



Gore District Council

Gore and Mataura
Wastewater Treatment
Plant discharges to water

Assessment of effects
on Mataura River ecology
and water quality

August 2020



Gore and Mataura Wastewater Treatment Plant discharges to water:

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August 2020

Prepared for Gore District Council

by

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Cover: Mataura River in the vicinity of the Gore oxidation pond, 6 March 2020.

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1 Introduction

Gore District Council (GDC) has consent to discharge treated wastewater and stormwater to the Mataura River from the Gore oxidation pond (Environment Southland (ES) Resource Consent 203595) and to discharge treated wastewater to the Mataura River from the Mataura oxidation pond (ES Resource Consent 203593). These discharges are consented for terms expiring on 11 May 2021 (Mataura) and 31 December 2023 (Gore).

Ryder Environmental was engaged to prepare an assessment of the environmental effects of the discharges on instream ecology and water quality of the receiving environment (the Mataura River) to accompany applications to renew these discharge permits.

2 Lower Mataura River - Setting

2.1 Mataura River

The Mataura River has one of the ten largest catchments in New Zealand, and the second largest in Southland after the Waiau River. The catchment extends from headwaters in the Eyre Mountains (near the southern tip of Lake Wakatipu) to Toetoes Bay in Foveaux Strait. The largest tributary of the Mataura River, the Waikaia River, joins approximately 32 km upstream of Gore. The catchment size and flow contributions of the upper Mataura River and the Waikaia River are similar. Another important tributary, the Waikaka Stream, joins the Mataura River at Gore.

The lower Mataura River, downstream of the Gore township, flows south to the sea in a channel up to approximately 80 m wide in places. The gradient is much lower in the river downstream of Gore than in the upper river, and the river bed is dominated by gravels and cobbles and isolated areas of bedrock. The Gore and Mataura discharges both enter the river south of the townships they service (Figure 1). Between the two discharge points is the township of Mataura and the Alliance Group Limited Mataura Meat Processing Plant, which discharges cooling water and wastewater to the Mataura River as well as taking water and operating a run-of-the-river hydroelectric scheme.

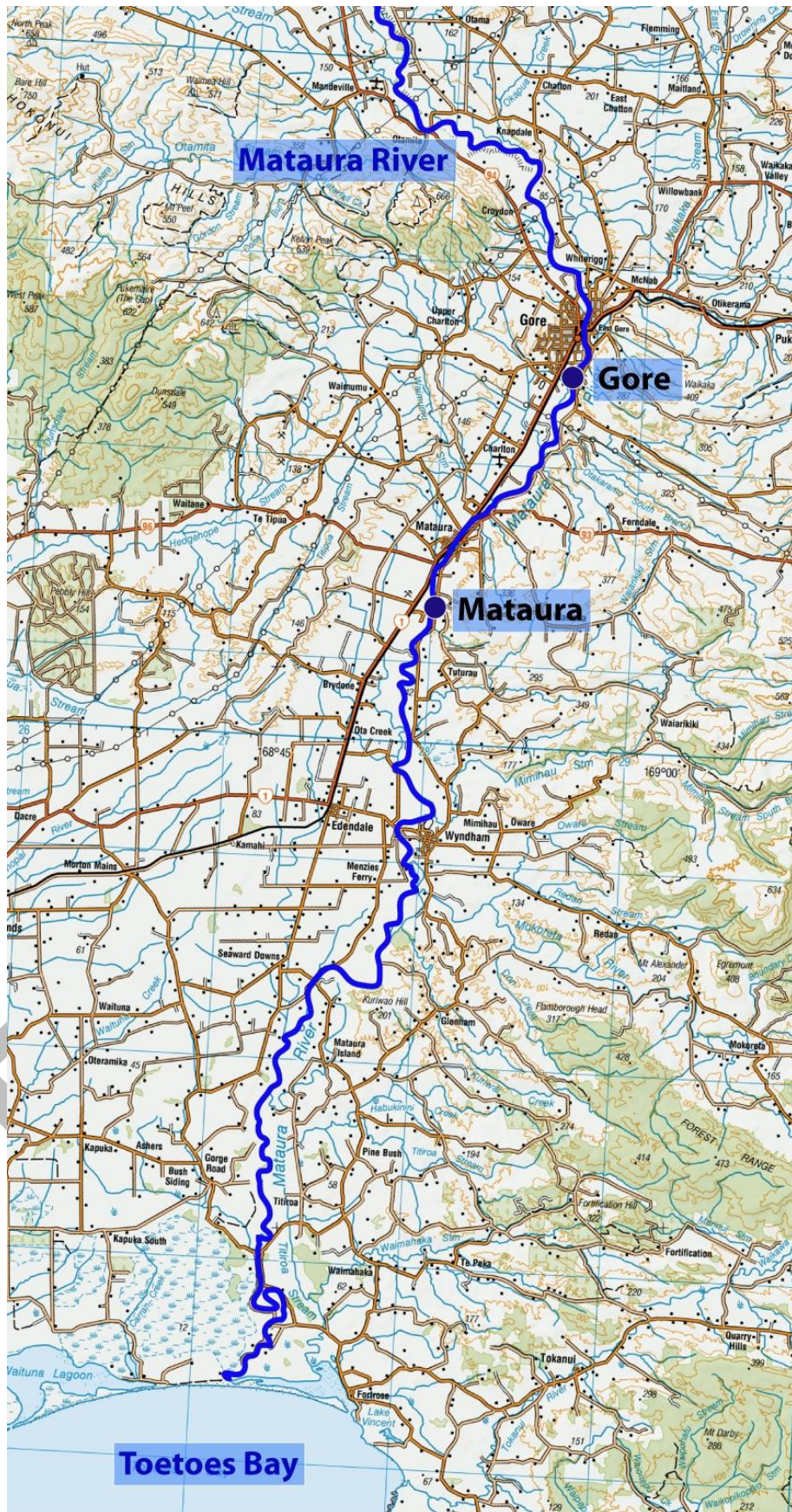


Figure 1. Map of the lower Matura River indicating the Gore and Matura plants.

2.2 Gore discharge

The Gore oxidation pond outfall is on the eastern side of the oxidation ponds, south of the Gore township, and comprises a pipe with a hinged flap valve and a concrete baffle discharging to the true right side of the Mataura River (Figures 2 and 3). An Actiflo® treatment plant, adjacent to the oxidation ponds, has been in operation since December 2008 and discharges treated wastewater to the Mataura River under low river flow conditions. The outfall from this plant also discharges to the true right side of the Mataura River, approximately 400 m upstream of the oxidation pond outfall, and comprises a pipe with a hinged flap valve and a concrete baffle (Figures 2 and 3).

Both Gore discharge points to the Mataura River are located in an area of deep and sluggish runs (Figure 4). These runs are generally contiguous, but have recently (following changes to the channel and bed) been separated at times of low flow by a short, high-velocity riffle section. Prior to 2019 these runs were bordered by mature willow trees that extended along the true right bank upstream and downstream of the outfalls and overhung the edge of the river channel. However, the willow trees were removed in 2018. Substrate character in the immediate vicinity of the outfalls is rip-rap, but river bed character beyond the immediate discharge points cannot be described due to the depth of the water. Patches of gravels, cobbles, and fine sediments are present in shallower areas downstream.

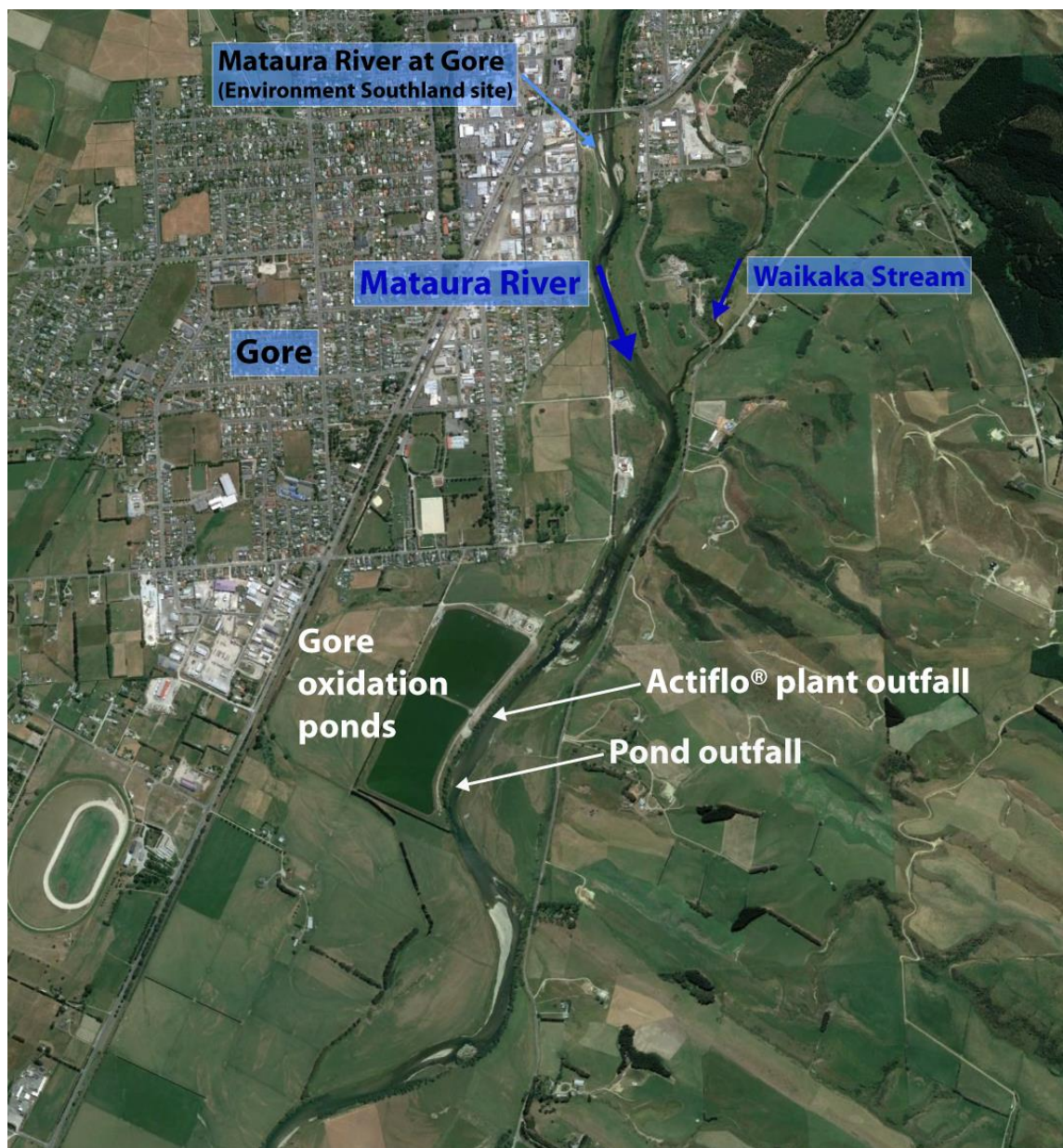


Figure 2. Aerial photo showing location of the Gore pond outfall and Actiflo® plant outfall.
Photo: Google Earth.



Figure 3. Gore Actiflo® plant outfall (top) and oxidation pond outfall (bottom), 6 March 2020.



Figure 4. Maitua River in the vicinity of the Actiflo[®] plant outfall (top) and the Gore pond outfall (bottom), 6 March 2020.

2.3 Mataura discharge

The Mataura oxidation pond outfall to the Mataura River is located on the south-eastern side of the oxidation pond, south of the Mataura township, and consists of a concrete pipe extending approximately 2 m out from the true right bank (Figures 5 and 6). Wetlands associated with the pond were constructed in 2008 and have had effluent flowing through them since December 2008.

The Mataura River in the immediate vicinity of the outfall is generally a relatively deep run. Prior to the 2018 periphyton and macroinvertebrate survey, a gravel island had formed in the river channel upstream of and adjacent to the outfall, but did not affect the path of the discharge plume which enters the river and flows down the true right of the channel (see Figure 6). Substrate character in the immediate vicinity of the outfall is comprised of cobbles and gravels. In early March 2020, following the large flood in early February, the outfall discharged to a much smaller channel that flowed over a bed of cobbles and gravels (see Figure 6).

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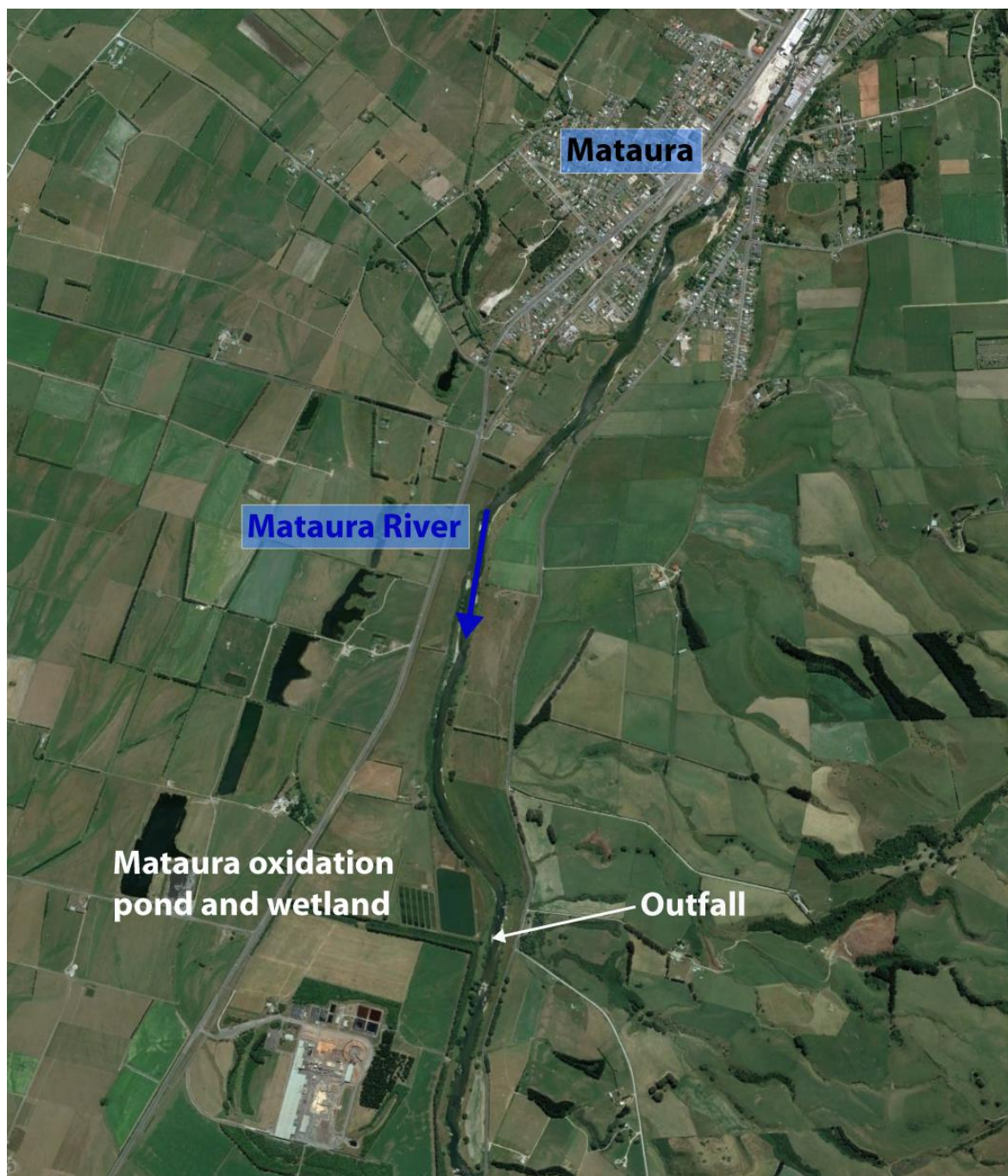


Figure 5. Aerial photo showing location of the Maitua pond outfall. Photo: Google Earth.



Figure 6. Maitua outfall, 29 January 2018 (top and middle) and 6 March 2020 (bottom).

3 Assessment Methodology

3.1 Sources of information

A review of existing ecological and water quality information was undertaken. A variety of sources were utilized including GDC's discharge and receiving water monitoring data (collected as part of existing resource consent conditions, and additional sampling undertaken to assist with the reconsenting project), ES reports and data (including state of the environment (SOE) monitoring data from the Mataura River), the New Zealand Freshwater Fish Database (NZFFD), and local surveys and reports of the Mataura River undertaken by Ryder Consulting/Environmental on behalf of GDC (undertaken to fulfil consent condition requirements).

3.2 Approach

This assessment focuses on existing information as described above.

Background water quality and biological communities in the river are described by analysing ES data from SOE monitoring sites in the Mataura River at Gore and the Waikaka Stream at Gore (both sites upstream of the Gore wastewater discharge) and from the Mataura River 200 m downstream of Mataura Bridge (downstream of the Gore wastewater discharge, and upstream of the Mataura wastewater discharge).

Water quality and biological data from resource consent compliance monitoring upstream and downstream of both the Gore and Mataura wastewater discharges are analysed. A comparison of data from the compliance sites with data collected from the ES SOE monitoring sites provides some context for the compliance sites' data with respect to the wider river.

3.3 Standards and guidelines

There are several standards/guidelines available for assessing the status of the Mataura River's water quality. These include the likes of national standards, limits and standards within the regional plan for water, and national guidelines. These documents often have several iterations, and as such at times it can be uncertain as to which version is most applicable. Different standards/guidelines have been used throughout this report, with the most relevant standards/guidelines used for each parameter, where possible. Standards/guidelines referred to in this report include:

- ES's Regional Water Plan for Southland (2014)
- ES's Proposed Southland Water and Land Plan (decision version, 4 April 2018)

- Water Conservation (Mataura River) Order 1997
- Australian and New Zealand Environment and Conservation Council's Australian and New Zealand guidelines for fresh and marine water quality (1992, 2000, 2018)
- Ministry for the Environment's (MfE) New Zealand periphyton guidelines (2000)
- Ministry of Health's (MoH) national standards for drinking water quality (2008)
- MfE's water quality guidelines (1992)
- MfE's microbiological water quality guidelines for marine and freshwater recreational areas (2003)
- MfE's National Policy Statement for Freshwater Management (NPS-FM) (2017)
- MfE's NPS-FM – Consultation Draft (2019)

The Mataura River is protected by a water conservation order (WCO). WCOs protect water within a water body in order to protect or preserve its identified outstanding amenity or intrinsic values. These values for the Mataura River are the '*outstanding fisheries and angling amenity features*'. The Mataura River WCO was promulgated on 7 July 1997 and includes provisions that have been incorporated into ES's Regional Water Plan for Southland (2014) and the Proposed Southland Water and Land Plan (decision version, 4 April 2018).

The draft NPS-FM (2019) was released late last year for submissions. The draft includes the same nationally set attribute states and minimum acceptable states, referred to as national bottom lines, as the NPS-FM (2017). However, some amendments have been made, including several additional attributes (e.g., dissolved reactive phosphorus, macroinvertebrates) referred to only in the draft NPS-FM (2019). Therefore, the draft NPS-FM (2019) will be referred to in this report for all attributes (hereafter the NPS-FM). For some parameters, the attribute state is determined based on a minimum of 60 samples over a maximum of 5 years. Some datasets included in this report do not meet the minimum criteria set out in the NPS-FM and as such the assessments should be regarded as indicative only.

ES's Regional Water Plan for Southland (2014) and Proposed Southland Water and Land Plan (decision version, 4 April 2018) have been developed by ES to provide direction and guidance regarding the sustainable use, development and protection of water and land resources in the Southland region. These plans fit within, and are influenced by, a framework of national, regional and local resource management policy documents, including the Resource Management Act (1991) (RMA), NPS-FM and WCOs. These plans will hereafter be referred to as the SWLP.

4 Discharge Character

4.1 Gore discharge

Daily discharge volumes from the Gore oxidation ponds (January 2018 to May 2020) are presented in Figure 7. The consent of the discharge has an average dry weather volume limit not exceeding 9,000 m³/d. Data from GDC between 2018 and 2020 shows volumes higher than the limit on occasions, however these are generally associated with high rainfall events and higher river flows (i.e., not during dry or normal weather events). The figure does not show the maximum volume during the February 2020 flood event, which was 53,163 m³/d.

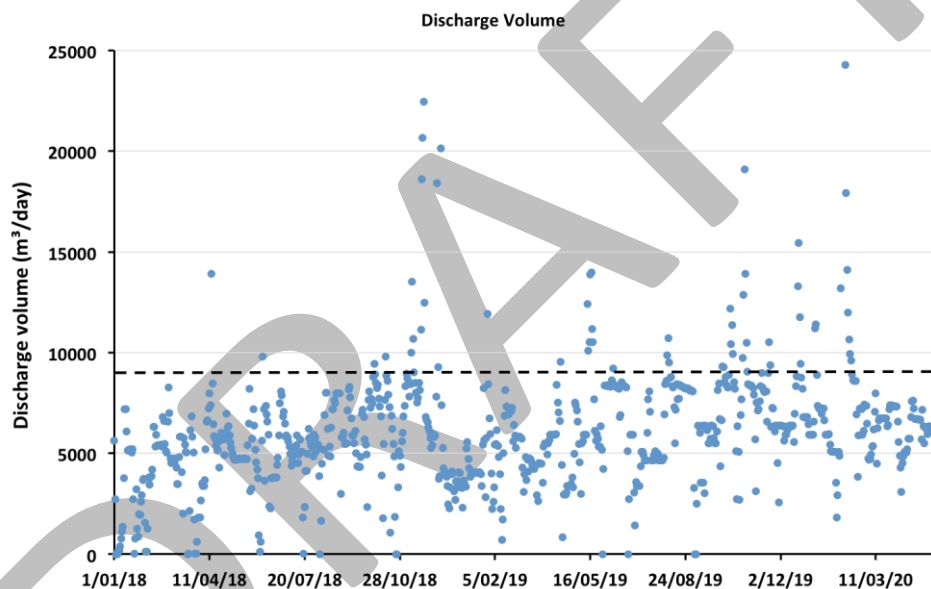


Figure 7. Effluent volume (m³/d) from the Gore oxidation ponds, January 2018 to May 2020 (data supplied by GDC). The dashed line indicates the consented average dry weather discharge volume (9,000 m³/d).

Since 1 January 2014, monitoring of the discharge quality is required by consent to be undertaken on at least two occasions each year; once during 1 August to 30 September and once during 1 January to 31 March. Additional monitoring is required on up to two further occasions per year; when the flow in the Mataura River at Gore is less than 25 m³/s. Discharge samples are to be analysed for pH, and concentrations of carbonaceous biochemical oxygen demand (BOD₅), total suspended solids (SS), total phosphorus (TP, dissolved reactive phosphorus (DRP), total ammoniacal nitrogen (NH₄-N), total kjeldahl nitrogen (TKN), aluminium (Al), and *Escherichia coli* (*E. coli*). As at 1

September 2008, and from that date onwards, the discharge shall conform with the limits set out in Table 1.

Table 1. Relevant wastewater discharge standards for the Gore discharge from ES resource consent 203595. River flow as measured at Gore. Rolling 80 percentile to be calculated using the five most recent consecutive monitoring results.

Parameter	<25 m ³ /s in river		25-60 m ³ /s in river		>60 m ³ /s in river	
	Rolling 80 th percentile	Maximum	Rolling 80 th percentile	Maximum	Rolling 80 th percentile	Maximum
BOD ₅ (mg/L)	≤20	50	≤30	55	≤30	75
SS (mg/L)	≤20	50	≤50	75	≤70	150
DRP (mg/L)	≤0.5	3	≤1	5	≤4.9	6.5
NH ₄ -N (mg/L)	≤30	50	≤30	50	≤30	50
<i>E. coli</i> (cfu/100 mL)	≤1,000	10,000	≤2,500	25,000	≤5,000	50,000

Monitoring of the physico-chemical characteristics of the discharge show that the effluent contains variable concentrations of contaminants, with no apparent patterns, except for NH₄-N), which in general appears to have been decreasing in recent years (Table 2, Figure 8).

Table 2. Characteristics of the Gore wastewater discharge between February 2014 and April 2020. Note sampling of TKN, TP, and TN commenced in June 2019. Data from GDC.

Parameter	Minimum	Maximum	Median	Mean	n
<i>E. coli</i> (MPN/100mL)	10	9,210	630	1,223	41
BOD ₅ (mg/L)	2	64	9.8	14.3	41
SS (mg/L)	3	130	19	28	38
NH ₄ -N (mg/L)	0.1	18.9	9.30	9.75	41
NO ₃ -N (mg/L)	0.77	0.77	-	-	1
TKN (mg/L)	2.2	29.0	13.0	12.8	21
TN (mg/L)	0.5	17.0	14.0	12.0	21
DRP (mg/L)	0.01	3.00	0.03	0.29	41
TP (mg/L)	0.06	3.20	0.41	1.00	19

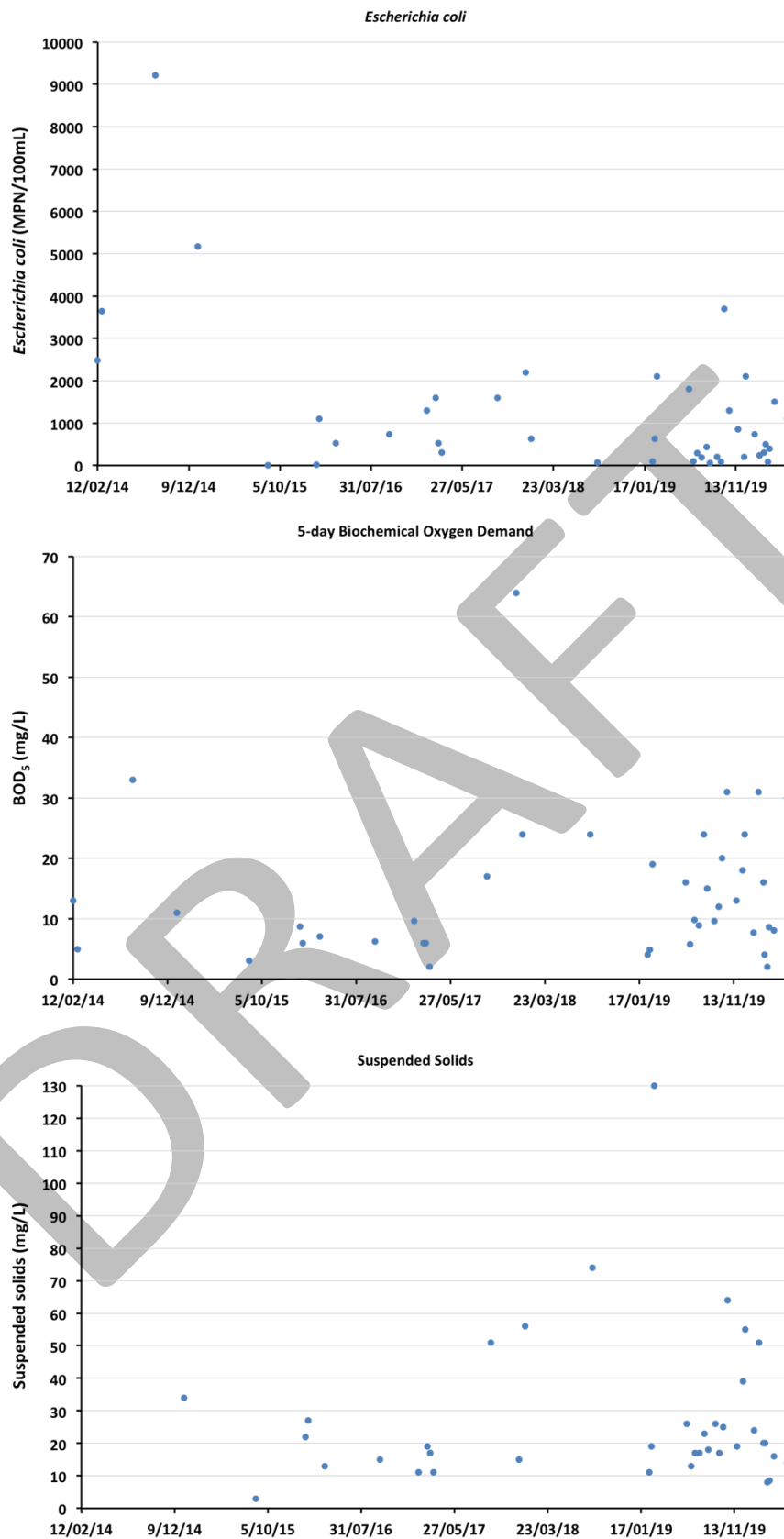


Figure 8. Characteristics of the Gore wastewater discharge between February 2014 and April 2020. Data from GDC.

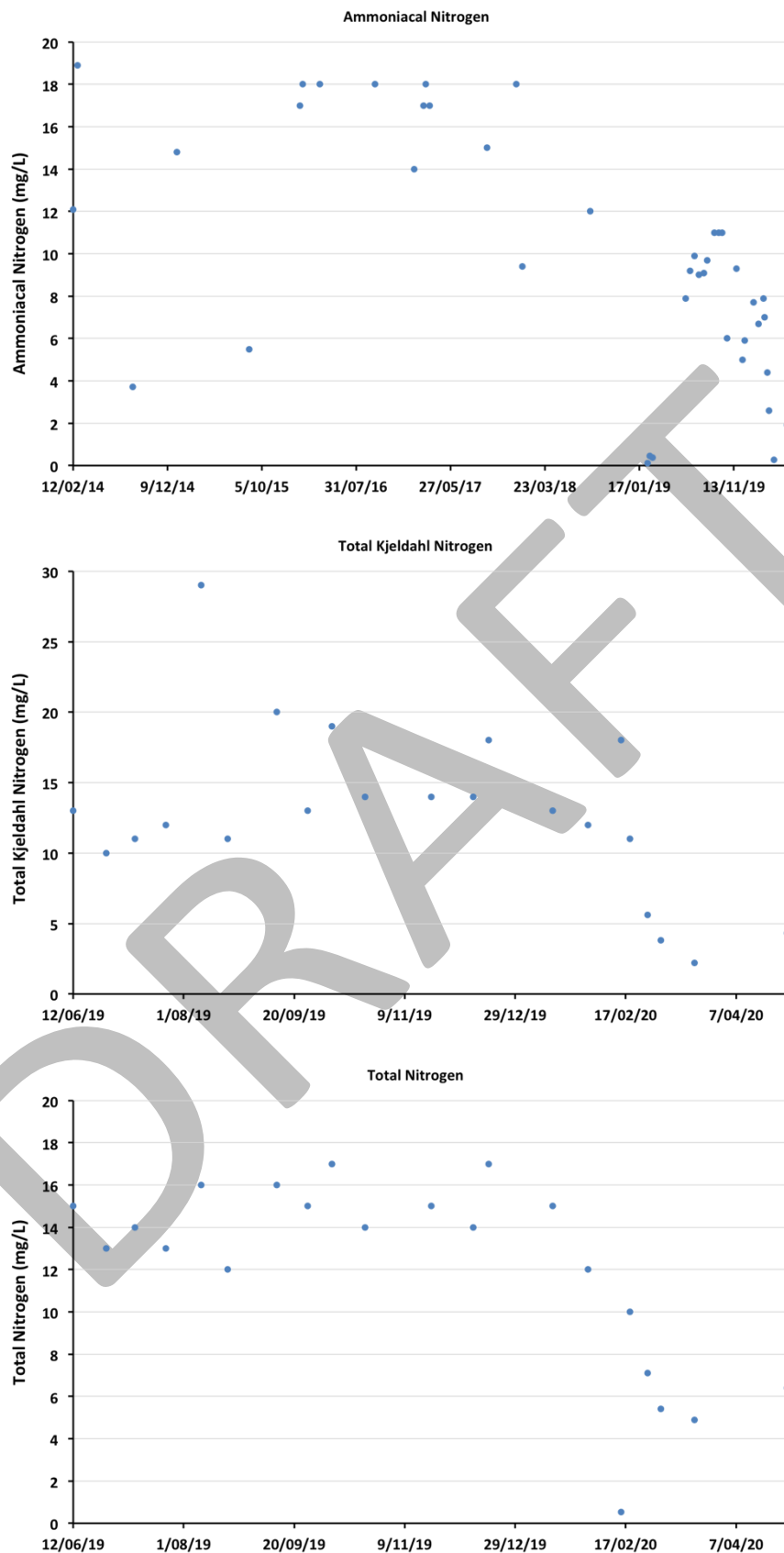


Figure 8 (cont.) Characteristics of the Gore wastewater discharge between February 2014 and April 2020. Data from GDC. Note different horizontal axis scale for TKN and TN.

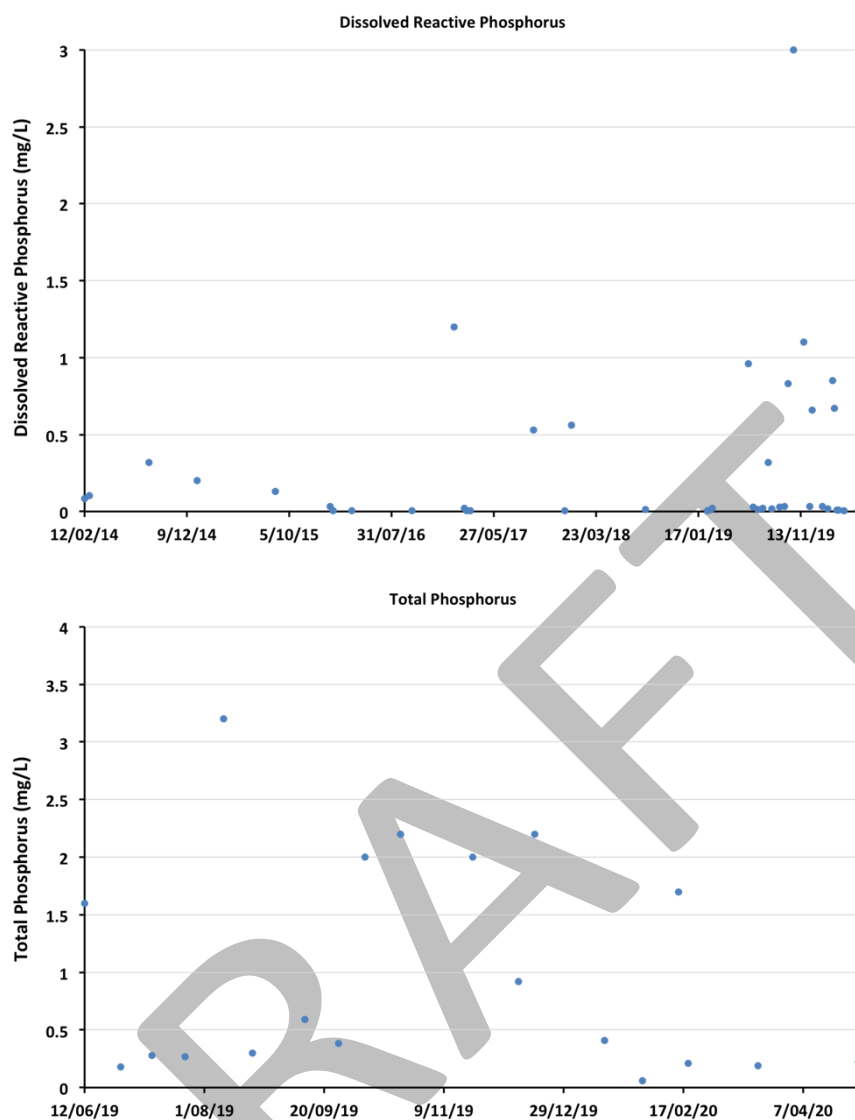


Figure 8 (cont.) Characteristics of the Gore wastewater discharge between February 2014 and April 2020. Data from GDC. Note different horizontal axis scale for TP.

4.2 Mataura discharge

Discharge volumes from the Mataura oxidation pond from January 2018 to May 2020 are presented in Figure 9. The discharge is consented to have an average dry weather volume not exceeding 2,000 m³/d. The data from GDC between 2018 and 2020 shows some volumes higher than the limit, however these are generally associated with high rainfall events and higher river flows (i.e., not during dry weather).

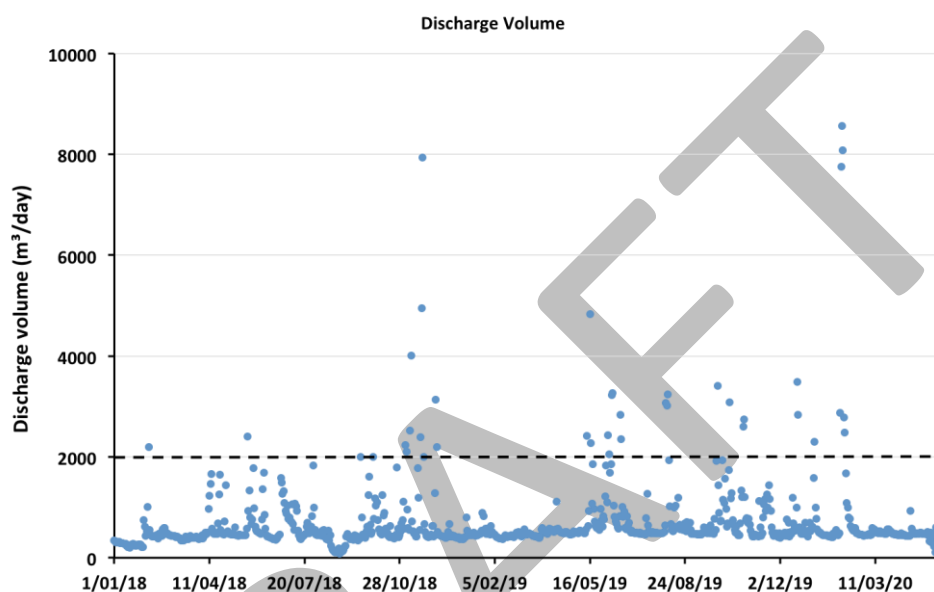


Figure 9. Effluent volume (m³/d) from the Mataura oxidation pond, January 2018 to May 2020 (data supplied by GDC). The dashed line indicates the consented average dry weather discharge volume (2,000 m³/d).

Monitoring of the discharge quality is required by consent to be undertaken at least four times per year; three times between November and April and once between August and September. Representative samples of wastewater prior to the outfall are to be analysed for temperature, electrical conductivity, pH, and concentrations of BOD₅, SS, *E. coli*, NO₃-N, TN, NH₄-N, TP and DRP. The discharge shall conform with the limits in Table 3.

Table 3. Relevant wastewater discharge standards for the Mataura discharge from ES resource consent 203593, with compliance to be determined from the results of four out the five most recent consecutive samples.

Parameter	Four out of the five most recent consecutive samples shall not exceed
After 30 June 2009	
BOD ₅ (mg/L)	20
SS (mg/L)	25
DRP(mg/L)	0.5
NH ₄ -N (mg/L)	8
<i>E. coli</i> (cfu/100 mL)	5,000

Measurements of the physicochemical characteristics of the discharge show that the effluent has circa-neutral pH and contains variable concentrations of contaminants with no apparent patterns, except for concentrations of DRP that have been lower in recent years (Table 4, Figure 10). Concentrations of *E. coli* have been generally less than 1,000 MPN/100 mL.

Table 4. Characteristics of the Mataura wastewater discharge between December 2015 and April 2020. Data from GDC.

Parameter	Minimum	Maximum	Median	Mean	n
<i>E. coli</i> (MPN/100mL)	52	7,400	435	870	28
BOD ₅ (mg/L)	2	11	5.8	5.7	28
SS (mg/L)	4	49	12	14	28
Conductivity (µS/cm)	270	382	329	326	17
pH	6.99	7.45	7.22	7.22	27
NH ₄ -N (mg/L)	4.4	12.0	8.0	8.5	28
NO ₃ -N (mg/L)	0.01	0.61	0.06	0.14	28
TN (mg/L)	6.0	18.0	9.4	10.4	28
DRP (mg/L)	0.01	0.74	0.22	0.31	28
TP (mg/L)	0.28	1.80	0.66	0.78	28

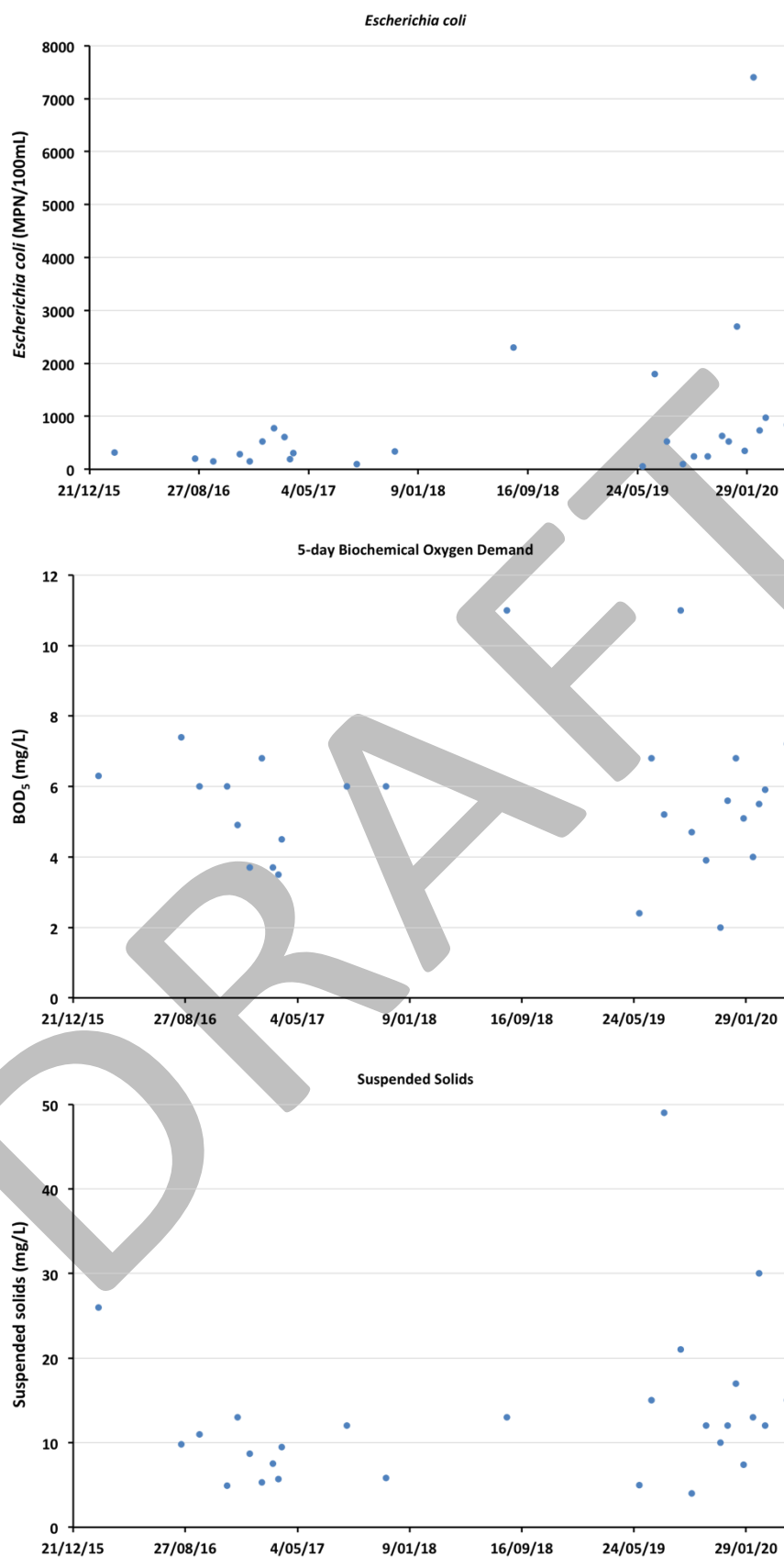


Figure 10. Characteristics of the Mataura wastewater discharge between December 2015 and April 2020. Data from GDC.



Figure 10 (cont.) Characteristics of the Mataura wastewater discharge between December 2015 and April 2020. Data from GDC.

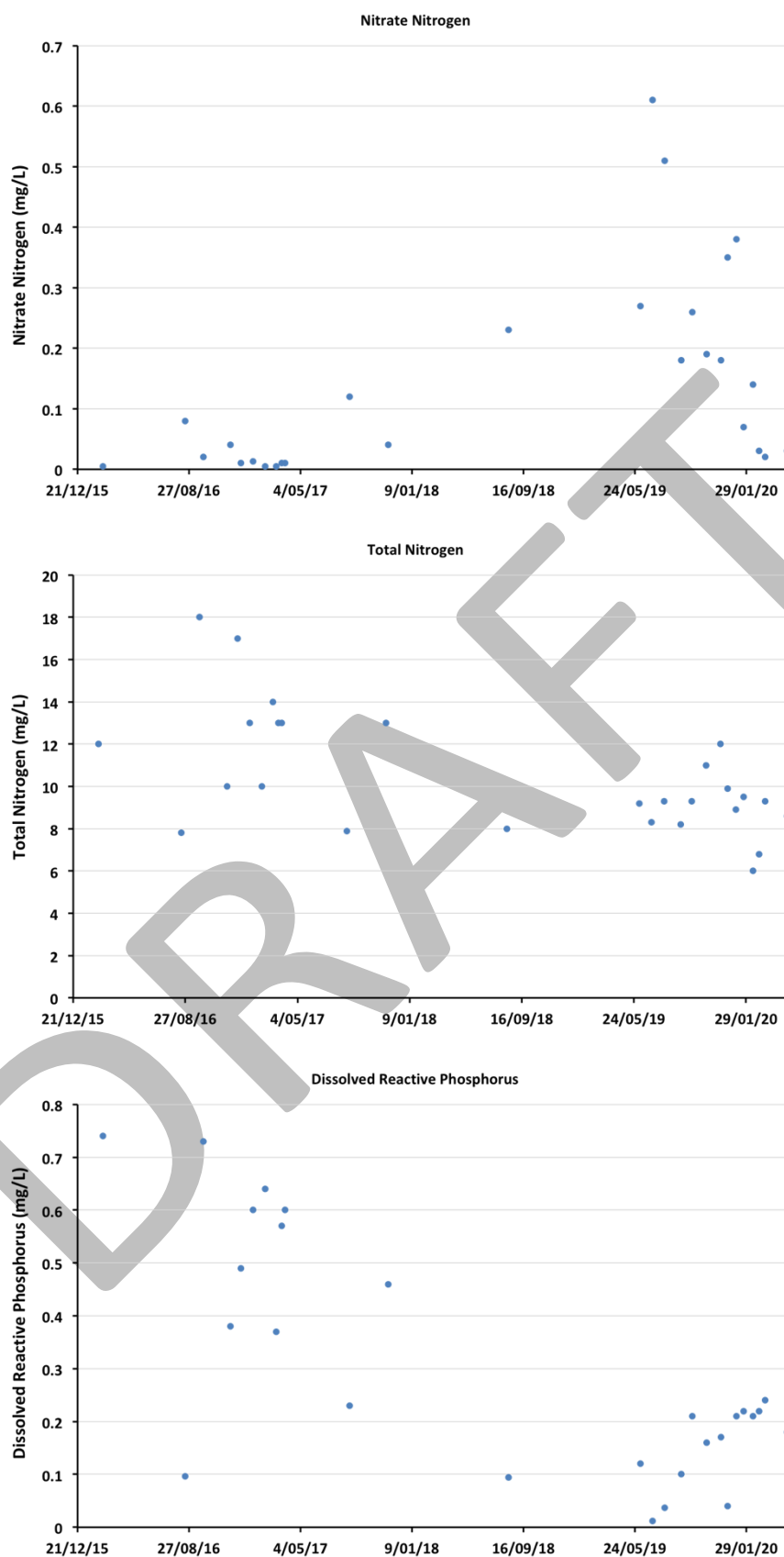


Figure 10 (cont.) Characteristics of the Mataura wastewater discharge between December 2015 and April 2020. Data from GDC.

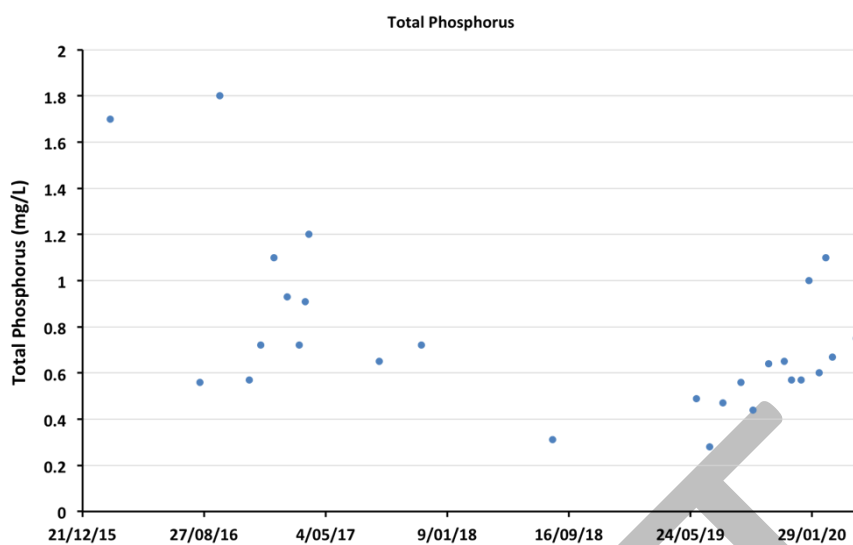


Figure 10 (cont.) Characteristics of the Mataura wastewater discharge between December 2015 and April 2020. Data from GDC.

5 Lower Mataura River - Environment

5.1 Kai Tahu values

The Mataura River is an important mahinga kai, noted for its indigenous fishery. Historically, Maori travelled to the lower river to catch eels, whitebait, freshwater crayfish and waterfowl. The Mataura Falls were particularly associated with the taking of kanakana (lamprey). In 2006, a 10 km stretch of the Mataura River encompassing the Mataura Falls was approved as the first freshwater mātaihai reserve in New Zealand. Long-standing values of importance to Kai Tahu include mauri (life force), knowledge of whakapapa, traditional trails and tauranga waka, places for gathering kai and other taonga, ways in which to use the resources of Mataura, the relationship of people with the river and their dependence on it, and tikanga for the proper and sustainable utilisation of resources (Ngāi Tahu Claims Settlement Act 1998).

5.2 Fishing

Angling

Three sports fish species are present in the Mataura River: brown trout (*Salmo trutta*), European perch (*Perca fluviatilis*) and very occasionally Chinook salmon (*Oncorhynchus tshawytscha*). The brown trout fishery of the Mataura River has been recognised around the world. Indeed, the Mataura WCO declares that the Mataura River and the Waikaia River and various other rivers, streams, and tributaries include outstanding fisheries and angling amenity features.

The Mataura River downstream of Gore to Gorge Road is open for sport fishing from 1 October until 31 May, excluding the first weekend in May; the reach from Gorge Road to the sea is open all year round. Fishing is allowed using artificial fly, spin or bait fishing, and a bag limit of 4 fish per person applies.

The 2014/2015 National Angler's Survey records the Mataura River catchment having approximately 44,270 angler days in 2014/2015, up from 39,530 angler days in 2007/2008 but down from 66,190 angler days in 2001/2002 (Unwin 2016, Table 5). Of these records, the Mataura River below Gore had 22,980 angler days in 2014/2015, an increase from angler days recorded in 2007/2008, but a decrease from 2001/2002. Approximately 52% of the 2014/2015 Mataura River catchment angler days were recorded for the lower Mataura River, an increase from 46% for 2007/2008, but lower than 56% for 2001/2002.

Total angling effort for the Southland region in 2014/15 was 122,660 angler days, with the Mataura River one of the four main catchments (Mataura River, Oreti River, Aparima River, Waiau River) with approximately 36% of the regional total (Unwin 2016). Total annual effort on Southland waters by New Zealand resident anglers was relatively stable

from 1994/95 to 2001/02, but decreased from 2001/02 to 2007/08 and again from 2007/08 to 2014/15, with most of this decline associated with river fisheries (Unwin 2016). On the Mataura River, most of the decline appears to have occurred between 2001/02 and 2007/08, with a similar pattern also evident on its largest tributary, the Waikaia River (Unwin 2016).

Table 5. Angler use of the Mataura River (Unwin 2016).

Location	1994/95 angling days per year (± 1 standard error)	2001/02 angling days per year (± 1 standard error)	2007/08 angling days per year (± 1 standard error)	2014/15 angling days per year (± 1 standard error)
Mataura River (undefined)	51,360 $\pm$ 3,260	300 $\pm$ 90	2,640 $\pm$ 560	
Mataura River (below Gore)		36,850 $\pm$ 3,510	18,070 $\pm$ 2,920	22,980 $\pm$ 3,090
Mataura River (Total)	51,360 $\pm$ 3,260	52,960 $\pm$ 3,950	32,460 $\pm$ 3,330	38,260 $\pm$ 3,470
Mataura River catchment	65,150 $\pm$ 3,570	66,190 $\pm$ 4,250	39,530 $\pm$ 3,510	44,270 $\pm$ 3,610

Whitebaiting

Whitebaiting is an important seasonal activity in the lower Mataura River, with the fishing season open from 15 August until November 30. The lower Mataura River is one of the most important whitebait fisheries in Southland. There are around 660 whitebait stands in Southland, with many of these located on the Mataura immediately upstream of Toetoes Harbour. As with many other whitebait fisheries, the most abundant whitebait species is inanga (*Galaxias maculatus*). Whitebait are caught by both commercial and recreational fishers.

Eel fishery

The lower Mataura River supports an important freshwater eel fishery that is harvested by both the commercial fishing industry and by Maori as a customary food source (see Section 4.1). As with other Southland rivers, the commercial fishery is considered to be a longfin eel fishery as longfin eels are the predominant species caught in the Mataura River and tributaries. All commercial fishing is prohibited within the mātaimai reserve.

5.3 Environment Southland SWLP classes

For planning and resource management purposes, Southland's surface water bodies are divided into different classes (e.g., lowland hard bed, mountain), generally based on the "source of flow" category of the River Environment Classification (REC) framework developed by the National Institute of Water and Atmospheric Research (NIWA) (MfE 2010). A somewhat complicating factor is that the Maitua River catchment has specific Maitua management unit and classes (Maitua 1, 2, and 3) to reflect the water quality standards and provisions set under the Maitua WCO. The Maitua River at the Gore and Maitua townships are classified in the SWLP as 'Maitua 3' waterbodies.

5.4 Water quality at Gore township

Maitua River at Gore

Water quality in the Maitua River has been monitored on a monthly basis at Gore (immediately downstream of the Gore bridge) by ES for many years, as part of its SOE monitoring network. This monitoring programme assesses a suite of water quality parameters in rivers throughout Southland. As the Gore site is approximately 2 km upstream of the Gore oxidation ponds, and therefore upstream of both the Gore and Maitua discharge points, the site provides a good indication of 'background' water quality conditions in the river prior to the discharges.

This monitoring indicates:

- Water quality is variable, with several parameters generally below guideline levels (Table 6).
- pH is well within the range 6.0 to 9.0, as specified for 'Maitua 3' waterbodies in the SWLP, and within the range 7.2 to 7.8 (ANZECC 2000).
- Dissolved oxygen concentrations are well above 8 g/m³, which is the proposed guideline 7-day mean concentration for protection of New Zealand freshwater fish communities (Franklin 2014), and well above 5 g/m³ as specified for 'Maitua 3' waterbodies in the SWLP.

Table 6. Water quality parameters for the Mataura River measured at Gore between March 2000 and February 2020. Data sourced from Environment Southland. Guideline levels from ANZECC (2000), MfE (1992) and MfE (2003). Guideline levels shown are the default trigger values for slightly disturbed lowland rivers.

Parameter	Minimum	Maximum	Median	Mean	n	Guideline levels
Temperature (°C)	2.9	18.4	10.0	10.1	239	<15
pH	6.80	7.70	7.30	7.32	238	7.2 – 7.8
DO (g/m ³)	8.2	12.4	10.3	10.3	102	–
Visual clarity (m)	0.06	4.50	1.22	1.39	232	>0.6
Turbidity (NTU)	0.4	230	4.1	12.9	222	<5.6
<i>E. coli</i> (cfu/100mL)	30	32,000	380	1,255	237	260, 550 ¹
Faecal coliforms (cfu/100mL)	30	40,000	430	1,397	237	–
NH ₄ -N (g/m ³)	<0.01	0.170	0.005	0.011	238	<0.021, <0.9 ²
NO ₃ -N (g/m ³)	0.29	1.52	0.89	0.88	91	
NO ₂ -N (g/m ³)	<0.002	0.007	0.003	0.003	90	
NNN (g/m ³)	0.27	2.29	0.82	0.84	238	<0.444
TKN (g/m ³)	0	1.10	0.17	0.21	91	
TN (g/m ³)	0.44	3.40	1.00	1.07	238	<0.614
DRP (g/m ³)	<0.004	0.055	0.008	0.009	228	<0.010
TP (g/m ³)	<0.004	1.20	0.018	0.036	228	<0.033

¹ Acceptable/Green Mode: No single sample greater than 260 *E. coli*/100mL, Alert/Amber Mode: Single sample greater than 260 *E. coli*/100mL, Action/Red Mode: Single sample greater than 550 *E. coli*/100mL.

² <0.021 = guideline for nutrient enrichment, <0.9 = guideline for ammonia toxicity.

New Zealand guidelines for fresh and marine water quality (ANZG 2018) include percentiles for default guideline values, with 80th percentiles for physical and chemical stressors (indicators) that are harmful at high values (e.g., nitrate) and 20th percentile for physical and chemical stressors that are harmful at low values (e.g., clarity). Guideline values have been developed for REC classes. The Mataura River at Gore is classed as a Cool Dry Hill (CDH) waterway. ANZG (2018) percentiles (20th and 80th percentiles) have been provided for this type of waterway for the relevant parameters (Table 7). The 20th percentile guideline for pH was exceeded, but the 80th percentile value was within guidelines. The guideline values for clarity and turbidity were exceeded at the Mataura River at Gore site.

Table 7. Water quality default guideline values for physical and chemical stressors for the CDH REC class from ANZG (2018), and the corresponding values for the Maitava River at Gore, 2000-2020.

Parameter	ANZG (2018): Cool Dry Hill		Maitava River at Gore	
	20 th percentile	80 th percentile	20 th percentile	80 th percentile
pH	7.31	7.7	7.2	7.4
DO(%)	84	104		
Visual clarity (m)	1.3		0.5	
Turbidity (NTU)		0.9		13.2
SS (g/m ³)		1.6		
Conductivity (μS/cm)		83		
NH ₄ -N (g/m ³)		0.006		0.015
NO ₃ -N (g/m ³)		0.018		1.06
TN (g/m ³)		0.103		1.3
DRP (g/m ³)		0.006		0.012
TP (g/m ³)		0.009		0.041

Nutrients in relation to nuisance growths and toxicity

Water quality monitoring at Gore indicates that concentrations of nitrogen and phosphorus are typically elevated, and frequently above guideline levels for the prevention of nuisance plant and algae growths (Tables 6 and 7).

- NH₄-N concentrations are below the guideline level for nutrient enrichment.
- The median and mean concentrations of both nitrate-nitrite nitrogen (NNN) and TN regularly exceed and almost double the relevant guideline levels (Table 6).
- DRP concentrations are generally below guideline levels.
- The average TP concentration mean of 0.036 g/m³ is higher than the guideline level of 0.033 g/m³ (Table 6).
- All ANZG (2018) guideline values for nitrogen and phosphorus for CDH waterways were exceeded at the Maitava River at Gore site.

The NPS-FM includes attribute states for DRP (ecosystem health), NH₄-N (toxicity) and NO₃-N (toxicity). An analysis of this dataset with respect to the NPS-FM shows:

- For DRP, using data for the previous five years (2015-2010), the median (0.006 mg/L) is just within the upper limit of band A (≤0.006 mg/L), and the 95th percentile (0.022 mg/L) is just within the upper limit of band B (>0.021 and ≤0.030 mg/L).
- For NO₃-N toxicity, the annual medians and 95th percentiles since 2015 have sat within band A, meaning effects even on sensitive species are unlikely.

- For NH₄-N toxicity, the annual medians and annual maximums since 2015 have sat within band A, which equates to 99% species protection.
- Overall, therefore, the Maitara River at Gore is within band B for DRP, and band A for NO₃-N and NH₄-N toxicity.

Faecal contamination

While concentrations of faecal indicator bacteria are variable in the lower Maitara River, they are generally high, with *E. coli* data from the Gore monitoring site having a median of 380 cfu/100 mL and a mean of 1255 cfu/100 mL (Table 8). Other important points to note from this dataset include:

- The MfE Alert/Amber Mode for *E. coli* is a single sample greater than 260 *E. coli* per 100 mL (MfE 2003). This guideline is regularly exceeded at the Gore monitoring site, with 158 of the 237 samples analysed by ES (66.7%) containing more than 260 *E. coli* per 100 mL.
- The MfE Action/Red Mode level for *E. coli* is a single sample greater than 550 *E. coli* per 100 mL (MfE 2003). This is interpreted that if this guideline is exceeded there could be a health-risk for swimming. This guideline is also regularly exceeded at Gore, with 80 of the 237 samples analysed by ES (33.8%) containing more than 550 *E. coli* per 100 mL.
- Faecal contaminant concentration standards are specified for 'Maitara 3' waterbodies in the SWLP as the concentration of *E. coli* shall not exceed 130 *E. coli* per 100 mL at defined "Popular Bathing Sites", which includes the Maitara River at Gore Bridge. The median and mean concentrations of *E. coli* at the Gore site are both well above the specified limits.
- The concentration of faecal coliforms for non-bathing 'Maitara 3' waterbodies shall not exceed 1,000 coliforms per 100 mL. The mean concentration of faecal coliforms (1,397 coliforms per 100 mL) is well above the specified limit (Table 6).

The NPS-FM includes *E. coli* as a compulsory attribute, with four numerical attribute values that must be met in order to achieve a particular "attribute band": % exceedences over 540 cfu/100 mL, % exceedences over 260 cfu/100 mL, median concentration, and 95th percentile. The attribute band should be determined based on a minimum of 60 samples over a maximum of 5 years. The data set available for the Maitara River at Gore consists of 237 samples collected over a 20-year time period (March 2000 – February 2020), however the previous 5-years of data includes 60 samples, so meets the minimum criteria set out in the NPS-FM. An analysis of this dataset with respect to the NPS-FM

shows:

- *E. coli* concentrations and percentiles for the Mataura River at Gore were within band E, meaning that the overall attribute band for this site was band E (Table 8).
- Based on the *E. coli* indicator, a site in band E indicates that for more than 30% of the time the estimated risk of Campylobacter infection is ≥ 50 in 1000 ($>5\%$ risk), and the predicted average infection risk is $>7\%$.

Table 8. Comparison of observed *E. coli* concentrations with the NPS-FM attribute states for *E. coli*, using previous five years of data (2015-2020).

Attribute	Mataura River at Gore
Number of samples >540 cfu/100 mL	19
Number of samples >260 cfu/100 mL	37
Total number of samples	60
% >540	32%
% >260	62%
Median	380
95 th percentile	81,500
OVERALL attribute band	E

The NPS-FM also includes attribute bands and a national bottom line for *E. coli* at primary contact sites. The Mataura River at Gore Bridge is a “Popular Bathing Site”, according to the SWLP:

- For the recreational bathing season 2019-2020 (end of October through to the end of March), the 95th percentile concentration of *E. coli* at the Mataura River at Gore Bridge was 463 cfu/100 mL. This result places the site in the ‘Fair’ attribute band (estimated risk of Campylobacter infection has a 1-5% occurrence, 95% of the time) and above the national bottom line.
- 95th percentile concentrations in all previous recreational bathing seasons since at least 2010 have been above 540 cfu/100 mL (range from 556-16,120 cfu/100 mL), and therefore in the ‘Poor’ attribute band (estimated risk of Campylobacter infection has a 1-5% occurrence, 95% of the time) and exceeding the national bottom line.

Water clarity

Analysis of monitoring data for the Mataura River at Gore show:

- Water clarity is typically within guideline levels for protecting aquatic ecosystems,

and turbidity is generally lower than the ANZECC (2000) guideline level (Table 6).

- ANZG (2018) percentile guideline values for clarity and turbidity were exceeded (Table 7).

New Zealand water quality guidelines (ANZECC 2000) state that *'to protect the visual clarity of waters used for swimming, the horizontal sighting of a 200 mm diameter black disc should exceed 1.6 m'*. Based on monitoring at Gore:

- The average water clarity in the lower Mataura River was 1.39 m, and water clarity was greater than the bathing guideline level of 1.6 m on 32.8% of 232 sampling occasions between 2000 and 2020.

In terms of these water clarity guidelines for recreation, the Mataura River at Gore can therefore be considered on many occasions to be unsuitable for bathing and general contact recreation.

Comparisons of recent river flow data and clarity data between 2000 and 2020 show the long term relationship between flow and clarity (Figure 11). Not surprisingly, water clarity decreases as flow increases. Clarity increases sharply as flows drop below about 25-30 m³/s. Rain in the catchments of tributaries such as the Waikaia River and Waikaka Stream can result in pulses of discoloured water even during low flow situations.

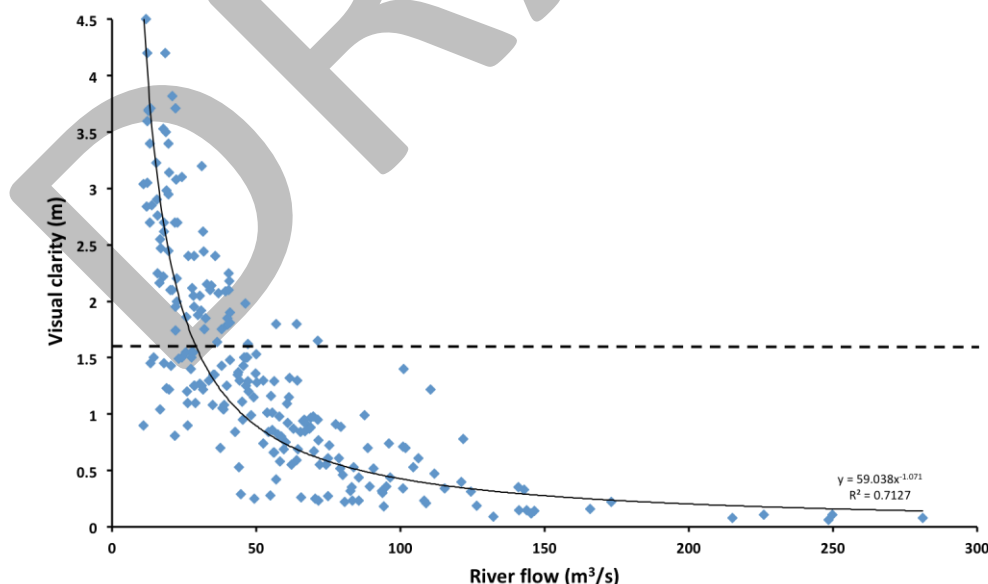


Figure 11. Relationship between visual clarity (m) and river flow (m³/s) measured on a monthly basis in the Mataura River at Gore between March 2000 and February 2020. Data sourced from ES. Dashed line indicates ANZECC (2000) guideline level of 1.6 m, below which water quality is deemed not suitable for swimming.

The NPS-FM includes the attribute of suspended fine sediment, which affects water clarity and turbidity. The numeric attribute values for different suspended sediment classes are based on REC classes. The attribute bands are defined, with the minimum record length for grading a site of two years of at least monthly samples (at least 24 samples). A national bottom line of 1.6 FNU (Formazin Nephelometric Units) is set for waterways such as the Mataura River at Gore, however the NPS-FM does not define whether this is a monthly average or a percentile. Regardless, over the previous two years, the median, mean, and the 80th and 95th percentiles are all well above 1.6 NTU (Nephelometric Turbidity Unit, generally comparable to FNU), and therefore above the national bottom line and in band D, indicating potential for a high impact of suspended sediment on instream biota.

Inputs to the Mataura River from Waikaka Stream

The Waikaka Stream enters the Mataura River downstream of the Gore bridge, and approximately 1 km upstream of the Gore oxidation ponds. The stream is classed as a 'Lowland soft bed' waterbody in the SWLP, and is in the Cool Dry Low-elevation Soft Sedimentary waterways REC class.

ES monitor water quality in the Waikaka Stream at Gore on a monthly basis as part of its SOE monitoring network, with the site located approximately 275 m upstream of the confluence with the Mataura River. Because inflows from Waikaka Stream can influence the water quality of the Mataura River, data from this monitoring was also assessed.

This monitoring indicates:

- Water quality is variable, with several parameters generally exceeding guideline levels (Tables 9 and 10).
- pH is well within the range 6.5 to 9.0, as specified for 'Lowland soft bed' waterbodies, and generally within the range 7.2 to 7.8 (ANZECC 2000).
- The median dissolved oxygen concentration is 9.8 g/m³ and the mean is 9.6 g/m³, both above 8 g/m³, which is the proposed guideline 7-day mean concentration for protection of New Zealand freshwater fish communities (Franklin 2014).
- Water clarity generally exceeds guideline levels for protecting aquatic ecosystems, but is within ANZG (2018) percentile guideline values (Tables 9 and 10).
- Turbidity is high, with the 80th percentile almost ten times the ANZG (2018) guideline (Table 10). The NPS-FM sets a national bottom line for suspended fine sediment (turbidity) of 6.4 FNU for Cool Dry Low-elevation Soft Sedimentary waterways. Over 2018-19, the mean, and the 80th and 95th percentiles are all above 6.4 NTU, with a median of 5.5 NTU. The site would therefore be graded in either band C (moderate to high impact of suspended sediment on instream biota)

or band D (high impact of suspended sediment on instream biota).

- Concentrations of nitrogen and phosphorus are high, and frequently above all guideline levels for the prevention of nuisance plant and algae growths (Tables 9 and 10). Mean and median concentrations for nitrogen and phosphorus are more than double the relevant guideline levels.
- All ammonia concentrations from the Waikaka Stream at Gore were lower than the standards in Table 1 of the SWLP.

Comparing Waikaka Stream nutrient monitoring data for the previous five years (2015-2010) with attribute states within the NPS-FM:

- The DRP median concentration (0.018 mg/L) is just within band C (>0.010 and ≥ 0.018 mg/L).
- The DRP 95th percentile concentration (0.042 mg/L) is also within band C (>0.030 and ≤ 0.054 mg/L).
- The DRP (ecosystem health) national bottom line has a median concentration of 0.018 mg/L and a 95th percentile concentration of 0.054 mg/L. The Waikaka Stream median is below the national bottom line for DRP.
- For NO₃-N toxicity, annual medians since 2015 (range 0.63-1.03 mg/L) and 95th percentiles since 2015 (range 1.4-2.3 mg/L) are within either band A ('unlikely to be effects even on sensitive species') or band B ('some growth effect on up to 5% of species').
- For NH₄-N toxicity, the annual medians for the same period are within band A, but the 2020 median (based on limited sampling so far this year) is within band B. The annual maximums have also been within band A (99% species protection level), except in 2017 when the maximum was in band B ('95% species protection level').
- Overall, the Waikaka Stream at Gore is within band C for DRP, and band A or B (depending on year) for NO₃-N and NH₄-N toxicity.

Table 9. Water quality parameters for the Waikaka Stream at Gore between January 2000 and February 2020. Data sourced from Environment Southland. Guideline levels from ANZECC (2000), MfE (1992) and MfE (2003). Guideline levels shown are the default trigger values for slightly disturbed lowland rivers.

Parameter	Minimum	Maximum	Median	Mean	n	Guideline levels
Temperature (°C)	1.4	23.7	10.4	10.4	242	<15
pH	6.6	8.0	7.4	7.3	241	7.2 – 7.8
DO(g/m ³)	6.2	12.9	9.8	9.6	105	–
Visual clarity (m)	0.06	3.5	0.89	0.91	233	<0.6
Turbidity (NTU)	1.7	330	6.8	14.0	226	<5.6
<i>E. coli</i> (cfu/100mL)	60	72,000	330	3,076	240	260, 550 ¹
Faecal coliforms (cfu/100mL)	60	82,000	390	3,453	240	–
NH ₄ -N (g/m ³)	<0.010	0.220	0.052	0.056	241	<0.021, <0.9 ²
NO ₃ -N (g/m ³)	0.002	2.70	0.73	0.83	91	
NO ₂ -N (g/m ³)	0.003	0.021	0.008	0.009	90	
NNN (g/m ³)	0.006	3.39	0.79	0.88	241	<0.444
TKN (g/m ³)	0.24	2.40	0.46	0.61	110	
TN (g/m ³)	0.24	4.70	1.30	1.46	241	<0.614
DRP (g/m ³)	0.006	0.081	0.020	0.024	233	<0.010
TP (g/m ³)	0.011	0.560	0.062	0.079	233	<0.033

¹ Acceptable/Green Mode: No single sample greater than 260 *E. coli*/100mL, Alert/Amber Mode: Single sample greater than 260 *E. coli*/100mL, Action/Red Mode: Single sample greater than 550 *E. coli*/100mL.

² <0.021 = guideline for nutrient enrichment, <0.9 = guideline for ammonia toxicity.

Table 10. Water quality default guideline values for physical and chemical stressors for the CDL REC class from ANZG (2018), and the corresponding values for the Waikaka Stream at Gore, 2000-2020.

Parameter	ANZG (2018): Cool Dry Low-elevation		Waikaka Stream at Gore	
	20 th percentile	80 th percentile	20 th percentile	80 th percentile
pH	7.23	7.8	7.2	7.6
DO (%)	81	101		
Visual clarity (m)	0.5		0.5	
Turbidity (NTU)		1.3		13
SS (g/m ³)		2.1		
Conductivity (µS/cm)		116		
NH ₄ -N (g/m ³)		0.01		0.08
NO ₃ -N (g/m ³)		0.265		1.42
TN (g/m ³)		0.913		2.1
DRP (g/m ³)		0.008		0.034
TP (g/m ³)		0.014		0.086

With respect to faecal indicator bacteria in Waikaka Stream:

- Concentrations are variable, but generally high, with a median of 330 cfu/100 mL and a mean of 3076 cfu/100 mL (Table 9).
- The MfE Alert/Amber Mode for *E. coli* (single sample greater than 260 *E. coli* per 100 mL) is regularly exceeded, with 146 of the 240 samples analysed by ES (60.8%) containing more than 260 *E. coli* per 100 mL.
- The MfE Action/Red Mode level for *E. coli* (single sample greater than 550 *E. coli* per 100 mL) is also regularly exceeded, with 83 of the 240 samples (34.6%) containing more than 550 *E. coli* per 100 mL.
- The mean concentration of faecal coliforms at the Waikaka Stream site (3,453 coliforms per 100 mL) is well above specified limits for 'Lowland soft bed' waterbodies in the SWLP¹ (Table 9).
- For the last 5-years of data, *E. coli* concentrations for the Waikaka Stream at Gore were within band D, despite the 95th percentile exceeding 1,200 cfu/100 mL (which is in bands D/E), meaning that the overall attribute band for this site was band D (Table 11).
- Based on the *E. coli* indicator, a site in band D indicates that for 20-30% of the time the estimated risk of Campylobacter infection is ≥50 in 1000 (>5% risk), and the predicted average infection risk is >3%.

Table 11. Comparison of observed *E. coli* concentrations with the NPS-FM attribute states for *E. coli*, using previous five years of data (2015-2020).

Attribute	Waikaka Stream at Gore
Number of samples >540 cfu/100 mL	18
Number of samples >260 cfu/100 mL	27
Total number of samples	60
% >540	30%
% >260	45%
Median	225
95 th percentile	17,300
OVERALL attribute band	D

¹ Faecal contaminant concentration standards for 'Lowland soft bed' waterbodies in the SWLP: the concentration of faecal coliforms shall not exceed 1,000 coliforms per 100 mL.

5.5 Water quality at Maitara township

Maitara River 200 m downstream of Maitara

Water quality in the Maitara River has been monitored on a monthly basis at a site 200 m downstream of Maitara township by ES for many years, as part of its SOE monitoring network. This site is downstream of the Gore discharge, but also downstream of discharges to the river from the Alliance meat processing plant, also located at Maitara. As this site is approximately 3 km upstream of the Maitara wastewater discharge point, the site provides a good indication of ‘background’ water quality conditions in the river prior to the Maitara discharge.

This monitoring indicates:

- Water quality is variable, with several parameters generally exceeding guideline levels (Tables 12 and 13).
- pH is well within the range 6.0 to 9.0, as specified for ‘Maitara 3’ waterbodies in the SWLP, and within the range 7.2 to 7.8 (ANZECC 2000).
- Dissolved oxygen concentrations are above 8 g/m³ and well above 5 g/m³ as specified for ‘Maitara 3’ waterbodies in the SWLP.
- Turbidity is high, with the 80th percentile sixteen times the ANZG (2018) guideline (Table 13). Over 2018-19, the mean, median, 80th and 95th percentiles are all above 1.6 NTU and therefore above the national bottom line, with a 20th percentile of 1.52 NTU. The site would therefore be placed in band D, indicating potential for a high impact of suspended sediment on instream biota.
- Water clarity is typically within guideline levels for protecting aquatic ecosystems, however ANZG (2018) percentile guideline values for clarity were exceeded (Table 13).
- The Maitara River at Maitara River Bridge is listed as a “Popular Bathing Site”, under the SWLP. The average water clarity monitoring site is 1.12 m. Clarity is greater than the ANZECC (2000) bathing guideline level of 1.6 m on 21.8% of 225 sampling occasions between 2000 and 2020. In terms of these water clarity guidelines for recreation, the Maitara River at Maitara can therefore be considered on many occasions to be unsuitable for bathing and general contact recreation.
- Concentrations of nitrogen and phosphorus are typically high, and frequently above guideline levels for the prevention of nuisance plant and algae growths (Tables 12 and 13).
- NH₄-N concentrations are generally higher than the guideline level for nutrient enrichment, and the median and mean concentrations of both NNN and TN

regularly exceed and are close to double relevant guideline levels (Table 12). Similarly, the mean and median DRP and TP concentrations are higher than guideline levels (Table 12). All ANZG (2018) guideline values for nitrogen and phosphorus for CDL waterways were exceeded at this monitoring site.

- Comparing the data for 2015-2010 with the NPS-FM, the DRP median concentration (0.010 mg/L) is just within the upper limit of band B (>0.006 and ≤ 0.010 mg/L), while the 95th percentile concentration (0.018 mg/L) sits within band A. For NO₃-N toxicity, annual medians (0.80-1.00 mg/L) and 95th percentiles (1.1-1.6 mg/L) sit within band A ('unlikely to be effects even on sensitive species'), except for the 2019 95th percentile, which was in band B ('some growth effect on up to 5% of species').
- For NH₄-N toxicity, annual medians have been within band A. The annual maximums have been within band A ('99% species protection level') for the period 2015 and 2020 (based on limited sampling in 2020), but between 2016 and 2019 they were within band B ('95% species protection level').
- Overall, for the Mataura River at the monitoring site 200 m downstream of Mataura township, water quality is within band B for DRP, and band A or B (depending on year) for NO₃-N and NH₄-N toxicity.

Table 12. Water quality parameters for the Mataura River measured 200 m downstream of Mataura between January 2000 and February 2020. Data sourced from Environment Southland. Guideline levels from ANZECC and ARMCANZ (2000), MfE (1992) and MfE (2003). Guideline levels shown are the default trigger values for slightly disturbed lowland rivers.

Parameter	Minimum	Maximum	Median	Mean	n	Guideline levels
Temperature (°C)	3.1	19.3	10.7	10.6	241	<15
pH	6.50	7.80	7.34	7.36	240	7.2 – 7.8
DO (g/m ³)	8.1	13.6	10.6	10.6	105	–
Visual clarity (m)	0.07	3.50	1.05	1.12	225	>0.6
Turbidity (NTU)	0.8	300	4.2	13.7	225	<5.6
<i>E. coli</i> (cfu/100mL)	57	60,000	1,100	2,998	233	260, 550 ¹
Faecal coliforms (cfu/100mL)	60	65,000	1,300	4,503	233	–
NH ₄ -N (g/m ³)	<0.01	0.300	0.041	0.060	239	<0.021, <0.9 ²
NO ₃ -N (g/m ³)	0.27	1.74	0.80	0.83	127	
NO ₂ -N (g/m ³)	<0.002	0.016	0.004	0.005	89	
NNN (g/m ³)	0.28	2.40	0.81	0.86	240	<0.444
TKN (g/m ³)	0.12	1.49	0.27	0.33	109	
TN (g/m ³)	0.07	3.45	1.18	1.25	240	<0.614
DRP (g/m ³)	<0.004	0.160	0.014	0.021	230	<0.010
TP (g/m ³)	0.008	1.20	0.034	0.056	230	<0.033

¹ Acceptable/Green Mode: No single sample greater than 260 *E. coli*/100mL, Alert/Amber Mode: Single sample greater than 260 *E. coli*/100mL, Action/Red Mode: Single sample greater than 550 *E. coli*/100mL.

² <0.021 = guideline for nutrient enrichment, <0.9 = guideline for ammonia toxicity.

Table 13. Water quality default guideline values for physical and chemical stressors for the CDH REC class from ANZG (2018), and the corresponding values for the Mataura River 200 m downstream of Mataura, 2000-2020.

Parameter	ANZG (2018): Cool Dry Hill		Mataura River 200 m downstream of Mataura	
	20 th percentile	80 th percentile	20 th percentile	80 th percentile
pH	7.31	7.7	7.2	7.5
DO (%)	84	104		
Visual clarity (m)	1.3		0.5	
Turbidity (NTU)		0.9		14.4
SS (g/m ³)		1.6		
Conductivity (µS/cm)		83		
NH ₄ -N (g/m ³)		0.006		0.09
NO ₃ -N (g/m ³)		0.018		1.07
TN (g/m ³)		0.103		1.54
DRP (g/m ³)		0.006		0.03
TP (g/m ³)		0.009		0.07

With respect to faecal indicators, data from the monitoring site 200 m downstream of

Mataura indicate:

- Concentrations of faecal indicator bacteria are high, with a median of 1100 cfu/100 mL and a mean of 2998 cfu/100 mL (Table 12).
- The MfE Alert/Amber Mode for *E. coli* (single sample greater than 260 *E. coli* per 100 mL) is regularly exceeded, with 203 of the 233 samples analysed by ES (87.1%) containing more than 260 *E. coli* per 100 mL.
- The MfE Action/Red Mode level for *E. coli* (single sample greater than 550 *E. coli* per 100 mL) is also regularly exceeded, with 167 of the 238 samples analysed by ES (71.7%) containing more than 550 *E. coli* per 100 mL.
- The median and mean concentrations of *E. coli* at this site are both well above specified limits for 'Mataura 3' and 'Popular Bathing Sites'. The concentration of faecal coliforms for non-bathing 'Mataura 3' waterbodies shall not exceed 1,000 coliforms per 100 mL. The median and mean concentrations of faecal coliforms at this site are well above the specified limits (1,300 and 4,503 coliforms per 100 mL respectively) (Table 12).
- With respect to the NPS-FM, *E. coli* concentrations at this site were within band E (Table 14). Based on the *E. coli* indicator, a site in band E indicates that for more than 30% of the time the estimated risk of Campylobacter infection is ≥ 50 in 1000 (>5% risk), and the predicted average infection risk is >7%.
- The NPS-FM includes attribute bands and a national bottom line for *E. coli* at primary contact sites. The 95th percentile concentrations of *E. coli* at this site during recreational bathing seasons (end of October through to the end of March) consistently exceed the national bottom line of 540 *E. coli* per 100 mL, with 95th percentiles between 2010 and 2020 ranging from 1,455 cfu/100 mL to 52200 cfu/100 mL. These results place this site consistently in the 'Poor' attribute band (estimated risk of Campylobacter infection has a 1-5% occurrence, 95% of the time).

Table 14. Comparison of observed *E. coli* concentrations with the NPS-FM attribute states for *E. coli*, using previous five years of data (2015-2020).

Attribute	Mataura River 200 m downstream of Mataura
Number of samples >540 cfu/100 mL	44
Number of samples >260 cfu/100 mL	52
Total number of samples	59
% >540	75%
% >260	88%
Median	1100
95 th percentile	17300
OVERALL attribute band	E

5.6 Aquatic algae and plants

Periphyton or benthic algae is the material that forms slippery surfaces often observed, or at least felt, on upper stone surfaces of rivers and streams. Under favourable conditions (high nutrient levels, warm temperatures, high light and stable flows), these growths flourish and develop into thick layers of varying colour and texture. Periphyton growths represent an important food source for benthic macroinvertebrates, but thick growths are typically less palatable and can adversely alter invertebrate habitat as well create a nuisance for river users and affect aesthetics.

The invasive diatom *Didymosphenia geminata* (didymo) was first discovered in the upper Mataura River in August 2006 and at other sites further downstream in the catchment in the following years. Didymo has been declared an unwanted organism under the Biosecurity Act 1993. Didymo is one of the larger freshwater diatoms and grows attached to both stone and plant substrates by long mucilaginous stalks. Favourable environmental conditions for proliferations of didymo include high light and stable flows. Many of the proliferations reported from overseas are in regulated or lake-fed rivers, although there are exceptions to this (Kilroy 2004). Didymo is able to attain very high cover levels, with mats capable of completely smothering the bed substrate in places.

Benthic cyanobacteria mats have been observed throughout the lower Mataura River, with warnings to river users at times of high risk due to high cover levels and the increased potential for toxin production.

Gore

Periphyton cover is visually assessed on an up to monthly basis by ES at the Mataura River at Gore and the Waikaka Stream at Gore monitoring sites (Table 15). Periphyton cover is assessed when wading is possible at a site, and includes categories from thin to thick mats,

and short to long filaments. Monitoring has found:

- Overall, cover at the Mataura River site is dominated by thin mats, with only low cover of other categories.
- Cover at the Waikaka Stream site is also dominated by thin mats, but cover of long filaments is also high.
- High cover levels that can be found at times, for example, up to an average of 86% cover of long filamentous algae at the Waikaka Stream site in January 2019.

Table 15. *Periphyton cover in the Mataura River and Waikaka Stream at Gore, December 2014 to May 2019. Values are averages of site averages per sampling occasion (range in brackets). Data from ES.*

Periphyton cover category	Mataura River at Gore (n = 27)	Waikaka Stream at Gore (n = 35)
Thin mat or film (< 0.5mm thick)	45.3 (0-96)	32.0 (0-76.75)
Medium mat or film (0.5mm to 3mm thick)	1.2 (0-21)	7.1 (0-45.5)
Thick mat or film (> 3mm thick)	1.1 (0-13.5)	2.9 (0-51.5)
Short filaments (< about 2cm long)	0.2 (0-3)	4.3 (0-41)
Long filaments (> about 2cm long)	0.1 (0-1.5)	18.9 (0-86)

Quantitative periphyton biomass assessments are also undertaken on a monthly basis by ES at the Mataura River at Gore and the Waikaka Stream at Gore monitoring sites (using chlorophyll-*a* as a surrogate for biomass). Over the last five years:

- The median monthly chlorophyll-*a* concentration at the Mataura River at Gore site was 2.9 mg/m², and 60.3 mg/m² at the Waikaka Stream at Gore site .
- Applying these values, the Mataura River at Gore is in band A² of the NPS-FM and the Waikaka Stream site is in band B³.

Mataura

The Mataura River 200 m downstream of the Mataura Bridge site is only sampled by ES for chlorophyll-*a* on an annual basis and therefore cannot be assessed against NPS-FM attribute states for periphyton. Results in recent years are as follows:

- 90.4 mg/m² (February 2016),
- 93.4 mg/m² (February 2017), and
- 54.3 mg/m² (February 2019).

² A band: rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat.

³ B Band: occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat.

5.7 Benthic macroinvertebrates

Freshwater benthic macroinvertebrates are small organisms that live on the beds of rivers, lakes and wetlands, have no backbone and are larger than 250 microns (0.25 mm) in size. This broad grouping includes insect larvae (e.g., caddisflies, mayflies, stoneflies), aquatic worms (oligochaetes), snails and crustaceans (e.g., amphipods, isopods and freshwater crayfish).

Macroinvertebrates are important in streams and lakes because they are a primary food item for many freshwater fish species and a number of wetland and riverine bird species. Their ability to transfer primary production (i.e., algae or 'periphyton' growth) into a food source for fish and birds is a fundamental aspect of healthy stream and river ecosystems.

Aquatic macroinvertebrates are also good indicators of ecological change in freshwater environments. Changes in abundance (density or 'numbers') can be influenced by changes in water quality, periphyton biomass and flow history. Because different macroinvertebrate species have different tolerances to instream environmental factors such as dissolved oxygen, temperature, contaminant concentrations, substrate disturbance, fine sediment deposition and periphyton cover, the presence or absence of particular species, and their relative abundance to one another, can provide an indication of water quality and general habitat conditions.

Mataura River at Gore

Information on benthic macroinvertebrate communities is collected annually by ES as part of the SOE monitoring. Results for the Mataura River at Gore site for the period 2010 to 2019 show the community is dominated by *Deleatidium* mayflies, with oligochaete worms and several types of caddisflies (e.g., *Hydropsyche-Aoteapsyche*, *Pycnocentroides*) also abundant at times (Appendix One). Community health index scores (MCI and SQMCI⁴) are indicative of 'good' to 'excellent' quality conditions.

The NPS-FM includes an MCI attribute requiring 'action plans'. This draft attribute includes a national bottom line for MCI and QMCI scores, based on five-year rolling averages (note that the QMCI and SQMCI use the same scale and are therefore comparable). The monitoring data for the Mataura River at Gore shows:

- Rolling average MCI scores for the period 2010-2019 range between 94 and 97, which are above the national bottom line of 90 and in band C⁵.

⁴ Macroinvertebrate Community Index (MCI) (Stark 1993) and semi-quantitative MCI (SQMCI) (Stark 1998): Taxon are assigned a score between 1 and 10, 1 representing a species tolerant to organic pollution (e.g., worms and some dipteran species) and 10 representing species sensitive to organic pollution (e.g., most mayflies and stoneflies). MCI site scores <80 represents 'poor' conditions and >120 represents 'excellent' conditions. SQMCI site scores <4.0 represents 'poor' conditions and >6.0 represents 'excellent' conditions.

⁵ C band: described as a macroinvertebrate community indicative of moderate organic pollution or nutrient enrichment with a mix of taxa sensitive and insensitive to organic pollution/nutrient enrichment

- Rolling average SQMCI scores for the period 2010-2019 range between 6.3 and 7.1, which are above the national bottom line of 4.5 and in band A or B⁶.
- The abundance of high-scoring *Deleatidium* mayflies at this site relative to lower scoring taxa contribute to the differences in MCI and SQMCI scores.
- Overall, the Mataura River at the Gore monitoring site is within band C for macroinvertebrates.

Waikaka Stream at Gore

At this site, macroinvertebrate communities have also been dominated by *Deleatidium* mayflies, however several other taxa have also been dominant, including *Paracalliope* amphipods, chironomid (midge) larvae, *Potamopyrgus* snails, oligochaete worms, and several types of caddisflies (Appendix One). MCI scores have been indicative of 'fair' quality conditions, while SQMCI scores have been indicative of 'poor' to 'good-excellent' quality conditions.

The 'Lowland soft bed' standards in ES's SWLP state that MCIs shall exceed 80 and SQMCIs shall exceed 3.5. Since 2015, both MCI and SQMCI scores at this site have been higher than the required standard.

With respect to the MCI attribute in the NPS-FM:

- Rolling average MCI scores for the period 2010-2019 range between 90 and 91, which are at or only just above the national bottom line of 90 and in band C.
- Rolling average SQMCI scores for the period 2010-2019 range between 4.7 and 5.2, which are above the national bottom line of 4.5 and also in band C.
- As for the Mataura River at Gore, while high-scoring *Deleatidium* mayflies are abundant at this site, other lower scoring taxa (e.g., oligochaete worms, *Potamopyrgus* snails) are also highly abundant.
- Overall, the Waikaka Stream at Gore is within band C for macroinvertebrate community health.

Mataura River 200 m downstream of Mataura

While *Deleatidium* mayflies also dominate macroinvertebrate communities at the Mataura River monitoring site 200 m downstream of Mataura township, several other taxa have been co-dominant, including chironomid (midge) larvae, *Potamopyrgus* snails,

⁶ A band: a community indicative of pristine conditions with almost no organic pollution or nutrient enrichment. B band: a community indicative of mild organic pollution or nutrient enrichment and largely composed of taxa sensitive to organic pollution/nutrient enrichment.

oligochaete worms, and several types of caddisflies, predominantly the net-spinner *Hydropsyche-Aoteapsyche* (Appendix One). MCI scores have been indicative of 'fair' to 'good' quality conditions, while SQMCI scores have been indicative of a range from 'poor' to 'excellent' quality conditions but 'fair' quality conditions have been most common.

With respect to the MCI attribute in the NPS-FM:

- Rolling average MCI scores for the period 2010-2019 range between 100 and 101, which are above the national bottom line of 90 and in band C.
- Rolling average SQMCI scores for the period 2010-2019 range between 4.8 and 5.1, which are above the national bottom line of 4.5 and also in band C.
- While high-scoring *Deleatidium* mayflies are abundant at this site, as seen in the monitoring site at Gore, other lower scoring taxa (e.g., oligochaete worms, *Potamopyrgus* snails) are also abundant and contribute to the lower community index scores relative to those observed at Gore.

5.8 Fish

The NZFFD was interrogated to find the known diversity and distribution of fish in the lower Mataura River catchment (Table 16). The database indicates that most fish surveys have been undertaken in the tributaries, with relatively few surveys of the Mataura River itself. This may in part due the size of the river and the associated difficulty to undertake efficient sampling.

Many fish species present in the catchment undergo migrations to sea, and so would likely be present in the lower Mataura mainstem during migration periods (Table 16). Upstream passage for some species (e.g., non-climbers such as inanga) will be restricted by the Mataura Falls at Mataura.

Several species are classified as being 'At risk – Declining' and lamprey are considered nationally vulnerable (Table 16). The threatened – nationally vulnerable Gollum galaxias (*Galaxias gollumoides*) is also found in the Mataura River catchment, however this species is generally found in smaller tributaries, and is a non-migratory native species.

Table 16. List of fish species identified in the NZFFD in the Mataura River catchment in the general vicinity of Gore and Mataura, and species expected to be present at times. Conservation status from Dunn et al. (2018).

Species	Common name	Native	Migratory	Conservation status
<i>Anguilla australis</i>	Shortfin eel	Y	Y	Not threatened
<i>Anguilla dieffenbachii</i>	Longfin eel	Y	Y	At Risk - Declining
<i>Cheimarrichthys fosteri</i>	Torrentfish	Y	Y	At Risk - Declining
<i>Galaxias brevipinnis</i>	Koaro	Y	Y/N	At Risk - Declining
<i>Galaxias maculatus</i>	Inanga	Y	Y	At Risk - Declining
<i>Geotria australis</i>	Lamprey	Y	Y	Nationally Vulnerable
<i>Gobiomorphus breviceps</i>	Upland bully	Y	N	Not threatened
<i>Gobiomorphus cotidianus</i>	Common bully	Y	Y/N	Not threatened
<i>Perca fluviatilis</i>	European perch	N	N	Introduced And Naturalised
<i>Salmo trutta</i>	Brown trout	N	Y/N	Introduced And Naturalised

5.9 Summary

Overall, water quality in the lower Mataura River is poor, at times, with elevated nitrogen and phosphorus concentrations, low clarity and high turbidity. Faecal contaminant concentrations are very high, well above standards for contact recreation, and within the lowest NPS-FM band (band E). Guideline levels, and ES standards for Mataura 3 waterways, are exceeded for many parameters. Inputs of nutrients and faecal contaminants from both the Mataura River upstream of Gore and from the Waikaka Stream contribute to the poor water quality upstream of the Gore and Mataura wastewater discharges. In addition, the Alliance meatworks discharge at Mataura contributes contaminants to the upstream of the Mataura wastewater discharge.

Periphyton communities are dominated by thin mats at Gore, and biomass is generally low. Further downstream at Mataura, biomass can be higher than at Gore, but there has only been limited sampling by ES at this site. Benthic cyanobacteria mats have reached nuisance levels at several sites in the lower river during summer low flow periods.

Macroinvertebrate communities are generally dominated by *Deleatidium* mayflies, however community health scores (MCI/SQMCI) have been relatively low and in the NPS-FM band C. Communities in the river are influenced by contributions from tributaries such as the Waikaka Stream where snails and midge larvae are more abundant. Benthic communities near Mataura have higher abundance of lower-scoring taxa (e.g., oligochaete worms, snails) than at Gore, and this contributes to lower community index scores at Mataura relative to Gore.

The fish community of the lower river catchment includes migratory species, although

upstream passage for some species is restricted by the Mataura Falls. Brown trout distribution is widespread and this species is found throughout the catchment. Recent surveys indicate a reduced fishing effort in recent years but it is unclear whether this is linked to a reduction in trout abundance.

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6 Potential adverse effects associated with the discharges

6.1 General

The discharges of treated wastewater from the Gore and Mataura schemes to the Mataura River contain contaminants such as nutrients, faecal contaminants, and suspended solids. These contaminants have the potential to adversely affect the quality of the receiving water, as well as benthic communities and fish, and increase the risk of nuisance plant and algae growths, if discharged in sufficient quantity.

6.2 Contact recreation

A minimum visual clarity distance of 1.6 m is often used as a national guideline for safe swimming (ANZECC 2000). Monitoring data for the Mataura River at Gore, upstream of any of the discharges and also upstream of inputs from Waikaka Stream, indicates that this guideline is regularly exceeded, with 67% of clarity measurements taken between 2000 and 2020 lower than 1.6 m (see Section 5.4).

Based on water clarity guidelines for recreation, the Mataura River at Gore can be considered on many occasions to be unsuitable for bathing and general contact recreation. In addition, cool water temperatures often limit comfortable bathing opportunities (the average water temperature measured at Gore between 2000 and 2020 is 10.1 °C, range 2.9 - 18.4 °C). While this temperature data is based on monthly samples, continuous temperature monitoring at the Gore site by ES provides a more complete picture of seasonal patterns in water temperature, with only two to three months over summer when temperatures exceed 16 °C.

Concentrations of faecal indicator bacteria are typically elevated in the river at Gore. Elevated levels of faecal bacteria, and the associated high risk of infection, coupled with the low clarity of the water, result in the Mataura River at Gore being largely unsuitable for bathing and general contact recreation for much of the time. Due to these poor and unsuitable conditions present in the river immediately upstream of the discharges, the discharges themselves have limited effect on opportunities for contact recreation.

As already noted, angling is popular throughout the Mataura River, with whitebaiting popular in the lower reaches of the river near the mouth at Toetoes Bay. Contaminant concentrations for contact recreation are similarly high upstream and downstream of the Gore and Mataura discharges, and as such they have a minor effect on recreational opportunities in downstream reaches.

6.3 Benthic habitat

The greatest impacts to stony bed river ecosystems caused by sediment are associated with finer fractions, such as silts and clays, which can remain in suspension in the water column for considerable periods of time. However, these very fine fractions eventually settle out in low velocity environments, potentially smothering benthic communities. Sediment influxes can also physically alter rivers by changing the nature of the bed. Coarser graded particles fill in the interstices between stones and cobbles, while finer graded particles smother or 'blanket' the bed.

Increased sedimentation and smothering of the bed as a result of the wastewater discharges are unlikely due to the nature of the effluent and the physical characteristics of the receiving environment.

In the vicinity of the Gore wastewater discharge, while deposited sediment in the river is not monitored regularly, monitoring in early 2020 (using the SAM 2 method⁷) provides an indication of benthic conditions. Average deposited sediment cover in January 2020 was estimated at 0.5% upstream, 0.3% 600 m downstream of the Actiflo® outfall, and 6.7% 1.4 km downstream of the Actiflo® outfall. In March 2020, following a large flood event in February, average deposited sediment cover was estimated at 0.4%, 0.3%, and 3.2% at these same sites, respectively.

Under the 'Mataura 3' standards, sediment cover must not increase by 10% as a result of a discharge. While sediment cover at the site 600 m downstream was higher than at the other sites, the difference between sites was much less than 10%, thereby meeting the required standard.

The NPS-FM sets a national bottom line for deposited sediment of 45% cover for Cool Dry Hill Hard Sedimentary waterways. The Mataura monitoring sites are unable to be graded due to a lack of monitoring data consistent with the NPS-FM, nonetheless a comparison of the 2020 monitoring data with the NPS-FM is useful. Cover levels at each site were well below the national bottom line, and in band A (<27% cover⁸).

At the Mataura wastewater discharge point, while there have been no specific surveys for sediments, there have been no records of sediment deposits being observed during biological surveys (periphyton and macrophytes). As the immediate receiving habitat is run/riffle habitat, with higher velocity waters further downstream, the opportunity for sediments to settle on to the bed are limited.

⁷ SAM 2: Sediment Assessment Method 2 – In-stream visual estimate of percentage sediment cover (Clapcott *et al.* 2011).

⁸ A band: minimal impact of deposited fine sediment on instream biota, with ecological communities similar to those observed in natural reference conditions.

6.4 Water quality

6.4.1 Mataura River in the vicinity of the Gore wastewater discharge

GDC are required by their resource consent to undertake water quality sampling in the Mataura River upstream and downstream (200 m downstream) of the Gore wastewater discharge point. The downstream site is located 200 m downstream of the pond outlet and approximately 600 m downstream of the Actiflo outlet, and is therefore outside the 200 m long mixing zone allowed for discharges from the Actiflo outlet (see Section 6.5). Sampling is required on at least two occasions each year (once between 1 August and 30 September, and once between 1 January and 31 March), and on up to two further occasions per year when river flows are low (less than 25 m³/s at Gore). In addition to the required sampling, since June 2019 additional sampling has been undertaken, with samples collected on a fortnightly basis (weekly under low flow conditions) at the two consent-required sites but also at two further downstream sites (300 m and 400 m downstream of the pond discharge point). A summary of the monitoring data from each site is presented in Table 17.

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Table 17. Water quality sampling results from the Mataura River upstream and downstream of the Gore discharge, January 2000 to March 2020. Data supplied by GDC. Note that downstream distance is distance from the pond outfall, and sampling at 300 m and 400 m Downstream commenced in June 2019.

Site	Temperature (°C)	pH	DO (mg/L)	BOD ₅ (g/m ³)	<i>E. coli</i> (mpn/100mL)	SS (g/m ³)	Visual clarity (cm)
Upstream							
n	28	132	109	13	114	131	38
Range	6.8 - 21.5	6.97 - 8.30	<0.1 - 18.0	<2.0 - 3.4	10 - 17000	0.8 - 80.0	12 - 100
Median	14.2	7.50	10.2	2.0	235	2.90	82
Mean	13.5	7.51	10.3	1.94	662	6.12	75.3
200 m Downstream							
n	27	131	108	13	114	131	38
Range	6.4 - 21.7	7.08 - 8.00	4.5 - 17.5	<2.0 - 3.5	20 - 31450	1.0 - 91.0	31 - 100
Median	14.7	7.49	10.0	2.0	270	2.80	84
Mean	13.7	7.48	10.1	2.02	1146	6.01	77.1
300 m Downstream							
n	13	12	11	12	12	12	13
Range	6.4 - 18.8	7.08 - 7.74	7.7 - 12.5	<2.0 - 3.4	51 - 20000	3.1 - 88.0	29 - 100
Median	14.4	7.38	9.7	2.0	230	6.50	65
Mean	13.1	7.42	9.6	2.03	1887	15.68	64.2
400 m Downstream							
n	13	12	11	12	12	12	13
Range	6.4 - 18.1	7.08 - 7.74	7.4 - 11.2	<2.0 - 3.6	20 - 20000	3.6 - 90.0	32 - 100
Median	14.1	7.39	10.0	2.0	255	6.75	65
Mean	13.0	7.43	10.0	2.04	1927	15.87	65.6

Table 17 (cont.) Water quality sampling results from the Mataura River upstream and downstream of the Gore discharge, January 2000 to March 2020. Data supplied by GDC. Note that downstream distance is distance from the pond outfall, and sampling at 300 m and 400 m Downstream commenced in June 2019.

Location	Conductivity ($\mu\text{S}/\text{cm}$)	$\text{NH}_4\text{-N}$ (g/m^3)	$\text{NO}_3\text{-N}$ (g/m^3)	TN (g/m^3)	DRP (g/m^3)	TP (g/m^3)
Upstream						
n	65	134	120	22	134	126
Range	44.0 - 93.0	<0.01 - 1.7	0.06 - 1.40	0.71 - 1.90	0.004 - 0.072	0.005 - 0.88
Median	79.0	0.023	0.85	1.20	0.009	0.017
Mean	77.5	0.055	0.84	1.19	0.012	0.032
200 m Downstream						
n	67	135	108	20	134	122
Range	45.0 - 103.0	0.01 - 0.8	0.01 - 1.30	0.72 - 2.00	0.004 - 0.300	0.004 - 1.45
Median	81.0	0.073	0.83	1.40	0.020	0.039
Mean	80.0	0.110	0.84	1.32	0.029	0.057
300 m Downstream						
n	-	12	4	12	12	12
Range	-	0.01 - 0.14	1.00 - 1.10	0.74 - 2.00	0.005 - 0.033	0.010 - 0.15
Median	-	0.035	1.10	1.35	0.010	0.020
Mean	-	0.043	1.08	1.31	0.011	0.031
400 m Downstream						
n	-	12	4	12	12	12
Range	-	0.01 - 0.13	1.00 - 1.20	0.75 - 1.90	0.005 - 0.031	0.010 - 0.15
Median	-	0.035	1.15	1.35	0.009	0.025
Mean	-	0.044	1.13	1.33	0.010	0.033

Water temperature

Water temperature was similar at all locations sampled upstream and downstream of the discharge (Figure 12), indicating that the discharge does not significantly affect water temperature in the Mataura River. Under ES standards for 'Mataura 3' waterbodies, changes in water temperature as a result of any discharge shall not exceed 3°C (when the natural or existing water temperature is 16°C or less) or 1°C (when the natural or existing water temperature is above 16°C). When the upstream temperature was above 16°C, differences between the upstream and downstream sites ranged from a maximum decrease downstream of 1.1°C to a maximum increase downstream of 0.4°C between sites. These temperature changes generally complied with the 'Mataura 3' standards. When the upstream temperature was 16°C or less, differences between the upstream and downstream sites ranged from a maximum decrease downstream of 1.2°C to a maximum increase of 1.1°C between sites, thereby complying with the 'Mataura 3' standards.

The consent requires that the discharge shall not result in water temperature exceeding 20°C. There has been only one sampling occasion with temperatures above 20°C, which was seen at sites upstream and downstream of the discharge.

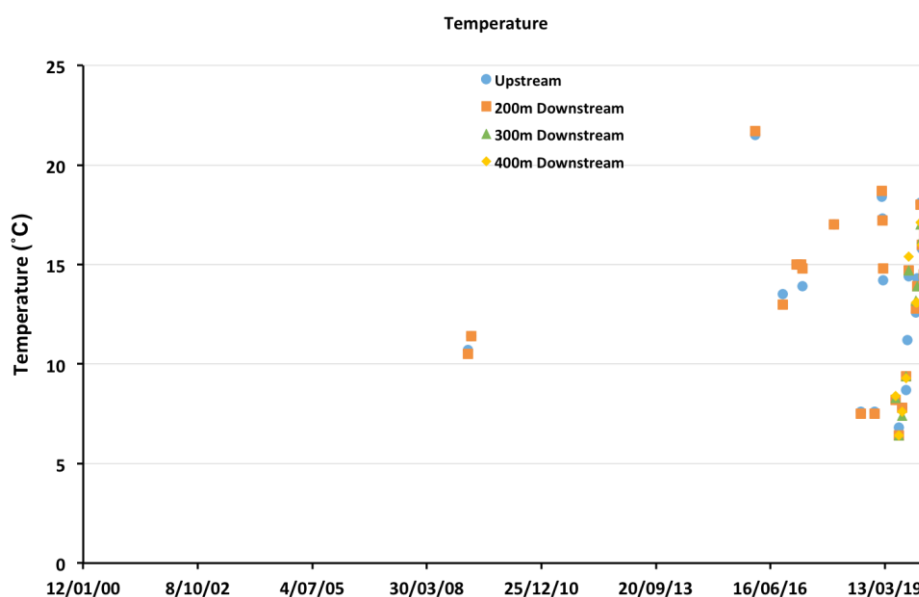


Figure 12. Water temperatures in the vicinity of the Gore discharge, January 2000 to March 2020.

pH

Monitoring data indicates that Mataura River pH was similar at all locations sampled upstream and downstream of the discharge (Figure 13), and all sites remains well within the pH range of 6.0 to 9.0, specified for 'Mataura 3' waterbodies, and generally within the range 7.2 - 7.8 in the ANZECC (2000) guidelines. The pH values recorded at the

downstream sites are circa-neutral and are not expected to result in any adverse biological effects.

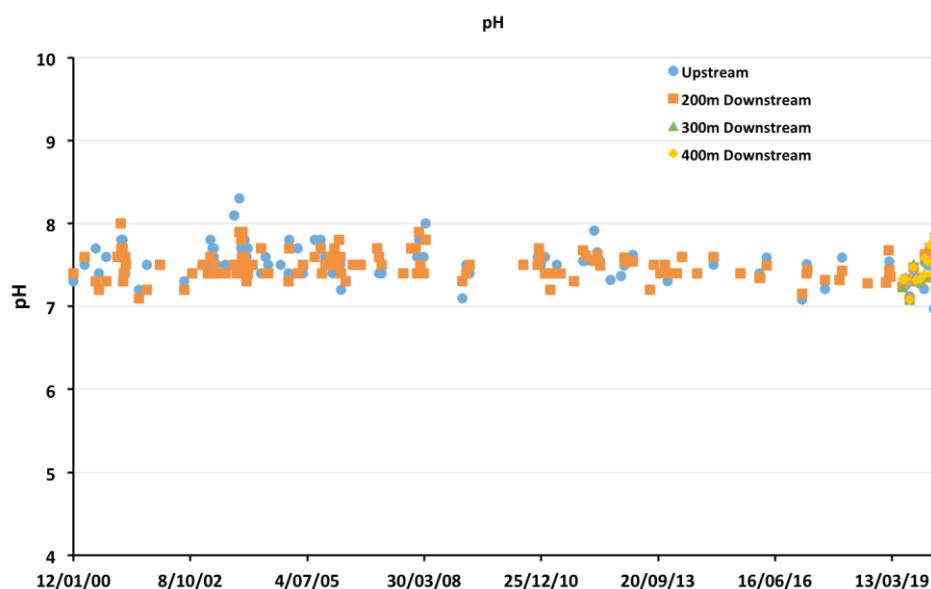


Figure 13. pH in the vicinity of the Gore discharge, January 2000 to March 2020.

Dissolved oxygen

Dissolved oxygen concentrations were similar at all locations sampled upstream and downstream of the discharge on all sampling occasions (Figure 14), indicating that the discharge does not significantly affect dissolved oxygen in the Mataura River. Concentrations were well above 5 g/m³ as specified for 'Mataura 3' waterbodies.

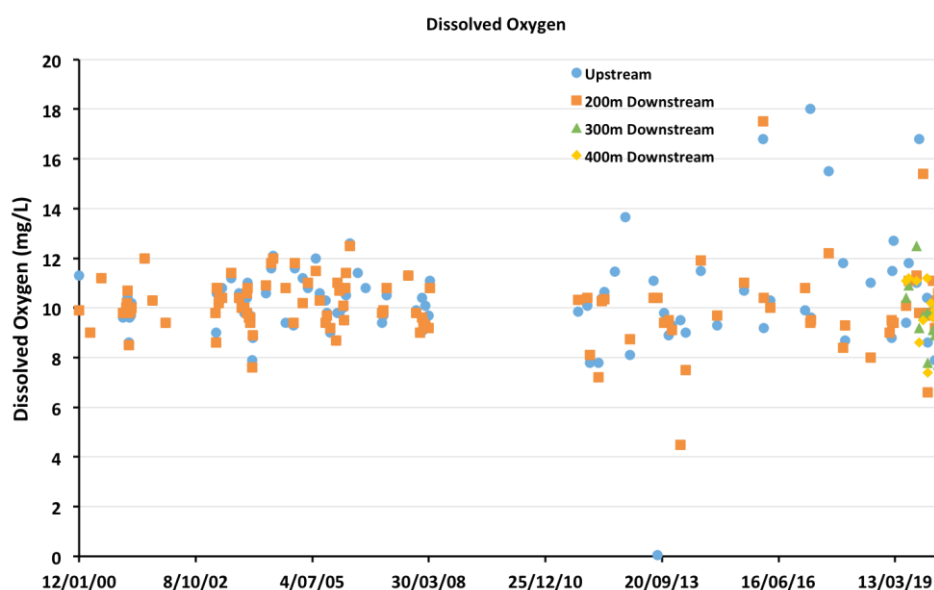


Figure 14. Dissolved oxygen concentrations in the vicinity of the Gore discharge, January 2000 to March 2020.

Visual clarity

Visual clarity, measured using the black disc method, had median values of >80 cm at the upstream and 200 m downstream sites. Sampling at the two most downstream sites only commenced in June 2019, and clarity between June 2019 and March 2020 was very similar between sites upstream and downstream of the discharge. This can be demonstrated by viewing the percentage change in downstream river water clarity relative to that upstream of the Gore discharge (Figure 15). On most occasions, changes in downstream clarity were barely discernible and sometimes greater than upstream.

For 'Mataura 3' waterbodies, discharges shall not cause a conspicuous change in the natural colour and clarity of the water. Similarly, the Gore wastewater discharge consent requires that the discharge shall not, beyond a zone of reasonable mixing, result in a reduction in visual clarity to below 80% of the value at the upstream site. Monitoring indicates that clarity readings downstream of the discharge have been more than 90% of that upstream on most sampling occasions, with only three clarity readings (out of 64) less than 90% of upstream readings. Only one of those readings (between upstream and 400 m downstream) was less than 80% (79.4%). Overall, water clarity is not adversely affected by the discharge.

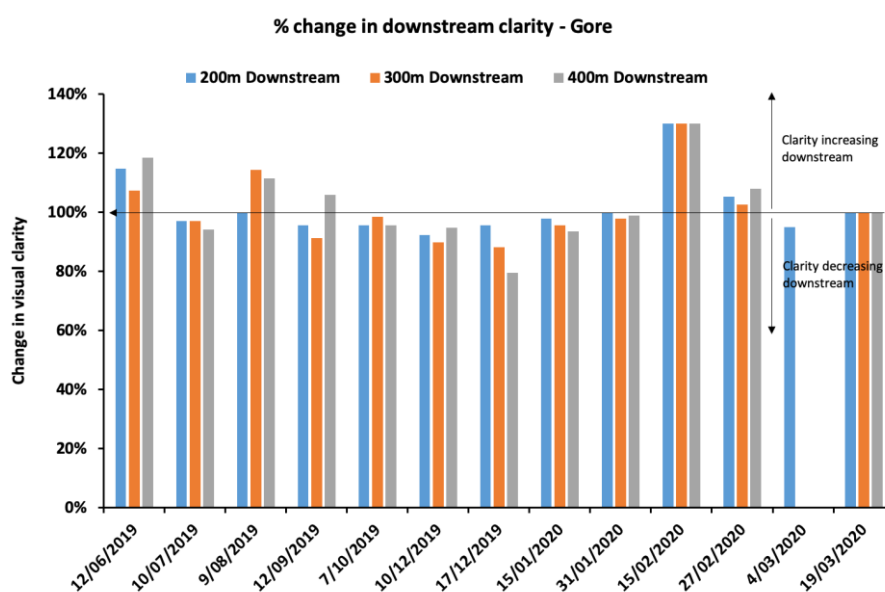


Figure 15. Changes in visual clarity downstream of the Gore discharge relative to upstream clarity, June 2019 to March 2020. Bars greater than 100% indicate a higher clarity reading downstream of the discharge relative to that upstream.

Suspended solids

Monitoring data indicates that the concentrations of SS were similar at sites upstream

and 200 m downstream of the discharge (Figure 16). As noted above, sampling at the two most downstream sites only commenced in June 2019, and SS concentrations between June 2019 and March 2020 were very similar between sites upstream and downstream of the discharge. Typically, SS concentrations downstream of the discharge do not change significantly relative to upstream concentrations.

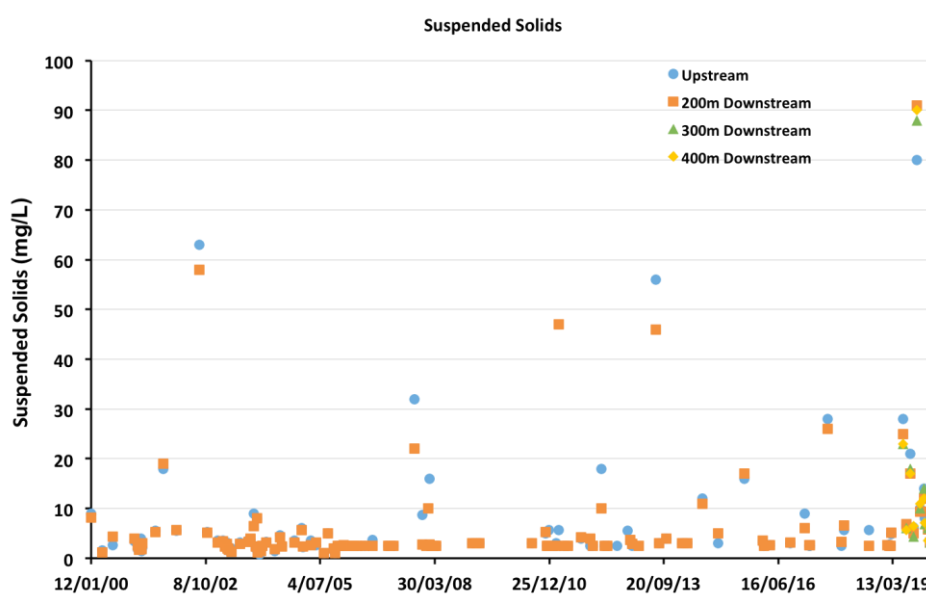


Figure 16. Suspended solids concentrations in the vicinity of the Gore discharge, January 2000 to March 2020.

***Escherichia coli* (*E. coli*)**

Concentrations of *E. coli* were high at all sites in the vicinity of the discharge (Figure 17). The Gore wastewater discharge consent requires that the discharge shall not, beyond a zone of reasonable mixing, result in *E. coli* concentration increasing by more than 200 units per 100 mL. Same day monitoring show that differences in *E. coli* concentrations between upstream and downstream sites ranged from a downstream decrease of 1,500 cfu/100 mL to a downstream increase of 28,855 cfu/100 mL. These extremes were probably influenced by high flow and/or rainfall events, given upstream concentrations on some of these occasions were very high. For example:

- In February 2007 the upstream concentration of *E. coli* was 4,400 cfu/100 mL and the downstream concentration was 2,900 cfu/100 mL.
- In March 2011, the upstream concentration was 2,595 cfu/100 mL when the downstream concentration was 31,450 cfu/100 mL.

Exceedances of this consent condition have generally occurred when upstream concentrations were already elevated, however there have been occasions when *E. coli* concentrations appear to have increased downstream as a result of the discharge.

Standards for 'Mataura 3' waterbodies state that the concentration of faecal coliforms shall not exceed 1,000 coliforms per 100 mL. The median *E. coli* concentrations in the river in the vicinity of the Gore discharge are well below this limit (230-270 cfu/100 mL) (Table 17). The mean concentration upstream (662 cfu/100 mL) is also below the limit, however mean concentrations at all downstream sites (1,146-1,927 cfu/100 mL) are higher than the limit (Table 18).

The monitoring dataset for the Gore wastewater discharge does not meet the minimum sampling criteria set out in the NPS-FM and consequently the results presented below should be treated as indicative only when considered in relation to NPS-FM attribute states for *E. coli*. This caution is due to the limited number of monitoring occasions, particularly at the two most downstream sites.

Using all available data, the overall attribute band for the site 200 m downstream of the discharge was in band E (the median concentration being above 260 cfu/100 mL, while other sites were all in band D) (Table 18). Assessing only the last five years of data, both the upstream and 200 m downstream sites were in band E (more than 50% of the samples exceeding 260 cfu/100 mL and median concentrations at both sites being above 260 cfu/100 mL) (Table 19).

These indicative assessments against the NPS-FM attribute states can be compared with the states assessed for the Mataura River and Waikaka Stream SOE monitoring sites at Gore. The Mataura River at Gore was within band E, and the Waikaka Stream at Gore was within band D.

Overall, while increased *E. coli* concentrations are found downstream of the discharge at times, concentrations are generally high throughout the river, and in the lowest *E. coli* attribute band under the NPS-FM. It is interesting to note that for the most recent 5 years of data, median *E. coli* concentrations at the three downstream monitoring sites are less than that for the upstream site (Table 19).

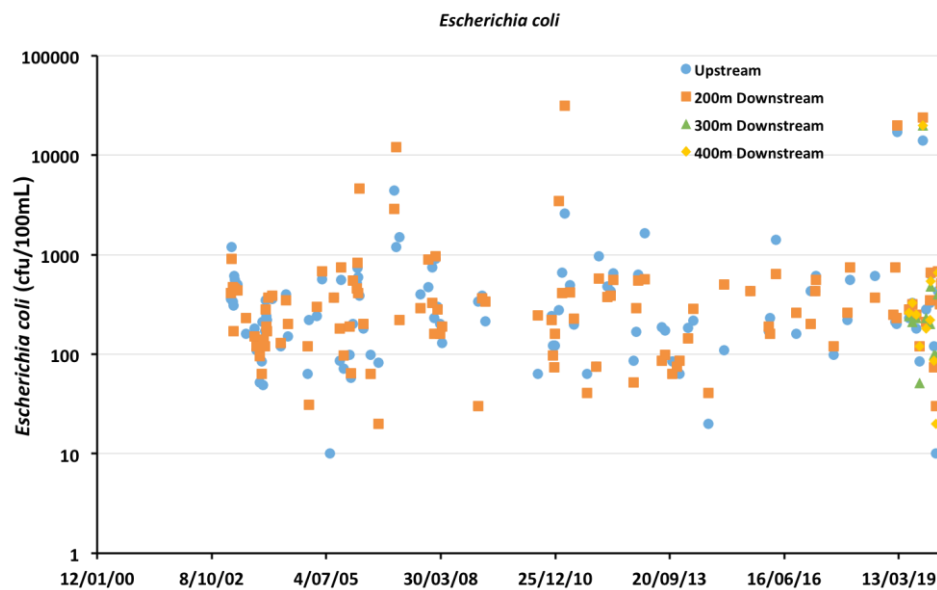


Figure 17. *E. coli* concentrations in the vicinity of the Gore discharge, January 2000 to March 2020.

Table 18. Comparison of observed *E. coli* concentrations with the NPS-FM attribute states for *E. coli*, using all available data (2000-2020).

Attribute	Upstream	Downstream		
		200 m	300 m	400 m
Number of samples >540 cfu/100 mL	26	24	1	2
Number of samples >260 cfu/100 mL	54	57	4	5
Total number of samples	114	114	12	12
% >540 cfu/100 mL	23%	21%	8%	17%
% >260 cfu/100 mL	47%	50%	33%	42%
Median	235	270	230	255
95 th percentile	1435	3092	9264	9363
OVERALL attribute band	D	E	D	D

Table 19. Comparison of observed *E. coli* concentrations with the NPS-FM attribute states for *E. coli*, using the most recent five years of data (2015-2020).

Attribute	Upstream	Downstream		
		200 m	300 m	400 m
Number of samples >540 cfu/100 mL	8	8	1	2
Number of samples >260 cfu/100 mL	16	17	4	5
Total number of samples	29	30	12	12
% >540 cfu/100 mL	28%	27%	8%	17%
% >260 cfu/100 mL	55%	57%	33%	42%
Median	330	320	230	255
95 th percentile	8960	11338	9264	9363
OVERALL attribute band	E	E	D	D

Ammoniacal-nitrogen toxicity

Concentrations of NH₄-N (corrected for pH) recorded from the first downstream site were generally higher than those from the upstream site, while concentrations further downstream were lower and more similar to those upstream (Figure 18).

Assessing the NH₄-N monitoring data against the NH₄-N toxicity attributes states in the NPS-FM indicate the following:

- Median and maximum NH₄-N concentrations at the upstream site between 2015 and 2020 have all been within band A (annual maximum ≤0.05 mg/L, annual median <0.03 mg/L).
- Annual medians concentrations at the downstream sites have all been within band A except at the first downstream site for 2016 and 2017 (medians 0.037 and 0.039 mg/L respectively). These medians were at the lower end of the range for band B (annual median >0.03 and ≤0.24 mg/L). Band B provides for 95% species protection level, with impacts occasionally on the 5% most sensitive species.
- Annual maximum concentrations at the downstream sites have been within band A except at all three downstream sites in 2019 and at the first downstream site (i.e., the compliance downstream site) in 2017, which were within band B (annual maximum >0.05 and ≤0.40 mg/L). However, the maximum concentrations within band B were at the lower end of the range, with maximums ranging from 0.058 to 0.073 mg/L.
- Overall, for NH₄-N toxicity, the upstream site is within band A and the downstream sites are within band A or B (depending on year). Concentrations of NH₄-N downstream of the discharge are not expected to result in toxic effects on aquatic life.

These indicative assessments against the NPS-FM attribute states can be compared with the states assessed for the Maitava River and Waikaka Stream SOE monitoring sites at Gore. The Maitava River at Gore was within band A, and the Waikaka Stream at Gore was within band A or B (depending on year).

The consent requires that the discharge shall not, beyond a zone of reasonable mixing, result in the ammoniacal nitrogen concentrations increasing above values in Appendix 2 of the consent. Appendix 2 specifies $\text{NH}_4\text{-N}$ concentrations at different pH, which are the same standards in the SWLP for 'Lowland and Hill surface waterbodies'. $\text{NH}_4\text{-N}$ concentrations downstream of the discharge were all lower than the required standards.

Overall, increased concentrations of $\text{NH}_4\text{-N}$ are found in the river downstream of the discharge, at times. Concentrations downstream of the discharge are lower than ANZECC (2000) guideline levels for ammonia toxicity ($<0.9 \text{ g/m}^3$), and are within NPS-FM toxicity guidelines. pH levels are also generally between the ANZECC (2000) guideline level of 7.2 – 7.8, while water temperatures are less than 20°C . Consequently, in this instance, ammonia toxicity is not an issue for benthic macroinvertebrates or other freshwater biota such as fish. Overall, the observed concentrations of $\text{NH}_4\text{-N}$ in the river downstream of the discharge are not expected to result in adverse effects with respect to toxicity.

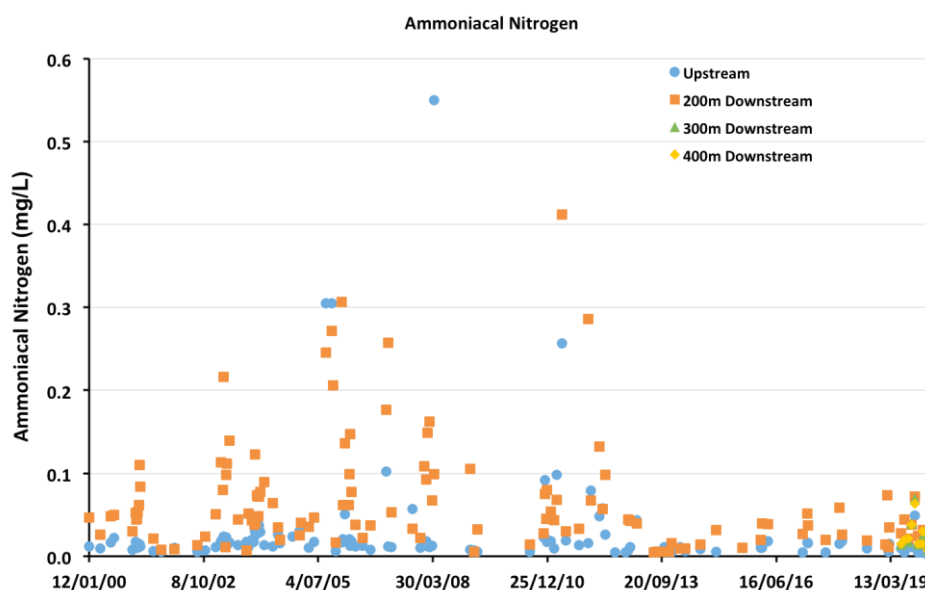


Figure 18. pH-corrected ammoniacal nitrogen concentrations in the vicinity of the Gore discharge, January 2000 to March 2020. Note one high value not shown in graph (0.88 mg/L Upstream on 8 November 2005).

Nitrate-nitrogen toxicity

Concentrations of $\text{NO}_3\text{-N}$ were similar upstream and 200 m downstream of the discharge. Sampling at the two most downstream sites commenced in June 2019, and concentrations over the period June 2019 and March 2020 were very similar between sites upstream and downstream of the discharge.

The NPS-FM includes an attribute for $\text{NO}_3\text{-N}$ toxicity. For the limited sampling in 2020, the annual median concentration at all sites was within band B. Bearing in mind that sampling in previous years has also been limited, the annual median concentration has been in either band A or B at the upstream and 200 m downstream sites.

The annual 95th percentile concentrations for each site for the period 2015 to 2020 have all been within band A. Overall, however, each site generally sits within band B for $\text{NO}_3\text{-N}$ toxicity. The Mataura River at Gore monitoring site sits within band A, and the Waikaka Stream at Gore monitoring site sits within band A or B (depending on year) for $\text{NO}_3\text{-N}$ toxicity.

Overall, downstream $\text{NO}_3\text{-N}$ concentrations are not adversely affected by the discharge.

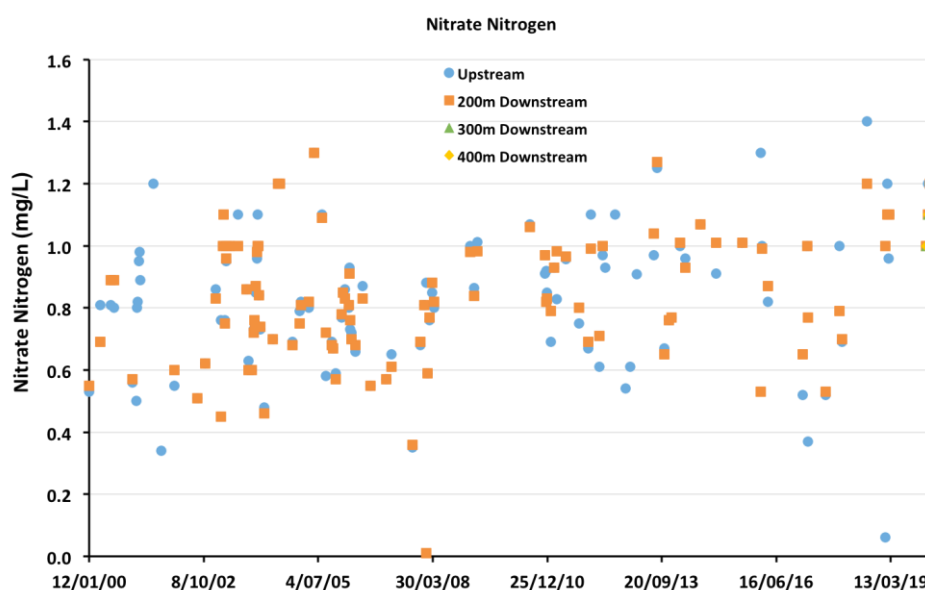


Figure 19. Nitrate nitrogen concentrations in the vicinity of the Gore discharge, January 2000 to March 2020.

Total nitrogen

At times, TN concentrations have been elevated downstream of the discharge, however, only limited sampling has been undertaken at downstream sites, and concentrations on more recent sampling occasions have been similar upstream and downstream of the discharge.

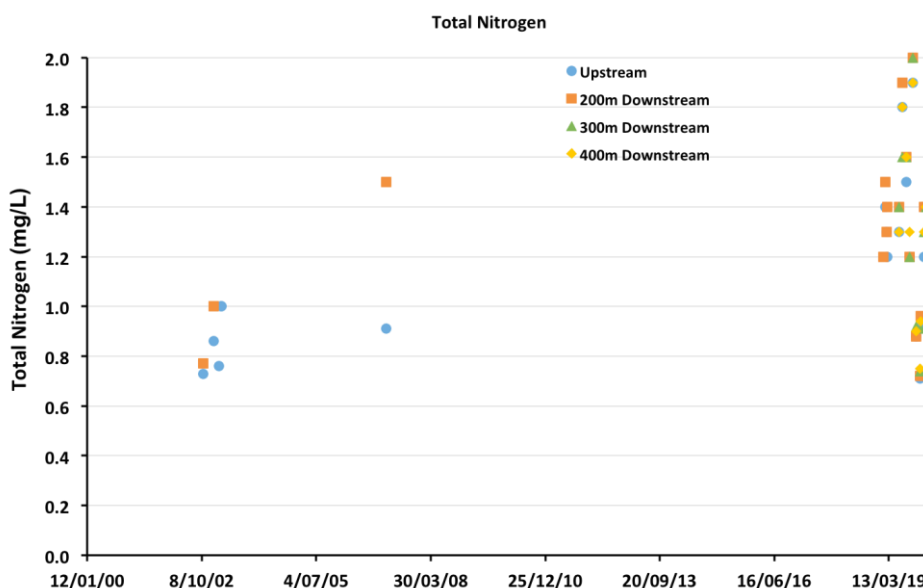


Figure 20. Total nitrogen concentrations in the vicinity of the Gore discharge, January 2000 to March 2020.

Dissolved reactive phosphorus

Up to approximately 2010, DRP concentrations were higher at the first downstream site relative to the upstream site, but since then (following the commissioning of the Actiflo Plant) concentrations have reduced and have been generally similar upstream and downstream (Figure 21).

The NPS-FM includes DRP as a compulsory attribute requiring limits, with attribute states including median and 95th percentile concentration values. The Gore wastewater receiving water monitoring data does not meet the minimum criteria set out in the NPS-FM and consequently any assessment should be regarded as indicative only, and not definitive. Looking at the monitoring data since 2015, and since June 2019 for the two most downstream sites, median values at all sites sit within band B. 95th percentile levels sit within band B at the first two downstream sites, in band A at the 400 m downstream site, and in band C at the upstream site. While these results are indicative only, overall the results indicate similar concentrations upstream and downstream of the discharge in recent years and above the national bottom line. For comparison, the Mataura River at Gore is within band B, and the Waikaka Stream at Gore is within band C for DRP.

Overall, downstream DRP concentrations are not significantly affected by the discharge.

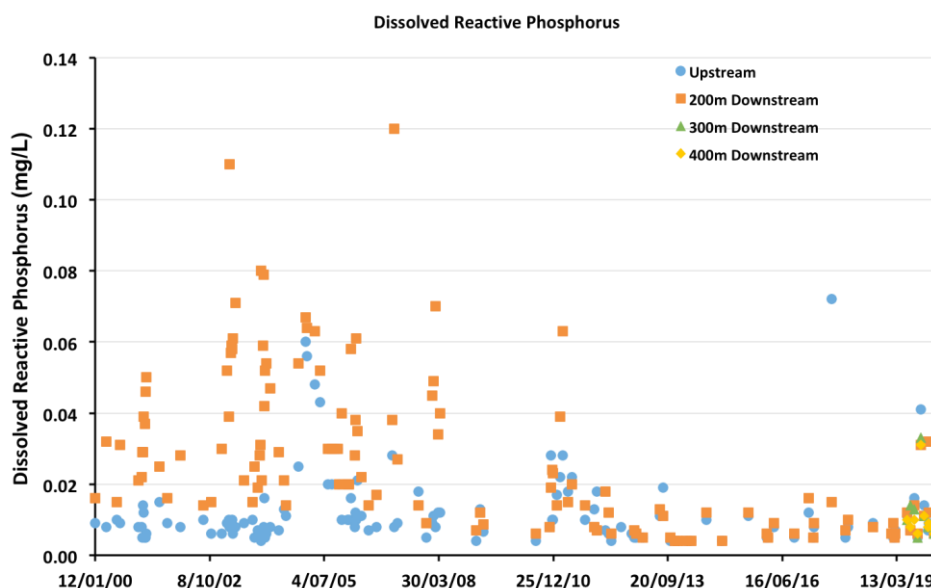


Figure 21. Dissolved reactive phosphorus concentrations in the vicinity of the Gore discharge, January 2000 to March 2020. Note one high value not shown in graph (0.3 mg/L 200 m Downstream on 17 January 2008).

Total phosphorus

Monitoring data indicate TP concentrations have been higher 200 m downstream of the discharge, although in recent years they have been lower and more similar to the upstream site (Figure 22). Some very high concentrations, both upstream and downstream of the discharge, have been recorded, such as in May 2012 when the upstream concentration was 0.88 mg/L, compared to a concentration of 0.055 mg/L at the 200 m downstream site. Conversely, in December 2012, when the downstream concentration was 1.45 mg/L, and 0.039 mg/L at the upstream site. Overall, downstream TP concentrations are considered not significantly affected by the discharge.

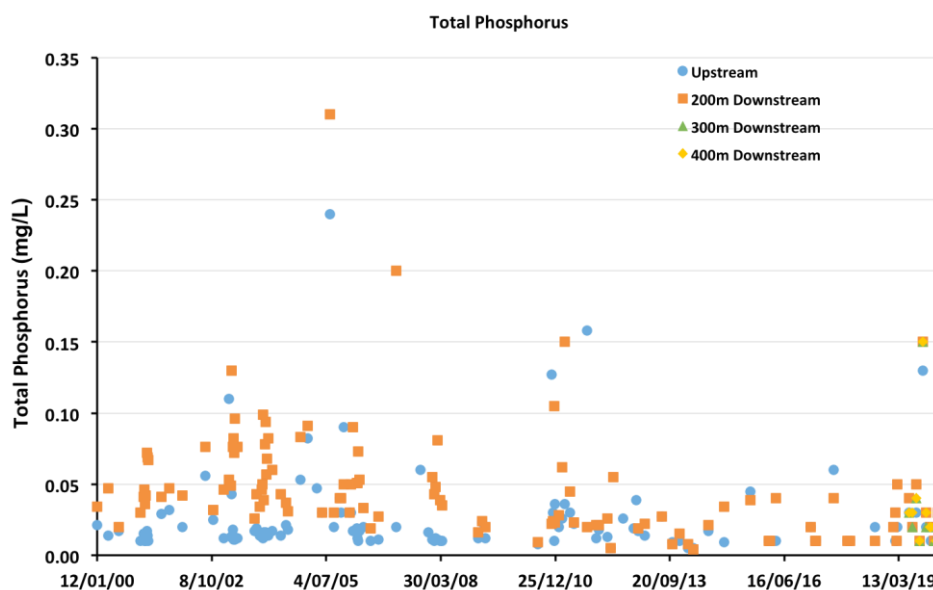


Figure 22. Total phosphorus concentrations in the vicinity of the Gore discharge, January 2000 to March 2020. Note two high values not shown in graph (0.88 mg/L Upstream on 14 May 2012, 1.45 mg/L 200 m Downstream on 3 December 2012).

Biochemical oxygen demand

BOD₅ has been sampled in the river since February 2019. Samples at all sites over this period have recorded low concentrations (Figure 23). In general, downstream BOD₅ concentrations are not affected by the discharge.

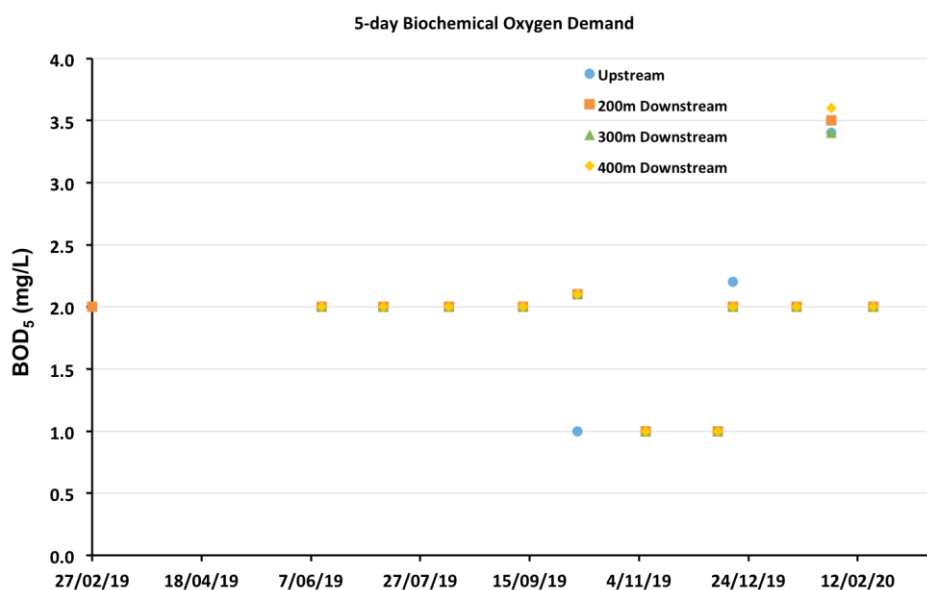


Figure 23. 5-day biochemical oxygen demand in the vicinity of the Gore discharge, February 2019 to March 2020.

Summary

Overall, contaminant concentrations downstream of the Gore wastewater discharge are similar to those upstream, with background river conditions often being influential in water quality guidelines and limits being exceeded downstream. Due largely to the inflows of water from the Waikaka Stream upstream of the Gore discharge point, the overall water quality immediately upstream of the Gore discharge can be poor, at times. However, concentrations of *E. coli* and NH₄-N can be elevated downstream of the discharge, to a point where the effects of the discharge on these contaminants may be more than minor. Other contaminants in the discharge probably have a less than minor effect on receiving water quality.

6.4.2 Mataura River in the vicinity of the Mataura wastewater discharge

GDC are required by resource consent to undertake water quality sampling in the Mataura River upstream (at least 5 m upstream) and downstream (300 m downstream) of the Mataura wastewater discharge point. The downstream site is located 300 m downstream of the outlet and is therefore outside the 200 m long mixing zone for discharges, stipulated in the SWLP (see Section 6.5). Sampling is required on at least four occasions each year (three times between November and April, and once between August and September), and on a weekly basis when river flows are low (less than 25 m³/s at Tukurau). In addition to the required sampling, since June 2019 additional sampling has been undertaken, with samples collected on a fortnightly basis (weekly under low flow conditions) at the two consent-required sites but also at two additional downstream sites (200 m and 400 m downstream of the discharge point). The 200 m downstream site is at the downstream limit of a 200 m long mixing zone. A summary of the data from each site is presented in Table 20.

Table 20. Water quality sampling results from the Mataura River upstream and downstream of the Mataura discharge, March 2009 to March 2020. Data supplied by GDC. Note that sampling at 200 m and 400 m Downstream commenced in June 2019.

Location	Temperature (°C)	pH	DO (mg/L)	BOD ₅ (g/m ³)	<i>E. coli</i> (mpn/100mL)	SS (g/m ³)	Visual clarity (cm)
Upstream							
n	47	60	48	13	62	59	40
Range	6.7 - 22.3	6.21 - 7.79	7.6 - 23.5	<2.0 - 2.4	52 - 49500	2.5 - 110.0	14 - 100
Median	12.3	7.41	10.4	<2.0	1355	3.0	70.0
Mean	12.6	7.44	11.2	1.11	4119	10.9	66.2
200 m Downstream							
n	13	13	12	13	13	13	13
Range	6.1 - 19.6	6.80 - 7.56	7.8 - 11.9	<2.0 - 2.4	74 - 45000	2.5 - 110.0	17 - 100
Median	9.5	7.37	10.1	<2.0	1000	15.0	45.0
Mean	10.6	7.31	10.3	1.11	6577	26.3	51.4
300 m Downstream							
n	47	60	50	13	62	59	40
Range	6.5 - 22.5	6.83 - 7.78	2.4 - 23.9	<2.0 - 2.4	31 - 55000	2.5 - 110.0	14 - 100
Median	12.4	7.44	10.7	<2.0	1100	3.0	75.5
Mean	12.6	7.45	11.1	1.11	3591	10.8	68.6
400 m Downstream							
n	13	13	13	13	13	13	13
Range	6.8 - 19.3	7.31 - 7.63	8.3 - 13.4	<2.0 - 2.4	140 - 60000	2.5 - 71.0	17 - 100
Median	8.6	7.39	10.6	<2.0	1100	14.0	65.0
Mean	10.5	7.42	10.4	1.11	7684	23.0	54.4

Table 20 (cont.) Water quality sampling results from the Mataura River upstream and downstream of the Mataura discharge, March 2009 to March 2020. Data supplied by GDC. Note that sampling at Downstream 2 and 3 commenced in June 2019.

Location	Conductivity ($\mu\text{S}/\text{cm}$)	$\text{NH}_4\text{-N}$ (g/m^3)	$\text{NO}_3\text{-N}$ (g/m^3)	TN (g/m^3)	DRP (g/m^3)	TP (g/m^3)
Upstream						
n	61	60	61	24	60	23
Range	56.0 - 122.0	0.003 - 0.34	0.002 - 1.50	0.62 - 1.80	0.004 - 0.25	0.01 - 0.11
Median	91.0	0.06	0.93	1.30	0.015	0.03
Mean	90.1	0.083	0.91	1.24	0.024	0.039
200 m Downstream						
n	13	13	13	13	13	13
Range	56.0 - 124.0	0.03 - 0.20	0.38 - 1.40	0.84 - 2.00	0.009 - 0.14	0.02 - 0.14
Median	97.0	0.09	1.10	1.40	0.014	0.04
Mean	96.0	0.107	1.06	1.45	0.028	0.056
300 m Downstream						
n	62	60	61	24	60	23
Range	28.0 - 121.0	0.01 - 0.21	0.002 - 1.50	0.67 - 2.00	0.004 - 0.25	0.01 - 0.13
Median	91.5	0.07	0.91	1.30	0.013	0.03
Mean	89.0	0.085	0.93	1.27	0.020	0.042
400 m Downstream						
n	13	13	13	12	13	13
Range	56.0 - 121.0	0.02 - 0.09	0.40 - 1.60	0.67 - 1.90	0.007 - 0.027	0.01 - 0.11
Median	95.0	0.06	1.10	1.40	0.013	0.04
Mean	94.1	0.054	1.08	1.44	0.014	0.040

Water temperature

Water temperatures have been variable at each site (Figure 24). For 'Mataura 3' waterbodies, water temperature change as a result of any discharge shall not be more than 3°C (when the natural or existing water temperature is 16°C or less) or 1°C (when the natural or existing water temperature is above 16°C). When the upstream temperature was above 16°C, differences between the upstream and downstream sites ranged from a maximum decrease downstream of 1.1°C to a maximum increase downstream of 0.8°C between sites. These temperature changes as a result of the discharge generally complied with the 'Mataura 3' standards. When the upstream temperature was 16°C or less, differences between the upstream and downstream sites ranged from a maximum decrease downstream of 1°C to a maximum increase of 2.6°C between sites, thereby complying with the 'Mataura 3' standards.

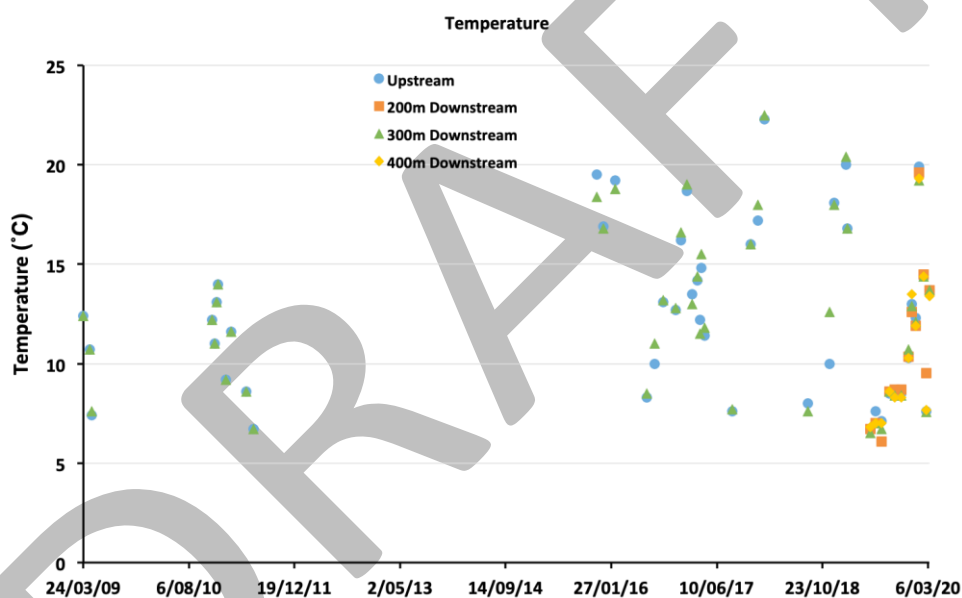


Figure 24. Water temperatures in the vicinity of the Mataura discharge, March 2009 to March 2020.

pH

The pH in the Mataura River is very similar at sites upstream and downstream of the discharge (Figure 25). pH at all sites remains well within the range 6.0 to 9.0 specified for 'Mataura 3' waterbodies, and within the ANZECC (2000) guideline range of 7.2-7.8.

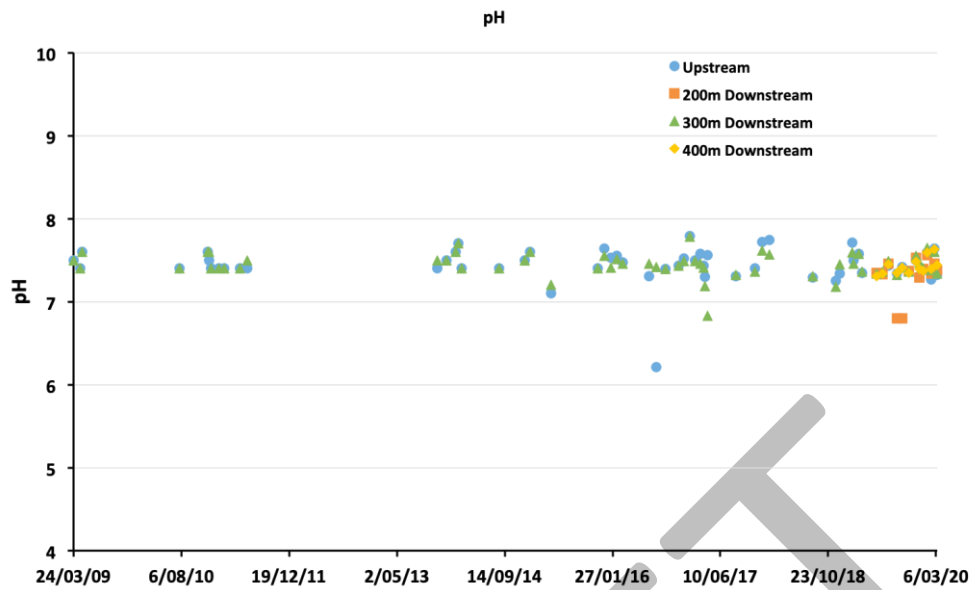


Figure 25. pH in the vicinity of the Mataura discharge, March 2009 to March 2020.

Dissolved oxygen

Dissolved oxygen concentrations were similar at all locations sampled upstream and downstream of the discharge (Figure 26), indicating that the discharge did not significantly affect dissolved oxygen in the Mataura River on the occasions monitoring took place. Median concentrations were all above 10 g/m^3 and well above 5 g/m^3 as specified for 'Mataura 3' waterbodies.

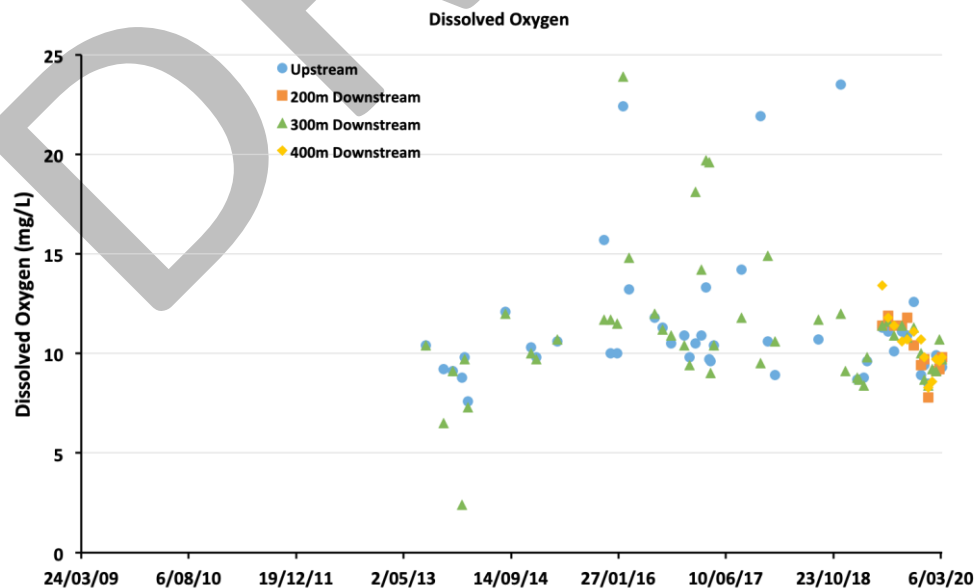


Figure 26. Dissolved oxygen concentrations in the vicinity of the Mataura discharge, March 2009 to March 2020.

Visual clarity

Since 2015, visual clarity has been similar at the upstream and 300 m downstream monitoring sites, with clarity at the 300 m downstream site often quite higher than that observed upstream of the discharge. These differences may be a reflection of the error associated with the monitoring method, as water clarity is unlikely to increase significantly over such a short distance. Clarity measurements have been taken at the 200 m and 400 m downstream sites since June 2019. Results are variable, with clarity on 8 out of 13 occasions at these two downstream sites being higher than that measured upstream of the discharge (Figure 27).

‘Mataura 3’ waterbodies shall not have a ‘conspicuous’ change in natural colour and clarity of the water due to discharges. On one occasion in July 2019, clarity at the three sites downstream of the Mataura discharge was 43%, 110%, and 63% respectively of clarity at the upstream site. However, on most occasions, clarity downstream of the discharge has been at least greater than 90% of that at the upstream site, indicating that conspicuous changes in downstream water clarity are not occurring as a result of the discharge.

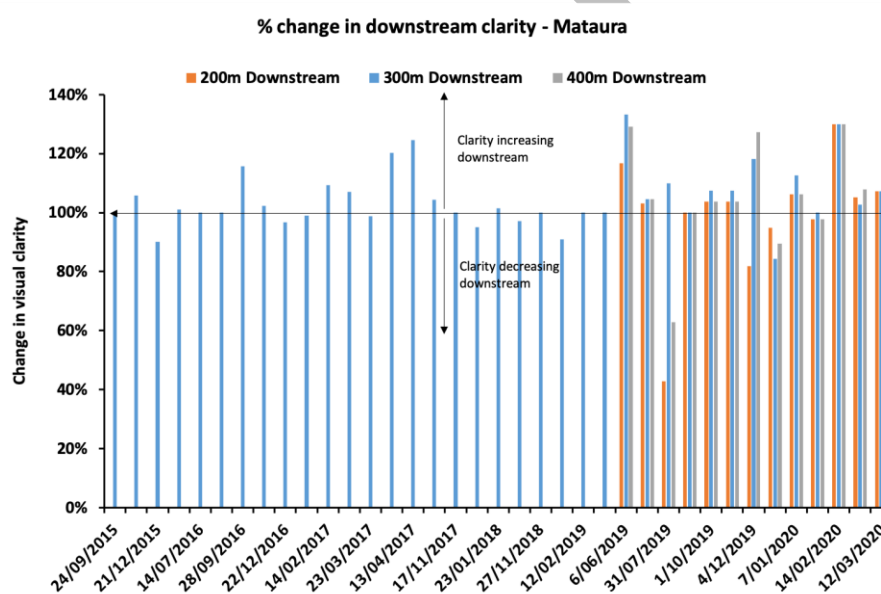


Figure 27. Black disc (visual clarity) measurements in the vicinity of the Mataura discharge, March 2009 to March 2020.

Suspended solids

The concentrations of SS were similar between the upstream and 300 m downstream sites (Figure 28). Sampling at the 200 m and 400 m downstream sites commenced in June 2019 and, up to March 2020, SS concentrations have been similar between all sites, although there were some slightly elevated concentrations downstream on occasions.

The median concentration at 200 m downstream between June 2019 and March 2020 was approximately 5 mg/L higher than that upstream, indicating the discharge may be influencing suspended solids concentrations downstream of the discharge. In recent years, SS concentrations have been high at all sites (Figure 28).

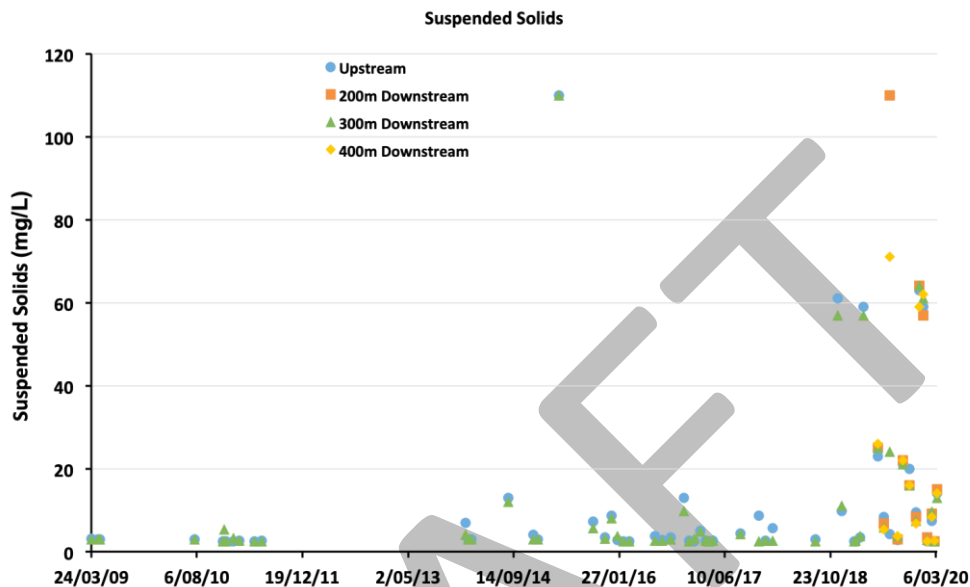


Figure 28. Suspended solids concentrations in the vicinity of the Mataura discharge, March 2009 to March 2020.

Escherichia coli (E. coli)

Concentrations of *E. coli* were elevated at all sites in the vicinity of the discharge, with mean and median concentrations at each site, including upstream of the discharge, above the 'Mataura 3' standard of 1000 cfu/100 mL (Figure 29).

While the dataset does not meet the criteria for the minimum number of samples required for assessment against NPS-FM attributes states for *E. coli*, such an assessment has been undertaken, but should be treated as indicative only.

Using only the most recent five years of data, the overall attribute state for all of the sites in the vicinity of the discharge was band E (Tables 21 and 22). Examining all data going back as far as 2009, there is some indication that *E. coli* levels maybe gradually trending upwards in this section of the river.

Notwithstanding this assessment, it is worth noting that, in recent years, the *E. coli* concentrations in the Mataura discharge are more often lower than that in the river immediately upstream (Figure 29), and, consequently, do not appear to be increasing the concentration of *E. coli* downstream. As such, the discharge appears to be having a minor effect on the river.

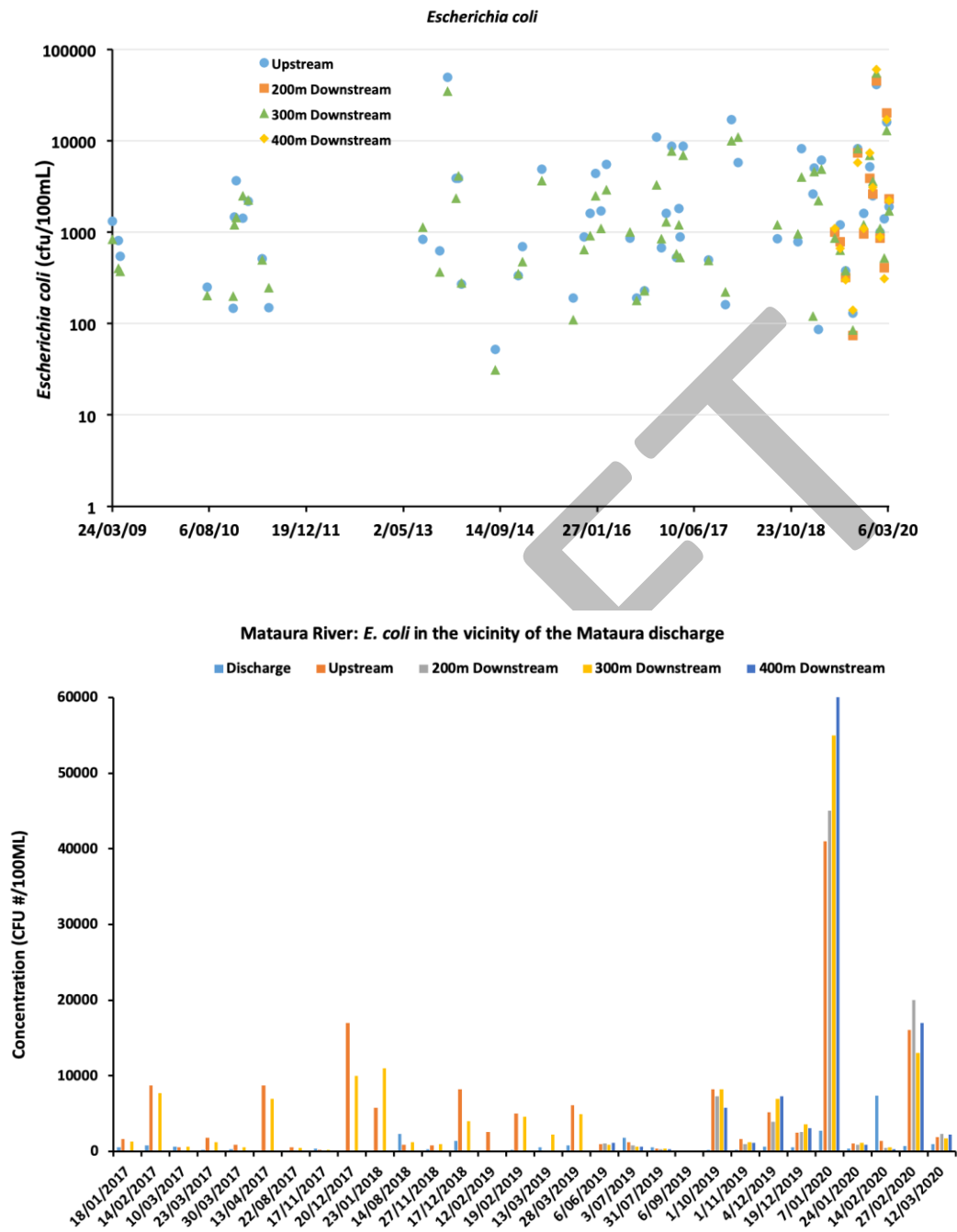


Figure 29. Top: *E. coli* concentrations in the vicinity of the Mataura discharge, March 2009 to March 2020. Bottom: Concentrations in recent years (2017-2020).

Table 21. Comparison of observed E. coli concentrations with the NPS-FM attribute states for E. coli, using all available data (2009-2020).

Attribute	Upstream	Downstream		
		200 m	300 m	400 m
Number of samples >540 cfu/100 mL	46	10	41	10
Number of samples >260 cfu/100 mL	52	12	52	12
Total number of samples	62	13	62	13
% >540 cfu/100 mL	74%	77%	66%	77%
% >260 cfu/100 mL	84%	92%	84%	92%
Median	1355	1000	1100	1100
95 th percentile	15750	30000	10950	34200
OVERALL attribute band	E	E	E	E

Table 22. Comparison of observed E. coli concentrations with the NPS-FM attribute states for E. coli, using the past five years of data (2015-2020).

Attribute	Upstream	Downstream		
		200 m	300 m	400 m
Number of samples >540 cfu/100 mL	34	10	32	10
Number of samples >260 cfu/100 mL	37	12	37	12
Total number of samples	43	13	43	13
% >540 cfu/100 mL	79%	77%	74%	77%
% >260 cfu/100 mL	86%	92%	86%	92%
Median	1600	1000	1200	1100
95 th percentile	15500	30000	10900	34200
OVERALL attribute band	E	E	E	E

Ammoniacal-nitrogen toxicity

Concentrations of NH₄-N (corrected for pH) at the first downstream site can be higher than those immediately upstream of the discharge, although concentrations at sites further downstream are lower and more similar to upstream (Figure 30).

Assessing the NH₄-N monitoring data against the NH₄-N toxicity attributes states in the NPS-FM indicate the following:

- Annual maximums at the upstream and 300 m downstream sites since 2016 have been within band B, while annual medians have sat either in band A or B, depending on the year. Overall, both of these sites would be classified as band B for ammonia toxicity since 2016.
- While there has been limited sampling only at the 200 m and 400 m downstream sites, the data shows that the 200 m downstream site sat in band B, while the

400 m downstream site sat in band A in 2019 and band B in 2020.

For the closest SOE site (Mataura River 200 m downstream of Mataura), $\text{NH}_4\text{-N}$ was in either band A or B (depending on year) for toxicity. $\text{NH}_4\text{-N}$ concentrations downstream of the discharge are also lower than ANZECC (2000) guideline levels for ammonia toxicity ($<0.9 \text{ g/m}^3$). Ammonia toxicity is not an issue for benthic macroinvertebrates or other freshwater biota such as fish. Overall, $\text{NH}_4\text{-N}$ concentrations in the river downstream of the Mataura discharge are not at levels that would cause toxic effects to aquatic life.

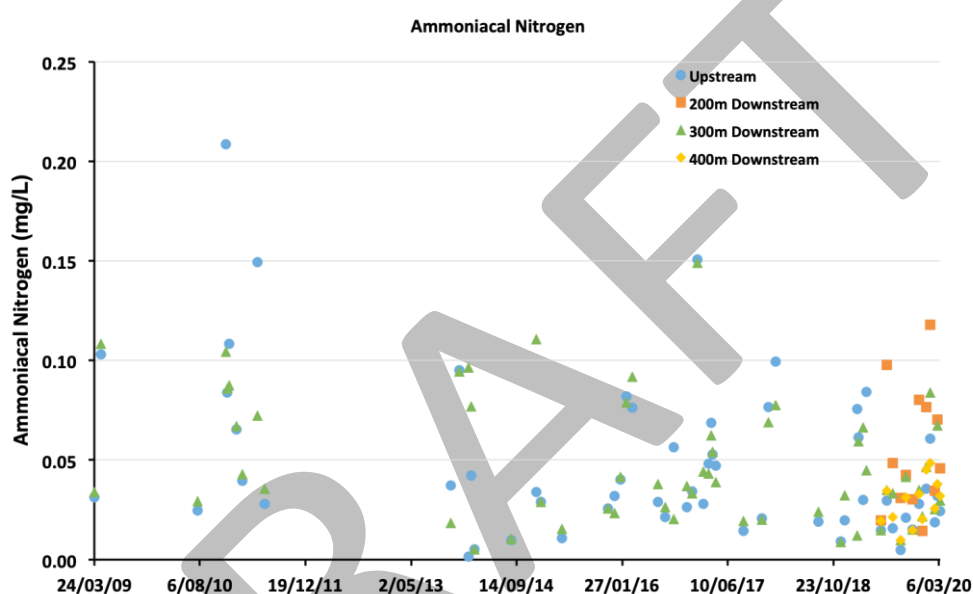


Figure 30. pH-corrected ammoniacal nitrogen concentrations in the vicinity of the Mataura discharge, March 2009 to March 2020.

Nitrate-nitrogen toxicity

The long-term monitoring record shows that concentrations of $\text{NO}_3\text{-N}$ are similar at sites upstream and 300 m downstream of the discharge (Figure 31, Top).

In recent years, on most occasions, there is no change or very little change in $\text{NO}_3\text{-N}$ concentrations between monitoring sites (Figure 31, Bottom) and the discharge is not affecting downstream nitrate levels. Comparing concentrations with the $\text{NO}_3\text{-N}$ toxicity attribute table in the NPS-FM, monitoring sites typically sit in either band A or band B. It is worth noting that $\text{NO}_3\text{-N}$ concentrations in the Mataura effluent are typically much lower than those in the river upstream of the discharge point (see Table 4).

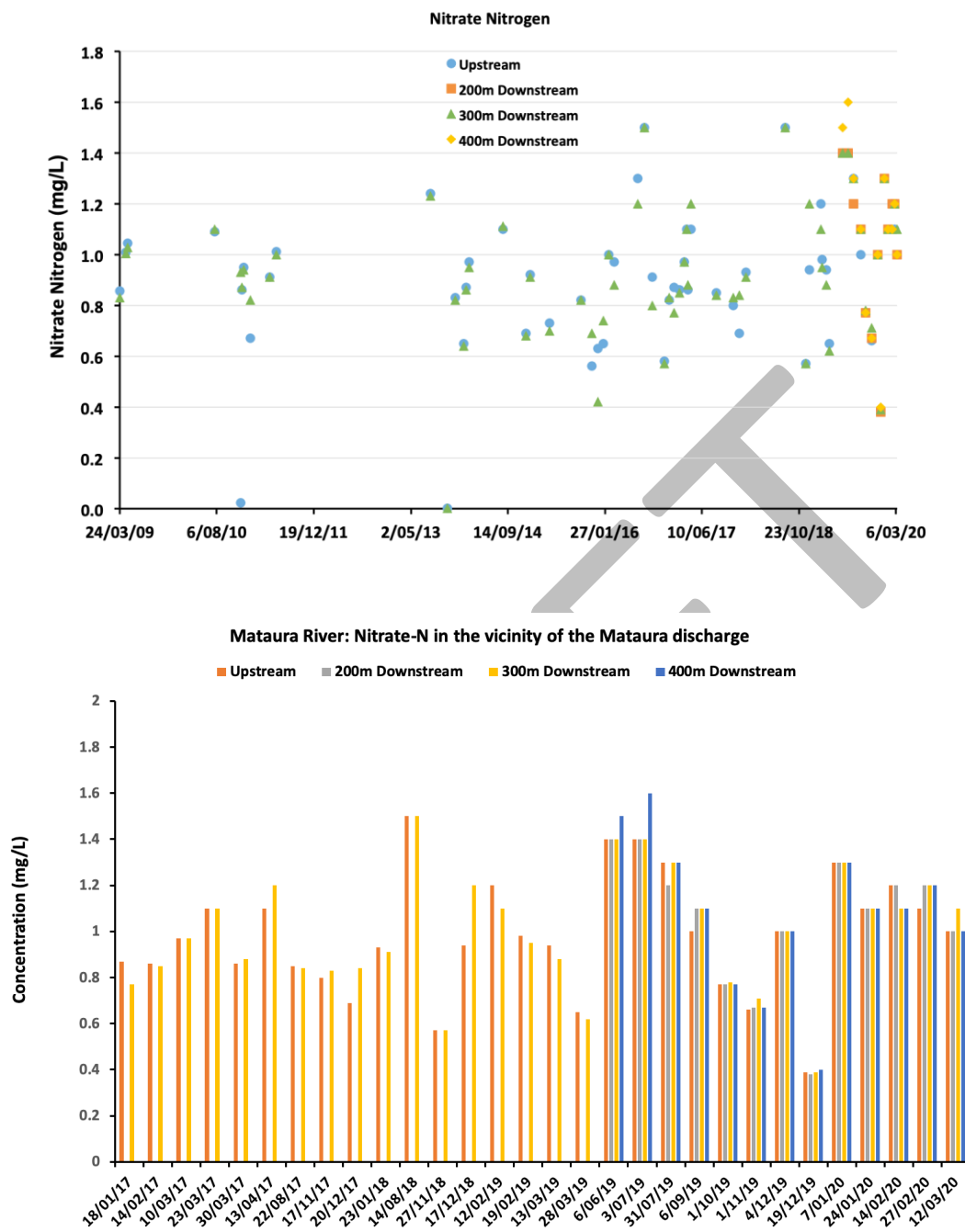


Figure 31. Top: Nitrate nitrogen concentrations in the vicinity of the Mataura discharge, March 2009 to March 2020. Bottom: Concentrations in recent years (2017-2020).

Total nitrogen

There has been limited sampling of TN at monitoring downstream sites (Figure 32). Although concentrations can be slightly higher downstream of the discharge point on some occasions, they are minor increases only.

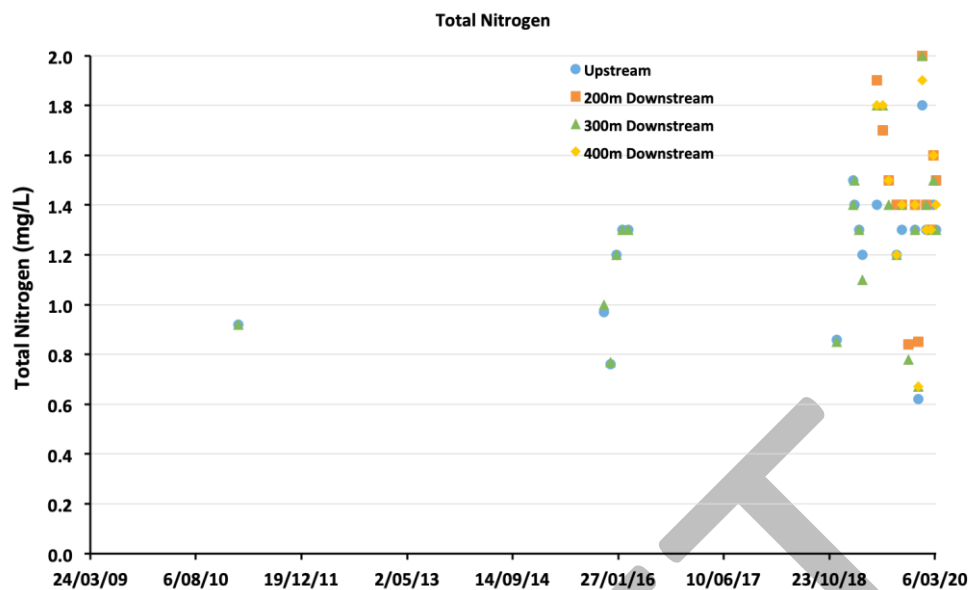


Figure 32. Total nitrogen concentrations in the vicinity of the Mataura discharge, March 2009 to March 2020.

Dissolved reactive phosphorus

DRP concentrations were similar at sites upstream and downstream of the Mataura wastewater discharge (Figure 33).

Comparisons have been made with concentrations with Appendix 2A attribute classes for DRP in the NPS-FM, although these are based on a limited dataset. Looking at values since 2015, and since June 2019 for the 200 m and 400 m downstream sites, median concentrations at all sites have been within band C of the NPS-FM. The 95th percentile concentration was in band C for the upstream site, below the national bottom line and in band D for the 200 m downstream site (but note only sampled since 2019, so a very limited dataset), and in band B for the 300 m and 400 m downstream sites.

While these assessments are indicative only, due to the lack of regular monitoring over time, overall they indicate that the upstream, 300 m and 400 m downstream sites are in band C for DRP, and in band D for the 200 m downstream. By comparison, the SOE monitoring site Mataura River 200 m downstream of Mataura is in band B for DRP.

Overall, DRP concentrations are not adversely affected by the discharge beyond the 200 m mixing zone.

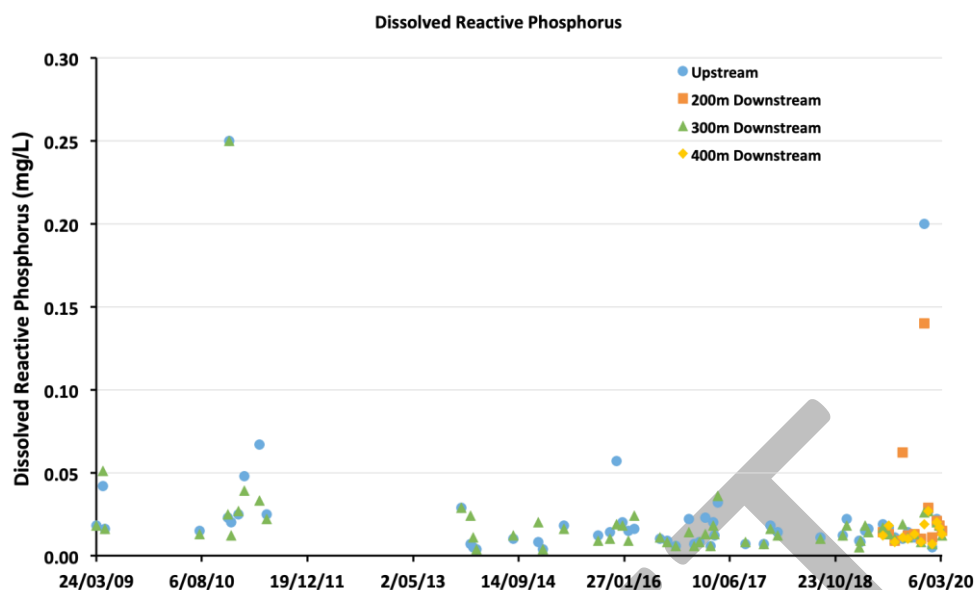


Figure 33. Dissolved reactive phosphorus concentrations in the vicinity of the Maitava discharge, March 2009 to March 2020.

Total phosphorus

There has been limited monitoring of river TP concentrations in the vicinity of the Maitava wastewater discharge. Of limited data available, TP concentrations have generally been similar upstream and downstream of the discharge, and at best the discharge appears to have only a minor effect on downstream TP concentrations (Figure 34).

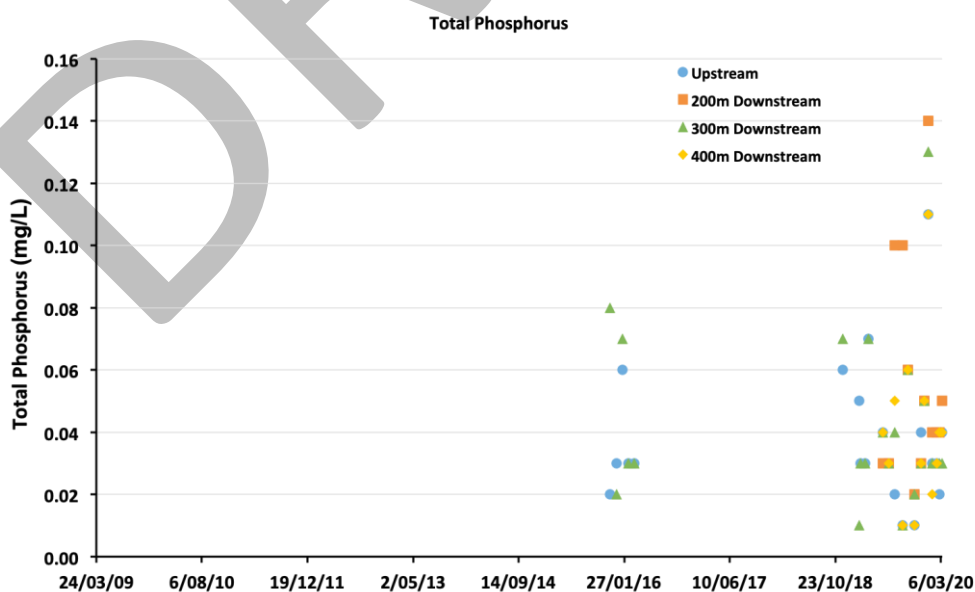


Figure 34. Total phosphorus concentrations in the vicinity of the Maitava discharge, March 2009 to March 2020.

Biochemical oxygen demand

BOD₅ has only been sampled in the river since June 2019, and results for all samples except on one occasion have been below laboratory detection limits (Figure 35). Overall, river BOD₅ concentrations are not adversely affected by the discharge.

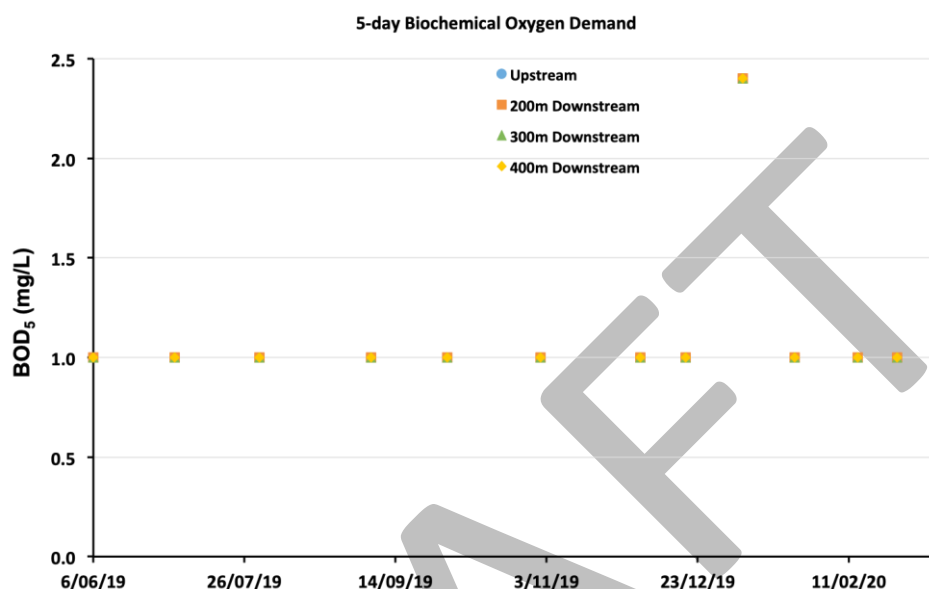


Figure 35. 5-day biochemical oxygen demand in the vicinity of the Mataura discharge, June 2019 to March 2020.

Summary

Overall, contaminant concentrations in the Mataura River downstream of the Mataura wastewater discharge are similar to concentrations immediately upstream. River conditions often influences water quality and upstream water quality can be poor, at times. However, concentrations of the contaminants ammoniacal nitrogen and suspended solids can be elevated immediately downstream of the discharge. Other contaminants in the discharge have a less than minor effect on water quality of the river.

6.4.3 Water supply

National standards for drinking water quality include the guideline value for turbidity of 2.5 NTU, above which appearance of the water is influenced, as an aesthetic determinand and additional information only (MoH 2008). The average turbidity level in the Mataura River, as measured at Gore between 2000 and 2020, is 12.9 NTU (median 4.1 NTU). Therefore, in terms of turbidity levels and appearance of the water, the Mataura River upstream of the discharges can be regarded as unsuitable for untreated drinking water.

6.4.4 Livestock water supply

The ES standards for surface water bodies classified as Mataura 3 state:

'The waters must not be tainted so as to make them unpalatable, nor must they contain toxic substances to the extent that they are unsafe for consumption by humans or farm animals, nor must they emit objectionable odours'.

The ANZECC (2000) guidelines for livestock drinking water include biological, chemical and radiological characteristics that may affect animal health. Of relevance to the discharge, the guidelines state:

'Drinking water for livestock should contain less than 100 thermotolerant coliforms per 100 mL (median value)'.

Thermotolerant coliforms (also known as faecal coliforms) provide an indication of faecal contamination and thus the possible presence of microbial pathogens. River water quality sampling in the Mataura River at Gore by ES, upstream of both discharges, includes testing for faecal coliforms and *E. coli* (the major species in the faecal coliform group). Over the period 2000-2020 at the Gore sampling site, the median *E. coli* concentration (380 cfu/100 mL) and the median faecal coliform concentration (430 cfu/100 mL) were both above 100 cfu/100 mL (see Table 6) and therefore did not meet the ANZECC guideline for livestock drinking water.

ANZECC (2000) indicate investigations of likely causes are warranted when 20% of results exceed four times the median trigger value (i.e., 400 cfu/100mL). Concentrations of faecal coliforms and *E. coli* at Gore exceeded 400 cfu/100mL 45% and 53% of the time respectively between 2000 and 2020, which is considerably higher than the 20% threshold for further investigation.

The exceedence of ANZECC guidelines for coliform concentrations in livestock drinking water upstream of both discharges indicate that the water quality of the Mataura River is not suitable for livestock drinking, irrespective of any contribution from the Gore and Mataura wastewater discharges.

6.5 Effluent mixing zones

Consents permitting the discharge of wastewater typically provide for an area of receiving water for mix and dilution of the discharge before compliance limits on the quality of the receiving water are applied. These areas are often referred to as the zone of reasonable mixing as they are not always of sufficient size to allow for full mixing.

For the Gore wastewater discharge consent, the zone of reasonable mixing extends from immediately upstream of the discharge point to 200 m downstream. For the Mataura

wastewater discharge consent, the zone of reasonable mixing extends from 5 m upstream of the discharge point to 100 m downstream. For both consents, there are no requirements relating to the width of the mixing zone.

According to the SWLP, a reasonable mixing zone is a zone within which relevant water quality standards may be exceeded, but which shall be no longer than 10 times the width of the wetted channel or 200 m along the longest axis of the zone (whichever is the lesser), and occupies no greater than two-thirds of the wetted channel width at the estimated Q95⁹ for that location.

Reasonable mixing in relation to each discharge is assessed below.

6.5.1 Gore discharge

The Maitava River at the Gore wastewater discharge point is approximately 45-60 m wide. Ten times the wetted width of the channel is approximately 450-600 m, in which case the zone of reasonable mixing would be 200 m long, in accordance with the SWLP. The mixing zone specified by the consent (i.e., 200 m downstream) is therefore in agreement with the requirements of the plan.

The discharge enters the Maitava River from the true right bank and travels along the true right edge of the river, as determined from dye studies (from the Actiflo® Treatment Plant outfall) conducted in December 2010 by GDC and ES staff. As the plume travels down the true right side of the river, it is expected to occupy less than two-thirds of the wetted channel width.

The average river flow of the Maitava River at Gore has been estimated to be approximately 65.1 m³/s (from ES Environmental Data website), which equates to a total daily volume of 5,620,320 m³/day. Combined with the average river flow in Waikaka Stream (at Willowbank: 3.35 m³/s, or 289,008 m³/day), the average river flow in the Maitava River upstream of the Gore discharge is approximately 68.4 m³/s or 5,909,328 m³/day. Similarly, the mean annual low flow (MALF) in the Maitava River at Gore is estimated to be approximately 16.0 m³/s, the MALF in Waikaka Stream is approximately 0.46 m³/s, which produces a combined MALF of 16.5 m³/s upstream of the Gore discharge.

The average dry weather consented discharge for Gore is 9,000 m³/day. This volume is extremely small relative to the daily volume of water in the river at the mean flow (0.15%) and at the MALF (0.63%). The instantaneous flow rate for the average dry weather consented discharge of 9,000 m³/day is approximately 104.2 l/s. At the MALF, and after full mixing, river water would dilute the discharge 158 times. At the mean flow, river water

⁹The naturalised flow that is exceeded 95% of the time during the year. According to the ES Environmental Data website, Q95 flow in the Maitava River is 15.662 m³/s at Gore and 17.724 m³/s at Tuturau.

would dilute the discharge 657 times.

The Gore discharge from the pond and the Actiflo plant enter the river in deep and sluggish runs, with water velocity increasing further downstream where riffles are present. There are no areas of low velocity backwater where the discharge can accumulate. The consent requires monitoring of the Gore discharge after mixing 200 m downstream of the pond outlet. This site is approximately 600 m downstream of the Actiflo outlet and is therefore outside a 200 m long mixing zone that would apply under the SWLP. Prior to 2019, approximately 800 m of the true right river bank upstream of, adjacent to, and downstream of both the Actiflo and pond outlets, was covered by willow trees. These trees restricted access to the river so, for practical purposes, the downstream monitoring site was located at the first location where the river could be observed and accessed safely for sampling. The willow trees were removed in 2018.

Contribution of the Gore discharge to downstream contaminant concentrations

ES water quality monitoring data from the Mataura River at Gore and the Waikaka Stream at Gore since January 2015 was used to derive median and 95th percentile concentrations of contaminants. MALF figures for these sites (16 and 0.461 m³/s respectively) were used along with median and 95th percentile contaminant concentrations to calculate contaminant loads for each river. Loads from both rivers were then combined to produce a combined river load for each contaminant upstream of the Gore wastewater discharge.

Using water quality and discharge flow data for the Gore wastewater discharge since June 2019 (when monitoring of more nutrient species commenced), median and 95th percentile flows and contaminant concentrations were used to calculate effluent contaminant loads in a similar way to that done for the river upstream.

These river and wastewater contaminant loads were then combined to provide a contaminant load downstream of the wastewater discharge point after full mixing. The load data were then converted back to concentrations to provide an estimate of downstream contaminant concentration after full mixing and assuming no assimilation of the contaminants (Table 23).

The typical annual worst-case scenario for receiving water quality can be assumed as being the river flowing at MALF and the wastewater discharging at the median daily discharge flow and having contaminants at median concentrations. An extreme worst-case scenario can be regarded as the river flowing at MALF and the wastewater discharging at the 95th percentile for its daily discharge volume and contaminant concentrations in the wastewater at their 95th percentile levels.

After full mixing of the discharge with river water, concentrations of some contaminants are similar to those upstream (e.g., DRP, TP) and in the case of *E. coli* is slightly lower than

upstream (i.e., the discharge has a slight diluting effect on *E. coli* concentrations in background river water).

The calculations indicate that TN concentrations are slightly higher and NH₄-N concentrations are higher downstream of the discharge at both median and 95th percentile discharge flow and concentrations. However, these are worst-case scenarios, as the high discharge flows and high effluent contaminant concentrations are unlikely to occur during periods of low river flows.

Table 23. Contaminant concentrations calculated for the Mataura River in the vicinity of the Gore discharge. River concentrations based on monitoring data since January 2015, discharge concentrations based on monitoring data since June 2019. Note NO₃-N could not be calculated due to insufficient data from the discharge.

	<i>E. coli</i> (#/100 mL)	NH ₄ -N (mg/L)	NO ₃ -N (mg/L)	TN (mg/L)	DRP (mg/L)	TP (mg/L)
Concentrations in river upstream of Gore discharge at MALF:						
Median concentration	380	0.003	0.915	1.128	0.007	0.018
95 th percentile concentration	9,023	0.010	1.473	1.734	0.023	0.123
Concentrations in river after full mixing with Gore discharge:						
Median concentrations (river at MALF + median discharge flow (6,722 m ³ /d), median discharge concentrations)	380	0.040	-	1.188	0.007	0.020
95 th percentile concentrations (river at MALF + 95 th % discharge flow) (8,908 m ³ /d), 95 th % discharge concentrations	8,977	0.079	-	1.829	0.030	0.136

6.5.2 Mataura discharge

The Mataura River at the site of the Mataura discharge point is approximately 50-60 m wide. Ten times the wetted width of the channel is approximately 500-600 m, in which case the zone of reasonable mixing would be 200 m long, in accordance with the SWLP. The mixing zone specified by the consent (i.e., 100 m downstream) is therefore not in agreement with the requirements of the plan, and an appropriate mixing zone would be 200 m long.

The discharge enters the river from the true right bank and travels down the true right edge of the river. Observations of the river during biological surveys noted surface bubbles near the outfall moving downstream along the true right edge until at least the

downstream biological monitoring site, located 130 m downstream of the outfall. As the plume travels along the true right edge of the river, it is expected to occupy less than two-thirds of the wetted channel width.

The average river flow in the Mataura River at the Tuturau flow monitoring site, approximately 1.4 km downstream of the Mataura discharge point¹⁰, is estimated to be approximately 75.9 m³/s (from ES Environmental Data website), which equates to a total daily volume of 6,556,723 m³/day. Similarly, the MALF at Tuturau is estimated to be approximately 18.3 m³/s.

The average dry weather consented discharge for Mataura is 2,000 m³/day. This volume is small compared with the river's mean flow (0.03%) and the MALF (0.13%). The instantaneous flow rate for the average dry weather consented discharge of 2,000 m³/day is approximately 23.2 l/s. At the MALF, and after full mixing, river water would dilute the discharge 790 times. At the mean flow, river water would dilute the discharge 3,278 times.

The Mataura wastewater discharge enters the river in a reach containing run habitat. The runs are generally deep, however gravel movement during high flow events can result in islands forming in the vicinity of the outfall, which can affect the path and mixing of the discharge in the river. Consent monitoring of the river downstream of the Mataura discharge is undertaken 300 m downstream of the outlet. This site is therefore outside the 100 m long mixing zone specified by the consent and also outside the 200 m long mixing zone for discharges, in accordance with the SWLP.

Contribution of the Mataura discharge to downstream contaminant concentrations

ES water quality monitoring data from the Mataura River 200 m downstream of the Mataura Bridge since January 2015 was used to derive median and 95th percentile contaminant concentrations. The MALF of 18.3 m³/s was used along with median and 95th percentile contaminant concentrations to calculate median and 95th percentile contaminant loads for the river upstream of the Mataura discharge.

Using water quality and discharge flow data for the Gore wastewater discharge since June 2019 (when monitoring of more nutrient species commenced), median and 95th percentile flows and contaminant concentrations were used to calculate effluent contaminant loads in a similar way to that done for the river upstream. These river and wastewater contaminant loads were then combined to provide a contaminant load downstream of the wastewater discharge point after full mixing. The load data were then converted back to concentrations to provide an estimate of downstream contaminant concentration after full mixing and assuming no assimilation of the contaminants (Table

¹⁰ Environment Southland has recently decommissioned this flow gauging site following the February 2020 flood.

24).

The typical annual worst-case scenario for receiving water quality can be assumed as being the river flowing at MALF and the wastewater discharging at the median daily discharge flow and having contaminants at median concentrations. An extreme worst-case scenario can be regarded as the river flowing at MALF and the wastewater discharging at the 95th percentile for its daily discharge volume and contaminant concentrations in the wastewater at their 95th percentile levels.

After full mixing of the discharge with river water, concentrations of most contaminants are either similar to (e.g., NO₃-N, DRP), slightly higher than (e.g., NH₄-N), or lower than upstream concentrations (e.g., *E. coli*). These scenarios are worst-case, as high discharge flows and high effluent contaminant concentrations are unlikely to occur during periods of low river flows.

Table 24. Contaminant concentrations calculated for the Mataura River in the vicinity of the Mataura discharge. River concentrations based on monitoring data since January 2015, discharge concentrations based on monitoring data since June 2019.

	<i>E. coli</i> (#/100 mL)	NH ₄ -N (mg/L)	NO ₃ -N (mg/L)	TN (mg/L)	DRP (mg/L)	TP (mg/L)
Concentrations in river upstream of Mataura discharge at MALF:						
Median concentration	1,100	0.020	0.900	1.210	0.010	0.024
95 th percentile concentration	17,900	0.067	1.563	1.885	0.019	0.133
Concentrations in river after full mixing with Mataura discharge:						
Median concentrations (river at MALF + median discharge flow (509 m ³ /d), median discharge concentrations)	1,100	0.023	0.900	1.213	0.010	0.024
95 th percentile concentrations (river at MALF + 95 th % discharge flow) (2,072 m ³ /d), 95 th % discharge concentrations)	17,882	0.081	1.562	1.897	0.019	0.114

6.6 Aquatic algae and plants

The composition and abundance of aquatic algae (periphyton) and plant communities of the lower Mataura River are influenced by river flows, including extremes such as sustained low flows and major flood events, and water quality character, particularly nutrient levels. While the invasive alga didymo has been found in the river, extensive mats that smother the bed and restrict habitat for other algae and plants have not been abundant in the river as they have been in other Southland rivers (e.g., Waiau River, Mararoa River). Benthic cyanobacteria mats have been observed throughout the Mataura

River, with warnings to river users at times of high risk due to high cover levels and the increased potential for toxin production.

6.6.1 Gore

Periphyton monitoring of the river in the vicinity of the Gore discharge are required under consent conditions. This monitoring is required during low flow periods in summer/autumn, which is when dilution of the discharge would be at its lowest. Monitoring has found no evidence of heterotrophic or nuisance periphyton growths at any of the survey sites.

Consent monitoring requires assessments of long filamentous algae cover (i.e., strands >3 cm long). The assessment requires the RAM-1 method¹¹, which enables cover to be assessed against MfE's New Zealand periphyton guidelines (Biggs 2000) to protect aesthetics/recreation waters and trout habitat and angling (Figure 36).

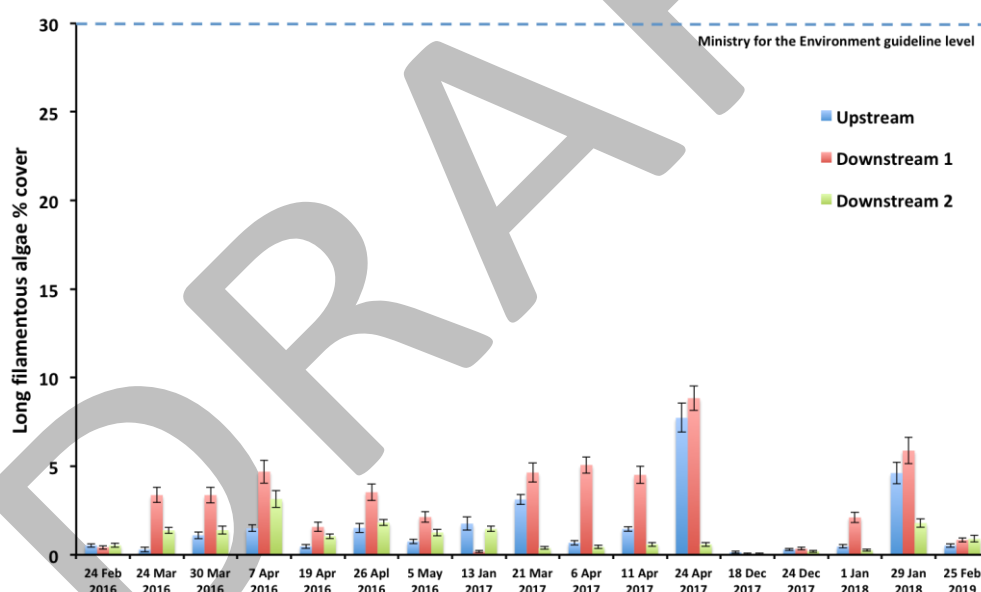


Figure 36. Percentage cover of the Mataura River bed by long filamentous algae in the vicinity of the Gore oxidation pond, 2016-2019 (mean $\pm$ one standard error). Guideline level from MfE's New Zealand periphyton guidelines (Biggs 2000).

While long filamentous algae cover has on several occasions been higher at the Downstream 1 site relative to that at the upstream site, there have been no consistent differences between sites throughout a monitoring season and overall cover at each site has been low (<10% cover on average) and well below guideline levels (Biggs 2000). Thin

¹¹ RAM-1: Rapid Assessment Method 1. Cover levels of long filamentous green/brown algae (i.e., filaments >3 cm long) (Biggs and Kilroy 2000).

films and medium algal mats, including cyanobacteria, have also been observed at each site during monitoring surveys.

To further understand to extent of periphyton cover near the Gore discharge under low flow conditions, more detailed assessments were undertaken in February 2019, January 2020, and March 2020 using the RAM-2 method¹² (Figure 37)¹³. These surveys found periphyton cover to be dominated largely by thin mats and films. While medium thick mats were most abundant in February 2019, when periphyton cover was higher at downstream sites, the average cover was generally less than 30% at each site. Short filaments were also observed at each site, with slightly higher cover at the Downstream 1 site, but again, the average cover was low and less than 20% at all sites. Cover of thick mats and long filaments was low at each site, and well below MfE's guideline levels (Biggs 2000).

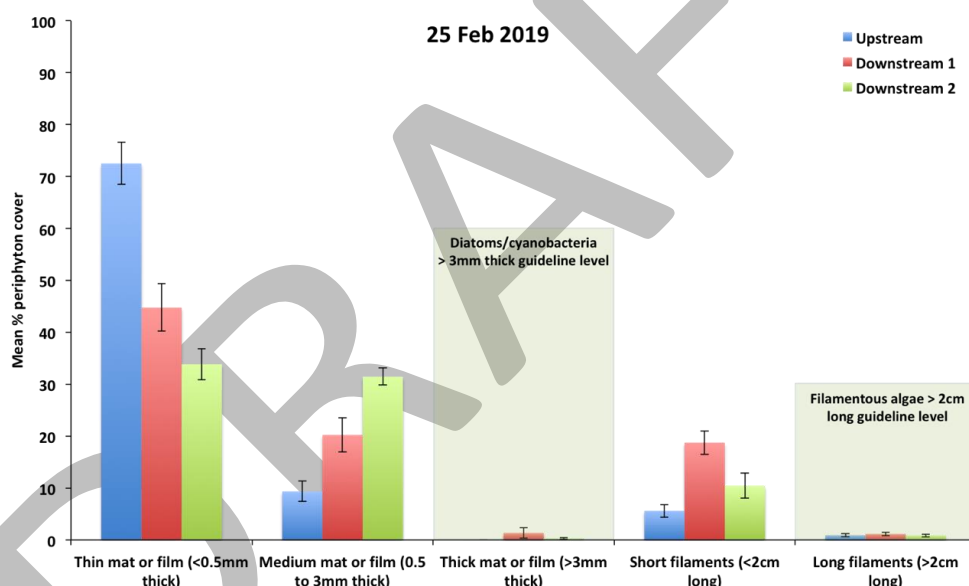


Figure 37. Percentage cover of the Mataura River bed by different periphyton categories in the vicinity of the Gore oxidation pond, 2019-2020 (mean +/- one standard error). Guideline levels from MfE's New Zealand periphyton guidelines (Biggs 2000).

¹² RAM-2: Rapid Assessment Method 2. A modified RAM-2 method, which assesses cover levels of different periphyton cover types (i.e., thin films, medium and thick algal mats, short and long filamentous algae) (Biggs and Kilroy 2000).

¹³ Further periphyton assessments were planned at these sites, and at additional sites further upstream and downstream of the discharge, but were prevented by higher flows and other restrictions.

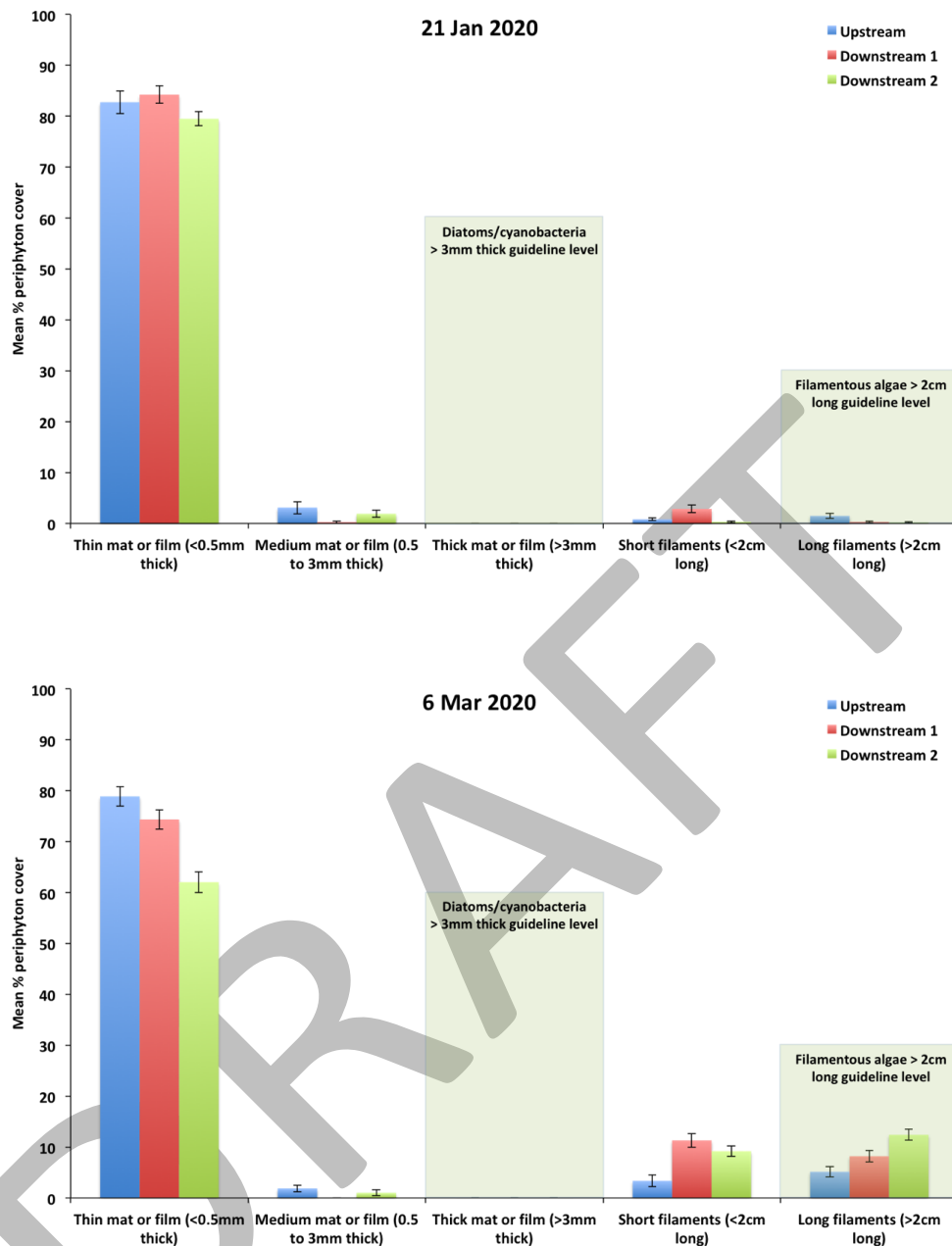


Figure 37 (cont.) Percentage cover of the Mataura River bed by different periphyton categories in the vicinity of the Gore oxidation pond, 2019-2020 (mean +/- one standard error). Guideline levels from MfE's New Zealand periphyton guidelines (Biggs 2000).

Periphyton biomass (as opposed to cover) can be quantitatively assessed by removing a known area of periphyton from stone surfaces and analysing the material for its chlorophyll-*a* content and organic content (by determining the ash free dry mass or AFDM). These indicators of biomass can be assessed against the MfE periphyton guidelines.

Periphyton biomass measured as chlorophyll-*a* (mg/m²), has exceeded the MfE guideline

for periphyton in gravel/cobble bed streams on several occasions between 2016 and 2019 (Figure 38). Elevated biomass has been found at sites both upstream and downstream of the discharge. The highest levels have been found at downstream sites, although there has been no consistent pattern between sites and years. Periphyton biomass measured as AFDM (g/m^2) also has no consistent pattern between sites, but levels have consistently been lower than the MfE guideline.

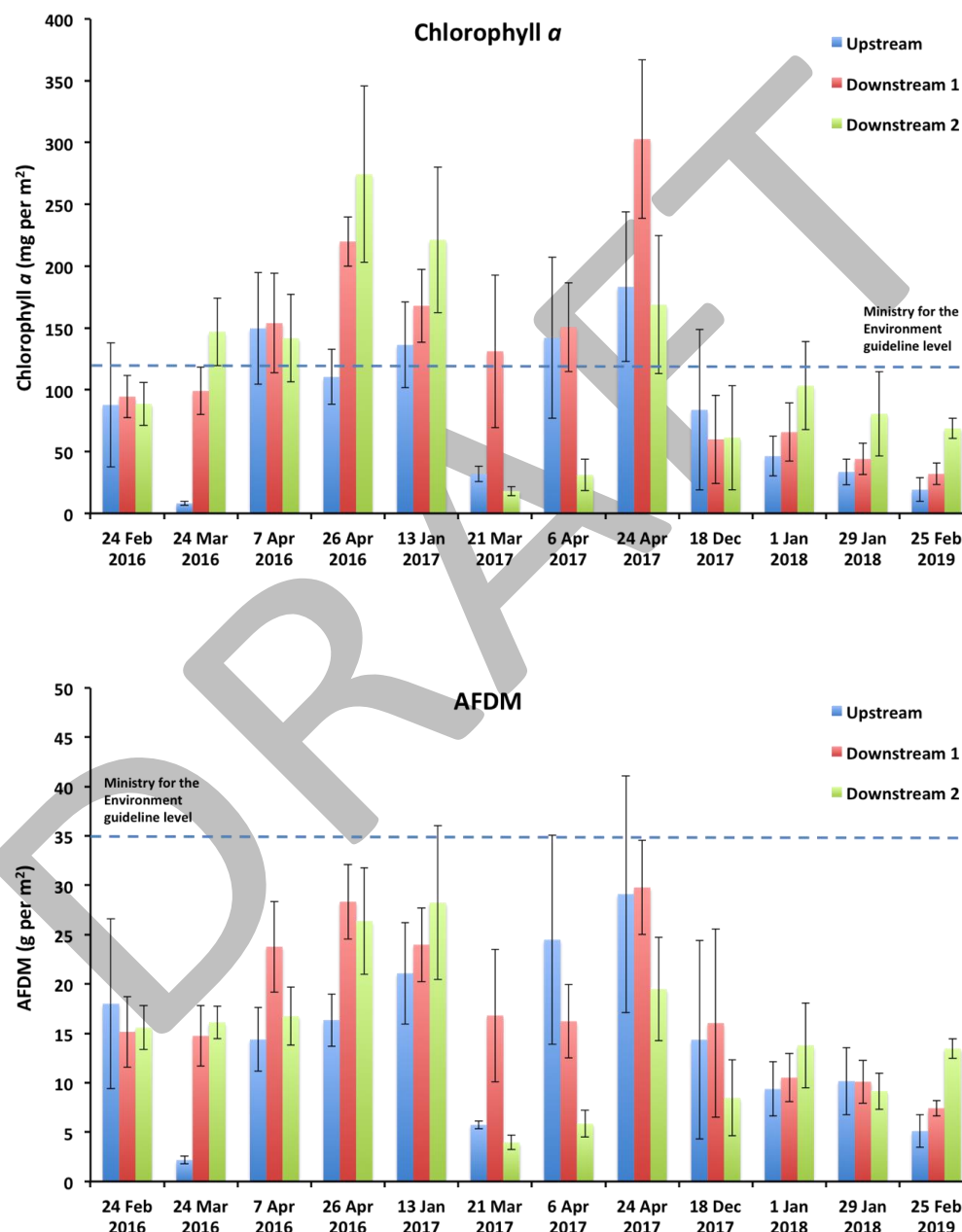


Figure 38. Percentage biomass in the Mataura River in the vicinity of the Gore oxidation pond, 2016-2019 (mean $\pm$ one standard error). Guideline levels from MfE's New Zealand periphyton guidelines (Biggs 2000).

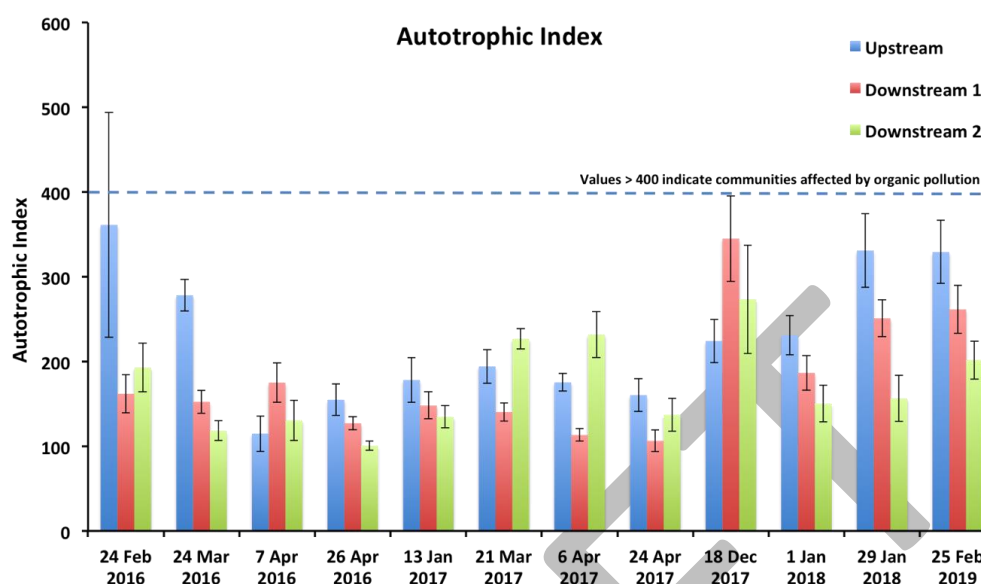


Figure 39. Percentage biomass expressed as the autotrophic index (ratio of AFDM (mg per m^2) : chlorophyll a (mg per m^2)) in the Mataura River in the vicinity of the Gore oxidation pond, 2016-2019 (mean $\pm$ one standard error). The dashed line indicates the level above which communities are starting to become impaired by organic pollution (Collins and Weber 1978, cited in Biggs and Kilroy 2000).

While at times there has been some localised increase in algal biomass downstream of the discharge, which may be influenced by the addition of nutrients from the wastewater discharge, habitat suitability also likely to be a contributing factor. Finding sampling sites with similar habitat character upstream and downstream of the Gore discharge has been challenging over the years. The river upstream of the discharge has smaller and more mobile substrate, and these are interspersed with bedrock. These characteristics contrast the river bed downstream of the discharge, which is dominated by cobbles. These differences in substrate character could also be in play at the ES Mataura River at Gore site, where regular monitoring has found thin films to dominate the periphyton community.

Overall, no clear patterns have been identified, and periphyton cover and biomass have generally been similar at sites upstream and downstream of the discharge. On occasions when periphyton cover and biomass has been found to be higher downstream of the discharge, differences in substrate size and mobility may be influential.

Consent monitoring also requires assessments of macrophyte (aquatic plant) cover. Macrophytes (e.g., *Elodea canadensis*) have generally been limited to small beds along the edges of sampling sites, where the current is gentle.

6.6.2 Mataura

As for Gore, periphyton monitoring of the river in the vicinity of the Mataura discharge are required under consent conditions. Monitoring is undertaken during low flow periods in summer/autumn. Monitoring has not found any evidence of heterotrophic or nuisance periphyton growths at any of the monitoring sites.

Assessments of periphyton cover between 2012 and 2018 found the periphyton community to be generally dominated by thin or medium mats/films and short filamentous algae (Figure 40). Community composition has been mostly similar upstream and downstream of the discharge. Cover of thick mats and long filaments was low at each site on most sampling occasions, and well below MfE's periphyton guideline levels. However, in 2013, average cover of long filamentous algae was considerably higher upstream of the discharge, and exceeded guideline levels.

There has been no obvious pattern with community composition, and no indication of an increase in cover downstream of the discharge, indicating that the discharge is not adversely affecting the periphyton community of the river.

While periphyton biomass has not been assessed at sites in the immediately vicinity of the Mataura discharge, the generally low cover of nuisance forms of periphyton identified above (and in Figure 40) indicates that biomass has been relatively low at each site, and there is no indication of increased biomass immediately downstream of the discharge.

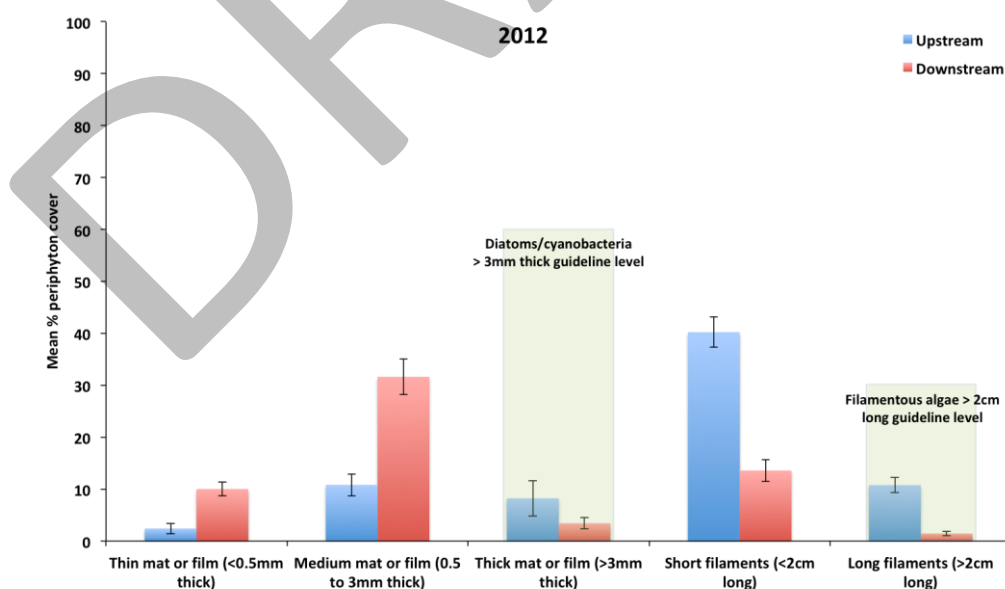


Figure 40. Percentage cover of the Mataura River bed by different periphyton categories in the vicinity of the Mataura oxidation pond, 2012-2018 (mean +/- one standard error). Guideline levels from MfE's New Zealand periphyton guidelines (Biggs 2000).

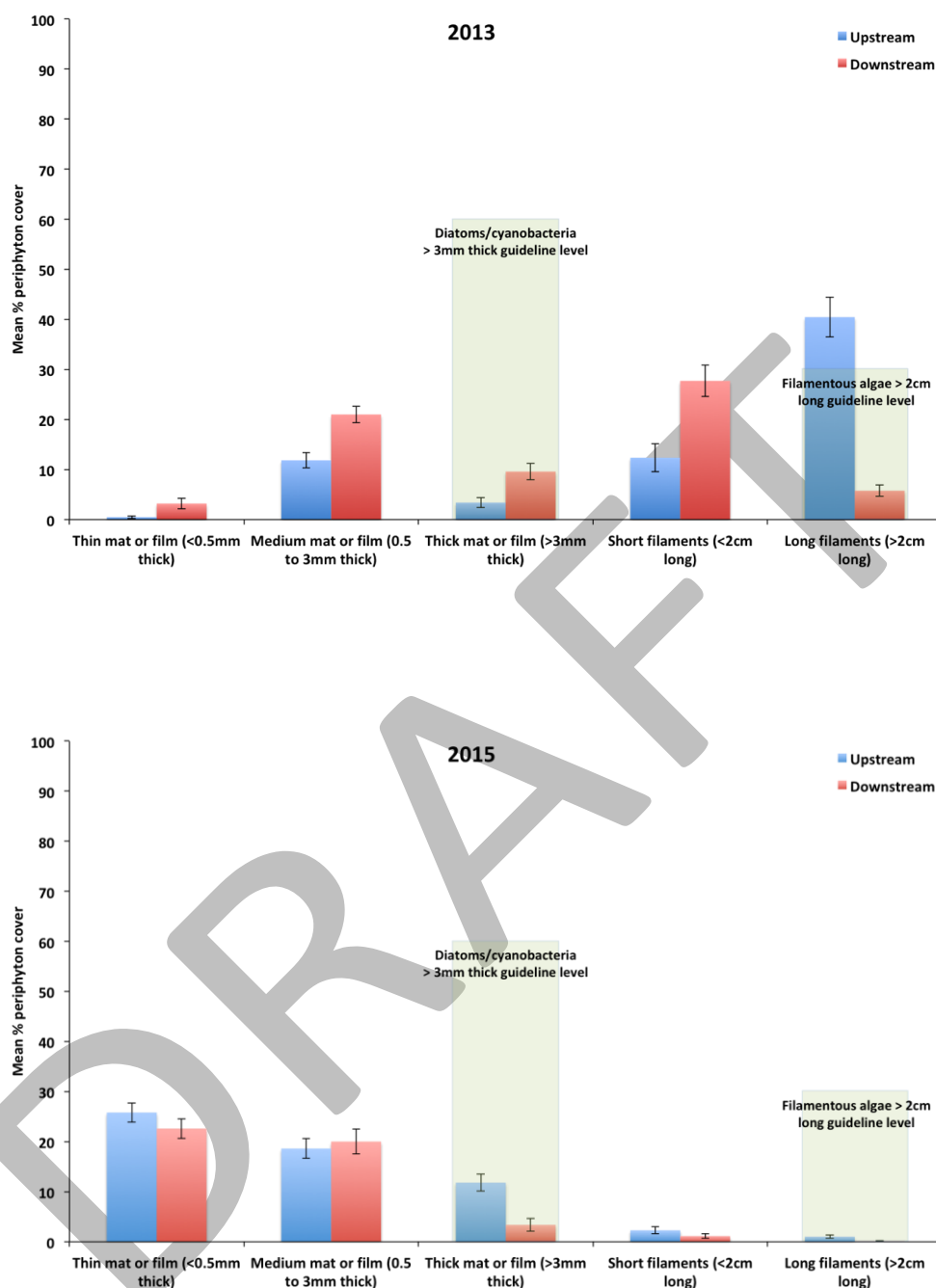


Figure 40 (cont.) Percentage cover of the Mataura River bed by different periphyton categories in the vicinity of the Mataura oxidation pond, 2012-2018 (mean +/- one standard error). Guideline levels from MfE's New Zealand periphyton guidelines (Biggs 2000).

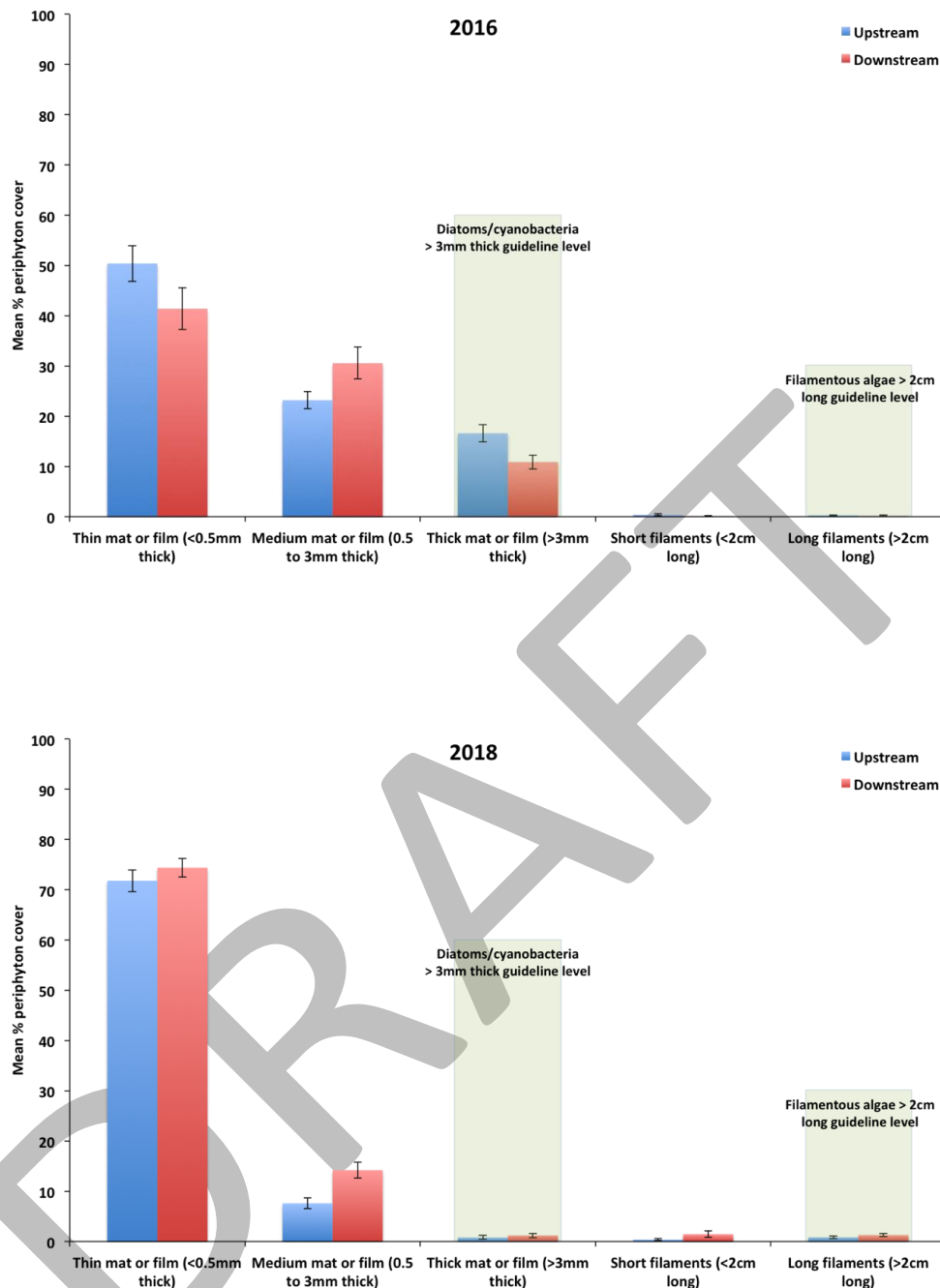


Figure 40 (cont.) Percentage cover of the Mataura River bed by different periphyton categories in the vicinity of the Mataura oxidation pond, 2012-2018 (mean +/- one standard error). Guideline levels from MfE's New Zealand periphyton guidelines (Biggs 2000).

ES monitoring of periphyton biomass in the Mataura River 200 m downstream of the Mataura Bridge site shows chlorophyll-*a* ranging between 54.3 mg/m² (February 2019) and 93.4 mg/m² (February 2017), which is below the MfE guideline.

6.7 Benthic macroinvertebrates

There are many different types of benthic invertebrates. Some are more sensitive to water quality than others, and some are more tolerant of habitat changes caused by fine sediment deposition and nuisance periphyton growths. They often have differing preferences for substrate type (sand, gravels, cobbles), food, current speed and water temperature. Different combinations of these biological, chemical and physical variables occur throughout the river, and can change over time, such that the make-up of the invertebrate community can change over a short distance in the river and through the course of the year.

The Gore and Mataura discharges are just two additional variables that may be affecting local invertebrate communities of the Mataura River, and the challenge is to assess their effect against all the other variables (natural and human) that potentially influence community composition and abundance.

6.7.1 Gore

Annual quantitative sampling of the benthic macroinvertebrate community in the Mataura River in the vicinity of the Gore discharge is required by consent. In some years, high river flows have prevented sampling from taking place. In recent times, sampling has occurred in 2010, 2012, 2013, 2015, 2016, and last undertaken in 2018.

The 2018 survey found macroinvertebrate communities to be dominated by *Deleatidium* mayflies, although densities of small chironomid (midge) larvae (e.g., Tanytarsini) and net-spinning caddisflies (*Hydropsyche-Aoteapsyche*) were also high (Appendix One). While community composition was very similar at sites upstream and downstream of the discharge, mayfly density was lower at the downstream site, which resulted in a lower average community health (QMCI) score downstream. The average QMCI score upstream was indicative of 'good' quality conditions, but downstream was indicative of 'poor-fair' quality conditions.

Comparing results from 2018 with survey results since 2010 shows that invertebrate community metrics in the vicinity of the Gore discharge have been generally similar in each survey (Figure 41). Some subtle differences have been apparent, with differences between sites more pronounced in 2016 and 2018 than in previous years. The upstream sampling site was relocated in 2016 due to changes in river character, which caused benthic habitat to differ between sites. As already noted, finding comparable habitat upstream and downstream of the discharge has been problematic for several years. The area upstream of the discharge is dominated by deep water overlying bedrock and very fine gravels, which contrasts the downstream cobble-dominated environment.

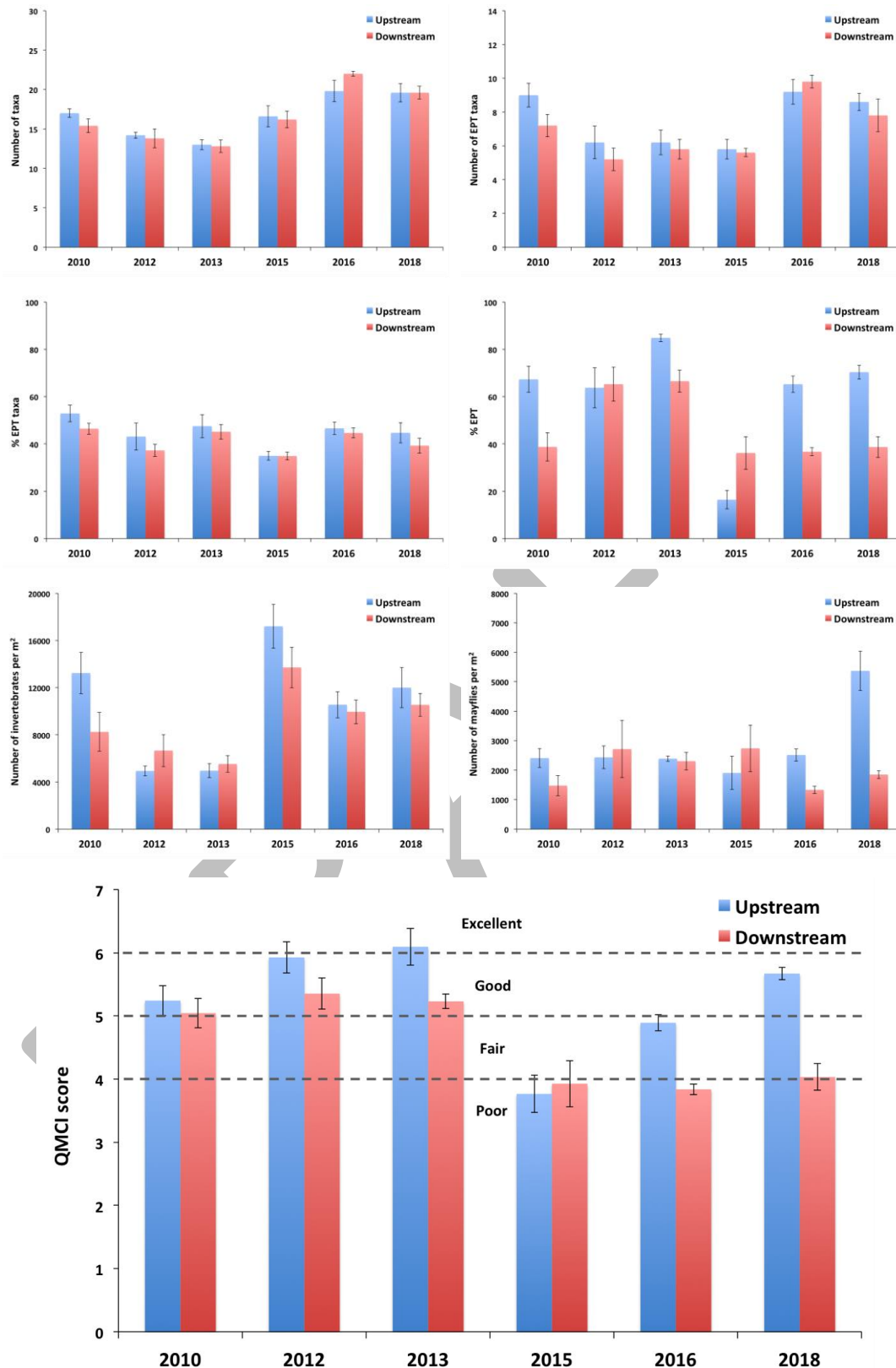


Figure 41. Macroinvertebrate metrics for samples collected at Gore discharge sites 2010 to 2018. Error bars are $\pm$ one standard error. Note the upstream site location changed between 2015 and 2016.

The differences in invertebrate communities found in the 2016 and 2018 surveys were primarily due to mayfly abundance. Mayfly abundance was highest at the upstream site in both surveys, with mayfly abundance at the upstream site in 2018 the highest observed at any site since 2010.

Average QMCI scores at the downstream site between 2015-2018 were lower than those from the 2013 survey and earlier, but have remained stable since 2015, indicating no continued reduction in invertebrate community health. QMCI scores at the upstream site have been similar to those at the downstream site, with scores increasing in 2016 and 2018.

A comparison of results from these compliance sites with those from the ES SOE site for the Mataura River at Gore is useful to place any differences in communities into a wider river context. Overall, abundance of *Hydropsyche-Aoteapsyche* caddisflies and midge larvae (e.g., Tanytarsini) is higher near the outfall, including at the upstream site, than at the ES Gore site. Differences in habitat (e.g., bed substrate, water velocities) between the ES Gore site and the compliance sites may be contributing to these difference in community structure. However, these taxa are lower-scoring and occur in higher abundance, resulting in reduced QMCI scores in the vicinity of the Gore discharge relative to the ES Gore site (Figure 42).

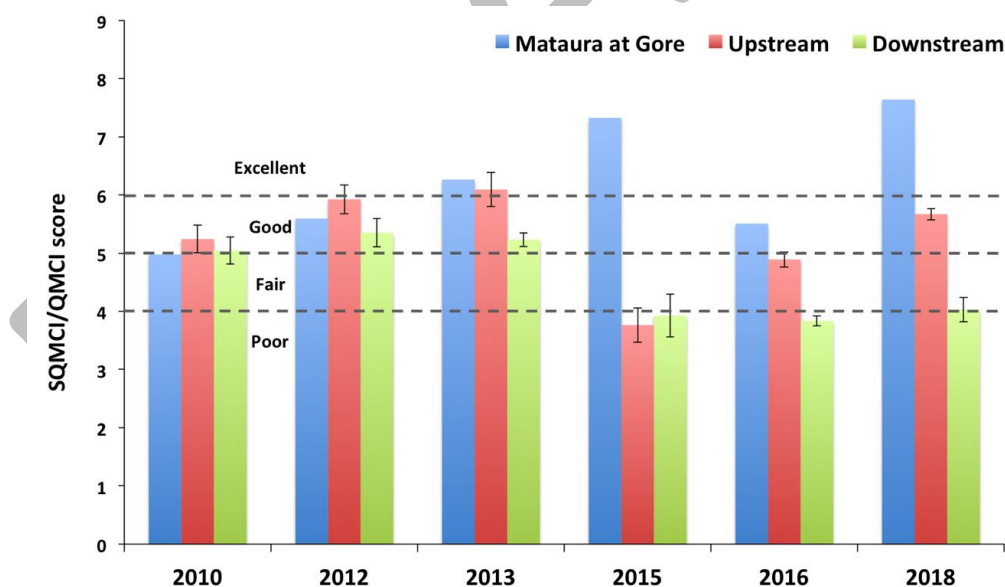


Figure 42. Macroinvertebrate health index (SQMCI/QMCI) scores for samples collected at Gore discharge sites and at the ES Mataura at Gore SOE site, 2010 to 2018. Error bars are +/- one standard error. Note the upstream site location changed between 2015 and 2016.

Overall, there have been subtle differences in community composition between sites

upstream and downstream of the Gore discharge, and these have been influenced by differences in habitat (e.g., bed substrate). This problem is exacerbated by the lack of similar habitat for sampling in the river immediately upstream of the discharge. Despite these differences and sampling difficulties, the general similarity in communities upstream and downstream of the discharge, and the lack of any patterns of reduced macroinvertebrate community health downstream of the discharge, indicate that the discharge is not causing significant adverse effects on macroinvertebrate communities.

6.7.2 Mataura

As for the Gore discharge consent, the Mataura discharge consent requires annual quantitative sampling of the benthic macroinvertebrate community in the vicinity of the Mataura discharge. As noted above, high river flows have prevented sampling from taking place in some years.

The most recent survey (2018) found macroinvertebrate communities were dominated by *Deleatidium* mayflies, with high densities of chironomid (midge) larvae (e.g., Tanytarsini), net-spinning caddisflies (*Hydropsyche-Aoteapsyche*), and *Potamopyrgus* snails (Appendix One). Community composition was very similar upstream and downstream of the discharge, with subtle differences between the sites resulting in slightly lower community health (QMCI) scores downstream. The average QMCI score at the upstream site was indicative of 'fair-good' quality conditions, but indicative of 'fair' quality conditions at the downstream site.

Comparing results from 2018 with survey results since 2010 show that invertebrate community metrics in the vicinity of the Mataura discharge have been very similar for each survey, and indicative of 'poor' to 'fair-good' quality conditions. (Figure 43). Some subtle differences in community metrics between sites are apparent, such as greater abundance of EPT taxa and higher densities of mayflies at the downstream site in some years.

A comparison of results from these compliance sites with those from the ES SOE site for the Mataura River 200 m downstream of Mataura is useful to place any differences in communities into a wider river context. Overall, abundance of elmids (riffle) beetles is higher at the ES site than at both sites in the vicinity of the discharge, which may be due to greater riffle habitat at the ES site. Other community characteristics are similar between all sites.

Overall, the similar communities indicate that the discharge is not causing significant adverse effects on macroinvertebrate communities.

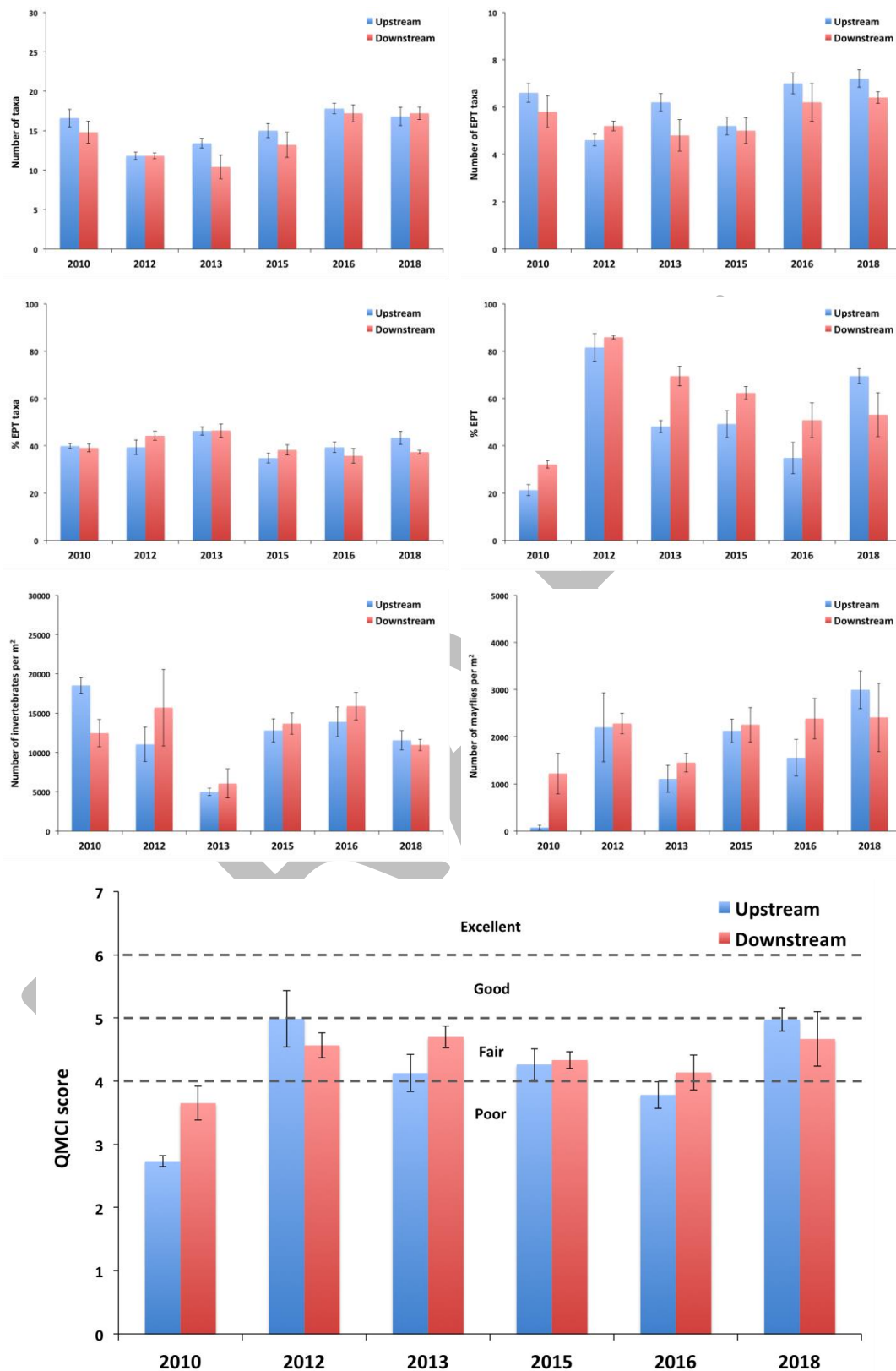


Figure 43. Macroinvertebrate metrics for samples collected at Mataura discharge sites 2010 to 2018. Error bars are +/- one standard error.

6.8 Fish

Fish monitoring is not required for either discharge consent and the size of the Maitava River is such that quantitative fish surveys are not practical. Effects on fish due to discharge quality are addressed in sections on water quality and through assessments against water quality guidelines, standards and NPS-FM attribute bands. Effects on fish food (benthic invertebrates) have been addressed in the previous section. Potential changes in instream habitat due to nuisance periphyton and plant growths, and fine sediment deposition have also been addressed in previous sections. The findings from these sections indicate there is nothing to suggest that local habitat and water quality is significantly adversely affecting fish communities. Fish may actively avoid the discharges, particularly in areas where they are yet to receive significant dilution from the river, however observations indicate that some fish (trout in particular) actively seek out the effluent plume from oxidation ponds, possibly to feed on zooplankton which can be abundant in these systems.

6.9 Cumulative effects

The Gore and Maitava discharges enter the Maitava River within 15 km of each other. In addition, the Alliance Maitava meatworks discharges effluent to the river between these discharges (approximately 4 km upstream of the Maitava discharge outfall). Urban stormwater discharges from the Gore and Maitava townships also occur in this section of the river. These discharges all contribute to the contaminant load to the river, consequently a discussion of cumulative effects of the discharges on water quality and river biota is warranted.

Monitoring of water quality and river ecology is undertaken by ES throughout the Maitava River catchment, as described in previous sections. Table 25 (below) presents five-year median data for a range of key monitoring parameters at relevant sites along the Maitava River. Land and Water Aotearoa (LAWA) ten-year trend analysis results for the sites are also shown, together with a comparison of median values with relevant National Objectives Framework (NOF) bands (from NPS-FM 2014; from LAWA website).

The LAWA data reveal similar median concentrations of several parameters in the lower Maitava River, such as clarity, total oxidised nitrogen and total nitrogen. Some contaminants have the highest concentrations at the site 200 m downstream of Maitava Bridge (e.g., *E. coli*, NH₄-N), which may be due to the Alliance discharge located a short distance upstream of the site. Note that tributary inputs to the river have been excluded from this table, such as the Waikaka Stream (at Gore) and several tributaries between the 200m downstream of the Maitava Bridge and the Maitava Island bridge sites (e.g., Mimiha Stream, Mokoreta River). Inputs from these tributaries will also have some

influence on water quality.

Median MCI site values decrease in a downstream direction, with the largest difference occurring between the Mataura Bridge and Mataura Island Bridge sites. As noted above, inputs to the river from tributaries also potentially contribute to benthic community composition in the river. Overall, all median values are indicative of 'fair' quality habitat, and the MCI at the most downstream site has a ten-year trend of 'likely improving'.

Overall, the data presented by LAWA does not indicate significant, consistent increases in contaminant concentrations or significant reductions in macroinvertebrate community health in the Mataura River between Gore and Mataura Island Bridge.

Table 25. Five-year median water quality data for Mataura River sites (2014-2018). Ten-year trends (2009-2018) are also reported, as either indicating 'improving' or 'degrading' water quality. Where appropriate, the relevant NOF bands are also reported ('A', 'B', and 'C' indicates that water quality is considered suitable for the designated use, and 'D' indicates water quality is not considered suitable for the designated use). Data and interpretation sourced from the LAWA website.

Parameter	Value	Mataura River at Gore	Mataura River 200 m d/s Mataura Bridge	Mataura River at Mataura Island Bridge
Visual clarity (m)	5-year median	1.04	1.05	1.07
	10-year trend	Likely improving	Likely degrading	Indeterminate
Turbidity (NTU)	5-year median	2.2	3.2	3.2
	10-year trend	Very likely improving	Likely improving	Very likely improving
<i>E. coli</i> (# per 100mL)	5-year median	395	1,100	285
	10-year trend	Indeterminate	Indeterminate	Likely improving
	NOF band	E	E	E
NH ₄ -N (g/m ³)	5-year median	0.005	0.038	0.0085
	10-year trend	Very likely improving	Likely improving	Not assessed
	NOF band	A	B	A
TON (g/m ³)	5-year median	0.88	0.89	0.89
	10-year trend	Very likely degrading	Indeterminate	Not assessed
TN (g/m ³)	5-year median	1.1	1.16	1.17
	10-year trend	Very likely degrading	Indeterminate	Not assessed
DRP (g/m ³)	5-year median	0.007	0.01	0.009
	10-year trend	Indeterminate	Very likely improving	Not assessed
TP (g/m ³)	5-year median	0.017	0.022	0.0235
	10-year trend	Indeterminate	Very likely improving	Not assessed
MCI	5-year median	99 (Fair)	97 (Fair)	90 (Fair)
	10-year trend	Indeterminate	Indeterminate	Likely improving

7 Future discharge characteristics

7.1 Gore discharge

Proposed future upgrades planned for the Gore wastewater treatment system should improve several aspects of the discharge quality. Estimated median contaminant concentrations have been provided by Harrison Grierson, and can be compared with current discharge quality to assess the improvements (Table 26). The estimated median concentrations for almost all contaminants are considerably lower than median concentrations based on sampling undertaken in recent years, especially concentrations of *E. coli*. However, median concentrations of DRP and TP are estimated to be higher relative to recent discharge quality (5 times higher in the case of DRP).

The estimated future average daily discharge volume is 8,792 m³/d, and has to take into account factors such as population growth. The current discharge is consented for an average dry weather volume not exceeding 9,000 m³/d. However, a more useful comparison is with the average discharge volume between January 2018 and May 2020, which was 6,165 m³/d. This comparison reveals that the volume of the discharge to the river will be higher in future years than recorded in recent years.

Table 26. Current (2014-2020) and estimated future median characteristics of the Gore wastewater discharge. Future median data from Harrison Grierson.

Parameter	2014-2020 Median	Estimated 2050 Median
<i>E. coli</i> (MPN/100mL)	630	50
BOD ₅ (mg/L)	9.8	5
SS (mg/L)	19	5
NH ₄ -N (mg/L)	9.30	3
NO ₃ -N (mg/L)	-	7
TN (mg/L)	14.0	10
DRP (mg/L)	0.03	0.15
TP (mg/L)	0.41	1

Using calculations for river and wastewater volumes and contaminant loads to provide contaminant concentrations downstream of the discharge point after full mixing (as described in Section 6.5.1), the estimated future characteristics for the discharge can be compared to current scenarios (Table 27). These calculations indicate that the estimated future median concentrations may result in similar concentrations downstream of the discharge for many contaminants (e.g., *E. coli*, TN) and lower concentrations for some contaminants (e.g., NH₄-N), when compared to current scenarios under worst case conditions.

Table 27. Contaminant loadings calculated for the Mataura River in the vicinity of the Gore discharge. River concentrations based on monitoring data since January 2015, discharge concentrations based on monitoring data since June 2019. Future discharge information from Harrison Grierson. Note NO₃-N could not be calculated for current scenarios due to insufficient data from the discharge.

	<i>E. coli</i> (#/100 mL)	NH ₄ -N (mg/L)	NO ₃ -N (mg/L)	TN (mg/L)	DRP (mg/L)	TP (mg/L)
Concentrations in river upstream of Gore discharge at MALF:						
Median concentration	380	0.003	0.915	1.128	0.007	0.018
95 th percentile concentration	9,023	0.010	1.473	1.734	0.023	0.123
Concentrations in river after full mixing with Gore discharge:						
Current median concentrations (river at MALF + median discharge flow (6,722 m ³ /d), median discharge concentrations)	380	0.040	-	1.188	0.007	0.020
Estimated Future median concentrations (river at MALF + mean discharge flow (8,792 m ³ /d), median discharge concentrations)	378	0.021	0.952	1.182	0.008	0.024

7.2 Mataura discharge

Estimated future median contaminant concentrations have been provided by Harrison Grierson for the Mataura wastewater treatment system discharge into the Mataura River. These concentrations can be compared with current discharge quality (Table 28). The estimated median concentrations for almost all contaminants are very similar to current concentrations. However, *E. coli* concentrations are expected to increase, as well as concentrations of NO₃-N and TN, and DRP and TP.

The estimated future average daily discharge volume is 895 m³/d, and has to take into account factors such as population growth. The current discharge is consented to have an average dry weather volume not exceeding 2,000 m³/d. However, a more useful comparison is with the average discharge volume between January 2018 and May 2020, which was 693 m³/d. This comparison reveals that the volume of the discharge to the river will only be slightly higher in future years than recorded in recent years.

Table 28. Current (2015-2020) and estimated future median characteristics of the Mataura wastewater discharge. Future median data from Harrison Grierson.

Parameter	2015-2020 Median	Estimated 2050 Median
<i>E. coli</i> (MPN/100mL)	435	600
BOD ₅ (mg/L)	5.8	6
SS (mg/L)	12	12
NH ₄ -N (mg/L)	8.0	10
NO ₃ -N (mg/L)	0.06	2
TN (mg/L)	9.4	10-12
DRP (mg/L)	0.22	0.5
TP (mg/L)	0.66	1

Using the same methodology described in Section 6.5.2, the estimated future characteristics for the discharge and downstream river after full mixing was compared to current scenarios (Table 29). These calculations indicate the estimated future median concentrations could result in similar contaminant concentrations downstream of the discharge when compared to current scenarios under worst case conditions.

Table 29. Contaminant loadings calculated for the Mataura River in the vicinity of the Mataura discharge. River concentrations based on monitoring data since January 2015, discharge concentrations based on monitoring data since June 2019. Future discharge information from Harrison Grierson.

	<i>E. coli</i> (#/100 mL)	NH ₄ -N (mg/L)	NO ₃ -N (mg/L)	TN (mg/L)	DRP (mg/L)	TP (mg/L)
Concentrations in river upstream of Mataura discharge at MALF:						
Median concentration	1,100	0.020	0.900	1.210	0.010	0.024
95 th percentile concentration	17,900	0.067	1.563	1.885	0.019	0.133
Concentrations in river after full mixing with Gore discharge:						
Current median concentrations (river at MALF + median discharge flow (509 m ³ /d), median discharge concentrations)	1,100	0.023	0.900	1.213	0.010	0.024
Estimated Future median concentrations (river at MALF + mean discharge flow (895 m ³ /d), median discharge concentrations)	1,100	0.026	0.901	1.216	0.010	0.025

7.3 Monitoring requirements

7.3.1 Gore

Receiving water quality monitoring

Under Gore's current consent, receiving water quality sampling is required at least two occasions each year; once during the period 1 August to 30 September and once during the period 1 January to 31 March. Sampling is also required on up to two further occasions per year, at times when the flow in the Mataura River at Gore is less than 25 m³/s. It is recommended that the sampling programme be amended such that sampling be undertaken once per month between November and April, once every two months between May and October, and on a weekly basis when river flows are low (less than 25 m³/s at Gore for a continuous period of more than seven days).

The current resource consent requires samples to be analysed for temperature, pH, concentrations of DO, *E. coli*, SS, DRP, TP, NH₄-N and NO₃-N, and visual clarity. It is recommended that these parameters be extended to include BOD₅ and TN.

The current consent requires sampling at one site upstream and one site downstream of the point of discharge. As the discharge is now continuous from the Actiflo outfall, it is recommended that the downstream site be located 200 m downstream of the Actiflo outfall, and therefore at the downstream end of the 200 m long mixing zone for discharges, as stipulated in the SWLP. It is also recommended that an additional site be sampled 500 m downstream of the Actiflo outfall to allow an assessment of the discharge after further mixing with the river. The 500 m downstream site would also be downstream of the pond outfall, should a discharge to the river from this outfall occur.

Ecological monitoring

Gore's current resource consent requires periphyton monitoring between 1 November and 31 May, during low flow conditions (following a 50-day accrual period, when the river flow at Gore has been at or below 35 m³/s for at least 20 consecutive days), and an annual macroinvertebrate survey. It is recommended that the monitoring programme be amended such that periphyton monitoring is undertaken on a monthly basis during summer low flows (i.e., less than 25 m³/s at Gore) for periphyton cover (RAM-2 assessments) and periphyton biomass (chlorophyll-*a*), and on a fortnightly basis when flows at Gore are less than 20 m³/s. The annual macroinvertebrate survey requirement should be retained.

Currently, periphyton sampling is required at one site upstream and two sites downstream of the point of discharge, and for macroinvertebrates at one site upstream and one site downstream of the point of discharge. As previously discussed, the sites available for periphyton and macroinvertebrate assessments are limited by water depth

and habitat. There have been difficulties finding similar habitat at sites upstream and downstream of the discharge for several years, and these difficulties are expected to continue. A review of monitoring requirements should therefore include the potential for additional methods (e.g., artificial substrates) to alleviate the difficulties finding similar upstream and downstream sites.

7.3.2 Mataura

Receiving water quality monitoring

Under Mataura's current consent, receiving water quality sampling is required on at least four occasions each year (three times between November and April, and once between August and September), and on a weekly basis when river flows are low (less than 22.3 m³/s at Gore for a continuous period of more than seven days). It is recommended that sampling be undertaken once per month between November and April, once every two months between May and October, and on a weekly basis when river flows are low (less than 20 m³/s at Gore for a continuous period of more than seven days).

The current resource consent requires samples to be analysed for pH, temperature, electrical conductivity, concentrations of DO, *E. coli*, SS, DRP, TP, NH₄-N and NO₃-N, and visual clarity. It is recommended that these parameters be extended to include BOD₅, TN and TP.

The current resource consent requires water quality at least 5 m sampling upstream and 300 m downstream of the discharge point. The downstream site is therefore outside the 200 m long mixing zone for discharges specified in the SWLP. It is therefore recommended that the downstream sampling site be moved to 200 m downstream of the discharge point, and an additional site 400 m downstream of the discharge point be added to allow assessment of the discharge after further mixing with the river.

Ecological monitoring

The current resource consent requires an annual survey of periphyton and macroinvertebrates when river flows are low (less than 25 m³/s at Tuturau for at least twenty consecutive days). It is recommended that periphyton monitoring be undertaken twice each summer, between November and April, during low flows (i.e., less than 20 m³/s at Gore) for periphyton cover (RAM-2 assessments) and periphyton biomass (chlorophyll-*a*). The annual macroinvertebrate survey requirement should be retained.

Sampling is required by the current resource consent upstream and at least 100 m downstream of the discharge point. The sites used for the periphyton and macroinvertebrate assessments are limited by water depth and habitat. Ideally the

downstream site would be located at least 200 m downstream of the discharge (i.e., at the downstream end of the zone of reasonable mixing), however habitat in this area may be unsuitable for benthic sampling. Therefore, a review of the downstream site placement is recommended, and if possible, the site be relocated further downstream than currently required. Should no other sites be suitable for sampling downstream of the discharge point, the current site should be sampled, but it should be noted that the site is within the zone of reasonable mixing.

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8 Summary and Conclusion

The potential for adverse effects of the Gore and Mataura wastewater discharges on the water quality and river ecology of the Mataura River have been assessed in this report. A brief summary of each assessed variable can be found in Tables 30 and 31 for the Gore and Mataura discharges respectively.

In conclusion, the effects of the wastewater discharges to the Mataura River may be more than minor for some variables, but overall the contribution of the discharges to the river do not appear to be contributing to consistent reductions in receiving water quality or river ecological health.

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Table 30. Summary of water quality and biological characteristics of the Mataura River in the vicinity of the Gore wastewater discharge.

Variable	Upstream	Downstream
Contact recreation	Often unsuitable for bathing and general contact recreation due to low clarity and faecal bacteria concentrations	Often unsuitable for bathing and general contact recreation due to low clarity and faecal bacteria concentrations
Benthic habitat	Little deposited sediment	Little deposited sediment
Water temperature	Generally < 20°C	Temperature change as a result of discharge generally within 'Mataura 3' standards
pH	Within 'Mataura 3' standards	Within 'Mataura 3' standards
Dissolved oxygen	Within 'Mataura 3' standards	Within 'Mataura 3' standards
Water clarity	Occasionally poor clarity	Clarity change as a result of discharge generally within 'Mataura 3' standards
Suspended solids	Generally low, except under high flow conditions	Generally low, except under high flow conditions
<i>E. coli</i>	High, often exceed 'Mataura 3' standards	High, often exceed 'Mataura 3' standards. Elevated downstream of discharge, at times. Effects of discharge may be more than minor
Ammoniacal nitrogen	Below toxic concentrations	Below toxic concentrations. Elevated downstream of discharge, at times. Effects of discharge may be more than minor
Nitrate nitrogen	Below toxic concentrations	Below toxic concentrations
Total nitrogen	-	Elevated downstream of discharge, at times
Dissolved reactive phosphorus	-	Lower in recent years. Generally similar to upstream.
Total phosphorus	Occasionally very high concentrations	Occasionally very high concentrations
Biochemical oxygen demand	Low	Low
Water supply	Unsuitable for untreated drinking water due to turbidity	Unsuitable for untreated drinking water due to turbidity
Livestock water supply	Unsuitable for livestock drinking due to faecal bacteria concentrations	Unsuitable for livestock drinking due to faecal bacteria concentrations
Periphyton - cover	Low overall cover of long filamentous algae and below guidelines	Occasionally higher cover of long filamentous algae than upstream, but low cover overall and below guidelines. No consistent differences from upstream
Periphyton - biomass	Elevated and above guidelines, at times	Elevated and above guidelines, at times. No consistent differences from upstream
Macroinvertebrates	Dominated by mayflies. QMCI indicative of 'fair' and 'good' in recent surveys	Dominated by mayflies, but lower abundance than upstream in recent surveys. QMCI indicative of 'poor' and 'poor-fair' in recent surveys. Community differences with upstream influenced by habitat differences
Fish	-	No effects on fish expected

Table 31. Summary of water quality and biological characteristics of the Mataura River in the vicinity of the Mataura wastewater discharge.

Variable	Upstream	Downstream
Contact recreation	Often unsuitable for bathing and general contact recreation due to low clarity and faecal bacteria concentrations	Often unsuitable for bathing and general contact recreation due to low clarity and faecal bacteria concentrations
Benthic habitat	Uncertain, but little deposited sediment expected	Uncertain, but little deposited sediment expected
Water temperature	Generally < 20°C	Temperature change as a result of discharge generally within 'Mataura 3' standards
pH	Within 'Mataura 3' standards	Within 'Mataura 3' standards
Dissolved oxygen	Within 'Mataura 3' standards	Within 'Mataura 3' standards
Water clarity	Occasionally poor clarity	Clarity change as a result of discharge mostly within 'Mataura 3' standards. Effects of discharge may be more than minor
Suspended solids	High in recent years	High in recent years. Elevated downstream of discharge, at times. Effects of discharge may be more than minor
<i>E. coli</i>	High, frequently exceed 'Mataura 3' standards	High, frequently exceed 'Mataura 3' standards
Ammoniacal nitrogen	Below toxic concentrations	Below toxic concentrations. Elevated downstream of discharge, at times. Effects of discharge may be more than minor
Nitrate nitrogen	Below toxic concentrations	Below toxic concentrations. Elevated downstream of discharge, at times
Total nitrogen	-	Elevated downstream of discharge, at times
Dissolved reactive phosphorus	-	Generally similar to upstream
Total phosphorus	-	Elevated downstream of discharge, at times
Biochemical oxygen demand	Low	Low
Water supply	Unsuitable for untreated drinking water due to turbidity	Unsuitable for untreated drinking water due to turbidity
Livestock water supply	Unsuitable for livestock drinking due to faecal bacteria concentrations	Unsuitable for livestock drinking due to faecal bacteria concentrations
Periphyton - cover	Low overall cover of algae and below guidelines	Low overall cover of algae and below guidelines. No consistent differences from upstream
Periphyton - biomass	Not assessed, but expected to be low	Not assessed, but expected to be low
Macroinvertebrates	Dominated by mayflies. QMCI indicative of 'poor' and 'fair-good' in recent surveys	Dominated by mayflies. QMCI indicative of 'fair' and 'fair-good' in recent surveys. Similar communities to upstream
Fish	-	No effects on fish expected

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Appendix One: Macroinvertebrate data

Table A1.1. *Invertebrate taxa found in the Mataura River at Gore, 2010-2019. Coded abundance scores from Stark (1998): R = rare, C = common, A = abundant, VA = very abundant, VVA = very very abundant. Data from ES.*

TAXON	MCI score	Mataura River at Gore								
		2010	2012	2013	2014	2015	2016	2017	2018	2019
COLEOPTERA										
Elmidae	6	VVA	VA	A	C	R	A	C	R	R
CRUSTACEA										
Ostracoda	3	C	C							R
<i>Paracalliope fluviatilis</i>	5	C					R	R		
<i>Paraleptamphopus</i> species	5		R					R		
DIPTERA										
<i>Aphrophila</i> species	5	A	C	C	R	C	A			
<i>Austrosimulium</i> species	3	C	A	C	R		C			C
Chironominae	2	C								
<i>Chironomus</i> species	1						R			
Eriopterini	9		R				R			R
Hexatomini	5								R	
<i>Maoridiamesa</i> species	3						R			
<i>Molophilus</i> species	5						R			
Muscidae	3		C			R				
Orthoclaadiinae	2	A	A	C		C	VA	R	R	R
Tanytarsini	3		A	C		C	A			R
EPHEMEROPTERA										
<i>Deleatidium</i> species	8	VVA	VVA	VVA	VVA	VVA	VVA	VVA	VA	VVA
MOLLUSCA										
<i>Gyraulus</i> species	3				R					
<i>Physa</i> / <i>Physella</i> species	3	C	C				C			
<i>Potamopyrgus antipodarum</i>	4	A	VA	VA	C	A	VA	A	C	R
Sphaeriidae	3		C	R		R	C	R		
NEMATODA	3						R			
OLIGOCHAETA	1	VVA	A	VA	A	A	VA	A	R	C
PLATYHELMINTHES	3	C	C				R			R
TRICHOPTERA										
<i>Beraeoptera roria</i>	8						R			
<i>Costachorema</i> species	7			C		R				C
<i>Helicopsyche</i> species	10	C					R			
<i>Hudsonema amabile</i>	6	A				C	A		R	
Hydrobiosidae early instar	5									R
<i>Hydrobiosis clavigera</i> group	5	C	A				C	R		
<i>Hydrobiosis umbripennis</i> group	5	C	A	C		R	A			
<i>Hydropsyche</i> - <i>Aoteapsyche</i> group	4	A	VVA	A	A	A	A	C		A
<i>Olinga</i> species	9	R	A				R	R		
<i>Oxyethira albiceps</i>	2									R
<i>Psilochorema</i> species	8	A	C	C	R	A	A	R	R	C
<i>Pycnocentria</i> species	7	C					A			
<i>Pycnocentrodes</i> species	5	A	A	C	R	C	VVA	C		R
Number of taxa		21	21	14	10	15	27	13	8	16
Number of EPT taxa		10	7	6	4	7	11	6	3	7
% EPT taxa		48	33	43	40	47	41	46	38	44
% EPT		45	77	65	94	88	84	84	90	95
MCI score		99	92	91	94	93	99	100	100	91
SQMCI score		5.0	5.6	6.3	7.5	7.3	5.5	7.5	7.6	7.7

Table A1.2. Invertebrate taxa found in the Waikaka Stream at Gore, 2010-2019. Coded abundance scores from Stark (1998). Data from ES.

TAXON	MCI score	Waikaka Stream at Gore								
		2010	2012	2013	2014	2015	2016	2017	2018	2019
ACARINA	5							R	C	A
COLEOPTERA										
Elmidae	6	VA	A	A	A	A	VA	VA	VA	A
COLLEMBOLA	6							R		
CRUSTACEA										
Cladocera	5					C				
Ostracoda	3		C			A	C	C	A	R
<i>Paracalliope fluviatilis</i>	5	VVA	C	VA	VVA	VA	VA	A	A	VVA
<i>Paraleptamphopus</i> species	5					C				
DIPTERA										
<i>Aphrophila</i> species	5	A	R	C	C	VA	R	C	R	A
<i>Austrosimulium</i> species	3	A	A	A	C		R	C		
Chironominae	2	VA								
<i>Chironomus</i> species	1					C				A
Empididae	3									R
Hexatomini	5						R			
<i>Maoridiamesa</i> species	3	R	R	C		A	VA			R
Muscidae	3	R	C	C	R	R	A	C		R
Orthocladinae	2	A	A	VA	VA	VA	VA	C	A	VA
Tanytarsini	3		A	A	VA	VVA	VA	C	VA	A
EPHEMEROPTERA										
<i>Austroclima</i> species	9	R								
<i>Coloburiscus humeralis</i>	9		R							R
<i>Deleatidium</i> species	8	VVA	VVA	VVA	VVA	VA	VVA	VA	A	VVA
HEMIPTERA										
<i>Microvelia macgregori</i>	5				C					
<i>Sigara</i> species	5				C					
MEGALOPTERA										
<i>Archichauliodes diversus</i>	7								A	R
MOLLUSCA										
<i>Physa / Physella</i> species	3	A		C		C	R		A	A
<i>Potamopyrgus antipodarum</i>	4	VA	VA	VA	VVA	VA	VVA	A	VVA	VVA
Sphaeriidae	3	A		C	R	C		R	C	
NEMATODA	3						R			R
NEMERTEA	3									A
ODONATA										
<i>Xanthocnemis zealandica</i>	5	R								
OLIGOCHAETA	1	VVA	VA		VA	VA	VA	A	A	VVA
PLATYHELMINTHES	3	R				R	C	C	A	A
PLECOPTERA										
<i>Megaleptoperla</i> species	9									R
TRICHOPTERA										
<i>Costachorema</i> species	7				C	R	C	R		
<i>Hudsonema amabile</i>	6	VA	C	A	R	A	A	C	A	VA
Hydrobiosidae early instar	5	A	C						A	
<i>Hydrobiosis clavigera</i> group	5				R		C			R
<i>Hydrobiosis</i> species	5				A					
<i>Hydrobiosis umbripennis</i> group	5	R	C	A	C	A	VA	C	R	VA
<i>Hydropsyche - Aoteapsyche</i> group	4	VA	C	A	VA	VVA	VVA	A	A	VVA
<i>Olinga</i> species	9	R				C			C	A
<i>Oxyethira albiceps</i>	2	A			C		VA			R
<i>Paroxyethira</i> species	2	R								
<i>Psilochorema</i> species	8		C		R		R	C		R
<i>Pycnocentria</i> species	7	R	VA	A	VA	VA	VA	C	A	VA
<i>Pycnocentrodus</i> species	5	VVA	A	VA	VA	VA	VA	C	VVA	VA
Number of taxa		25	20	17	23	25	25	22	21	30
Number of EPT taxa		11	9	6	11	9	10	8	8	12
% EPT taxa		44	45	35	48	36	40	36	38	40
% EPT		37	69	60	39	55	48	52	28	50
MCI score		88	95	88	93	86	87	93	94	93
SQMCI score		4.6	6.1	6.0	5.1	3.9	4.8	5.7	4.5	4.5

Table A1.3. *Invertebrate taxa found in the Mataura River 200 m downstream of Mataura, 2010-2019. Coded abundance scores from Stark (1998). Data from ES.*

TAXON	MCI score	Mataura River 200m d/s Mataura Bridge						
		2010	2012	2013	2014	2015	2016	2019
ACARINA	5		C				C	C
CNIDARIA								
<i>Hydra</i> species	3						C	
COLEOPTERA								
Elmidae	6	VA	A	A	A	A	A	A
CRUSTACEA								
Ostracoda	3	R					R	
<i>Paracalliope fluviatilis</i>	5	C					R	R
<i>Paraleptamphopus</i> species	5					A	A	R
DIPTERA								
<i>Aphrophila</i> species	5	C	C	C	A	R	A	
<i>Austrosimulium</i> species	3	R		C		R	C	
Chironominae	2	VA						
<i>Chironomus</i> species	1						C	R
Eriopterini	9			R	R	A		R
<i>Maoridamesa</i> species	3	A	A	A	C	C	VA	C
Muscidae	3		R	R	R	R	A	R
Orthoclaadiinae	2	VA	VVA	A	A	VA	VA	VVA
Tanypodinae	5							C
Tanytarsini	3		A		C	VA	VVA	VA
EPHEMEROPTERA								
<i>Austroclima</i> species	9	C		C	R	C		R
<i>Deleatidium</i> species	8	VA	VVA	VVA	VVA	VVA	VVA	VVA
<i>Neozephlebia scita</i>	7							A
<i>Zephlebia</i> species	7		A					
MEGALOPTERA								
<i>Archichauliodes diversus</i>	7			R		C		
MOLLUSCA								
<i>Physa</i> / <i>Physella</i> species	3				R	C		R
<i>Potamopyrgus antipodarum</i>	4	VA	VA	A	VVA	VVA	VVA	
Sphaeriidae	3						C	VA
NEMATODA	3	C	A		C			
NEMERTEA	3						C	
OLIGOCHAETA	1	VVA	A	A	VA	VVA	VA	VA
PLATYHELMINTHES	3	R	C		C	VA	A	C
PLECOPTERA								
<i>Stenoperla</i> species	10						C	
<i>Taraperla</i> species	7		R					
TRICHOPTERA								
<i>Costachorema</i> species	7		C	A	R	R		
<i>Hudsonema amabile</i>	6			R		C	A	
Hydrobiosidae early instar	5	C		R				A
<i>Hydrobiosis clavigera</i> group	5		C					
<i>Hydrobiosis</i> species	5				R	C		
<i>Hydrobiosis umbripennis</i> group	5	C	A	R	R	C	A	
<i>Hydropsyche</i> - <i>Aoteapsyche</i> group	4	VA	VVA	A	VA	VA	VVA	VA
<i>Neurochorema</i> species	6	C						R
<i>Olinga</i> species	9	R		C	R	A	C	A
<i>Oxyethira albiceps</i>	2	C						A
<i>Psilochorema</i> species	8		A	C	R	R	C	C
<i>Pycnocentria</i> species	7			C	R	A	A	A
<i>Pycnocentroides</i> species	5	A	A	C	A	A	VA	R
Number of taxa		21	20	21	22	25	27	26
Number of EPT taxa		9	9	11	10	11	9	11
% EPT taxa		43	45	52	45	44	33	42
% EPT		30	58	74	21	33	36	48
MCI score		89	94	110	102	104	91	98
SQMCI score		2.9	4.6	7.1	5.3	4.2	4.5	4.5

Table A1.4. Invertebrate taxa found in the Mataura River in the vicinity of the Gore discharge, January 2018. Results are shown as number of individuals per sample (0.04 m²). From Ludgate and Goldsmith (2018).

TAXON	MCI score	Upstream					Downstream				
		1	2	3	4	5	1	2	3	4	5
ACARINA	5	1	2								
CNIDARIA											
<i>Hydra</i> species	3						2	5			
COLEOPTERA											
Elmidae	6		1	5	7	6		3	3	2	3
CRUSTACEA											
Ostracoda	3	4	4		3	7		1	2		1
<i>Paracalliope fluviatilis</i>	5			1		1	2		1		
DIPTERA											
<i>Aphrophila</i> species	5		1	2		1	2	1	5	1	1
<i>Austrosimulium</i> species	3			2							
<i>Chironomus</i> species	1							5			
Empididae	3			1			1		1	1	
<i>Lobodiamesa</i> species	5										1
<i>Maoridiamesa</i> species	3			2	1	1	1	2	1	2	
Muscidae	3		1			1					
Orthocladiinae	2	8	21	7	2	2	65	41	18	66	42
<i>Polypedilum</i> species	3								1		
Tanytarsini	3	68	97	114	60	61	181	179	109	174	117
EPHEMEROPTERA											
<i>Austroclima</i> species	9						3			1	1
<i>Deleatidium</i> species	8	148	196	310	226	194	50	79	79	80	77
MOLLUSCA											
<i>Physa</i> / <i>Physella</i> species	3	6	1			7	22	55	1	6	8
<i>Potamopyrgus antipodarum</i>	4	2	11	24	10	16	2	6	1	9	8
Sphaeriidae	3			2							
NEMATODA	3			1	2	8	2			1	
NEMERTEA	3			1		1				2	1
OLIGOCHAETA	1	14	22	8	10	32	59	56	10	8	6
PLATYHELMINTHES	3		2	5	1	8	3	9		1	4
TRICHOPTERA											
<i>Aoteapsyche</i> species	4	15	62	170	65	40	75	36	44	48	76
<i>Costachorema</i> species	7								1		
<i>Helicopsyche</i> species	10				1						
<i>Hudsonema amabile</i>	6		1	5	3	1			1		1
<i>Hydrobiosidae</i> early instar	5	1			1		1	3	4	1	1
<i>Hydrobiosis clavigera</i> group	5	6		4	1						1
<i>Hydrobiosis umbripennis</i> group	5	1	11	15	8	6	4	1	2		1
<i>Neurochorema</i> species	6		1								
<i>Olinga</i> species	9	1		4	1	1			1		1
<i>Oxyethira albiceps</i>	2										1
<i>Psilochorema</i> species	8	1	2	1							
<i>Pycnocentria</i> species	7	8	19	6	10	14	3	3	2	9	3
<i>Pycnocentrodes</i> species	5	9	30	28	47	37	13	20	8	23	26
Number of taxa		16	19	23	19	21	19	18	21	18	22
Number of EPT taxa		9	8	9	10	7	7	6	9	6	11
% EPT taxa		56	42	39	53	33	37	33	43	33	50
% EPT		65	66	76	79	66	30	28	48	37	50
Number of invertebrates (per sample)		293	485	718	459	445	491	505	295	435	381
Number of invertebrates (per m ²)		7325	12125	17950	11475	11125	12275	12625	7375	10875	9525
QMCI score		5.7	5.4	5.7	6.0	5.5	3.4	3.7	4.6	4.1	4.3
Average QMCI score				5.7					4.0		

Table A1.5. Invertebrate taxa found in the Mataura River in the vicinity of the Mataura discharge, January 2018. Results are shown as number of individuals per sample (0.04 m²). From Ludgate and Goldsmith (2018).

TAXON	MCI score	Upstream					Downstream				
		1	2	3	4	5	1	2	3	4	5
COLEOPTERA											
Elmidae	6	4		1			1		1		
Staphylinidae	5			1							
CRUSTACEA											
Cladocera	5							1		1	
Ostracoda	3					4	13	7	4	6	2
<i>Paracalliope fluviatilis</i>	5	1									
DIPTERA											
<i>Aphrophila</i> species	5	2	1	1			2	3		1	
<i>Austrosimulium</i> species	3	3	1	1	1	2					3
<i>Chironomus</i> species	1						2				
<i>Lobodiamesa</i> species	5									1	
Muscidae	3							1			
Orthocladinae	2	2	6	2	1	1	21	15	6	7	8
<i>Polypedilum</i> species	3							1			
Tanytarsini	3	56	72	52	50	42	178	163	67	75	43
EPHEMEROPTERA											
<i>Austroclima</i> species	9	1	3	1						1	
<i>Deleatidium</i> species	8	105	102	77	172	138	11	59	92	162	157
MOLLUSCA											
<i>Gyraulus</i> species	3							2			
<i>Physa</i> / <i>Physella</i> species	3	1	1	2	2	3	43	15	9	8	2
<i>Potamopyrgus antipodarum</i>	4	106	68	30	8	20	60	72	66	28	13
NEMATODA	3	2		2			10	2		1	2
NEMERTEA	3	1	7	3	9		3		7	9	5
OLIGOCHAETA	1	10	32	19	52	8	40	3	17	10	1
PLATYHELMINTHES	3	1	6	4	5				2	4	2
TRICHOPTERA											
<i>Aoteapsyche</i> species	4	227	206	74	110	68	72	129	56	80	79
<i>Hudsonema amabile</i>	6	1		1		1	3	2	1		
Hydrobiosidae early instar	5		4	2	3	3				2	1
<i>Hydrobiosis umbripennis</i> group	5	5	2	2	1	2	4	5	7	4	8
<i>Olinga</i> species	9							1			
<i>Oxyethira albiceps</i>	2					1					
<i>Pycnocentria</i> species	7	10	10	15	20	19	1	9	21	10	11
<i>Pycnocentroides</i> species	5	36	31	24	44	80	17	25	60	20	11
Number of taxa		19	16	20	14	15	17	19	15	19	16
Number of EPT taxa		7	7	8	6	8	6	7	6	7	6
% EPT taxa		37	44	40	43	53	35	37	40	37	38
% EPT		67	65	62	73	80	22	45	57	65	77
Number of invertebrates (per sample)		574	552	314	478	392	481	515	416	430	348
Number of invertebrates (per m ²)		14350	13800	7850	11950	9800	12025	12875	10400	10750	8700
QMCI score		4.7	4.5	4.9	5.2	5.6	3.3	4.1	4.8	5.3	5.7
Average QMCI score				5.0					4.7		