REPORT

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Subject: Waianakarua River Water Quality

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1. Précis

The Waianakarua River is a medium-sized river (catchment area of 262 km^2) in north eastern Otago. Much of the catchment consists of extensively grazed grasslands and scrub, native forest and plantation forestry. However, intensification of land use in the lower catchment has the potential to affect water quality in the lower part of the river.

In 2012, the Otago Regional Council initiated a 9-month water quality sampling programme with the aim of gaining a better understanding of the existing water quality, habitat quality and ecological values in the Waianakarua catchment. Results are compared with the water quality standards notified in Water Plan Change 6A.

Water quality and habitat in the Waianakarua catchment is generally very good and long-term monitoring (2001-2013) indicates that water quality at Browns Pump has been stable over this period. However, NNN concentrations in the South Branch at SH1 and at all main stem sites exceeded the Receiving Water Quality Standard in Schedule 15 of the Water Plan Change 6A. *Escherichia coli* counts at the upper site in the South Branch exceeded the Schedule 15 value, although this was due to a single, elevated value.

Cyanobacteria (blue-green algae) have been the dominant type of periphyton on most occasions, with diatoms occasionally abundant. Macroinvertebrate communities are diverse and indicate good to excellent water quality, while the Waianakarua River supports a diverse fish community, with 14 species collected including seven species that have been classified as "at risk" and "declining" under the New Zealand Freshwater Fish Threat Classification.

A full technical report has been circulated separately.

2. Introduction

The Waianakarua River is a medium-sized river rising in the Horse Range and Kakanui Mountains in North Otago. Much of the catchment consists of extensively grazed grasslands and scrub, native forest and plantation forestry. However, the intensification of land use in the lower catchment, with several dairy farms operating near the mouth of the river and proposals for further intensification of land use in areas upstream of State Highway 1, has the potential to affect water quality in the lower part of the river.

The objectives of this report are:

1. To provide a baseline of water quality in the Waianakarua River catchment including at unimpacted (reference) sites.
2. Compare water quality in the Waianakarua catchment to water quality standards set out in Plan Change 6A.
3. To identify any patterns in water quality in the Waianakarua catchment and to relate these to land-use activities, where possible.

3. Water quality parameters considered

- **Nitrate-nitrite nitrogen** (NNN) is the nitrogen available for plant growth and is beneficial up to a point, but can lead to nuisance algal growths. NNN better reflects bioavailability than total nitrogen (TN). NNN is affected by: wastewater effluent, agricultural run-off and animal waste.
- **Ammoniacal nitrogen** refers to the ionic (ammonium, NH_4^+) and non-ionic (NH_3) forms of ammonia. These occur in equilibrium with the relative quantities of each form being related to water temperature and pH. The non-ionic form is highly toxic to aquatic life. High concentrations of ammoniacal nitrogen are generally related to effluent entering surface waters or discharges from waste water treatment plants.
- **Dissolved reactive phosphorus** (DRP) is a measure of orthophosphate, the filterable (soluble, inorganic) fraction of phosphorus, which is directly taken up by plant cells. Phosphorus is often found to be the growth-limiting nutrient, because it occurs in the least amount relative to the needs of plants. DRP is affected by e.g. wastewater effluent, fertilizers and animal waste (MfE, 2009).
- ***Escherichia coli*** is a faecal coliform bacterium that is commonly used as an indicator of faecal contamination of waterways and of the risk to recreational users. Faecal material reaches streams in numerous ways, including run-off from the land, effluent-pond discharges, stock and water fowl defecating directly into the water, overland run-off after rain and septic-tank discharges.
- **Turbidity** is a measure of how "cloudy" or "milky" water is and is an indirect and inverse measure of water clarity (i.e. as water turbidity increases, clarity decreases). Turbidity is usually caused by inorganic sediments suspended in the water that scatter light. Potential sources of such sediment include stock access to waterways and banks, bank instability, vegetation clearance, and forestry roads.

4. Water quality guidelines – Water Plan Change 6A

Water Plan Change 6A was notified on 20 March 2013 and sets out numerical water quality standards for all catchments in the Otago region (Schedule 15) and establishes limits for all discharges to lakes, rivers, wetlands and drains in two discharge limit areas (Schedule 16). The receiving water standards outlined in Table 1 are applied as 5-year, 80^{th} percentiles when flows are at or below median flow (0.783 m^3/s), with the flows in the Waianakarua catchment being set at the gauging site at Browns Pump.

The Waianakarua catchment is in Receiving Water Group 2 and the numerical water quality standards for this group are outlined below:

Table 1.

	Nitrate-nitrite nitrogen	Dissolved reactive phosphorus	Ammoniacal nitrogen	*Escherichia coli*	Turbidity
Numerical standard	0.075 mg/l	0.01 mg/l	0.1 mg/l	260 cfu/100 ml	5 NTU
Timeframe	31 March 2012	31 March 2012	31 March 2012	31 March 2012	31 March 2012

5. Long-term water quality trends

Water quality at the SoE monitoring site in the Waianakarua River (at Browns Pump) was consistent over the period of monitoring (2001-2013), with no trends detected for any of the water quality variables considered.

6. Spatial patterns in water quality - Nutrients

Nutrient concentrations affect the growth of algae and other periphyton and high biomasses of periphyton can affect a wide range of instream values, including aesthetics, biodiversity, recreation and water quality (Biggs 2000).

Total nitrogen and NNN were lowest at both sites in the North Branch. The slightly higher concentration observed in the upper South Branch is likely to result from low nitrogen uptake by algae due to the reach upstream of this site being more heavily shaded due to the valley aspect (angle relative to the sun), topography and vegetation. Total nitrogen and NNN concentrations in the South Branch at SH1 were markedly higher than were recorded at the upstream site (McKerrow Road, 3.5 km upstream), suggesting that a significant source of nitrogen enters the river between these two sites. Concentrations of total nitrogen and NNN increased with distance downstream of the confluence, most likely reflecting the intensive farming practices in the lower catchment. Few tributaries enter the lower river, suggesting that nitrogen is entering surface water via leaching to groundwater which then enters the lower river.

Concentrations of dissolved reactive phosphorus were generally very low, with the concentration at the majority of samples being below the detection limit at all sites sampled. Nitrogen to phosphorus (N:P) ratios suggest that periphyton in the South Branch at SH1 and all main stem sites are phosphorus-limited. However, ratios in the North Branch and upper South Branch varied markedly, indicating that no one nutrient was consistently limiting algal growth and/or that they may be co-limiting.

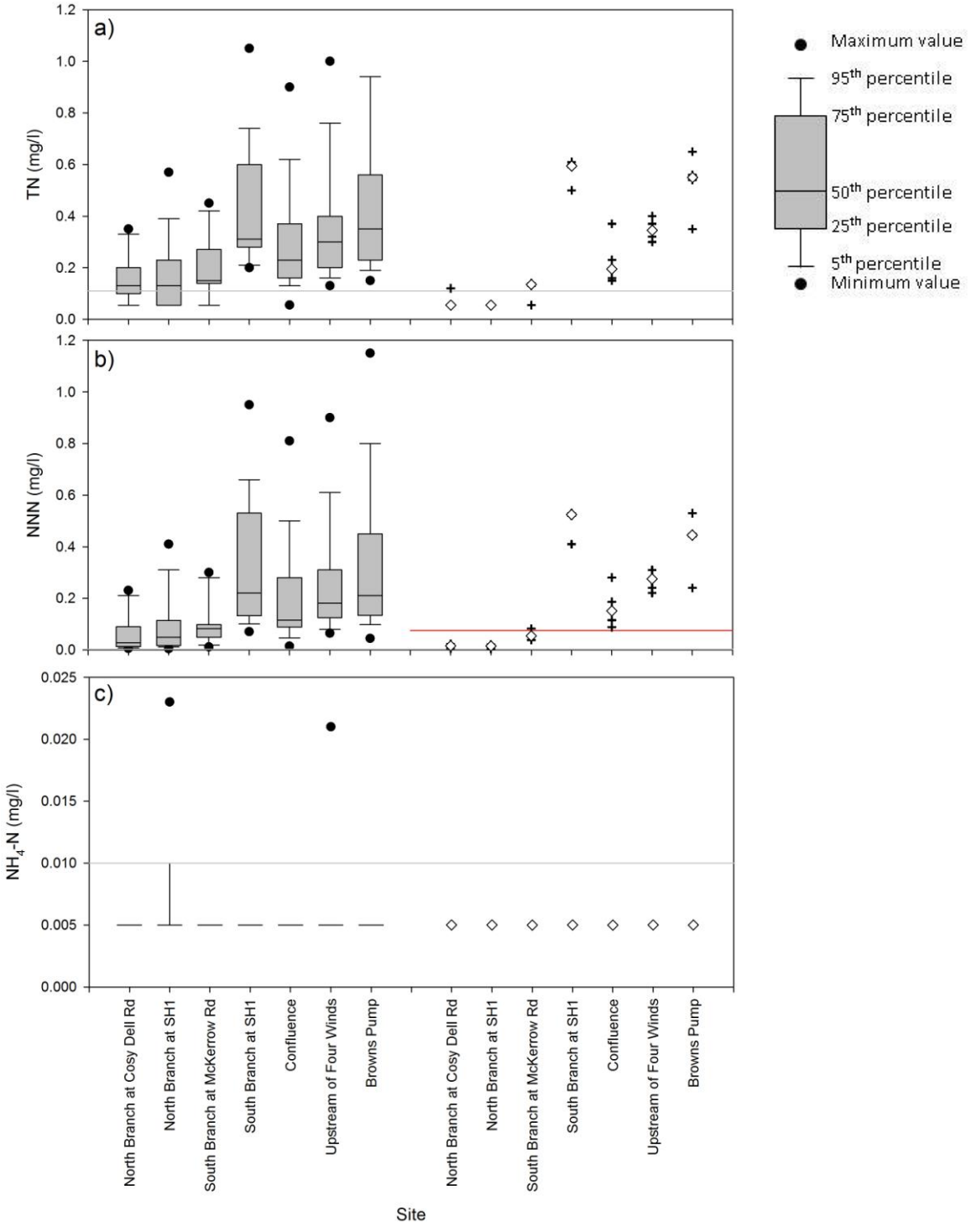

Figure 1. **a). Total nitrogen, b). Nitrate-nitrite nitrogen, and c). Ammoniacal nitrogen concentrations in the Waianakarua River. The red line represents the Schedule 15 standard from Plan Change 6A. No Schedule 15 standard shown for ammoniacal nitrogen because observed concentrations were much lower than the standard. Grey lines represent the detection limit for each variable.**

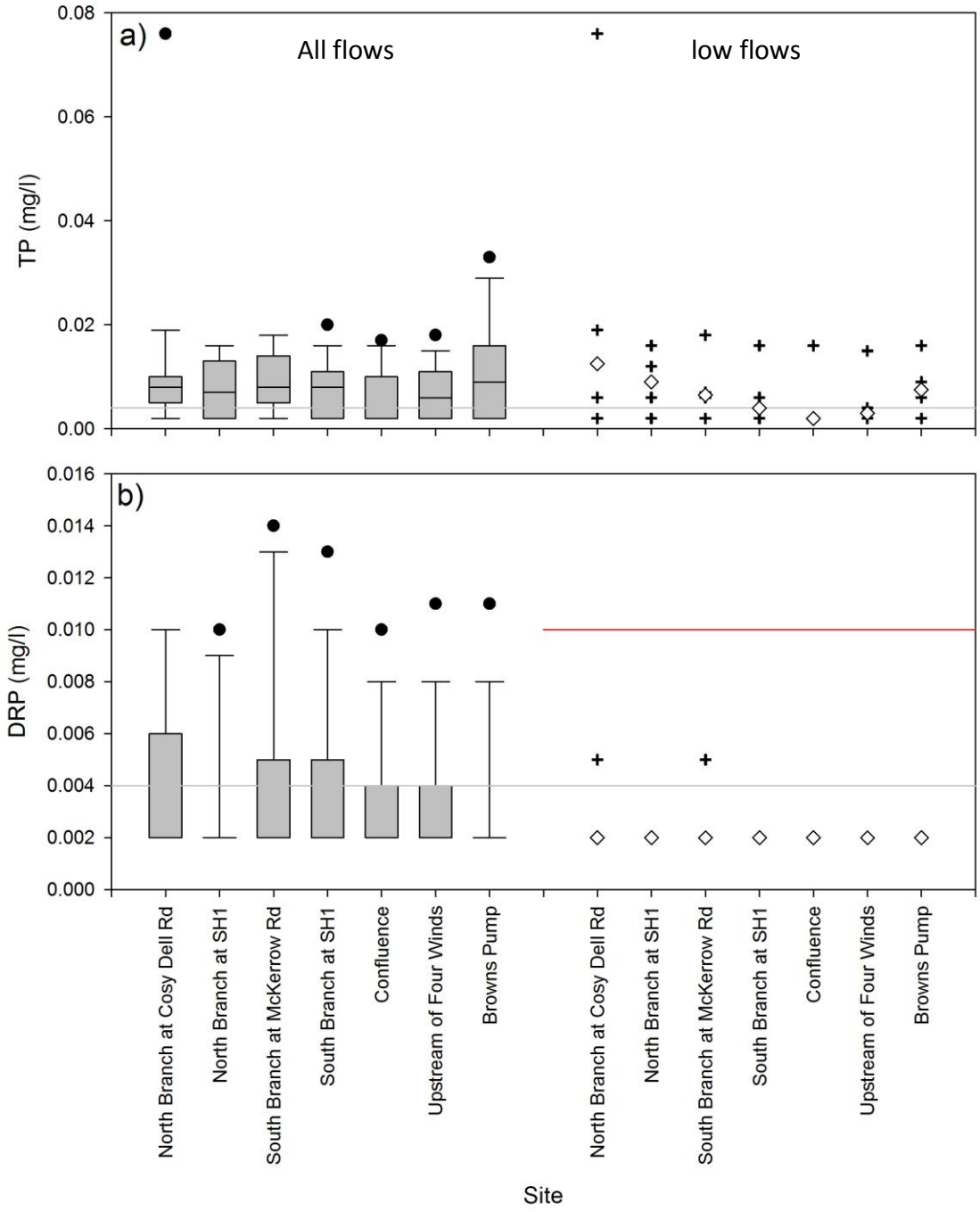

Figure 2. **a). Total phosphorus, and b). dissolved reactive phosphorus concentrations in the Waianakarua River. The red line represents the Schedule 15 standard from Plan Change 6A. Grey lines represent the detection limit for each variable.**

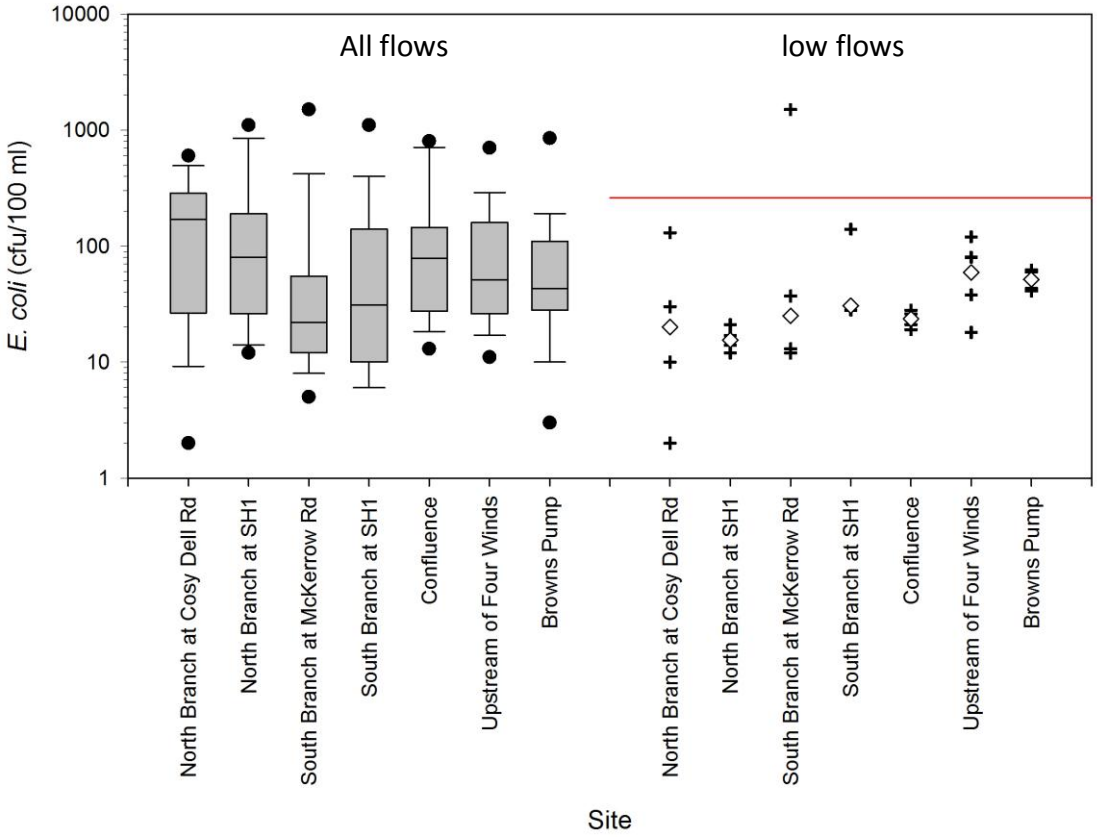

Figure 3. ***Escherichia coli*** **concentrations in the Waianakarua River. The red line represents the Schedule 15 standard from Plan Change 6A. The grey line represents the detection limit (1 cfu/100 ml).**

7. Spatial patterns in water quality - faecal contamination

Water contaminated with faecal matter poses a range of possible health risks to recreational users including serious gastrointestinal and respiratory illnesses. Counts of the bacterium *E. coli* are commonly used as an indicator of faecal contamination and a measure of the probability of the presence of other disease-causing agents, such as the protozoa *Giardia* and *Cryptosporidium*, the bacterium *Campylobacter* and various other illness-causing bacteria and viruses.

Counts of *E. coli* in the Waianakarua catchment were generally low, with the highest median counts observed at the two downstream sites (mid-main stem and Browns Pump). However, elevated counts were observed in the upper South Branch (420 and 1500 cfu/100 ml on 18 March and 3 April 2013, respectively). The reasons for these observations are not clear. Elevated counts were observed at all sites sampled on 3 April 2013, although there is no clear reason for these observations, as flows at the time of, and prior to, sampling were low and stable. There was no indication of effluent contamination at any of the sites in the Waianakarua catchment.

8. Spatial patterns in water quality - Substrate and riparian cover

In addition to water quality, the quantity and quality of habitat are important factors affecting many in-stream values. Among these factors, the composition of the streambed is particularly important as it provides the attachment substrate for periphyton as well as the characteristics of habitat for macroinvertebrates and fish. The substrate at all sites in the Waianakarua catchment was dominated by gravels, cobbles and bedrock with no signs of significant fine sediment deposition. Similarly, there was no significant sediment compaction or embeddedness at any of the sites.

The sites in both branches had stable banks and were shaded by the surrounding landscape and riparian vegetation. In contrast, the main stem sites had less stable banks and were more open with shading mainly being provided by riparian vegetation. Whilst the openness of these sites is a natural attribute, it is likely to exacerbate the effects the higher nutrient levels observed at these sites on the growth of periphyton by increasing light and water temperatures relative to more heavily shaded sites. Light, nutrients and water temperature are the most important factors affecting periphyton accrual (Biggs 2000). The results of these habitat assessments along with the observation of increasing NNN concentrations with distance downstream in the main stem suggest that the lower Waianakarua River is at greatest risk of nuisance growths of periphyton developing.

9. Comparison with Water Plan Change 6A standards

Water Plan Change 6A sets out water quality standards for receiving waters (Schedule 15, Table 1) as well as discharge limits (Schedule 16). Receiving water standards are applied as 5-year, 80th percentiles when flows are at or below median flow (0.783 m^3/s), with the flows in the Waianakarua catchment being set at the gauging site at Browns Pump.

Most of the sites sampled in the Waianakarua catchment were only sampled over the period July 2012-April 2013, with only five of these samples being collected when flows were below the median flow. As a consequence, 80th percentiles were calculated on the basis of limited data and should be treated with caution. This is not an issue for the SoE monitoring site at Browns Pump.

Nitrate-nitrite nitrogen concentrations at four of the sites surveyed as part of this study as well as at Browns Pump over the period 2001-2013 exceeded the Schedule 15 Standard (Table 2). In contrast, the 80th percentiles of ammoniacal nitrogen and dissolved reactive phosphorus over the 2012-2013 period did not exceed the Schedule 15 standards at any of the sites sampled (Table 2). The 80th percentiles of *E. coli* counts at the upper site in the South Branch exceeded the Schedule 15 value (Table 2). The 80th percentile of turbidity at Browns Pump was very low and was well below the Schedule 15 value (Table 2).

Table 2. Comparison of 80th percentiles of water quality parameters with Receiving Water Quality Standards in Water Plan Change 6A (Schedule 15). Values that exceed the Schedule 15 Standard are highlighted grey. 80th percentiles were calculated based on samples collected when flows were below median flow.

Site	Period	NNN 0.075 mg/l	NH_4-N 0.1 mg/l	DRP 0.01 mg/l	*E. coli* 260 cfu/100 ml	Turbidity 5 NTU
North Branch - upper	2012-2013	0.021	0.005	0.003	70	-
North Branch at SH1	2012-2013	0.019	0.005	0.002	19	-
South Branch - upper	2012-2013	0.066	0.005	0.003	622	-
South Branch at SH1	2012-2013	0.530	0.005	0.002	75	-
Main stem at confluence	2012-2013	0.224	0.005	0.002	27	-
Main stem at midpoint	2012-2013	0.310	0.005	0.002	96	-
Main stem at Browns Pump	2012-2013	0.482	0.005	0.002	61	-
	2001-2013	0.238	0.010	0.007	59	0.55

10. Conclusions

Water quality and habitat in the Waianakarua catchment is generally very good and long-term monitoring (2001-2013) indicates that water quality at Browns Pump has been stable over this period. However, NNN concentrations in the South Branch at SH1 and at all main stem sites exceeded the Receiving Water Quality Standard in Schedule 15 of the Water Plan Change 6A. *Escherichia coli* counts at the upper site in the South Branch exceeded the Schedule 15 value, although this was due to a single, elevated value.

Cyanobacteria (blue-green algae) have been the dominant type of periphyton on most occasions, with diatoms occasionally abundant. Macroinvertebrate communities are diverse and indicate good to excellent water quality, while the Waianakarua River supports a diverse fish community, with 14 species collected including seven species that have been classified as "at risk" and "declining" under the New Zealand Freshwater Fish Threat Classification.

11. Recommendations

That this report is noted.

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