p 44.

treatment system in 15 years is estimated to reduce total annual nitrogen loads by around 50%.[22] After installation of the biological treatment system, Alliance propose to set an annual total nitrogen load limit of 25 tonnes (~0.8% of catchment total nitrogen load), which is greatly reduced from the currently proposed limits of 60 tonnes during the current time where there is no nitrogen removal in the waste streams.[23] An annual total nitrogen load of up to 25 tonnes is a more appropriate limit to see overall reductions in nutrients from the catchment into the Toetoes Estuary.

The need for improvements to Mataura River water quality is supported by the findings from broad-scale intertidal habitat mapping of the Toetoes Estuary by Stephens (2018)[24] that were also presented in the Freshwater Solutions report. Specifically, the findings from the habitat mapping showed that "*although large sections of the lower estuary remain in good condition, sheltered upper estuary embayments have developed stable nuisance macroalgal growth with poorly oxygenated sediments since 2013*." The report also states that "*excessive nutrient inputs are the primary driver of the eutrophication* [nutrient enrichment] *symptoms*" and that "*the estuary is in a "MODERATE" but declining condition in relation to eutrophication*." These findings highlight the adverse effects of elevated nutrient levels on the Toetoes Estuary.

2.6 Total suspended solids and oil and grease

The PSWLP Receiving Water Quality Standards for Surface waterbodies Classified as Mataura 3 states that "*Any discharge is to be substantially free from suspended solids, grease and oil.*" There is no formal definition of substantially free. Environment Southland commissioned a legal analysis that concluded, "[s]*ome guidance may be taken from the concentrations accepted by the Planning Tribunal under the Water and Soil Conservation Act 1967. These cases indicated that concentrations of 30g/m^3 and 150g/m^3 of suspended solids, and a concentration of 75g/m^3 of grease and oil, in a discharge would still be considered "substantially free*".[25]

The discharge has a median Total Suspended Solids concentration of 67 g/m^3 and median oil and grease concentration of 13 g/m^3 (Figure 7). Based on the cases cited by the memo above, this is likely to fall within the range of 'substantially free'.

TSS concentrations in the discharge increased from around 50 g/m^3 to 75 g/m^3 between 2012 and 2015 and then reduced again to around 55 g/m^3 in 2017. The median discharge concentration has increased by 10 g/m^3 TSS over the past 5 years (from 65 g/m^3 in 2013 to 75 g/m^3 2018[26]). Overall, there has been an increase in the TSS concentration of 2 g/m^3 per year between 2012 and 2019.[27] If the median TSS concentration continues to increase at this rate, the median TSS concentration will exceed 100 g/m^3 by 2031.

There is a 27% increase in TSS concentration downstream from the Plant than upstream.[28] Elevated concentrations downstream from the Plant may also arise from the increased mixing from the Mataura Falls and the discharges from the cooling and processing water.

The proposed upgrade of the wastewater treatment to include a biological treatment system is estimated to reduce the TSS concentration in the discharge to a rolling 12-month median of 20 g/m^3 and 95th percentile of 40 g/m^3.[29] This

[22] AEE p 43.

[23] AEE p 59.

[24] Stevens, L.M. 2018. Fortrose (Toetoes) Estuary 2018: Broad Scale Habitat Mapping. Report prepared by Wriggle Coastal Management for Environment Southland. 50p.

[25] Doesburg, M., Langford, A. Memorandum: Interpretation of "substantially free". 2 December 2019.

[26] Freshwater Solutions report Table 5, p 9.

[27] Seasonally adjusted Kendall trend test with months used as seasons. Slope = 2.0, $p < 0.001$.

[28] Upstream mean = 21.93 g/m^3; downstream mean = 23.27 g/m^3; paired sample t-test: $f = 3.41$, $p = 0.001$.

[29] AEE p 58.

is a substantial reduction from the current discharge limits a maximum of 200g/m^3 and consistently maintained at <100 g/m^3 and will assist with reducing the total sediment loading in the Mataura River.

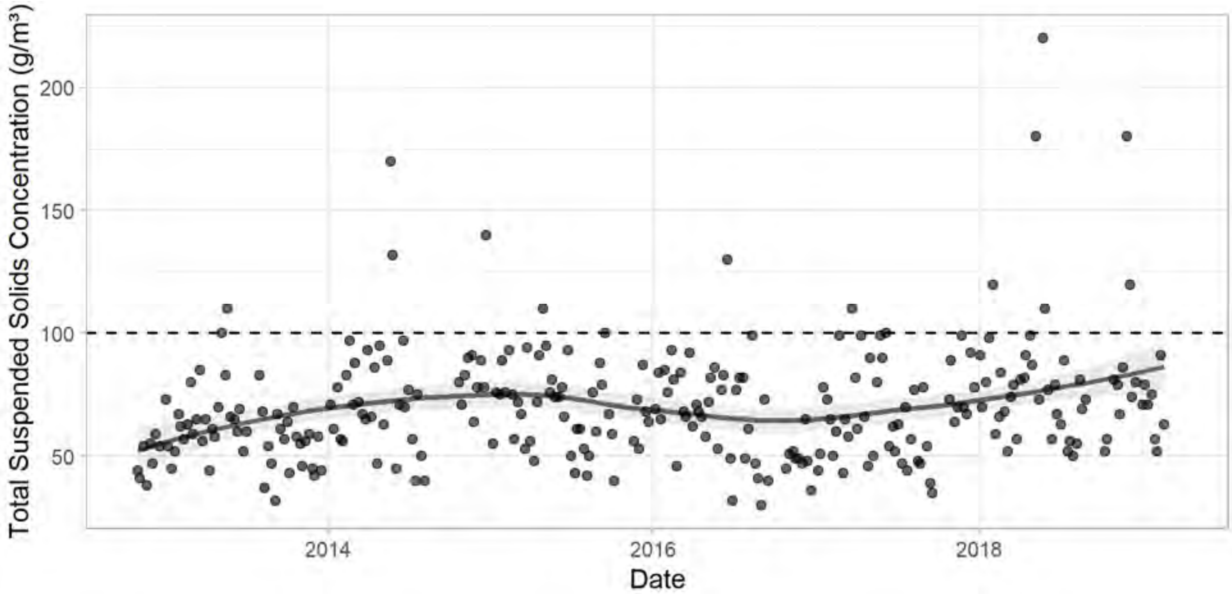

Figure 7: Total suspended solids concentrations measured in the discharge from November 2012 to March 2019. The dashed horizontal line shows the discharge concentration limit of "consistently maintained at <100 g/m^3" and the fit through the data is a Loess fit with the shaded area showing the 95% confidence interval of the fit.

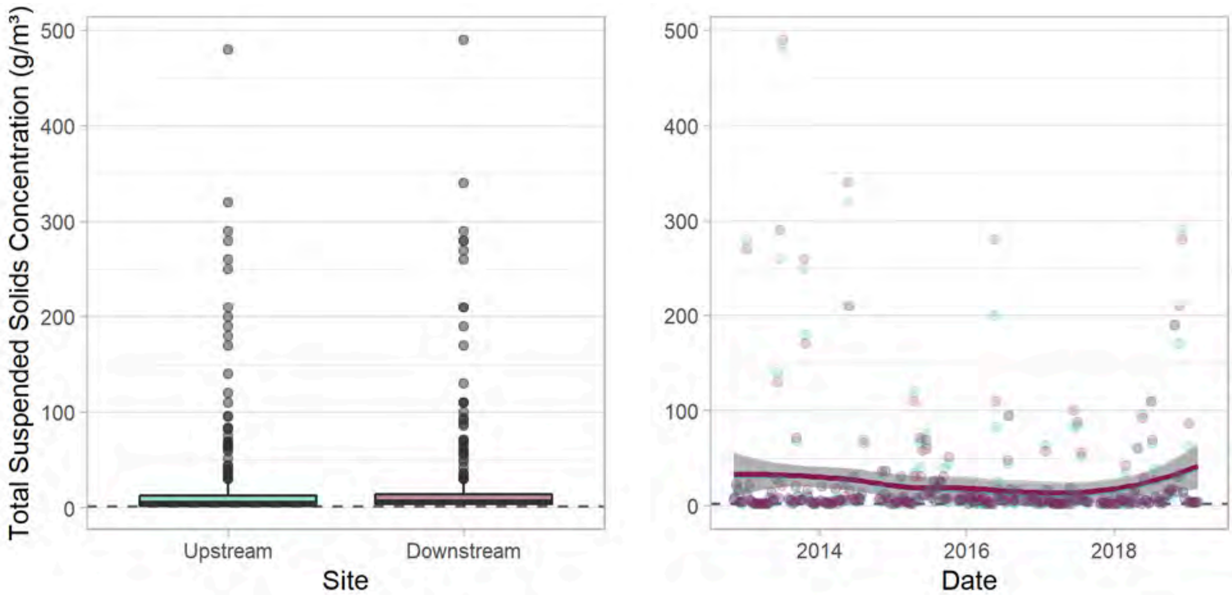

Figure 8: Boxplot and scatterplot of total suspended solids data collected between November 2012 and March 2019 upstream and downstream of the discharge. The range of the boxes (interquartile range) shows the extent of the lower and upper quartiles of the data and the horizontal line, the median. Black circles above the boxes show results that are greater than 1.5 times the interquartile range. The fit through the data of the scatterplot is a loess fit. The dashed horizontal line in both plots shows the ANZG (2018) ecosystem health guideline value for rivers classified as Cool Dry Hill (1.6 g/m^3).

2.7 Temperature and dissolved oxygen

The following assessment of the effects of the discharge on temperature and dissolved oxygen are from the consent monitoring conducted between 2012 and 2019 and from high-frequency measurements made upstream and downstream of the discharge between 25 January 2019 and 19 March 2019. The high-frequency data were not available for the Freshwater Solutions report (p. ii).

Overall, the discharge does not appear to have any significant adverse effects on water temperature and dissolved oxygen.

2.7.1 Temperature

In the high-frequency dataset, the temperature downstream is on average 1.3 °C higher than the temperature upstream (Figure 9).[30] This is approximately a 1% increase in water temperature. When assessing the longer-term dataset, there is no statistically significant difference between the upstream and downstream water temperatures (Figure 10).[31]

The Mataura Falls potentially cools the river water due to the mixing and aerosolization of water; therefore, the temperature increase from beneath the falls to downstream of the discharge may be greater than 1.3 °C on average. This would require further targeted sampling to confirm. Regardless, the effect of the discharge on the water temperature of the Mataura River appears to be very low.

The PSWLP states that, when the "*temperature is above 16°C, the natural or existing water temperature shall not be exceeded by more than 1°C as a result of any discharge.*" When the upstream water temperature was above 16 °C, the average temperature downstream of the discharge was only increased by 0.1 °C. This is compliant with the PSWLP.

[30] Upstream mean = 15.8 °C; downstream mean = 16.1 °C; paired sample t-test; $t = 7.84$, $p < 0.001$.

[31] Upstream mean = 11.2 °C; downstream mean = 11.2 °C; paired sample t-test; $t = 0.09$, $p = 0.93$.

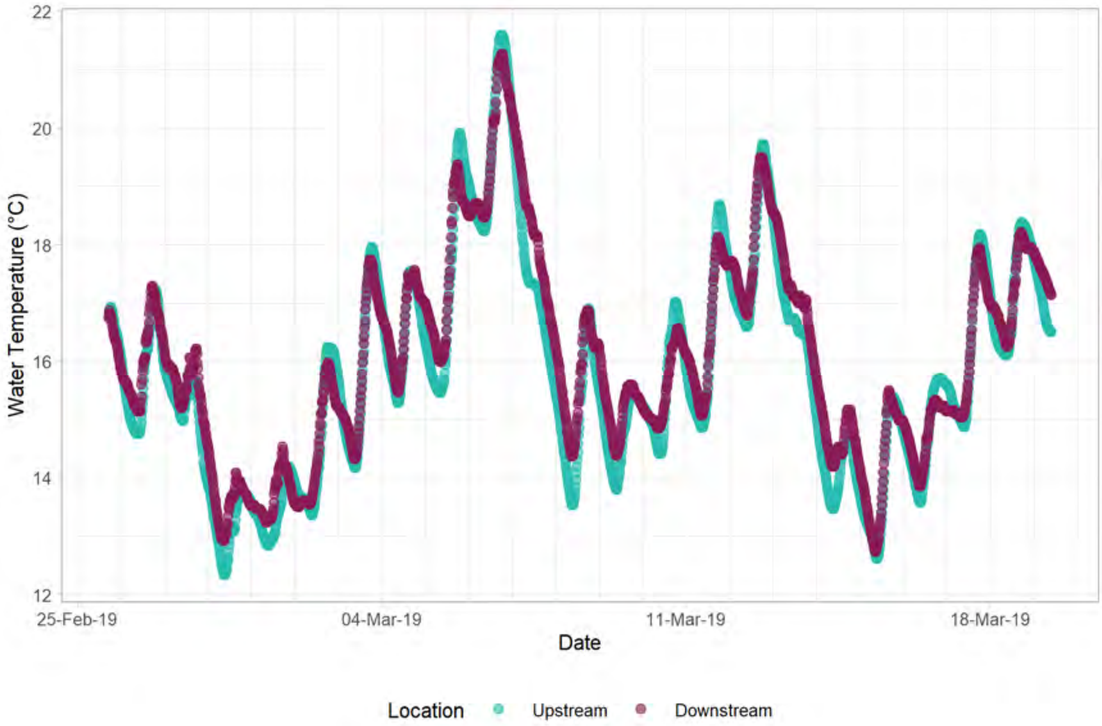

Figure 9: High-frequency water temperature measurements upstream and downstream of the discharge

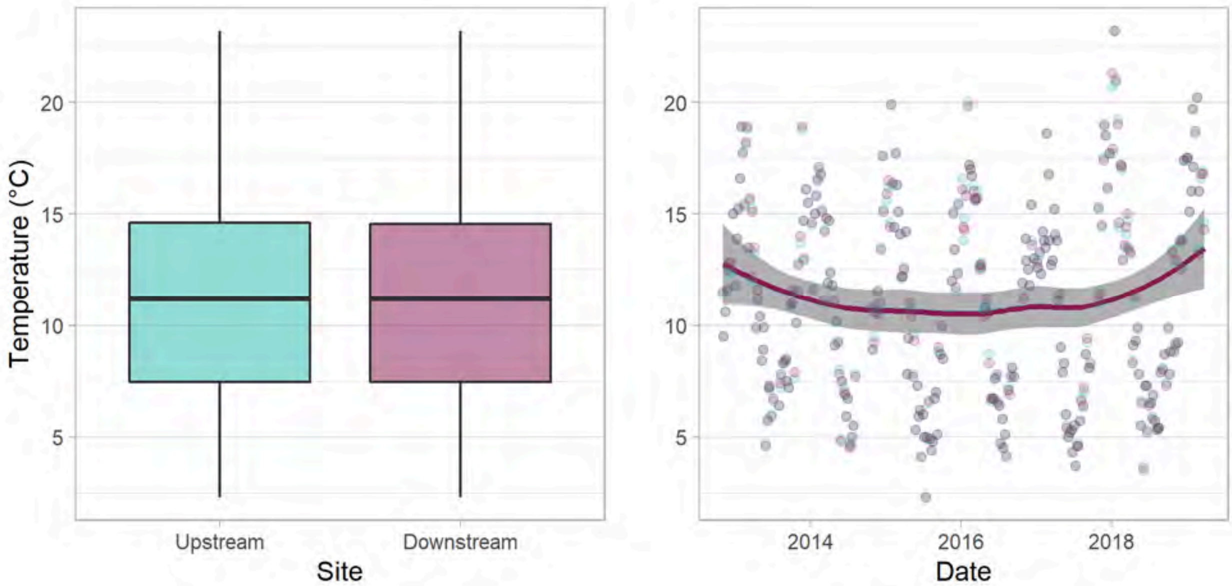

Figure 10: Boxplot and scatterplot of temperature data collected between November 2012 and March 2019 upstream and downstream of the discharge. The range of the boxes (interquartile range) shows the extent of the lower and upper quartiles of the data and the horizontal line, the median. Black circles above the boxes show results that are greater than 1.5 times the interquartile range. The fit through the data of the scatterplot is a loess fit.

2.7.2 Dissolved oxygen

Dissolved oxygen concentrations downstream of the discharge were statistically significantly lower than they were upstream by 0.75 mg/L on average (Figure 11).[32] This is approximately a 7% decrease in dissolved oxygen but the concentration is still compliant with the PSWLP water quality standard (>5 mg/L).

Furthermore, the Mataura Falls likely increases the dissolved oxygen concentration in the water. In a similar manner to temperature, above, there is a possibility that the oxygen concentration is higher after the falls than at the upstream monitoring site. As a result, the effect of the Plant's discharge on dissolved oxygen concentration may be greater than this monitoring indicates.

Dissolved oxygen concentrations upstream and downstream of the Plant are typically within the PSWLP water quality standards. On the occasions that downstream concentrations were <5 mg/L, upstream concentrations were similarly low. We conclude that the effect of the discharge on dissolved oxygen is low, which is in agreement with the AEE.

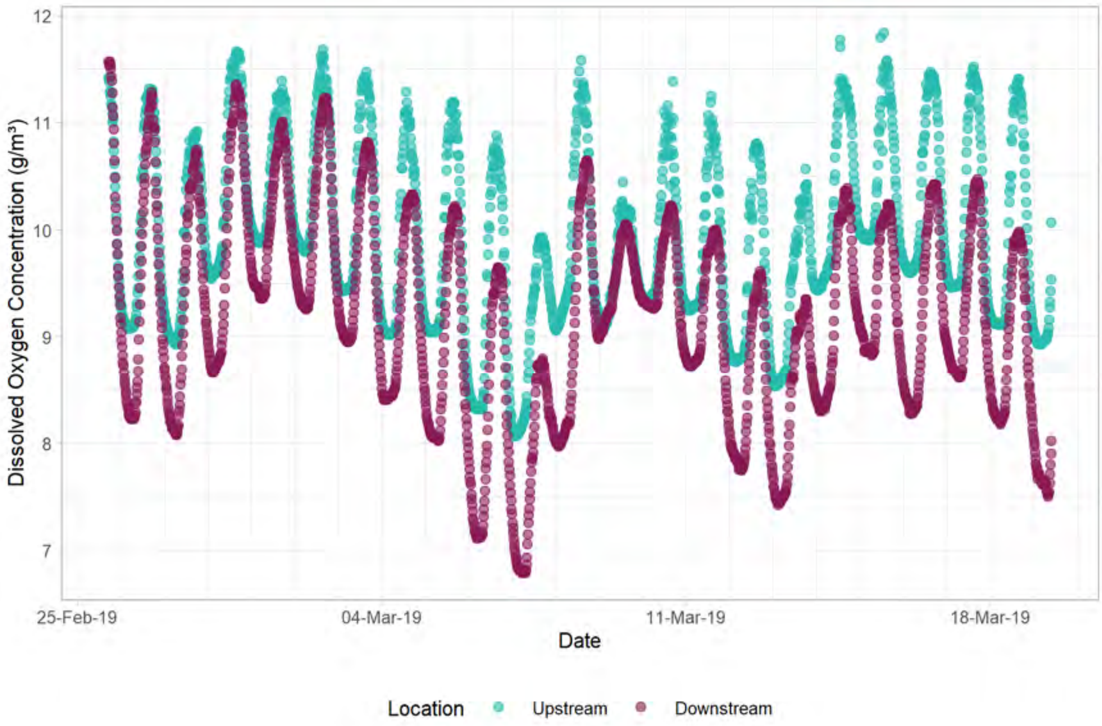

Figure 11: High-frequency dissolved oxygen measurements made upstream and downstream of the discharge.

2.8 pH

The pH of the Mataura River is affected by the wastewater discharge from the Plant. There is a statistically significant decrease from a mean pH upstream of 7.39 to a mean pH downstream of 7.45 (i.e., more basic / less acidic; Figure 12).[33] The decrease in pH downstream of the Plant's discharge means that a greater proportion of the samples are within the ANZG (2018) pH range for ecosystem health.[34] In this regard, the discharge provides a slight improvement in the water quality of the Mataura River.

[32] Upstream mean = 9.19 mg/L; downstream mean = 9.94 mg/L; paired sample t-test; $t = 86.35$, $p < 0.001$.

[33] Paired sample t-test; $t = 13.74$; $p < 0.001$.

[34] 80th percentile = 7.7; 20th percentile = 7.31.

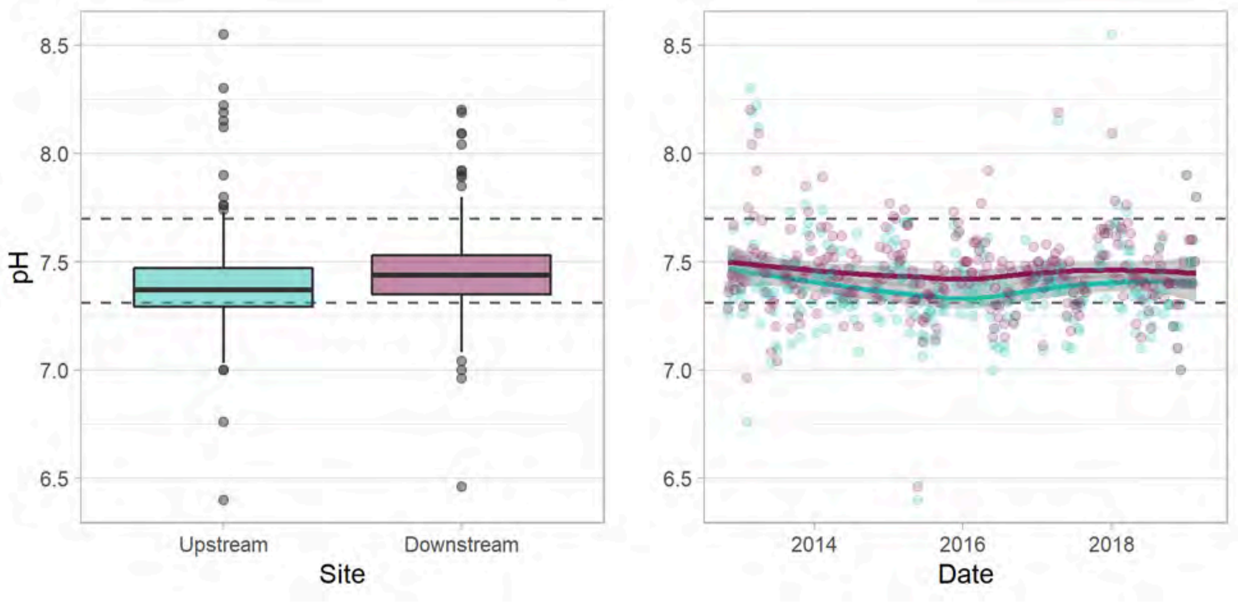

Figure 12: Boxplot and scatterplot of pH data collected between November 2012 and March 2019 upstream and downstream of the discharge. The range of the boxes (interquartile range) shows the extent of the lower and upper quartiles of the data and the horizontal line, the median. Black circles above the boxes show results that are greater than 1.5 times the interquartile range. The fit through the data of the scatterplot is a loess fit. The dashed horizontal lines in both plots show the upper and lower ANZG (2018) ecosystem health guideline value for rivers classified as Cool Dry Hill.

3 ECOLOGICAL EFFECTS

The key potential biological effects associated with the Mataura Plant abstraction and discharges are identified in the AEE and associated Freshwater Solutions report as:

- Potential entrainment of freshwater fish into pump intakes;
- Proliferation of nuisance algal growths;
- Reduced benthic invertebrate community health; and
- Reduced fish abundance, diversity and health.

Of the 18 pumps, 11 are located within the hydro-race and are currently screened with an aperture size of 5–6 mm. The remaining pumps are located within a channel between the hydro-race and the plant and are screened with a passive screen with a 1.5 mm bar spacing. Due to high water velocity through the race and across the screen faces, the potential for entrainment of small fish is considered to be low. Nevertheless, the applicant is proposing to replace the 5–6 mm screens with 2–3 mm screens to further reduce the risk of entrainment. The reduction in intake screen size for all pump intakes is supported because it is in line with currently available best practice guidelines[35].

The Mataura River is characterised in the main AEE as "having long periods of low flow interspersed with high magnitude but low frequency flood events"[36]. Surveys of periphyton cover above and below the discharge from 2012–2019 returned no indication of significant increases in algal growth or cover as a result of the discharge. Periphyton biomass and chlorophyll-a concentrations have been variable over time with no clear patterns between upstream and downstream levels. The analysis in the applicant's ecology report determined that algal communities in the river surrounding the discharge were predominantly reflective of the length of the accrual period, and during periods of stable low flows can reach levels at all sites that are likely to have an adverse effect on benthic invertebrate

[35] NIWA (2007). Fish screening: good practice guidelines for Canterbury. NIWA client report: CHC2007-092. October 2007.

[36] Main AEE. Section 3.2.3, page 10

communities. Where increases in algal biomass can be attributed to the discharge, they were in the period prior to the end of sheep and lamb processing.

Analysis of benthic macroinvertebrate indices from sites above and below the discharge between 2012–2019 found communities reflective of the catchment-wide inputs to the river. Benthic communities at all sites were in 'fair' to 'poor' health, with no clear evidence that the discharge was adversely impacting community diversity within the river. Most recent results indicated a reduced abundance of the mayfly *Deleatidium* below the discharge, despite a general increase in *Deleatidium* abundance that occurred since the processing of sheep and lamb ceased at the Plant. That decline in *Deleatidium*, a taxon sensitive to ammonia and other water quality reductions, below and ultimately above the discharge was attributed to elevated river temperatures and excessive algal growth in the river following a long period of low flow, high-stress conditions. Interestingly, the impacts of these conditions were observed below the discharge before also being observed above the discharge. This may indicate that effects of some chemical stressors, such as elevated ammonia concentrations, resulting from the discharge may at times be exacerbated or expressed during such conditions.

The Mataura River below the Plant to the Toetoe Estuary provides habitat for a diverse range of native fish as well as exotic sports fish including trout and salmon. The Mataura Falls near the Plant are a natural barrier for the upstream movement of some fish species. One fish survey was undertaken in the period between 2012 and 2019, completed in late February 2019. The survey was undertaken using electric fishing and fyke nets, which is in line with standard assessment methods, although there is little further detail of methodology in the Freshwater Solutions report. The area of run and riffle habitat fished at each site was provided and fyke nets appeared to target pool habitats where larger eels are more likely, predominantly downstream of the discharge. That survey determined that a limited range of fish species were recorded from the river surrounding the Plant, the most common being shortfin eel and upland bully. Elvers (juvenile eels) were recorded upstream of the discharge and weir, indicating ongoing recruitment. No indicators of a direct impact of the discharge on freshwater fish or fish health were evident from the single survey undertaken, however further surveys would be required to determine any long-term trends.

Chemical contaminants such as ammonia can have toxic effects for freshwater fish. While concentrations outside the mixing zone were within the range unlikely to result in toxic effects for aquatic biota, there may be localised areas of elevated concentrations within the mixing zone and this was acknowledged in the Freshwater Solutions report[37]. It is accepted that such areas would be localised, likely constrained to the western (true right) bank around the discharge prior to full mixing and are unlikely to limit fish migration through the area.

Ammonia concentrations are notably elevated below the Plant as a result of the discharge and, in conjunction with other nutrients, contribute to the cumulative effects on the wider Mataura River and Toetoes Estuary. The elevated ammonia concentrations are recognised in the AEE as an effect of the discharge. The AEE also notes that improvements in water quality will be required in the Mataura catchment under the NPSFM and the installation of a biological treatment system would significantly reduce ammonia and nitrogen outputs from the Plant. Nonetheless, the application recognises no urgency to reduce ammonia or other nutrient concentrations to the river, instead proposing to implement any Plant upgrade within 15 years of any granted consent commencing. This extended timeframe appears at odds with the objectives of the NPSFM and the operative and proposed regional plans to improve water quality and biodiversity values, including those associated with ecologically significant and interconnected waterways and estuaries.

4 REVIEW OF WEIR APPLICATION

The resource consent applications for the Mataura Weir ('**the weir**') include:

- Land use consent – To use an existing weir and hydro race structure to dam and divert water.
- Water Permit – To dam and divert water using an existing weir and hydro race structure.

[37] Freshwater Solutions report, page 26

The application, with a proposed 35-year term, is supported by an AEE (‘**the weir AEE**’). The application also refers to information provided in the AEE supporting the water take and wastewater discharge application (for consistency labelled as ‘**the main AEE**’).

The application provides little information on the weir, other than that it is u-shaped and believed to have been constructed in the 1920s or 1930s. The weir dams and diverts water into a channel along the true right (western) bank of the Mataura River. The channel is known as the ‘**hydro race**’. The Alliance Mataura Plant water intakes and hydro scheme turbine operates within this race. A similar race and associated hydro scheme are present on the true left (eastern) bank of the river but is understood to be currently non-operational. That scheme is operated by Mataura Industrial Estate (**MIE**) under a separate set of consents.

Neither the weir AEE nor the main AEE provide detail on the features of the weir. No information on the weir height, shape, face slope or materials is provided in either application. No information on how the design maintains flow over the weir, particularly during periods of low flow, is provided. Aerial photographs indicate that each ‘arm’ of the weir following the hydro races diverts river flows over a length of approximately 400 m. The volume of water overtopping the weir to follow the ‘original’ river alignment versus that diverted into the Alliance hydro race, or the MIE race is not clear, however, the main AEE indicates the Alliance hydro-race conveys 6–10 m^3/s. As such, there is no context to, or potential discussion on, the potential effects of the weir on the river through that section, including flow changes that may have impacted fish passage through the falls and bedrock sections of the river between the hydro-races.

The weir AEE provides a high-level description of the river below the weir only, including the bedrock dominated substrate and the presence of the Mataura Falls within this reach. The Freshwater Solutions report (Appendix 2 of the main AEE) provides a slightly more detailed description of the river through this zone. The area is described in that report as a shallow, bedrock dominated substrate, with a main channel constrained to the centre of the river at low flows. At high flows, the weir is overtopped across a wider area and the entire bedrock channel is covered with swiftly flowing water. Freshwater fish species known to surmount these falls include migratory native species (longfin and shortfin eels, lamprey and koaro). The exotic brown trout is also present within and surrounding this part of the river. Trout migrate within the river system at times.

The weir application notes that the use of the weir to dam and divert the river water to the hydro race facilitates the positive social and economic effects generated by the meatworks. However, the application provides no assessment or discussion of any alternative options or means of diverting flow that have been considered, such as a reduced or remodelled weir structure. This lack of consideration of alternatives was also raised by Aukaha in the Cultural Impact Assessment[38].

Potential effects on the upstream and downstream migration of fish are considered in the weir AEE. The weir is recognised as a fish barrier, in addition to the natural barrier created by the Mataura Falls that are a short distance below the weir. The weir AEE refers to the requirements of an existing resource consent associated with the hydro scheme and weir (AUTH.20171566-01) for an Elver Trap and Transfer Plan to be implemented, and for a fish ladder to be maintained, to assist in the upstream migration of fish. That consent will expire in November 2026, however, as part of the weir applications, the weir AEE indicates that Alliance is proposing to continue the same requirements.

No information on the fish ladder is provided in the weir AEE and application material, however, other available information[39] indicates it is intended to provide upstream passage for salmonid species. No comment on the ability of the fish ladder to provide passage for native fish species is provided in the application.

The trap and transfer system is designed to facilitate the upstream passage of juvenile eels or elvers, to maintain and enhance the upstream passage of elvers over the Mataura Falls and weir structure. Effects on lamprey (kanakana) are not discussed in the application. These, along with eels, are considered taonga and important mahinga kai species by mana whenua. There appears to be no assessment of effects of the weir structure on these fish, which seasonally

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[38] Aukaha (2019) Alliance – Mataura Plant – Cultural Impact Assessment. Instream Structures and Water Permits. 19 September 2019. (Attachment 3 of s 92 response dated 30 September 2019).

[39] Environment Southland. Report and Decision of Independent Hearings Commissioner Hearing held in the Council Chambers, Environment Southland, Invercargill on 3 December 2018. Independent Hearings Commissioner Dr Rob Lieffering decision on hydro scheme operation, Application No. APP-20171566.

migrate from the sea as adults to breed. While they have excellent ability to traverse obstacles, features of artificial structures, such as sharp edges or 'lips', can limit success. The application provides no comment on the features of the weir structures, nor any assessment of potential impacts on lamprey migration, or other fish that can surpass many natural barriers, such as koaro. The downstream migration of juvenile lamprey and adult migratory eels is being considered by the monitoring programme required under the hydroelectric turbine resource consent AUTH.20171566-01.[40]

The effects of the weir cannot be fully assessed based on the information provided. Further information on the following is requested to inform the assessment:

- Detail of any alternative options or means of diverting flow that have been considered, such as a reduced or remodelled weir structure.
- Detail of the features of the weir structure, including height, shape and face, and the means of maintaining flow over the weir face, particularly during low flows. Detail of the proportion of flows overtopping the weir in comparison to that discharged to the hydro race.
- Effects of the weir on the migration of native fish other than eels, particularly lamprey and koaro, and any mitigating measures proposed to alleviate any adverse effects on those species.
- Detail of the fish ladder design and installation, including any benefits for fish other than trout.

5 SUMMARY AND RECOMMENDATIONS

This section presents a summary of the findings from our assessment and our recommendations.

E. coli

- Current *E. coli* concentrations in the discharge are having significant adverse effects on the water quality of the Mataura River. *E. coli* levels frequently exceed the PSWLP limits at the popular swimming location 300 m downstream at the Mataura River Bridge. This is a combination of elevated levels of *E. coli* in the water upstream of the Plant and highly elevated levels downstream because of the discharge.
- UV treatment, or similar, is highly recommended to reduce the levels of *E. coli* in the discharge. This should decrease the concentration of *E. coli* downstream of the Plant to be close to ambient/upstream concentrations.
- It is recommended that *E. coli* is included in the weekly water quality sampling upstream and downstream of the discharge. The upper detection limit for *E. coli* measurements should be >100,000 CFU/100 mL to avoid underestimating *E. coli* concentrations.

Nutrients

- The discharge has a very small effect on the concentrations of nitrate in the Mataura River after mixing.
- The discharge substantially increases the concentration of ammonia in the Mataura River downstream of the discharge. Although ammonia concentrations below the mixing zone are below the toxicity limit, improved treatment is recommended to reduce downstream ammonia concentrations to be closer to ambient/upstream concentrations.

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[40] Review of the decision surrounding the damming and diversion of the river for use in the hydroelectric turbine (AUTH.20171566-01 and AUTH.20171566-02) indicate that a shortened consent period was applied in order to bring the end date in line with the lapse date associated with the adjacent MIE diversion and hydro turbine. The reason for this was, largely, in relation to the uncertainty surrounding potential effects of the diversion of flows through the turbines on downstream migratory fish, including adult eels and juvenile lamprey. The commissioner considered the time period appropriate to enable both consent holders (Alliance and MIE) to collect information on effects of the weir and hydro schemes on downstream fish migration. The outcomes of that assessment may impact reconsenting of the hydro scheme and/or result in changes to the race and intake setup, including options such as screening of the intakes, or modifications to the weir.

This application attempts to separate the operation and use of the weir for the diversion of water to the hydro race for water takes (abstraction) from the diversion of water, using the same weir and hydro race, through the hydroelectricity turbine. It is difficult to see how they can reasonably be separated in that way, as the system is clearly linked. The overall use of the weir and hydro races may better be considered in conjunction with the hydro scheme during reconsenting prior to the 2026 lapse date for the two hydro schemes.

- The Toetoes Estuary is approximately 60 km downstream from the Plant and it is a Ramsar site. The discharge from the Plant contributes around 1–2% of the total nitrogen and phosphorus load from the catchment to the Toetoes Estuary (1.1–1.7% TN; 0.7–1.1% TP). Considering the known elevated nutrient levels in the catchment, this is a substantial nutrient load. Installation of the biological treatment system is recommended in order to reduce nutrient loading to the Mataura River and Toetoes Estuary, specifically with regard to nitrogen. The Toetoes estuary is in a "moderate" but declining condition in relation to eutrophication due to excessive nutrient inputs.

TSS and oil and grease

- TSS concentrations in the discharge have shown an increasing trend. At its current rate, the median TSS concentration will exceed the current consent limit of 100 g/m^3 by 2031. The biological treatment system is estimated to reduce TSS concentrations by an order of magnitude, which is likely to reduce TSS concentrations closer to ambient/upstream concentrations.
- The concentrations of oil and grease in the discharge fall within the range of 'substantially free'.

Temperature and dissolved oxygen

- The discharge does not appear to have any significant adverse effect on water temperature and dissolved oxygen, although effects may be somewhat mitigated by the cooling and aerating effects of the Mataura Falls.

pH

- The discharge is slightly more acidic than the water in the Mataura River. The subsequent (small) decrease in pH downstream of the Plant's discharge means that a greater proportion of the samples are within the ANZG (2018) pH range for ecosystem health. In this regard, the discharge provides a slight improvement in the water quality of the Mataura River.

Ecology

- No notable adverse effects of the discharge on biological communities were recorded, other than localised, short-term impacts on macroinvertebrate communities during periods of low, stable flow and high periphyton accrual.
- While ammonia concentrations outside the mixing zone were within the range unlikely to result in toxic effects for aquatic biota, there may be localised areas of elevated concentrations within the mixing zone that may impact fish and macroinvertebrate communities. The proposed treatment upgrade will significantly lower ammonia concentrations in the discharge and reduce the potential for adverse effects on biota.
- Proposed screening of water intakes to a mesh size of 2–3 mm is in line with best practice and is supported, to minimise the risk of entrainment of fish.

Timeframes for wastewater treatment improvements

- Given the national and regional objectives to improve water quality, the proposed 15-year timeframe proposed for the treatment plant upgrade should be reviewed and reduced to achieve the benefits proposed in a timelier manner.

7B:

Technical Review- Mataura Processign Plant resource Consent Applications- Wastewater Assessment, 4Sight Consulting, June 2020 (4Sight Wastewater Review);

4SIGHT CONSULTING

LAND. PEOPLE. WATER.

TECHNICAL REVIEW – MATAURA PROCESSING PLANT RESOURCE CONSENT APPLICATIONS

For Environment Southland

Wastewater Assessment

June 2020

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

REPORT INFORMATION AND QUALITY CONTROL

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1 INTRODUCTION

Alliance owns and operates a Meat Processing Plant ('the Plant') on the riverbank of the Mataura River in the Mataura township, which is approximately 44 km upstream from the Toetoes Estuary.

Alliance is applying for resource consents with a consent term of 35 years for the Plant for the following activities:

- Discharge up to 8,000 m^3 per day of treated meat works wastewater into the Mataura River;
- Discharge of condenser cooling water into the Mataura River;
- Take up to 21,200 m^3 water per day from the Mataura River for cooling water.
- Take up to 8,000 m^3 water per day from the Mataura River for meat processing and truck washing; and
- Use an existing weir and hydro race structure to dam and divert water.[1]

The purpose of this report is to review the wastewater treatment aspects of the proposal in light of the proposed disposal option, as presented in the Assessment of Environmental Effects (AEE) and supporting reports, specifically the Pattle Delamore Partners (PDP) report titled *Mataura Plant Wastewater Treatment and Disposal Alternatives Assessment*, dated 2019 (hereby referred to as the PDP report).

In undertaking this review, I have also considered 4Sight's technical review of ecology and water quality aspects associated with the proposed discharge.[2]

2 SCOPE OF REVIEW

In terms of the wastewater treatment and disposal aspects of the application being considered by this review, the existing situation is summarised below:

- There are two waste streams generated onsite[3]
  - Green waste stream from stock yards, gut cutting and tripe processing; and
  - Non-green waste stream from the slaughterhouse floor, further processing, and hide wash overflow.
- The treatment system is comprised of preliminary treatment (screening), primary treatment (settling) and physio-chemical treatment via a dissolved air floatation (DAF) system.
- Discharge of the treated wastewater to the Mataura River.

It is worth noting here, that the AEE states that "*treated wastewater is discharged through two 200 mm diameter pipes that exit the Plant approximately 100 m below the hydro race discharge and drop approximately 10 m to the riverbed."*[4] However the discharge monitoring results only seem to be taken from one location. This should be clarified to ensure that the assessment of environmental effects is taking into account the full discharge.

The existing discharge consent provides for a maximum daily discharge of 14,400 m^3 per day. The application seeks to renew the wastewater discharge consent for a term of 35 years, reduce the maximum daily discharge to 8,000m^3 per day, and to undertake a staged upgrade as follows:

- Year 1 to 3 – implementation of water reduction initiatives and addressing existing resilience issues.
- Within 5 years – implementation of an Ultraviolet Disinfection System (UV) to reduce microbial contaminants.
- Within 15 years – implementation of biological treatment to reduce nutrient and BOD loading.

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[1] Resource consents for land and water permits for this activity were applied for under a separate application to the others titled 'Use of Mataura River weir to dam and divert water'.

[2] Wilson, P., Bennett, K. (2020). Technical Review – Mataura Processing Plant Resource Consent Applications: Ecology and Water Quality. 4Sight Technical Report prepared for Environment Southland.

[3] Domestic waste is discharged directly to the local authority sewerage network and therefore is not considered within the application.

[4] AEE Section 4.4.1

The proposed wastewater management approach is based on the assumption (as set out in the AEE) that the existing effects of the discharge on the receiving environment do not trigger the need for immediate or urgent mitigation[5]. It should be noted that this has been based on an assessment of the actual volume being discharged which is substantiality less than the maximum allowable discharge.

However, based on 4Sight's technical review of the ecological and water quality effects of the discharge on the receiving environment, *Escherichia coli (E. coli)* concentrations in the existing discharge are having significant adverse effects on the water quality of the Mataura River. Furthermore the report concludes that the river is also degraded from a nutrient perspective, and given the national and regional objectives to improve water quality, it is recommended that the 15-year timeframe proposed for the treatment plant upgrade to address nutrient and BOD loading (and *E. Coli*) be reviewed and reduced to achieve the benefits proposed in a more timely manner.

3 WASTEWATER FLOWS AND LOADS

This section reviews and discusses PDP's assessment of flows and contaminant loads from which the basis of design for the proposed options was prepared.

In undertaking their assessment, PDP carried out a water survey in January 2019. A number of process flows (including separate green and non-green waste streams) were measured, and a site observation and walk through was conducted. Water saving measures were assessed, and the potential to implement white-water recycling within the DAF was identified as the only major water saving opportunity.

The report points out that most moderns DAF treatment systems utilise recycled treated water for generation of the white-water (rather than using potable or similar clean water), and this could achieve approximately 35% reduction in water use. However, as acknowledged by PDP this does have the consequential effect of increasing the contaminant load by reducing the dilution afforded by the introduction of clean water to the waste stream. The options assessment and design has been undertaken on the assumption that this will be implemented as part of the staged upgrade.

No further comment regarding the potential for further water savings can be made without carrying out an independent site assessment. Therefore, PDPs assessment has been assumed to be fundamentally sound.

3.1 Basis of Flow Design

PDP have based their preliminary design for the upgrade options, on flows estimated from their 2019 water usage survey, estimated processing days, and a 35% reduction in discharge flow due to no white-water contribution.

I have undertaken a brief validation of the flows estimated by PDP by comparing them against the actual daily flow data and processing days from Alliance records for the plant from 2017 and 2018 (with a corresponding reduction for no white-water contribution). This is shown below in Table 1:

[5] AEE Section XYZ

Table 1 Comparison of processing days and actual flow data with PDP estimate

	2017 flow data			2018 flow data			PDP estimates 2019[6]	
	Processing Days	**Discharge Flow (m³)**	**Calculated Flow (m³)**	**Processing Days**	**Discharge Flow (m³)**	**Calculated Flow (m³)**	**Estimated Processing Days**	**Estimated Discharge Flow (m³)**
Monthly	23.4 (average)	83,562 (total)	54,315 (reduced by 35%)	23.9 (average)	91,064 (total)	59,191 (reduced by 35%)	15	55,759
Annual	**281**	1,002,751	**651,788**	**287**	1,085,369	**710,299**	**191**[7]	**669,136**

As can be seen, the PDP processing days (191) have been estimated as being less than the actual processing days in 2017 and 2018 (281 to 287 respectively), while the AEE[8] states that stock numbers and therefore processing days will remain around the levels shown in 2017 and 2018.

However, despite the large discrepancy in processing days, the PDP annual estimated discharge flow (669,109 m^3) was within the range of the actual flows (651,788 m^3 to 710,299 m^3) for the two-year period, taking into account a reduction of 35% for white-water recycling. Therefore, for the purpose of this report, the design flow is considered appropriate.

It should be noted that based on the raw data for 2018 the maximum daily discharge was 7,475 m^3, the average daily flow was 3,782 m^3, and annual flow was 1,085,369 m^3.[9] However, the application proposes to discharge up to 8,000 m^3 per day, which could theoretically equate to a maximum annual discharge of 2,920,000 m^3. As the AEE is based on data resulting from an annual discharge flow in the order of 1,100,000 m^3, a lower monthly average and annual limit is recommended. For example:[10]

- to discharge up to 8,000 m^3 per day.
- to discharge up to 100,000 m^3 per month prior to any white-water recycling being implemented.
- to discharge up to 75,000 m^3 per month post white-water recycling.
- to discharge up to 1,100,00 m^3 per year prior to any white-water recycling being implemented.
- to discharge up to 815,000m^3 per year post white-water recycling.

However, it should be reiterated that 4Sight's technical review of the ecological and water quality effects of the discharge on the receiving environment conclude that even at these discharge flows there are adverse effects on the receiving environment and that further treatment should be required.

Furthermore, it may be worth Alliance/PDP revisiting these calculations (during detailed design) to understand whether the discrepancy in processing days and flow assumptions affect the future treatment options, although it does not fundamentally change the approach proposed or affect the feasibility of the options proposed.

[6] Based on Table 4 Monthly Discharged Flow and Load Distribution of the PDP report

[7] This number is taken from the PDP report and is thought to be a typing error as based on the estimated days, should add up to 195.

[8] AEE - section 9.3.2.2

[9] Discharge Volume Data AEE1 (2012 to 2019)

[10] Based on 2018 flow data and rounded for convivence

3.2 Contaminant Loads

3.2.1 Waste Streams

There are two waste streams of approximate equal volume,[11] generated onsite that are treated separately due to their different contaminant loads:

- Green waste stream from stock yards, gut cutting and tripe processing, which is reported to have a higher Phosphorus load and, from the data, also contributes 80% of the total ammoniacal-nitrogen (Amm-N), 60% Total Kjeldahl Nitrogen (TKN) and 50% Biological Oxygen Demand (BOD).
- Non-green waste stream from the slaughterhouse floor, further processing, and hide wash overflow.

The treatment process is represented in the figure below:[12]

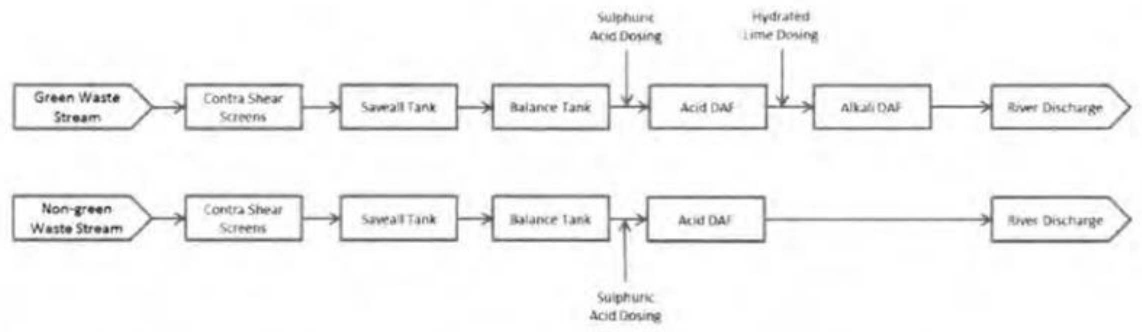

Figure 1 Existing Wastewater Treatment Process for the Two Waste Streams

3.2.2 Contaminants of Concern

PDP's report assessed *E. coli*, Amm-N, Total Nitrogen (TN) and Total Phosphorous (TP) as the contaminants of concern along with the organic load, which I consider appropriate.

However, as discussed earlier, the PDP and subsequent application, is based on the conclusion that "*no adverse effects of the Alliance Mataura discharge, requiring immediate or urgent mitigation have been identified with respect to the above parameters (Freshwater Solutions 2019).*"[13] PDP do recognise that the planning framework anticipates a long-term catchment wide improvement in water quality and that if a longer term application is sought that it will be necessary to show how the plant will be managed to progressively improve the quality of the discharge.

In the upgrade options assessment, TP was not considered as a key contaminant that is required to be further reduced, as a significant percentage (in the order of >90% dissolved reactive phosphorus (DRP) removal) of the load produced is already removed by the existing process. PDP, therefore, did not propose the addition of chemical precipitation to achieve this. Therefore, the options have focused on reducing *E. coli*, Amm-N, Total Nitrogen (TN) and the organic load.

4Sight's technical review of ecology and water quality aspects associated with the discharge confirmed that current E. coli concentrations in the discharge are in fact having significant adverse effects on the water quality of the Mataura River, primarily due to the popular swimming location 300 m downstream of the discharge. It was also concluded that

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[11] Table 2 Current Treated Wastewater Flows and Concentrations, PDP 2019

[12] Figure 1; Existing Wastewater Treatment Process, PDP 2019

[13] Section 1 Introduction, PDP 2019

while the discharge has a very small effect on the concentrations of nitrate in the river after mixing, it substantially increases the concentration of ammonia downstream.

Therefore, it is agreed that although reductions in phosphorus and DRP would be beneficial to improve water quality and overall ecosystem health and should therefore be supported, the reduction of *E. coli* and nitrogen are a higher priority over phosphorus.

New Zealand does not have specific regulation for discharge limits for the meat processing industry. Based on 4Sight's findings, it is recommended that if discharge to the river is to continue full biological treatment before disposal be implemented and the timeframe proposed to upgrade be reviewed and reduced to achieve the benefits proposed in a more timely manner.

3.2.3 Increase in Contaminant Load Concentrations due to White-water Recycling

For the options assessment, PDP have assumed that white-water recycling will be implemented, and that this will not change the contaminant load, but the wastewater concentrations post DAF will increase.

As discussed earlier, this involves recycling treated wastewater for use in the DAF treatment process rather than using a potable (or similar clean) water supply. While the base contaminant load does not change, the concentration increases due to the removal of the dilution afforded by the introduction of "clean water" to the waste stream.

It should be also noted that it is assumed that the existing white-water supply comes from the water abstracted from the river, and it is unclear whether this is treated prior to use within the process. If it is, and depending on the treatment process, this could introduce other contaminants of concern that have been not considered (i.e. chorine).

PDP have considered the implications of increased contaminant load concentrations on the potential treatment options and the relationship with disposal options.

The AEE[14] states that the issue of increased contaminant concentration also needs to be carefully considered to avoid unforeseen adverse toxicity and eutrophication effects within the mixing zone and downstream. It goes on to state that the implementation of white-water recycling may not be able to be realised prior to installation of the biological treatment system to address such concerns.

This is important when considering the approved discharge volume limits, and why it has been recommended that these be set both pre and post any implementation of white-water recycling (ref Section3.1) and that conditions should also be included to limit both contaminant concentration and total load.

4 WASTEWATER MANAGEMENT OPTIONS

4.1 Existing Wastewater Assets

The existing wastewater treatment system is comprised of preliminary treatment (screening), primary treatment (settling) and physio-chemical treatment via a dissolved air floatation (DAF) system, with an extended DAF process for the Green-waste stream. The treatment process is represented in Figure 1.

As discussed in Section 2, the AEE states that the waste streams are discharged via two separate outfalls, however the there is only one set discharge monitoring indicating that they have be taken from one location. This should be clarified to ensure that the assessment of environmental effects is taking into account the full discharge.

PDP carried out an assessment of the resilience of the wastewater treatment plant and associated assets, which determined the treatment plant to be in 'good operational order' overall. However, the following resilience issues were identified by PDP:

14 AEE Section 4.5.2.3

Table 2 Review of resilience issues

Resilience issue	Review comments
Green Waste Cross Contamination	PDP identified there is the potential for overflow of the Green waste stream into the Non-green waste stream. If this occurred, it would mean that the Green waste would receive a lower level of treatment and result in a higher phosphorus concentration in the discharge. Therefore, I agree with PDP's recommendation to modify the system to decrease this risk, which should be actioned as a matter of priority.
Wastewater transfer pipe location	PDP identified the risk of accidental discharge of contaminants to the river is possible due to the location of the pipes running through the hydro scheme water race. I agree the pipes should be relocated immediately to minimise this risk.
Age of Asset	PDP identified that some of the existing DAF treatment process infrastructure is over 40 years old and best practice would be to upgrade or replace this infrastructure. Elsewhere in the PDP report it is also noted that 3 of the 12 DAF units are not currently operational. I agree with the recommendation that upgrade or replacement of the DAF be part of the consideration to improve the overall level of treatment and add that the 3 inoperable DAF units should be remediated.

Resilience measures identified in the PDP report have been assumed to be fundamentally sound based on PDPs professional judgement. It is not possible to further verify the validity of these without a site engineer visiting the site and carry out monitoring and further assessment.

4.2 Review of Wastewater Management Options

PDP were engaged to outline the wastewater treatment methods and technology that could be used in order to reduce the loads of key parameters in the wastewater discharge. 'Practicable' solutions were sought by Alliance that were proportionate to the likely environmental risks from contaminants in the discharge.

PDP developed 16 management options for the Plant, which included the continued discharge to the Mataura River; irrigation to land; a dual discharge option to both land and water; and discharge to the local municipal plants. Those incorporating significant risk and uncertainty, and substantial lifecycle costs were discarded. This resulted in 5 options being considered further, which all involved full or partial river discharge.

Full disposal to land was discarded without significant investigation on the basis of the area of land required and potential operational difficulty particularly during winter months. PDP suggested in their report that the environmental effects of discharging to land may be greater than discharging to the river. I believe this assumption warrants further assessment.

Connection to the either municipal plants (Gore or Mataura) was also discarded, primarily due to uncertainty due to consenting, treatment plant capacity, and future costs. As noted previously, the domestic wastewater from the facility is already connected to a municipal wastewater treatment plant. I feel further detailed explanation of these assumptions is warranted.

All of the shortlisted options include continuation of the use of the existing wastewater treatment system. A review of the short-listed options is provided in Table 3.

Table 3 Review of short-listed options

Short listed Option		Review Comments

1C	Existing river discharge with biological treatment utilising an Activated Sludge (AS) lagoon for BOD, and Nitrogen removal, with disinfection requiring a clarifier and sandfilter, and Ultraviolet (UV) treatment.
	
	NPV $20.5 M
		▪ Of the shortlisted options this provides the highest discharge quality with a significant decrease BOD, Nitrogen (including ammonia) and bacteria as follows:
		  ▫ BOD<20mg/l (92% reduction)
		  ▫ TN<20mg/l (68 % reduction)
		  ▫ *E. coli* 3 – 4 log reduction (95th%ile <1,000 CFU/100ml)
		▪ Has the ability to produce acceptable minimum standards for a river-based discharge.
		▪ UV Trials have been undertaken (i.e. the Alliance Pukeuri UV installation) to prove adequate removal of solids to be effective).
		▪ Lagoons are considered to be a conventional and reliable treatment option, though activated sludge options with a smaller footprint are available which could offset the high pumping costs.
		▪ High sludge management was highlighted as a disadvantage.
		▪ Whilst activated sludge lagoons considered a potentially suitable solution, newer more modern technology combined with efficient practices, have not been considered.
		▪ PDP considered this best practice.

1D	Existing river discharge with sand filter and UV NPV $5.6 M	Not recommended due to: ▪ Insignificant reduction of BOD and TN ▪ *E. coli* 2-3 log reduction (95th %ile <10,000 CFU/100ml) - larger reduction should be sought ▪ UV transmissivity has associated risks and needs further investigation ▪ PDP considered this is not best practice.
1F	Existing river discharge with biological treatment of the green water stream, utilising AS tanks for BOD and Nitrogen removal. With disinfection of both waste streams requiring a clarifier and sand filter, and Ultraviolet (UV) treatment. NPV $16.1 M	▪ Targets a 40 -50% reduction in BOD as compared with 92% option 1C. ▪ Low TN reduction (52%), as it reduces green stream only. ▪ *E. coli* 2-3 log reduction (95th%ile <10,000 CFU/100ml) - larger reduction should be sought. ▪ AS Tanks could be superseded by newer more modern technology combined with efficient practices, have not been considered. ▪ Does not achieve same or better water quality outcomes, compared with Option 1C.
4A/5A	Dual discharge options: 4A Discharge to dairy pasture during drier summer months, with discharge to river during wet summer months and	▪ Both options include no additional (further) treatment prior to river discharge. ▪ PDP estimates the volume discharged to the river will only be 30% of the current annual wastewater volume.

Short listed Option		Review Comments
	winter. No additional treatment is proposed. NPV $14.2M 5A Discharge to cut and carry crop during drier summer months, with discharge to river during wet summer months and winter. No additional treatment is proposed. NPV $24 M	▪ The reduction in contaminant load discharged to the river will be seasonal. ▪ Not discharging to the river during summer, will reduce the risk to recreational users of the Mataura River. However, if the discharge occurs during wet summer periods the benefits may be negligible. ▪ Discharge to the river during winter and wet summer months will likely result in similar concentrations of contaminants to current discharge levels. ▪ Dual discharge options could provide a higher level of resilience in that it introduces a second option for discharge should failure occur. ▪ Needs further work to understand whether: ▫ The benefits of the potential decrease in annual contaminant load that can be achieved could lead to a 'practicable' solution. ▫ The system should be designed to ensure adequate storage or ground conditions are suitable to so that rain does not prevent irrigation and mean discharging to land during summer. ▫ Discharge to the river during the winter months will be appropriate to meet future national and regional water quality objectives. This is discussed further below in section 5.2

The upgrade options were informed by feasibility studies and, where applicable, based on trials. Further assessment or comment regarding the validity of the upgrade options and whether they are achievable is not possible in this report without conducting further investigations. However, given the comprehensiveness of the information, the qualifications, experience and track record of the engineers who made the assessments, and the reputation and professionalism of the consultancy firm that prepared the report, Environment Southland should be able to assume that the preliminary designs presented as options can be relied upon to be accurate and achievable.

The proposed reduction of contaminants in the discharge appear to be within the range of reductions that are possible with the proposed wastewater treatment technology. Further, the proposed contaminant reductions appear to be similar to other wastewater treatment discharges using similar treatment devices.

Furthermore, until detailed design of treatment options and site-specific investigations are undertaken, we suggest that no further benefit would be gained from technically reviewing the process designs proposed. This review therefore focuses on alternative approaches and gaps identified.

4.3 Proposed Wastewater Management Option

From the PDP options assessment, Alliance are proposing to continue discharging to the river and to undertake a 3-step upgrade (based on the PDP report recommendations),[15] over 15 years. This involves:

- Year 1 to 3 – implementation of water reduction initiatives and addressing existing resilience issues. Conditions have been recommended that require the actual volume reduction to be determined via a Resilience and Water

[15] AEE Section 5.5.2

Saving Strategy to determine what can be reasonably achieved (without giving rise to unforeseen toxicity from increased contaminant load concentrations in the discharge water).

- Within 5 years – implementation of an Ultraviolet Disinfection System (UV) to reduce E. coli concentration in the discharged wastewater not to exceed an annual median of 1,000CFU/100ml and 95th percentile of <10,000 CFU/100mL.
- Within 15 years – implementation of biological treatment to reduce nutrient and BOD loading.

As discussed in Section 2, this proposed approach is based on the assumption (as set out in the AEE) that the existing effects of the discharge on the receiving environment do not trigger the need for immediate or urgent mitigation. However, based on 4Sight's technical review of the ecological and water quality effects of the discharge on the receiving environment, *E. coli* concentrations in the existing discharge are having significant adverse effects on the water quality of the Mataura River. Furthermore the report concludes that the river is also degraded from a nutrient perspective, and given the national and regional objectives to improve water quality, it is recommended that the 15-year timeframe proposed for the treatment plant upgrade to address nutrient and BOD loading be reviewed and reduced to achieve the benefits proposed in a more timely manner.

Furthermore, I believe that more detailed consideration should be given to other options. This is discussed in the following sections.

5 ALTERNATIVE OPTIONS/MANAGEMENT

Whilst 16 options were initially presented, they were primarily focused on providing a range of disposal options and proposed traditional treatment methods (Activated Sludge lagoons and tanks, plus clarifiers, and in some cases a sand filter and UV), but did not explore a variety of other treatment methods.

Whilst we are cognisant that feasible or 'practicable' solutions are essential, the PDP report does not elaborate on the reasons why a range of other treatment technologies were not considered (or removed from consideration).

Based on the key findings of our review, we therefore recommend further investigation of the following would assist in providing Environmental Southland with confidence that the best practicable option has been determined:

1. The feasibility of land-based discharge (full and partial).
2. An assessment and comparison of the effects of discharging to the river all year-round vs during the winter months only. This would involve further investigation of the feasibility of a dual based discharge.
3. Consideration of a broader range of treatment and review of alternative wastewater management approaches including the potential to use newer improved more efficient modern technology that considers the broader aspects and costs of the plant.

These are discussed further in detail below.

5.1 Discharge to Land

From a water quality, and cultural perspective (as the Mataura River is attributed significant value by iwi), and given the location of the Toetoes Wetland downstream (which is a Ramsar site)[16], and considering national and regional objectives to improve water quality, avoiding a river-based discharge altogether should be the most preferred option.

While connection to either of the two available municipal treatment plants, and full land disposal, were considered at a high level, all were discarded and did not make the short list for further consideration.

The PDP assessment suggested that a potentially higher level of adverse effects may be associated with two of the land based only options (options 3A and 3B with an estimated cost of $24M and $37M respectively) than the discharge to water. We recommend that this assumption be reviewed in light of the river being degraded with respect to *E. coli* and nutrients being substantiated.

[16] UNESCO World Heritage Site, ref 4Sight Ecology Report

It is recommended that further evidence be provided to demonstrate that land-based discharge is not a 'practicable' option (and is not associated with a higher level of adverse effects). This should include consideration that with appropriate treatment the effects of discharging wastewater to land could be beneficial (i.e. avoiding the need for fertiliser application).

5.2 Seasonal Discharge to Land and Water

Further consideration should be given to the option of seasonal discharge to land during dry summer months, and to the river during wet summer periods and winter when soil absorption capacity may be exceeded.

PDP report that this option could reduce the discharge to the river by up to 70%, which would represent a significant reduction in the contaminant load. The cost of achieving this reduction, versus the cost of achieving a similar via additional treatment should considered.

5.3 Treatment Technologies

The treatment options proposed by PDP are commonly used in meat processing in New Zealand. A paper from Massey University[17] confirms that New Zealand meat processing wastewater is primarily treated by screens, sedimentation tanks or DAF, and secondarily by pond (lagoon) systems, however typically with a discharge to land.

This is also the case in Australia where activated sludge technology and chemically dosed DAFs are the most widely applied treatment technology for reducing nitrogen concentrations in meat processing wastewater [18].

However, there may be other alternative secondary treatment options that were not discussed in the report that may be suitable, especially within a constrained footprint (thus reducing land acquisition costs). Furthermore, the implications of sludge management were not presented

For example, the Australian paper (referenced above) also pointed out that aerated ponds such as that proposed typically only remove 65% of nitrogen compared with 80% for Continuous Biological Nutrient Removal Systems. The Massey University paper[19] also points out that although pond systems remove a substantial amount of organic carbon, nutrient removal is limited when compared to Sequencing Batch Reactors (SBR).

A Canadian paper[20] concluded that anaerobic digestion is the preferred method for meat processing wastewater treatment due to its effectiveness in treating highly concentrated effluents. This research demonstrates that anaerobic systems have the advantage of achieving low sludge production, minimum energy requirements with potential resource recovery and result in lower chemical oxygen demand. Anaerobic system technology generates methane which can be captured and used for energy generation. Furthermore, where the discharge to water is required, the paper suggests further treatment by Advanced Oxidation Processes (or other technology) is required, and that the use of combined processes has become a cost-effective approach for the treatment of meat processing effluents to comply with more stringent global regulations.

Other more efficient treatment technologies being employed in the meat processing industry around the world, such as include Moving Bed Biofilm Reactor (MBBR) Technology and Membrane Aerated Biofilm Reactor (MABR) Technology.[21]

From a cultural perspective, it may be of interest to note that some of the earliest constructed wetlands in New Zealand were for meat processing wastewater. These were considered a cost-effective option (low investment and

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[17] Thayalakumaran, N. (2002) Treatment of Meat Processing Wastewater for Carbon, Nitrogen and Phosphorus removal in a Sequencing Batch Reactor, Massey University.

[18] The Australian Meat Processor Corporation, (2017). Wastewater Management in the Australian Red Meat Processing Industry, Version 2, Section 5.1.1

[19] Thayalakumaran, N. (2002) Treatment of Meat Processing Wastewater for Carbon, Nitrogen and Phosphorus removal in a Sequencing Batch Reactor, Massey University.

[20] Bustillo-Lecompte, C and Mehrab, M. (2016). Slaughterhouse Wastewater: Treatment, Management and Resource Recovery

[21] Grabas, M. (2000) Organic Matter Removal from Meat Processing Wastewater using Moving Bed Biofilm Reactors

operating costs) and to some extent address Maori cultural and spiritual issues (as noted in a NZ paper on treated wetlands [22]). The advantaged and disadvantages of this option would need to be carefully considered.

Another consideration for treatment technology that could be investigated further includes separate treatment of targeted processing waste streams. If combined, high contaminant loadings within separate waste streams can have a large impact on the overall level of the treatment (and associated cost) required to meet desired discharge standards. PDP identified that the green waste stream has the higher contaminant load and is treated through the DAF process separately. Further consideration of the segregation of other waste streams could be beneficial.

In determining the best practicable option, I believe a wider lens should be applied. Some options may become more economically feasible when assessing to seek broader outcomes for energy and resource use as well as water quality

6 CONCLUSIONS AND RECOMMENDATIONS

Alliance sought advice from PDP on wastewater treatment methods and technology that could be used to reduce the amount of *E. coli*, Amm-N and TN discharged from the Plant into the Mataura River. The AEE states that this is based on a comprehensive assessment of the effects of the discharge on the receiving environment that determined that no adverse effects trigger the need for immediate or urgent mitigation. However, 4Sights review has outlined that the river is degraded with respect to *E. coli* and nutrients, that current *E. coli* concentrations in the discharge are shown to be having significant adverse effects on the water quality of the Mataura River, and therefore a solution that does not significantly reduce nutrient and microbial contaminant loads is not recommended. Also given regional and national policy objectives the timeframes should be reconsidered and reduced.

It is therefore recommended that:

- As the AEE is based on data resulting from an annual discharge flow in the order of 1,100,000 m^3, a lower monthly average and monthly and annual limits are recommended
- The continuation of a full or partial river discharge only be considered once further sufficient evidence is provided to demonstrate that land-based discharge is not a practicable option (or is associated with higher level of adverse effects). Further evidence/justification is also recommended to adequately demonstrate whether the environmental effects of a land-based discharge can be managed and mitigated.
- Further investigation into a seasonal discharge option and the potential water quality benefits associated with this.

If discharge to land is not feasible then it is recommended that:

- Both *E. coli* and nitrogen are considered as priority contaminants of concern and their concentrations should be reduced in the wastewater discharge.
- Full biological treatment will become necessary together with tertiary disinfection of microbial contaminant as it is the most effective in reducing contaminant loads of *E. coli* and nutrients to the Mataura River.
- The proposed 15-year staged approach for the treatment plant upgrade should be reviewed and its timeframe reduced to achieve the benefits proposed in a more timely manner.
- A broader range of technologies should be further investigated as practicable options.
- Other opportunities could be investigated that incorporate waste to energy conversion and provide broader benefits in not only reducing the discharge of contaminants to the river but also provider cleaner energy from methane production.

[22]Kadle, R, Wallace, S. (2009). Treatment Wetlands, Second Edition - Page 19

7C:

State of Environmental Analysis, 4Sight Consulting, 14 October 2019 (4Sight SoE Review);

4SIGHT CONSULTING

14 October 2019

Alex Erceg
Consents Officer
Environment Southland
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By e-mail: Alexander.Erceg@es.govt.nz

Dear Alex,

Re: Technical Review – Mataura Processing Plant: SOE Data Analysis

The purpose of this letter is to support the review of the consent application by Alliance Group Ltd for the Mataura Processing Plant (APP-20191339).

In order to place the technical review of the application for the Mataura Processing Plant in context of the water quality of the Mataura River, Environment Southland asked for an analysis of their State of the Environment water quality monitoring data from locations nearby the processing plant.

The following analysis includes two locations approximately 13 km upstream from the processing plant, 'Mataura River at Gore', and 'Waikaka Stream at Gore' and one location about 800 m downstream from the processing plant, 'Mataura River 200m d/s Mataura Bridge' (Figure 1).

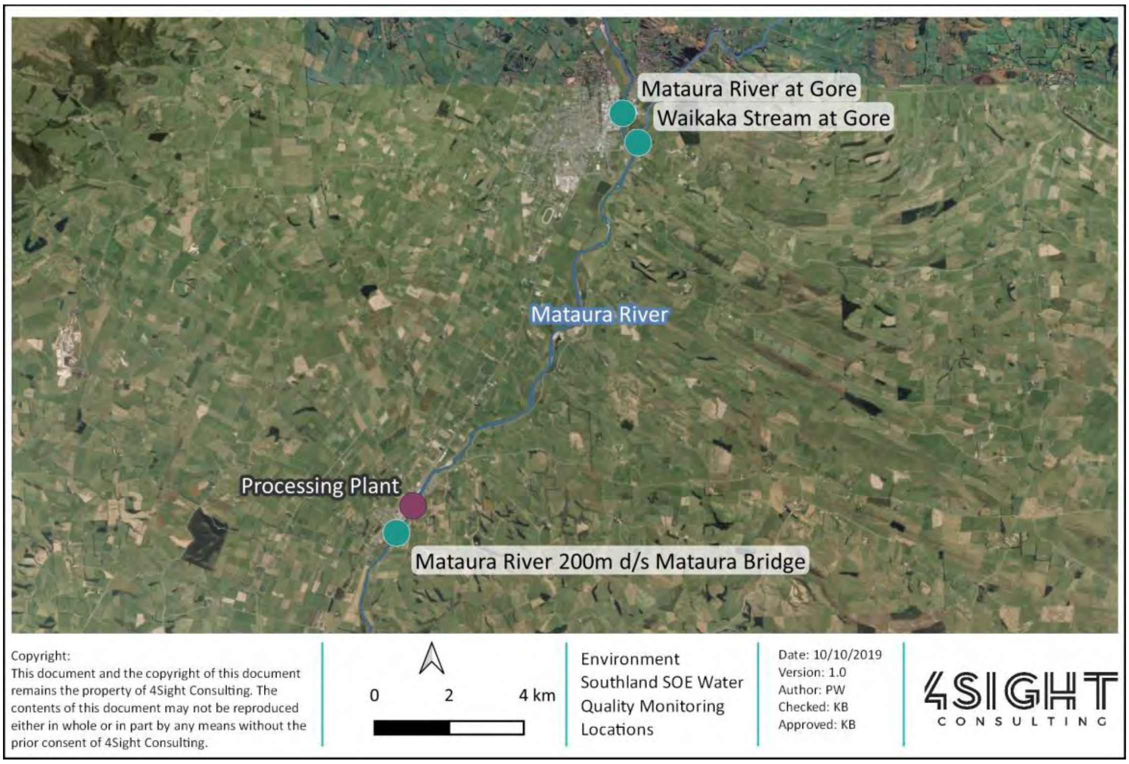

Figure 1: Environment Southland state of the environment water quality monitoring locations assessed in this report. The location of the Meat Processing Plant is shown in purple for context.

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Data analysis methods

Monitoring data were supplied by Environment Southland by email on 25/09/2019. Data were analysed 'as-is'; that is, supplied data were assumed to be correct and no further QA was carried out.

For the purpose of statistical analysis, results that were reported to be below the analytical level of detection were assumed to be half their value (e.g., total suspended sediment <3 g/m^3 was converted 1.5 g/m^3). Similarly, results that were reported to be greater than the level of detection were assumed to be 10% higher than the upper reported limit (e.g., clarity >1.5 m was converted to 1.65 m). Only clarity and *E. coli* had results reported as greater than the upper reported limit. Both of these approaches are widely used for environmental data analysis.

Water quality guidelines and data summaries

Results were first compared to water quality standards for waters classified as 'Mataura 3' from the Proposed Southland Water and Land Plan (PSWLP), however, only *E. coli* standards were relevant for the supplied data.

> *"The concentration of faecal coliforms shall not exceed 1,000 coliforms per 100 millilitres, except for popular bathing sites, defined in Appendix G "Popular Bathing Sites" and within 1 km immediately upstream of these sites, where the concentration of Escherichia coli shall not exceed 130 E. coli per 100 millilitres."*[1]

All three sites in this assessment were listed in the PSWLP as popular bathing sites or were within 1 km immediately upstream of a bathing site; therefore, the 130 CFU/100 mL standard was applied.

Results for total ammoniacal nitrogen (herein, ammonia) were supplied, however, there was no accompanying pH data. This means that the ammonia concentrations could not be adjusted for pH, which is required to determine its potential toxicity to aquatic animals; therefore, ANZG (2018)[2] guideline values were used to assess ammonia concentrations in the context of ecosystem health, rather than for toxicity.

Summary statistics were calculated for each water quality parameter at each site and presented graphically as a boxplot using the minimum, 20th percentile, median, 80th percentile, and maximum values in each dataset. This differs slightly to the more common representation by boxplots that would present the lower 25th and upper 75th percentiles. The 20th and 80th percentiles were used in this instance as they directly relate to ANZG (2018) water quality guideline values, except for *E. coli* (Table 1). River environment classifications for the Mataura River and Waikaka Stream were identified as 'Cool Dry Hill' from NIWA's NZ River Maps.[3]

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[1] Proposed Southland Water and Land Plan (Decisions Version, 4 April 2018) at p 154.
[2] ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines
[3] Booker, D.J., Whitehead, A.L. (2017). NZ River Maps: An interactive online tool for mapping predicted freshwater variables across New Zealand. NIWA, Christchurch. https://shiny.niwa.co.nz/nzrivermaps/

Table 1: ANZG (2018) guideline values for rivers classified as 'Cool Dry Hill'.

Parameter	Guideline value	Unit	Percentile of data for compliance
Ammoniacal nitrogen	0.006	g/m^3	80th
Clarity	1.3	g/m^3	20th
Conductivity	83	µS/cm	80th
Dissolved oxygen	104	%	80th
	84	%	20th
Filterable reactive phosphorus	0.006	g/m^3	80th
Nitrate nitrogen	0.018	g/m^3	80th
Suspended solids	1.6	g/m^3	80th
Total nitrogen	0.103	g/m^3	80th
Total phosphorus	0.009	g/m^3	80th
Turbidity	0.9	NTU	80th
pH	7.7	—	80th
	7.31	—	20th

Statistical methods

The datasets being analysed were relatively large, with each parameter having over 300 data points. Because of the large dataset, it was appropriate to use parametric statistics without the need for testing for normally distributed data.

Statistically significant differences between each site for each parameter were determined using an Analysis of Variance (ANOVA). Where differences between sites were significant ($p < 0.05$), a Tukey's Honest Significant Difference test was run to identify the nature of those differences. The results of these tests are presented graphically in a bar plot with the 95% confidence interval of the mean calculated using a bootstrap method. Statistically significant differences among groups ($p < 0.05$), if any, are indicated by a group letter above each bar.

Long-term trends were investigated using a seasonally adjusted Mann-Kendall trend test on data from 2014–2019. Months were used as the season variable as samples were collected monthly. A shorter time period than that dataset spanned was used as not all sites had monitoring prior to 2014. Analysing shorter time periods is also able to show changes that may have only occurred over the past few years that would have otherwise been hidden in a long time-series. Where sites had a significant trend, the slope was compared to the median of the data set to put the results in context (i.e., a percent annual change from the median value of the data was calculated).

Results and discussion

Escherichia coli (*E. coli*)

E. coli concentrations were elevated at all sites and exceeded the limits in the PSWLP for popular bathing site or for sites that are within 1 km upstream of these (Figure 2). Even when compared to the less conservative guideline of 1,000 CFU/100 mL for the rest of 'Mataura 3' waters, all sites exceeded this level at least 20% of the time. Mataura River 200m d/s Mataura Bridge exceeded 1,000 CFU/100 mL on more than half of all sampling occasions.

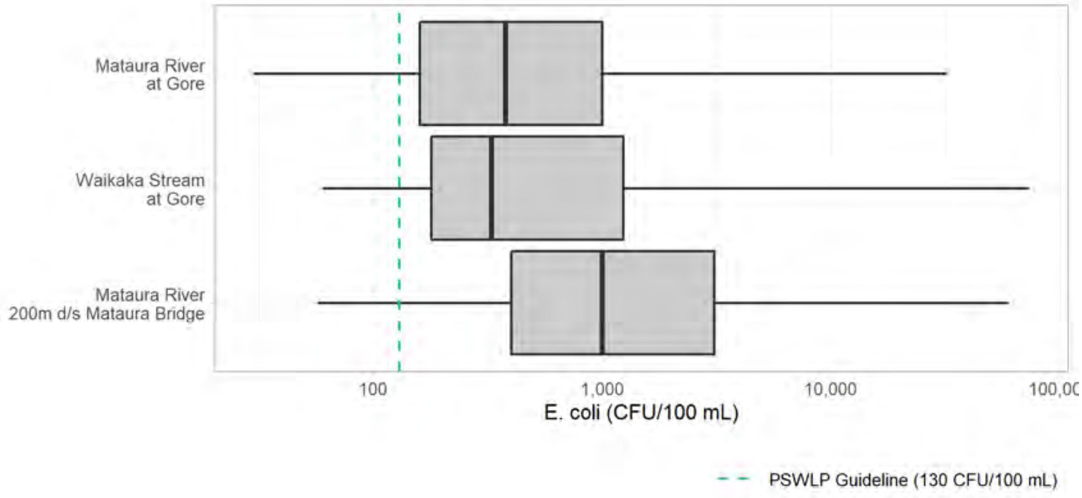

Figure 2: Summary of E. coli results from Environment Southland state of the environment monitoring from 2000–2019. Note the logarithmic scale on the x-axis. The lower and upper bounds of each box show the 20th and 80th percentile of the data, respectively.

The mean *E. coli* concentration at Mataura River at Gore (1,200 CFU/100 mL) was statistically significantly lower by about three times than the other two upstream sites (about 3,000 CFU/100 mL) (Figure 3). The median *E. coli* concentration of all sites is substantially lower than the means due to the wide range of measured results. The median value of Mataura River 200m d/s Mataura Bridge (1,000 CFU/100 mL) is about three times higher than the median *E. coli* concentration at the other two sites (about 350 CFU/100 mL).

All sites had highly variable concentrations of *E. coli* with a range of results among all sites between 30 and 73,700 CFU/100 mL. The highest three *E. coli* concentrations (73,700 to 72,000 CFU/100 mL) were measured at the Waikaka Stream at Gore site between 2002 and 2017 and during the spring/summer months of November to March.

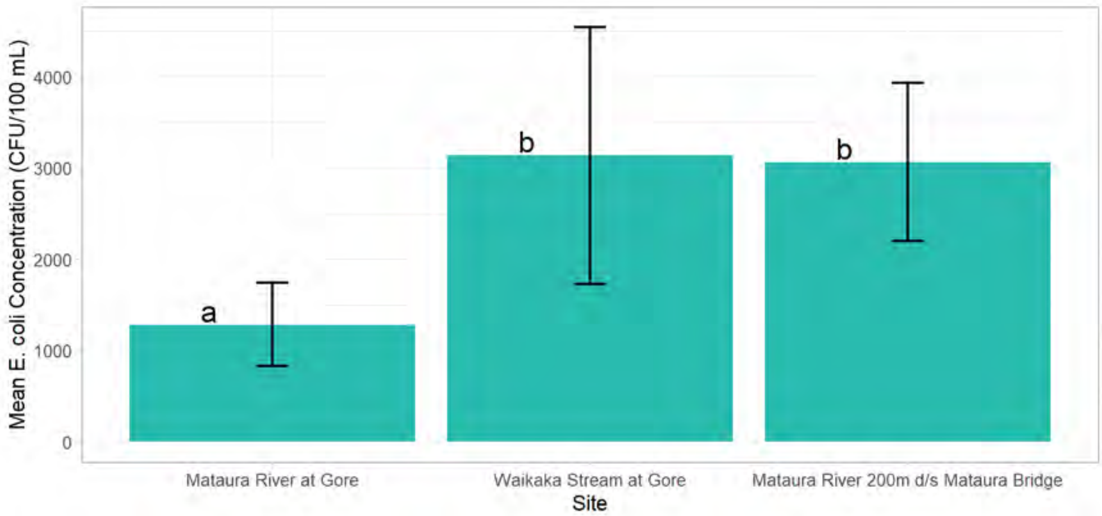

Figure 3: Mean concentrations of E. coli at each site from 2000–2019. Error bars show the 95% confidence interval of the mean. Significant differences among sites are denoted by the group letter above each bar.

Clarity

The PSWLP states that "The natural colour and clarity of the waters must not be changed to a conspicuous extent."

Clarity measurements at all sites were variable and ranged between 0.06 and 4.5 m (Figure 4). None of the sites met the ANZG (2018) guideline of the 20th percentile of the data being greater than 1.3 m (i.e., to meet this guideline, the lower bound of the box in Figure 4 must be ≥1.3 m). The Waikaka Stream at Gore site had a clarity greater than 1.3 m on less than 20% of sampling occasions.

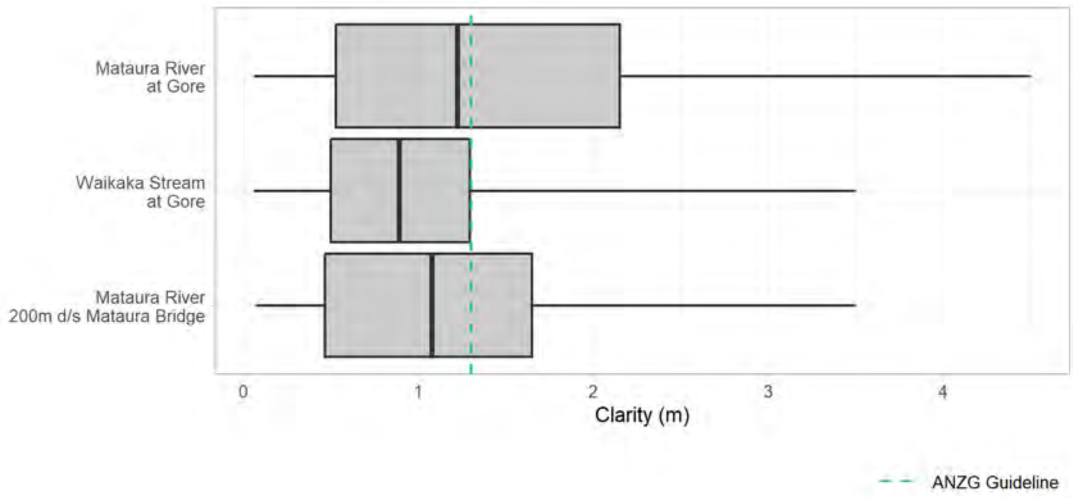

Figure 4 Summary of clarity results from Environment Southland state of the environment monitoring from 2000–2019. The lower and upper bounds of each box show the 20th and 80th percentile of the data, respectively.

The mean clarity at each site was statistically significantly different to each other, with the order from highest to lowest clarity being Mataura River at Gore, Mataura River 200m d/s Mataura Bridge, and Waikaka Stream at Gore (Figure 5).

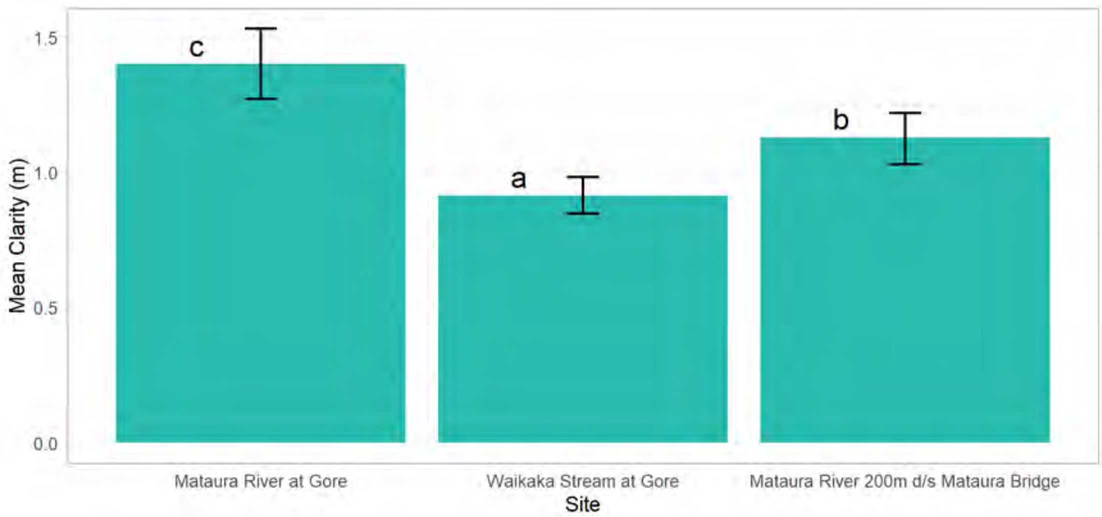

Figure 5: Mean water clarity at each site from 2000–2019. Error bars show the 95% confidence interval of the mean. Significant differences among sites are denoted by the group letter above each bar.

Total suspended solids

Total suspended solids

With regard to total suspended solids, the PSWLP states that "*any discharge is to be substantially free from suspended solids…*"

Total suspended solids concentrations were elevated at all sites compared to the ANZG (2018) guideline (Figure 6). The total suspended solids concentration was greater than 1.6 g/m^3 on more than 75% of all sampling occasions at all sites.

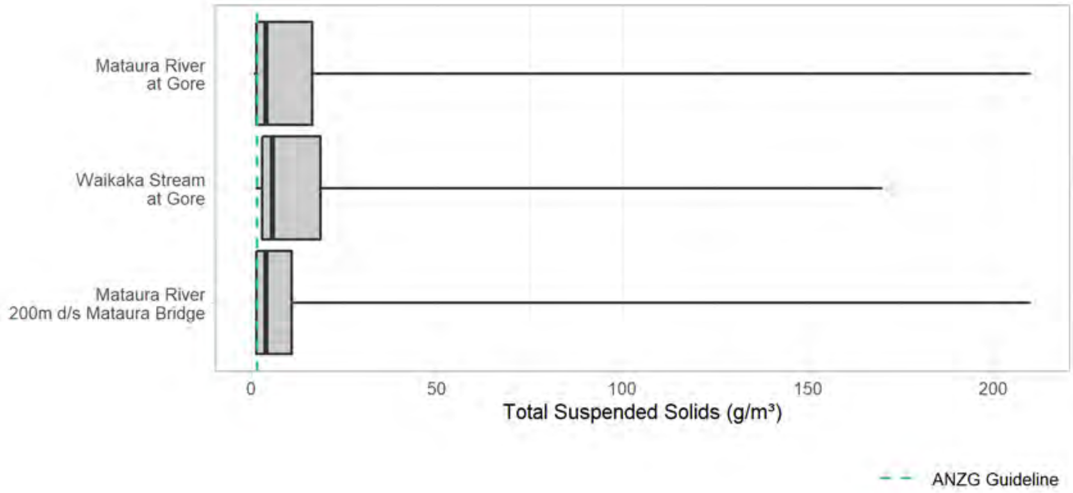

Figure 6 Summary of total suspended solids results from Environment Southland state of the environment monitoring from 2000–2019. The lower and upper bounds of each box show the 20th and 80th percentile of the data, respectively.

There was no statistically significant difference in the mean total suspended solids concentration at each site (Figure 7). This may be partly due to the high variance of the sites and the occasional high result.

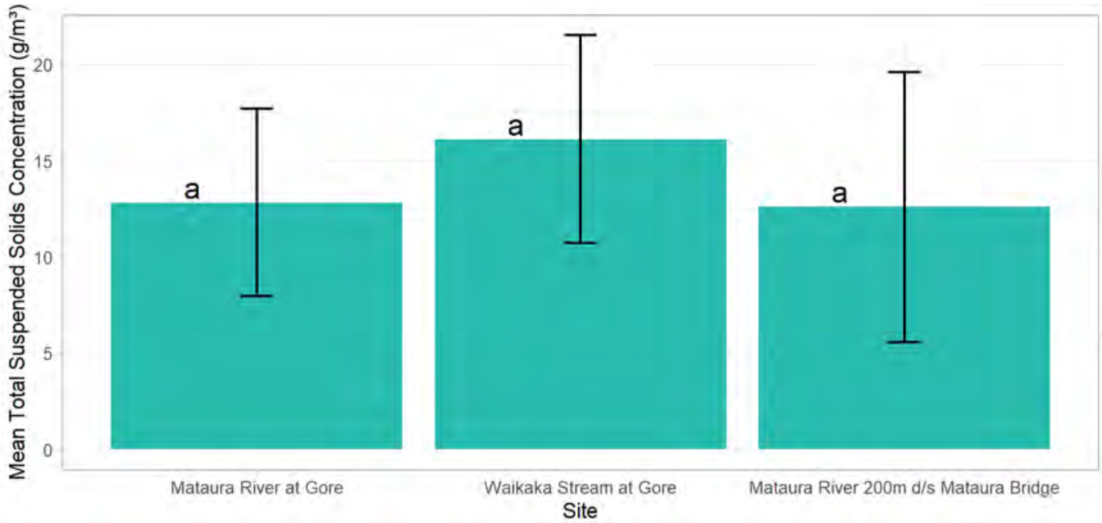

Figure 7: Mean total suspended solids concentrations at each site from 2000–2019. Error bars show the 95% confidence interval of the mean. Significant differences among sites are denoted by the group letter above each bar.

Nitrate (nitrate-N)

The median nitrate concentration at all sites was more than 40 times greater than the ANZG (2018) guideline value (Figure 8). This indicates a substantial elevation of nitrate in the water, which could lead to nuisance algal growth. All measured nitrate concentrations at both Mataura River sites were above the guideline value, and all except for three measurements at the Waikaka Stream at Gore site.

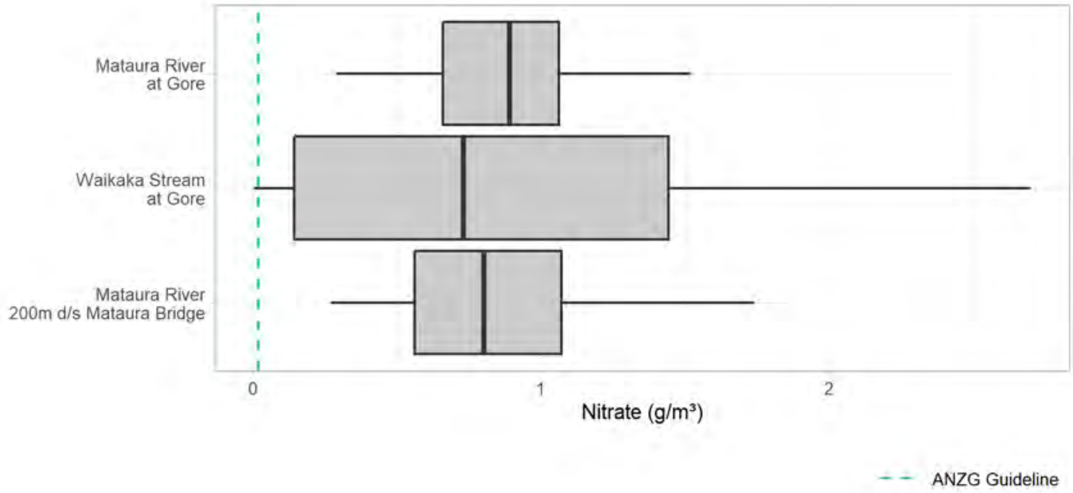

Figure 8 Summary of nitrate (nitrate-N) results from Environment Southland state of the environment monitoring from 2000–2019. The lower and upper bounds of each box show the 20th and 80th percentile of the data, respectively.

Nitrate results were variable at all sites and there was no statistically significant difference in the mean nitrate concentrations among sites (Figure 9).

Nitrate is toxic to some aquatic species at high concentrations. The ANZG (2018) guideline values listed in Table 1 are for ecosystem health, not for toxicity. Although there are no current ANZG guideline values for nitrate toxicity in freshwater, ANZG recommends using guideline values for nitrate toxicity values from Hickey (2003).[4] The most relevant nitrate guideline values from this report are the chronic guideline – slightly to moderately disturbed systems – for 95% species protection (2.4 g/m^3) and the chronic guideline – highly disturbed systems – for 90% protection (3.8 g/m^3). The report states that "The Grading values [stated in the previous sentence] are derived from the species NOEC [No Observed Effect Concentration] values and recommended for compliance assessment based on the annual median concentrations."

The mean and median nitrate concentrations are well below the chronic guideline values for both moderately and highly disturbed systems. The highest measured nitrate concentration exceeded the 95% protection guideline value and it was measured at Waikaka Stream at Gore with a concentration of 2.7 g/m^3. Note that the toxicity guidelines are not necessarily relevant for one-off measurements.

High levels of nitrate in the water can also make the water unsuitable for livestock to drink. The ANZECC (2000) guidelines (from which the ANZG (2018) guidelines were based) states a trigger value of 400 g/m^3 for nitrate (equivalent to 90 g/m^3 nitrate-N as referred to in this report). Based on this information, the nitrate levels are still suitable for livestock to drink the water.

[4] Hickey, C. W. 2003. Updating nitrate toxicity effects on freshwater aquatic species. NIWA Client Report Np. HAM2013-009, Prepared for Ministry of Building, Innovation and Employment: Funded by Envirolink.

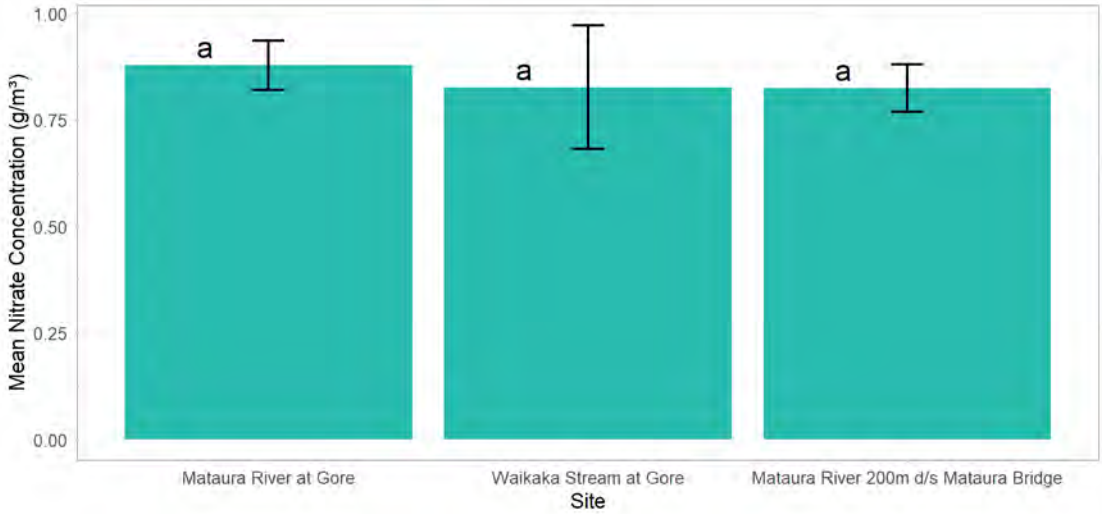

Figure 9: Mean nitrate (nitrate-N) concentrations at each site from 2000–2019. Error bars show the 95% confidence interval of the mean. Significant differences among sites are denoted by the group letter above each bar.

Ammonia (total ammoniacal nitrogen)

Ammonia concentrations at all site exceed the ANZG (2018) guideline, that is, the 80th percentile of the data for each site is >0.006 g/m^3 (Figure 10). Mataura River at Gore has the lowest overall ammonia concentrations and the median concentration at this site is 0.005 g/m^3.

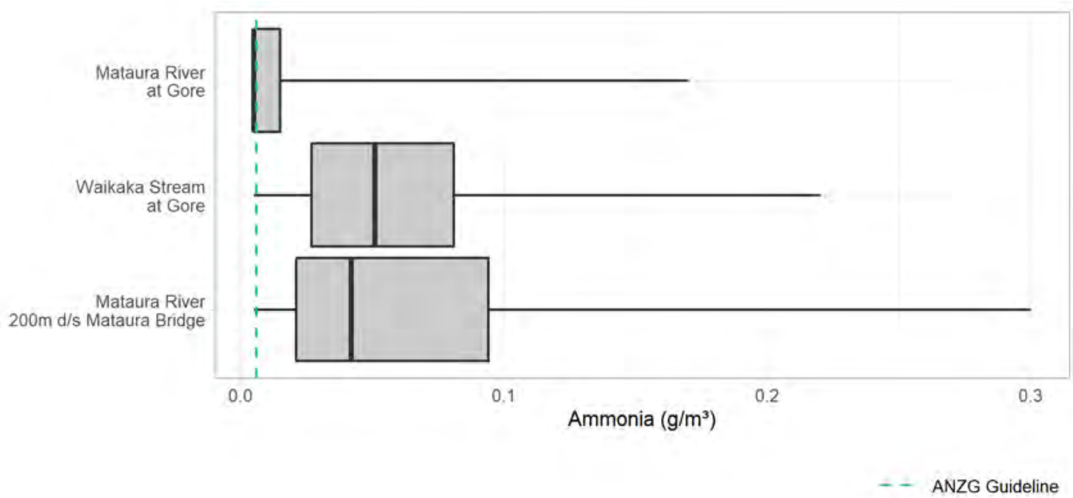

Figure 10 Summary of ammonia (total ammoniacal-N) results from Environment Southland state of the environment monitoring from 2000–2019. The lower and upper bounds of each box show the 20th and 80th percentile of the data, respectively.

The mean ammonia concentrations measured at the Waikaka Stream at Gore and Mataura River 200m d/s Mataura Bridge are substantially higher (statistically significant) than those measured at Mataura River at Gore (Figure 11)

Ammonia, like nitrate, can be toxic to aquatic species. The toxicity of ammonia is primarily a factor of pH, but also temperature and conductivity of the water. The reason for this is that total ammoniacal nitrogen (as these data have been measured) comprises NH_3 (ammonia) and NH_4^+ (ammonium). The associated toxicity is primarily due to NH_3 and the ratio of NH_3 to NH_4 in solution is dependent on pH, temperature, and conductivity.

The PSWLP has ammonia standards for lowland hill surface waterbodies that apply to these waters. The standards are given for pH ranges from 6.0 to 9.0 and this results in ammonia standards ranging from 2.38 g/m^3 to 0.18 g/m^3, respectively. The standard is lower at higher (more alkaline) pH because there is a higher proportion of NH_3 to NH_4^+.

pH data were not supplied with the SOE data and, therefore, it is not possible to accurately assess the ammonia concentrations against toxicity guidelines. Assuming a typical river pH of around 7.5 units, the ammonia guideline would be 1.61 g/m^3. The ammonia results in this dataset are well within this limit. In the most extreme situation, if the water was at pH 9.0, the median ammonia values are still within the guideline value; however, some individual results exceeded this on occasion.

It is highly recommended the pH measurements are taken so more accurate toxicity assessments can be conducted in the future.

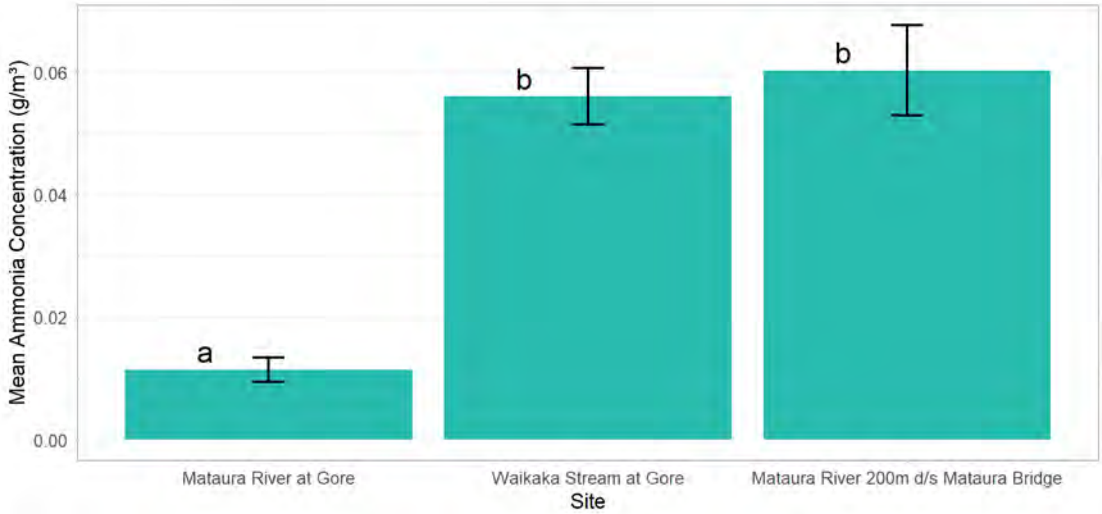

Figure 11: Mean ammonia (total ammoniacal-N) concentrations at each site from 2000–2019. Error bars show the 95% confidence interval of the mean. Significant differences among sites are denoted by the group letter above each bar.

Total phosphorus

The median total phosphorus concentration at all sites is above the ANZG (2018) guideline value (0.009 g/m^3) (Figure 12). The highest measured concentration was at Waikaka Stream at Gore (0.086 g/m^3), which is more than nine times greater than the guideline value. This indicates enrichment of the water with total phosphorus, which could contribute to nuisance algal growth.

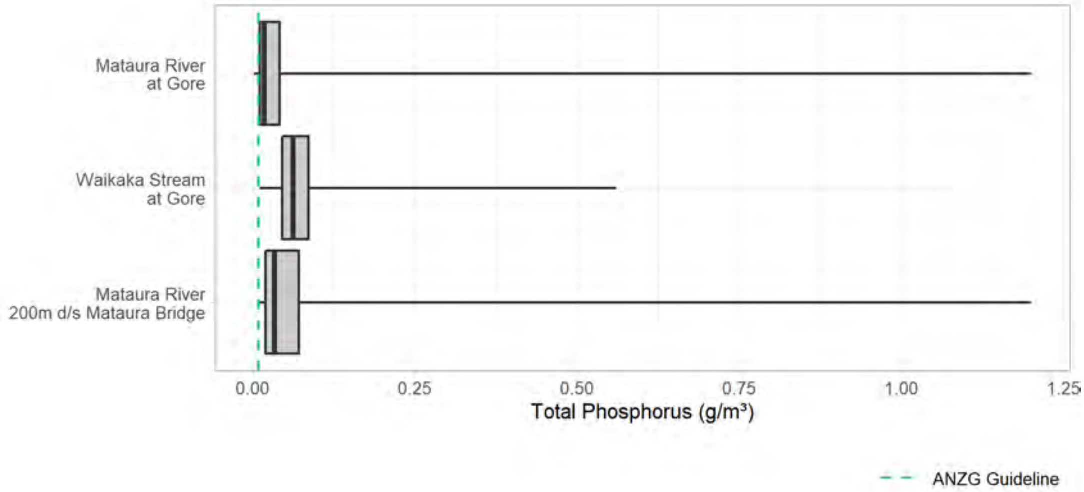

Figure 12 Summary of total phosphorus results from Environment Southland state of the environment monitoring from 2000–2019. The lower and upper bounds of each box show the 20th and 80th percentile of the data, respectively.

There was a statistically significant difference among the mean total phosphorus concentration at each site (Figure 13). Waikaka Stream at Gore had the highest, followed by Mataura River 200m d/s Mataura Bridge and Mataura River at Gore.

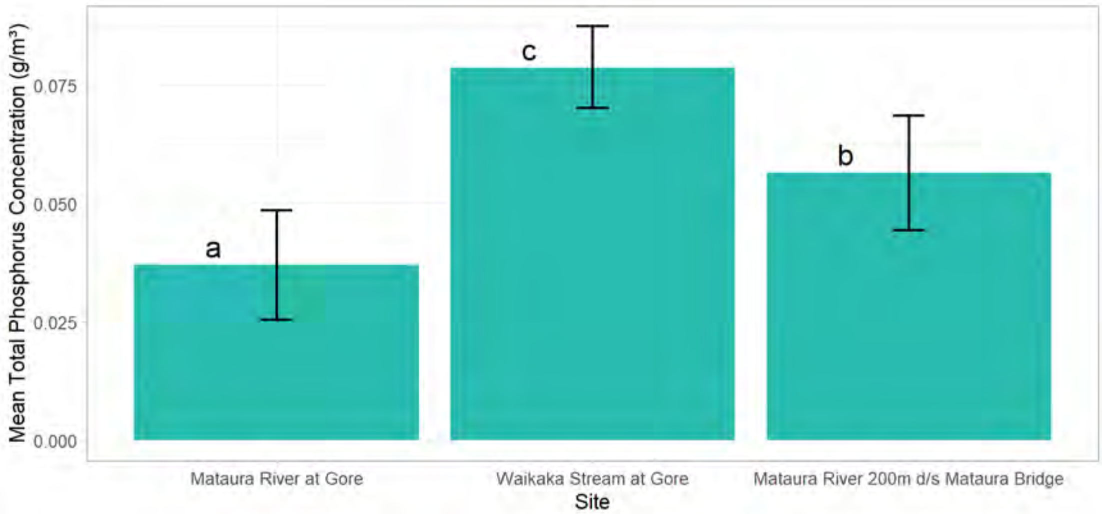

Figure 13: Mean total phosphorus concentrations at each site from 2000–2019. Error bars show the 95% confidence interval of the mean. Significant differences among sites are denoted by the group letter above each bar.

Dissolved reactive phosphorus

The median concentrations of dissolved reactive phosphorus follow a similar pattern to that of total phosphorus, which is unsurprising. The median concentrations at all sites exceeds the ANZG (2018) guideline value and indicates enrichment of dissolved reactive phosphorus in the water (Figure 14).

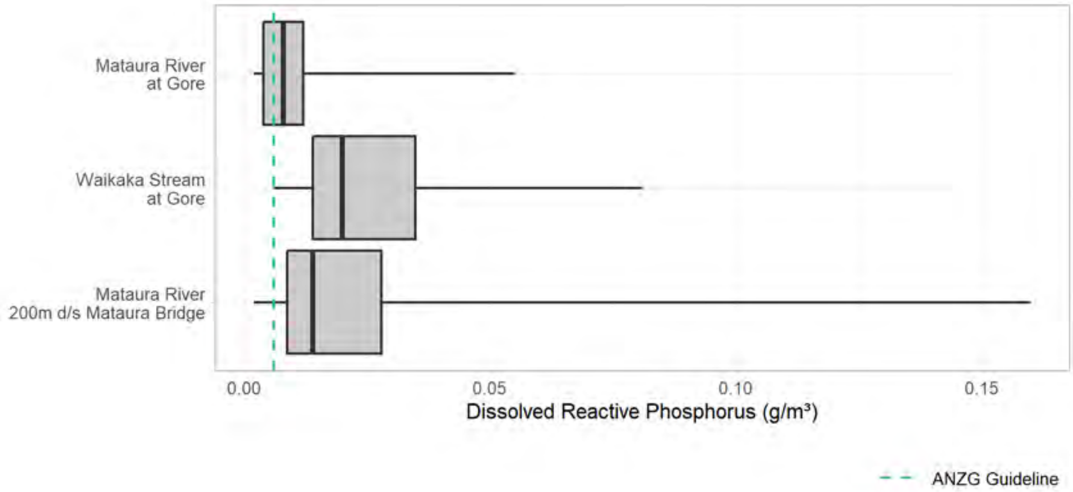

Figure 14 Summary of dissolved reactive phosphorus results from Environment Southland state of the environment monitoring from 2000–2019. The lower and upper bounds of each box show the 20th and 80th percentile of the data, respectively.

The mean dissolved reactive phosphorus concentrations at Waikaka Stream at Gore and Mataura River 200m d/s Mataura Bridge were statistically significantly higher than Mataura River at Gore, but their means were not significantly different to each other (Figure 15).

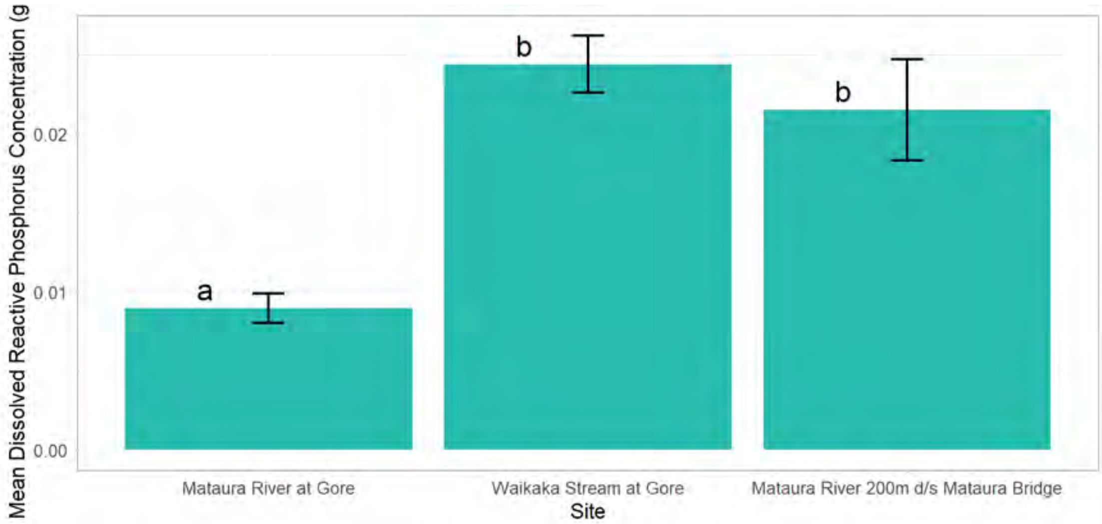

Figure 15: Mean dissolved reactive phosphorus concentrations at each site from 2000–2019. Error bars show the 95% confidence interval of the mean. Significant differences among sites are denoted by the group letter above each bar.

Long-term trends

Trend analysis was performed on data from the most recent five years (i.e., 2014–2019).

Improved water clarity was detected at Waikaka Stream at Gore, with an increase of 0.1 m per year (Table 2). There were no significant trends in clarity at the other two sites.

Nitrate concentrations increased by about 0.04 g/m^3 per year at both the Mataura River sites. This equates to about a 4–5% increase from the median nitrate concentration each year. This indicates a decline in water quality with regard to nitrate levels.

The ammonia concentration at Waikaka Stream at Gore decreased over the past five years with a reduction by 0.004 g/m^3 per year. The median ammonia concentration over this time period was 0.04 g/m^3, which indicates a decrease of around 12% of the median ammonia concentration per year. This indicates an improvement in ammonia concentrations in the Waikaka Stream.

Mataura River at Gore and Waikaka Stream at Gore both had decreases in dissolved reactive phosphorus concentrations of about 5% and 10% per year, respectively. This indicates an improvement in water quality with regard to dissolved reactive phosphorus.

Table 2: Seasonal Kendall trend test on Environment Southland SOE monitoring data from 2014–2019. Only results with significant p-values ($p < 0.05$; bold text) have additional slope and % change data shown.

Parameter	Site	p-value	Slope	% annual change
E. coli (CFU/100 mL)*	Mataura River at Gore	0.32		
	Waikaka Stream at Gore	0.10		
	Mataura River 200m d/s Mataura Bridge	0.21		
Clarity (m)	Mataura River at Gore	0.16		
	Waikaka Stream at Gore	**0.01**	0.114	13
	Mataura River 200m d/s Mataura Bridge	0.41		
Total Suspended Solids (g/m^3)	Mataura River at Gore	0.49		
	Waikaka Stream at Gore	0.16		
	Mataura River 200m d/s Mataura Bridge	Insufficient data		
Nitrate (g/m^3)	Mataura River at Gore	**0.01**	0.042	5
	Waikaka Stream at Gore	0.22		
	Mataura River 200m d/s Mataura Bridge	**0.04**	0.035	4
Ammonia (g/m^3)	Mataura River at Gore	0.10		
	Waikaka Stream at Gore	**0.02**	−0.004	−12
	Mataura River 200m d/s Mataura Bridge	0.77		
Total Phosphorus (g/m^3)	Mataura River at Gore	0.64		
	Waikaka Stream at Gore	0.68		
	Mataura River 200m d/s Mataura Bridge	0.31		
Dissolved Reactive Phosphorus (g/m^3)	Mataura River at Gore	**0.05**	−0.0003	−5
	Waikaka Stream at Gore	**0.01**	−0.0022	−10
	Mataura River 200m d/s Mataura Bridge	0.18		

* Trend analysis was also conducted on log-transformed data with the same results

Conclusions

<u>*E. coli*</u>

- *E. coli* concentrations were elevated at all sites and exceeded the limits for popular bathing sites (130 CFU/100 mL) more than 80% of the time.
- The median *E. coli* concentration at Mataura River 200m d/s Mataura Bridge was about three times higher (statistically significant) that at the two upstream sites.

<u>Clarity</u>

- The mean clarity was different at each site (statistically significant), with Mataura River at Gore having the highest (1.2 m) and Waikaka Stream at Gore having the lowest (0.9 m).
- None of the sites met the ANZG (2018) guideline of the 20th percentile of the data being greater than 1.3 m.

<u>Total suspended solids</u>

- Total suspended solids concentrations were elevated at all sites compared to the ANZG (2018) guideline.
- There was no difference (statistically significant) among the mean total suspended sediment concentrations at each site.

<u>Nitrate</u>

- The median nitrate concentration at all sites was more than 40 times greater than the ANZG (2018) guideline value.
- There was no significant difference in the mean nitrate concentration among sites.
- Nitrate concentrations were not at levels that are likely to have toxic effects on aquatic species or make it unsuitable for livestock to drink.

<u>Ammonia</u>

- Ammonia concentrations at Waikaka Stream at Gore and Mataura River 200m d/s Mataura Bridge were substantially (statistically significant) higher than at Mataura River at Gore. All sites had elevated ammonia concentrations relative to the ANZG (2018) guidelines.
- pH data were not provided with the SOE results and, therefore, accurate assessment of potential toxicity could not be carried out. Based on the assumption that the Mataura River had a typical pH of around 7.5 units, it is unlikely that ammonia concentrations are at levels that would be harmful to aquatic species.

<u>Total phosphorus</u>

- Total phosphorus concentrations were elevated relative to the ANZG (2018) guideline value at all sites. This indicates enrichment of the water with total phosphorus, which could contribute to nuisance algal growth.
- Differences in the mean total phosphorus concentration between sites were statistically significant, with the order from highest to lowest being Waikaka Stream at Gore, followed by Mataura River 200m d/s Mataura Bridge and Mataura River at Gore.

Dissolved reactive phosphorus

- Dissolved reactive phosphorus concentrations followed a similar pattern to total phosphorus.
- The median concentration at all sites exceeded the ANZG (2018) guideline value.
- The mean dissolved reactive phosphorus concentration at Waikaka Stream at Gore was statistically significantly lower (by more than half) than at the other two sites.

Long-term trends

- Water quality trends resulting in a reduction of water quality were only identified for (increasing) nitrate concentrations at the two Mataura River sites (at Gore and at 200m d/s Mataura Bridge). Both sites had an increase in nitrate concentrations of around 5% per year.
- The remaining detected trends indicated improvements in water quality.
- Clarity increased by 0.1 m per year at Waikaka Stream at Gore.
- Dissolved reactive phosphorus reduced by 5 and 10% per year at Mataura at Gore and Waikaka Stream at Gore, respectively.

Kind Regards,

Dr Pete Wilson
Senior Water Quality Scientist
4Sight Consulting Ltd

7D:

Public Health Review of the Alliance Meatworks Ltd Assessment of Environmental Effects at Mataura, Dr Marion Poore, 1 November 2020 (Public Health Review)

Public Health review of the Alliance Meatworks Ltd Assessment of Environmental Effects for their Consent application to continue operating the Mataura Meat Processing Plant at Mataura

Author **Dr Marion Poore**
Public Health Physician

Prepared for **Environment Southland**

Date **1 November 2020**

Introduction

1) The purpose of this report is to provide Environment Southland with a public health review of the Alliance Group Ltd application for resource consent to continue operating its Mataura Meat Processing Plant at Mataura. This report is primarily focused on the public health effects of waterborne microbial pathogens in relation to animal wastewater in the environment.

2) Environment Southland has also commissioned additional reviews on water quality, ecology and wastewater management/treatment (undertaken by 4Sight Consulting Limited).

The Application

3) Alliance Group Ltd (Alliance or the Applicant) has applied for a 35 year consent under the RMA 1991 to continue operating its Mataura Meat Processing Plant at Mataura. Specifically the resource consents applied for are:

   a. To take water from the hydro race fed by the Mataura River for water cooling purposes;

   b. To take water from the hydro race fed by the Mataura River for meat processing and truck wash activities;

   c. To discharge condenser cooling water from the meat works to the Mataura River;

   d. To discharge treated meat works wastewater to the Mataura River;

   e. To use an existing weir and hydro race structure to dam and divert water;

   f. To dam and divert water using an existing weir and hydro race structure.

4) The application includes an Assessment of Environmental Effects (AEE) by Alliance Group Ltd with appendices, to support " *'re-consent' of its activities such that the Plant can continue to operate and contribute in a major way to the social and economic wellbeing of the surrounding community*" .

5) The Applicant proposes the following discharge quality improvements:

   a) The installation of '*Equipment to disinfect the process wastewater discharged from the site in order to inactivate pathogens'* within five years of the commencement of the consent (proposed Condition 8) ; and

   b) A further *Wastewater Treatment Plan Upgrade*, with specific discharge limits (primarily associated with BOD, suspended sediment and nutrients), within 15 years of the commencement of the consent (proposed Conditions 9 to 15).

6) The AEE is supported by a range of technical assessments. Of particular relevance to this public health review is the report entitled: *Quantitative Microbial Risk Assessment for the discharge of treated meat processing factory wastewater into the Mataura River, May 2019, prepared by Streamlined Environmental Limited*[1].

7) A key conclusion of this report is that while '*E. coli concentrations increase significantly following discharge of the Alliance Plant wastewater it is concluded that the current wastewater treatment applied at [the] Alliance Plant is sufficient to reduce health risks associated with swimming below the discharge to levels below 'the NZ threshold for tolerable risk', even at [a] maximum discharge of 14,400 m^3/d* [2].

Public Health Definitions and Alliance Application

8) Public health is defined as, "all organized measures (whether public or private) to prevent disease, promote health, and prolong life among the population as a whole".[3]

9) Public health professionals aim to prevent illness in communities by explicitly addressing the risk factors for disease and by promoting actions that achieve health and wellbeing. Where evidence for action is limited, taking a precautionary approach based on the best available evidence rather than waiting for complete scientific certainty is appropriate.

10) A public health approach takes account of the social and environmental determinants of health and how they impact on the health of populations. Successful public health approaches generally involve partnerships and collaboration with communities, industry, NGOs, government and others.[4]

11) The primary public health risks from the activities for which consent is being sought in this application, are associated with exposure to meat works wastewater discharged from the plant to the Mataura River from bathing or contact recreation activities in the river; and the potential use of river water for potable water downstream of the discharge point[5].

12) The health and safety of people and communities is explicitly provided for in the purpose of the Resource Management Act, 1991 (RMA) as follows.

Section 5 Purpose

(1) The purpose of this Act is to promote the sustainable management of natural and physical resources.

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[1] Dada AC,(2019) Quantitative Microbial Risk Assessment for the discharge of treated meat processing factory wastewater into the Mataura River. Report AES 1704

[2] Dada AC,(2019) Quantitative Microbial Risk Assessment for the discharge of treated meat processing factory wastewater into the Mataura River. Report AES 1704. P 9

[3] World Health Organization 1946 Definition of health from the preamble of the WHO constitution https://www.who.int/about/who-we-are/frequently-asked-questions

[4] Productivity Commission Australia 2010 https://www.pc.gov.au/inquiries/completed/gambling-2010/submissions/sub059-attachment6.pdf

[5] I am advised that there are no consented takes for potable water downstream of the site. Hence, I do not comment on this further.

(2) *In this Act, **sustainable management** means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being <u>and for their health and safety</u> while -*

(a) *sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*

(b) *safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*

(c) *avoiding, remedying, or mitigating any adverse effects of activities on the environment*.

Microbial contamination of the Mataura River and notifiable disease

13) The AEE (9.3.1, p 51) states the *"lower Mataura River contains very high levels of E. coli and the Plant's discharge significantly increases those levels in the downstream receiving water"* and "*The Mataura River can generally be characterized as degraded in respect of nutrient loads….... with the Plant's discharge contributing to the catchment nutrient loads."*

14) Discharge of meat processing and truck wash material, and treated meat works wastewater from the Mataura Meat Processing Plant is a significant contributor to the microbial contamination of the Mataura River. Broadly this contamination impacts the mauri of ecosystems and affects te ao Maori values such as mahinga kai and kaimoana (traditional foods), recreation (swimming, waka ama), and oranga (health and well-being) of Māori.[6] Water that is not contaminated, is a prerequisite for creating and maintaining a healthy environment and essential for sustainable and healthy human communities.

15) *E.coli* is used as an indicator organism for faecal contamination of freshwater and is found in the gastrointestinal tract of multiple species - animals, humans, birds. It indicates the presence of faecal organisms that may cause human illness and can be used to describe the level of contamination in water. Index pathogens for monitoring water quality have been selected in order to indicate the presence of a large amount of pathogens in water. *E. coli* has been extensively used due to the fact that detection methods are relatively easy and inexpensive; nonetheless, they do not always provide information on their host origin and, sometimes, they do not correlate with other pathogens present in the water, such as the viruses and protozoa. Thus, water characterized as pathogen-free by monitoring *E. coli,* may still be contaminated with viruses or protozoa. [7] Conversely high *E.coli* levels do not always correlate with high levels of pathogens.

16) Exposure to faecally contaminated water potentially causes gastrointestinal (GI) illness in humans. While there are risks of different diseases from human and animal sources of wastewater, the most common microorganisms that cause GI illnesses in humans are also

[6] Environment Aotearoa Summary 2019 https://www.mfe.govt.nz/environment-aotearoa-2019-summary

[7] Ramirez-Castillo F Y et al; Waterborne Pathogens: Detection Methods and Challenges . https://www.mdpi.com/2076-0817/4/2/307 Pathogens. 2015 Jun; 4(2): 307–334.

found in animal wastewater. These include bacterial diseases such as campylobacteriosis and salmonellosis; and protozoan infections including cryptosporidiosis, giardiasis. Once diagnosed, these diseases are all notifiable to the public health service for further investigation and public health management.

17) Exposure to pathogenic organisms in water is possible through multiple pathways including ingestion of water, inhalation of airborne aerosols and water droplets, or direct contact with contaminated water[8]

18) Exposure leading to illness may result in a variety of health outcomes. These range from asymptomatic infection, mild to moderate illness managed in the community, hospitalisation for serious illness, and in some cases death. Attributing the cause of a waterborne gastrointestinal illness to a specific exposure, time or place may be difficult. Detection of specific GI pathogens, such as those referenced in (16), from waterways can be difficult because of low concentration of pathogens in the water, time delays between sample collection and laboratory processing which may result in death of pathogens in the sample, the length of time (often days) it takes to culture the organism. Therefore the detection of a GI pathogen from any surface water sample is significant and in practical terms is taken to mean the likely source of illness in a person exposed to that water.

Difficulties in detecting pathogenic organisms may result in delays to identifying cases of illness or outbreaks of disease. Effective public health investigation and management may be exacerbated by delay in seeking diagnosis through reluctance of people to seek health care or difficulties in accessing health care services especially in a community where there is economic deprivation.

19) Diagnosis of a notifiable disease comes with a requirement for it to be reported to the local public health service. This prompts investigation of the case, including identification of potential risk factors. It is estimated that only 1 in 222 cases (0.4%) of gastrointestinal illness are actually notified to the public health service throughout NZ, thus resulting in a considerable underestimate of the true burden of disease [9] .

20) It is widely known within the Southland community that rivers such as the Mataura River are contaminated from animal wastewater especially in their lower reaches, so people are likely to limit their exposure to the river water thereby reducing the chance of exposure and subsequent illness.

21) The Southern District Health Board's (SDHB) Public Health Service reviewed its surveillance information for notifiable water borne diseases for the period 2013 - 2017[10] . This identified that overall SDHB has the second highest rate of campylobacteriosis in

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[8] Ramirez-Castillo F Y et al; Waterborne Pathogens: Detection Methods and Challenges . https://www.mdpi.com/2076-0817/4/2/307 Pathogens. 2015 Jun; 4(2): 307–334.

[9] A Ball. *Estimation of the burden of water borne disease in New Zealand: Preliminary Report.* Ministry of Health 2006

[10] Public Health South. Surveillance Report: Risk factors that may contribute to enteric diseases in Southern DHB. Unpublished report. 2019

New Zealand after South Canterbury, but similar rates of cryptosporidiosis and giardiasis as other parts of the country. Rural communities have a greater burden of water-borne gastrointestinal disease than urban communities. This burden is associated with risk factors such as farming activities and contact with farm animals, consumption of untreated water and recreational contact with freshwater which may be a receiving environment for contamination. There are seasonal variations with increased rates of cryptosporidiosis cases during the spring and an increase of campylobacteriosis cases during later summer.

Quantitative Microbial Risk Assessment

22) Quantitative microbial risk assessment (QMRA) is a systematic quantitative assessment aimed at estimating the health risks or illness rates of human exposure to particular pathogens. The approach combines dose response information for the infectious agent with information on the distribution of exposures routes[11]

23) A QMRA has been provided by Streamlined Environmental Ltd 2019[12] to assess the health risk associated with the animal wastewater discharge from the Mataura plant. This report concluded that '*with the current level of treatment within the existing plant, children and adults' recreational health risk fall above the 1% threshold in winter and summer for all zoonotic pathogens for normal and peak flow scenarios. When treatment was applied, children and adults' recreational health risk falls below the 1% threshold in winter and summer for all zoonotic pathogens.' Thus, there is less than 1% probability of an individual becoming ill due to swimming at the study site.'*

24) I understand that '*normal and peak flow scenarios'* refer to a discharge rate of 6,638 m^3/day and 14,400 m^3/day .

25) The QMRA report states[13] *"there are no substantial risks established for transmission of fungi and viruses through animal wastewater discharge"*. As outlined in Appendix 2 of the QRMA report, a wide variety of viruses from animals can be found in water. Many of these are pathogenic. Laboratory techniques for detecting, culturing and identifying viruses in waterways are relatively new. The assumption that *"there is no substantial risk established for transmission of animal viruses*" is questionable in my opinion, and not a conservative approach. While the risk may be difficult to ascertain and measure because of the limits of scientific methods, that does not mean there is no risk.

26) Viable, but nonculturable microorganisms may lead to an underestimation of numbers of pathogens in a sample. There is a broad environmental distribution of human pathogens

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[11] Ramirez-Castillo F Y et al; Waterborne Pathogens: Detection Methods and Challenges https://www.mdpi.com/2076-0817/4/2/307 Pathogens. 2015 Jun; 4(2): 307–334

[12] Dada AC,(2019) Quantitative Microbial Risk Assessment for the discharge of treated meat processing factory wastewater into the Mataura River. Report AES 1704.

[13] Section 3.2, page 25

that exist in a viable but non-culturable (VBNC) state such as *E. coli, Helicobacter pylori* and *V. cholerae*, and false negative results may arise from culture dependent methods.[14]

27) Some challenges around detection methods for pathogens from water samples include: the physical differences between the major pathogen groups; the low concentration of pathogens in a large volume of water which usually requires enrichment and concentration of the samples prior to detection processing; the presence of inhibitors from the sample (especially if it comes from polluted water); established general protocols for sample collection, culture-independent detection method, as well as detection of the host origin of pathogens.

28) Even though culture dependent methods are extensively used for the detection of pathogens in water, these methods are limited by their low sensitivity and the excessive time needed to obtain reliable results. [15]

29) The QRMA conclusions are based on 18 samples taken between 5 Dec 2017 to 21 March 2018. These samples were taken over a single, 4 month period during summer and outside the period when there is a trend of higher notifications to the local Public Health Service, of cases of cryptosporidiosis increase associated with spring. The QRMA Report notes (p48) that few QMRA studies have been done on animal factory wastewater as a source of waterborne infections.

30) All samples showed elevated *E.coli* levels with positive detections of one or more of *salmonella, campylobacter, E. coli 0157, giardia, or cryptosporidium* in every sample when these were tested for specific pathogens. This indicates the presence of gastrointestinal pathogens on a consistent basis and hence an elevated risk to health for those people who use the river for recreational purposes.

31) Estimates of minimum infectious doses of pathogenic organisms are available in the literature. The risk of infection from ingestion of water containing pathogenic organisms is related to the extent of contamination but it is recognised that only small numbers of bacteria or protozoa can cause disease. Enteric bacteria have a minimum infectious dose in the range of 10^7 to 10^8 cells but it is much lower with some species, such as *Shigella* spp., (10^1–10^2), *Campylobacter* spp., (about 500), *E. coli* O157:H7 (10^6–10^8), and *V. cholera* (10^3). Only a few protozoan oocysts (10^1–10^2) are needed to produce disease, and only a small number of viruses are enough to develop a disease.[16, 17]

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[14] Ramirez-Castillo F Y et al; Waterborne Pathogens: Detection Methods and Challenges https://www.mdpi.com/2076-0817/4/2/307 Pathogens. 2015 Jun; 4(2): 307–334.

[15] Ramirez-Castillo F Y et al; Waterborne Pathogens: Detection Methods and Challenges . https://www.mdpi.com/2076-0817/4/2/307 Pathogens. 2015 Jun; 4(2): 307–334.

[16] WHO: infectious dose of protozoan parasites https://www.who.int/water_sanitation_health/dwq/admicrob5.pdf

[17] Ramirez-Castillo F Y et al; Waterborne Pathogens: Detection Methods and Challenges . https://www.mdpi.com/2076-0817/4/2/307 Pathogens. 2015 Jun; 4(2): 307–334.

32) In my opinion, caution is needed around the conclusions of this QMRA study. The technique is complex [18] and very few such studies on animal wastewater and impacts on human health have been conducted.

33) It is based on only 18 samples taken over a 4 month period during the summer months only, and therefore excludes the spring time during which elevated case numbers of cryptosporidiosis disease occur. All samples demonstrated the presence of one or more pathogens indicating the consistent presence of these organisms and therefore increased risk to health.

34) This report concluded that '*with the current level of treatment within the existing plant, children and adults' recreational health risk fall above the 1% threshold* ***in winter and summer*** *for all zoonotic pathogens for normal and peak flow scenarios. When treatment was applied, children and adults' recreational health risk falls below the 1% threshold in* ***winter and summer*** *for all zoonotic pathogens.' Thus, there is less than 1% probability of an individual becoming ill due to swimming at the study site.'*

35) In my opinion extrapolating the conclusion (above) to apply to both winter and summer is questionable given the lack of data across the whole year.

36) The proposed mitigation of using UV treatment on the animal wastewater will significantly assist in reducing the microbiological load and therefore improve the quality of the receiving waters. In my opinion, this mitigation should be introduced as soon as possible to reduce the potential for health risk.

Animal reservoirs and emerging infectious diseases - wastewater

37) The majority of emerging infectious diseases in humans originate in animal reservoirs and this includes viral infections such as norovirus [19]. Animal wastewater discharged from meat production plants will contain these viruses with potential to impact human health. While the science is poorly understood and incomplete this is a risk that needs to be considered in respect of this discharge. The risk may change with season given the fluctuations of GI disease as shown in the Southern DHB notifiable diseases report for example the increase in cases of cryptosporidiosis during spring.

38) I recommend that Alliance's environmental monitoring programme include an assessment of viruses in wastewater discharge to improve understanding of this issue.

Emerging Organic Compound (EOCs) Microplastics and human health

[18] Jing L et al. Rapid detection methods for bacterial pathogens in ambient waters at the point of sample collection: a brief review *Clinical Infectious Diseases*, Volume 71, Issue Supplement_2, 15 August 2020, https://academic.oup.com/cid/article/71/Supplement_2/S84/5877836

[19] Villabruna et al. *Animals as reservoirs for human norovirus*; Viruses 2019 May. Published online 2019 May 25. doi: 10.3390/v11050478. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6563253/

39) Emerging Organic Compound (EOCs) and their potential impact on human health is of growing concern to scientists and public health practitioners. Although the science is incomplete and still poorly understood this issue is not covered in the AEE.

40) EOCs include natural or manufactured chemicals found in household and personal care products, pharmaceuticals, and agrichemicals. These include human and animal medicines (pharmaceuticals), antimicrobial disinfectants in soaps/shampoos, UV-filters in sunscreens, fragrances, pesticides, and those associated with industry (plasticisers, corrosion inhibitors, surfactants, flame retardants). There is considerable overlap of similar types of EOCs found in wastewater, stormwater, and landfill leachate, whereas those derived from agriculture, horticulture and aquaculture are more specialised to these industries.

41) The use and discharge of EOCs is largely unregulated and one key concern from regulators, industry, Māori and communities is the potential for development of antibiotic resistance in microorganisms. There is a knowledge gap in assessing the impacts of EOCs on our physical, environmental, and economic wellbeing as well as short and long term health outcomes.[20]

42) Given that animals coming to the Mataura Plant for processing have been exposed to agricultural chemicals, pesticides and pharmaceuticals there is potential for animal wastewater from processing animal wastes and meat products to contain EOCs. The discharge of process wastewater to the river has the potential to distribute these substances to the wider environment with implications for freshwater quality and human and aquatic health. [21, 22]

43) Microplastic contamination in animal wastewater and the potential risks to human health through discharge to waterways is of increasing concern. More work is needed to understand the sources and routes by which microplastics enter waterways including environmental levels, uptake rates by different species, and the impacts they have on both the animals and the ecosystem. Research into the extent of microplastic contamination in the environment is in the early stages but should be accepted as an emerging risk.[23] [24]

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[20] Environmental Science and Research NZ. https://www.esr.cri.nz/home/about-esr/our-science-in-action/managing-the-risk-of-emerging-organic-contaminants/

[21] Stewart, M et al. (2017). *Literature review of the risks and adverse effects from discharges of stormwater, wastewater, industrial and trade waste, and other hazardous substances in Otago.* Report ORC1601-FINAL-v2, Streamlined Environmental, Hamilton.
https://www.orc.govt.nz/media/3745/literature-review.pdf

[22] Moreau et al *A baseline assessment of emerging organic contaminants in New Zealand groundwater.* **Science of The Total Environment** Volume 686, 10 October 2019, p425-439 https://www.sciencedirect.com/science/article/pii/S0048969719322491

[23] ESR: *Optimising the process for microplastic analysis 2019.* https://www.esr.cri.nz/home/about-esr/our-science-in-action/optimising-the-process-for-microplastic-analysis/

[24] Cawthron Institute 2019. *A Review of microplastics risk - Implications for Environment Southland*.
https://www.cawthron.org.nz/media_new/publications/pdf/2019_09/CawRpt_3350_A_review_of_microplastics_risk__implications_for_Environment_Southland.pdf

44) I recommend that Alliance's environmental monitoring programme includes an assessment of EOCs and microplastics in the wastewater discharge to improve understanding of these two emerging issues.

Recreation

45) The AEE outlines that freshwater bodies are important places for recreational activity for New Zealanders. Mataura is a small town economically dependent on one major industry. Recreational facilities in communities are also important for promoting all dimensions of healthy lives - physical, social, mental and cultural so the closure of the school swimming pool in 2017, means the river becomes an even more important recreational resource.

46) However, the dilemma for community members is that exposure to contaminated river water through direct contact such as swimming, may result in illness. This is likely to result in people using the river less for recreation.

47) Regular information about recreational water quality is provided on the LAWA website but not everyone may be able to access it. Public Health risks can be managed to some extent through providing information, and erecting warning signs. However not everyone reads english, signage is subject to damage or may be vandalized. Furthermore, such information may be disregarded and not taken seriously as a safeguard to health. The National Policy Statement: Freshwater Management 2020, puts an obligation on Councils[25] to take steps to monitor health risk and may require signage to be erected in the area. Without doubt, a more certain and effective approach from a public health perspective is to improve water quality by reducing the amount of contaminants being discharged into the water.

Summary

48) There is a significant level of microbial contamination in the Mataura river from the discharge of animal wastewater from the Mataura Plant. This is of a level that it creates a significant risk to the health of those who may use the water for swimming or contact recreation below the plant.

49) The QRMA report indicates a low health risk associated with the discharge, due to the low levels of pathogens in the discharge.

50) In my opinion, this conclusion should be treated with caution as:

a) all samples of wastewater included one or more pathogens;

b) The sampling programme was conducted only over the 4 months of summer when evidence from notifiable disease reporting shows that some pathogen loads are likely to peak during spring;

[25] Subpart 3 – 3.27

c) The QRMA technique is complex and very few such studies on animal wastewater and impacts on human health have been completed.

51) While establishing causal relationships between waterborne microorganisms and human illness can be challenging because of multiple pathways and underreporting of gastrointestinal infections, and technical issues around detecting pathogens in water, this does not mean that risks to health do not exist [26]. A precautionary approach is necessary to improve understanding of emerging risks to public health associated with animal wastewater being discharged into the Mataura River. Three risks are identified including emerging pathogenic zoonotic organisms such as viruses, emerging organic compounds, and microplastics

52) In my opinion, the best way to manage the public health risk associated with animal wastewater being discharged to the Mataura River is to reduce the contaminant levels being discharged. The proposals to install a UV plant and to upgrade the wastewater treatment plant to remove nitrogen and other contaminants will help reduce the microbial contamination from the wastewater discharge.

53) Given that degradation of freshwater bodies is the environmental issue of highest concern among New Zealanders [27] and the longstanding nature of the levels of contamination being discharged into the Mataura River from animal waste at the Mataura Plant, a precautionary approach to addressing the public health risks would be to complete the installation of the UV plant and upgrade to the wastewater treatment plan in a more timely manner than is proposed.

Recommendations:

54) To ensure that public health risk is effectively managed using a precautionary approach, I recommend the following:

a) Complete the proposed plant upgrades as soon as possible. From a public health perspective, this particularly relates to the proposed UV plant although there will also be considerable benefit from the wastewater treatment plan upgrade. These will contribute to improved water quality and bring associated community, cultural and environment benefits to improving the health of the local community.

b) Regular monitoring of E.coli levels above and below the discharge point should be undertaken.

c) An assessment of the nature of the virus load, emerging organic compounds and microplastics in the discharge should be undertaken.

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[26] V Hammond *New Zealand Freshwater management: A public health perspective. p 62 in Mountains to Sea, solving New Zealand's freshwater crisis* edited by Mike Joy BWB texts 2018.

[27] Stats NZ https://www.stats.govt.nz/news/freshwater-quality-kiwis-biggest-environmental-concern

d) Consider a shorter consent term, and/or the ability to review discharge standards, to ensure that the consent keeps pace with increasing knowledge on the discharge and changing community expectations for public health risk.

About the author

Marion Rosalind POORE has been a registered medical practitioner since 1979 and qualified as a specialist in Public Health Medicine in 2004. She is a member of the NZ College of Public Health Medicine - which is concerned with the health of populations, the factors that may cause disease and the implementation of evidence based interventions for preventing disease and ill health.

She has extensive experience as a public health practitioner having worked as a Medical Officer of Health for Southern DHB in the Otago and Southland Health Districts between 2004 - 2019. This includes managing outbreaks of infectious disease, health risk assessment of environmental situations, advising on human health risk related to environmental contamination including water.