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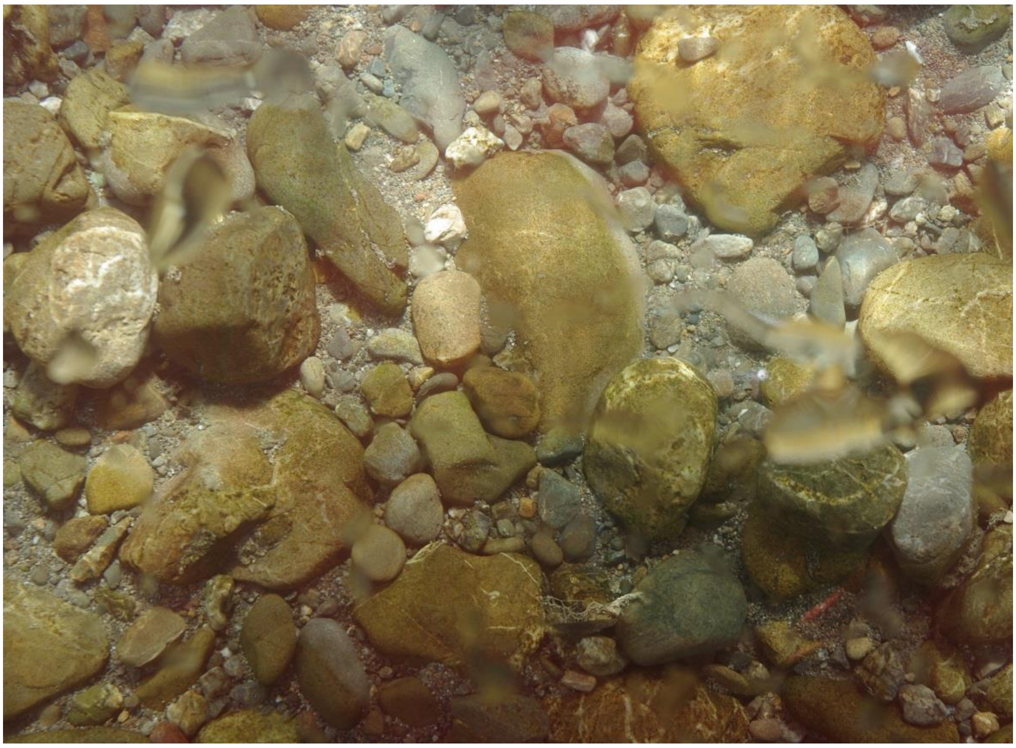
Martinborough, Greytown, and Featherston Treated Wastewater Discharges: Low-flow Assessment of Ecological Effects

Prepared for South Wairarapa District Council



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Cover photograph: Small cobble, gravel, and sand substrates of the Ruamahunga River.

EXECUTIVE SUMMARY

The South Wairarapa District Council engaged Forbes Ecology to undertake a receiving environment monitoring programme in relation to the treated wastewater discharges from the Martinborough, Greytown, and Featherston Municipal Wastewater Treatment Plants.

The monitoring programme had the principle objective of assessing the effect of treated wastewater discharges on in-river periphyton communities during the November 2012–April 2013 low-flow period. The programme also included collection of water quality data, and targeted studies at the Martinborough and Greytown sites to quantify the extent and nature of the treated wastewater in-river mixing zone.

Martinborough

The discharge from the Martinborough Wastewater Treatment Plant was found to result in a concentrated, relatively poorly mixed plume area which extended <4 m laterally across the river from the TL bank. Beyond that zone more uniform mixing was found.

The discharge is having a locally significant effect in increasing periphyton cover and biomass. Periphyton surveys show the effect of the treated discharge peaks within an area <190 m downstream of the outfall and reliable signs of diminishing periphyton cover are apparent by 250–290 m downstream of the outfall.

The effect of those nutrient and other contaminant concentrations held within the most concentrated area of the plume, along the river's TL bank were unaccounted for by the survey (which covered the river's width up to 290 m downstream, and no further).

Greytown

Despite monitoring at the 50 m downstream location probably missing the most concentrated area of the treated wastewater plume, it is clear from the water quality data that nutrients discharged to the Papawai Stream are the central management issue regarding water quality impacts to the Papawai Stream and Ruamahunga River. Downstream of the outfall within the Papawai Stream in many cases nutrient concentrations are well in excess of relevant ecological trigger values, and are therefore, deserving of specific management consideration.

Featherston

The heavy cover by riparian forest downstream of the outfall masked the effect of discharged nutrients on aquatic plant growth and therefore the full potential for periphyton growth was probably not realised during the course of the monitoring programme.

Water quality monitoring found that the discharge was reducing water clarity (significantly), elevating suspended solids, increasing BOD (significantly), and increasing electrical conductivity (significantly). The discharge was found to be causing significant increases in nutrient concentrations within Donald’s Creek. Both nitrogen (total nitrogen and DIN) and DRP concentrations were well in excess of relevant ecological thresholds. The mean/median result for DIN of three-fold the ANZECC trigger value, and the 33-fold increase in DRP (at the 53 m site) are results which provide clear evidence that the discharge, in its current form, is unsustainable in ecological terms.

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1.0 INTRODUCTION

1.1 Objective

The South Wairarapa District Council engaged Forbes Ecology to undertake a receiving environment monitoring programme in relation to the treated wastewater discharges from the Martinborough, Greytown, and Featherston Municipal Wastewater Treatment Plants.

The monitoring programme had the principle objective of assessing the effect of treated wastewater discharges on in-river periphyton communities.

Along with periphyton assessment, the programme included collection of water quality data, and targeted studies at the Martinborough and Greytown sites to quantify the extent and nature of the treated wastewater in-river mixing zone.

1.2 Scope

This report presents the results of visual periphyton assessments, periphyton sampling results, and water quality sampling over the November 2012–April 2013 period.

1.3 Report layout

This report adopts the following layout:

BACKGROUND: Providing a graphical description of study sites, and monitoring locations, and covering river and treated wastewater flows during the monitoring programme.

METHODS: Providing a description of the methods, both field and analytical, adopted for the monitoring programme.

SITE ASSESSMENTS: Providing a discrete presentation and discussion of results from receiving environment surveys and drawing overall conclusions in a synthesis of all results.

APPENDICIES: All appendices are provided on a compact disc, attached inside the rear cover of this report. Appendices are as follows:

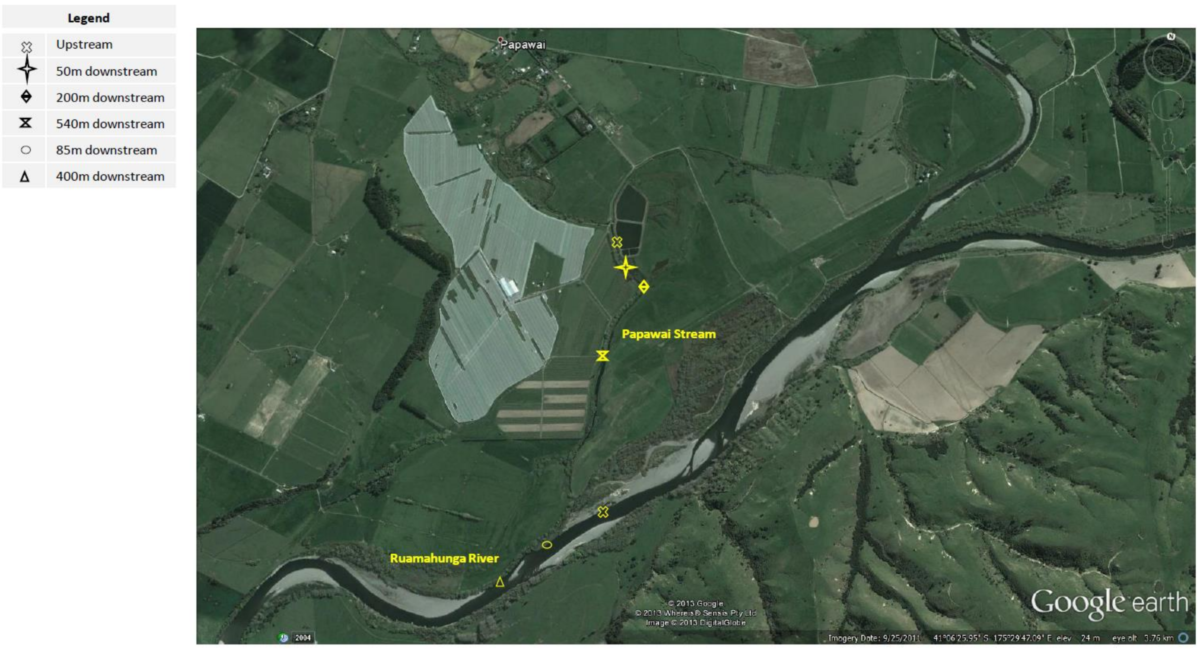
1. Ryder Consulting Limited periphyton analysis reports.
2. Martinborough visual periphyton and water quality and mixing study data.
3. Greytown (Papawai Stream) water quality and mixing study data.
4. Greytown (Ruamahunga River) visual periphyton and water quality data.
5. Featherston visual periphyton and water quality data.

2.0 BACKGROUND

2.1 Study sites

2.1.1 Martinborough

2.1.2 Greytown



2.1.3 Featherston

2.2 River flows

2.2.1 Ruamahunga River

The minimum flow, which occurred around the 16 March 2013, was the lowest recorded since 1976, when reliable low-flow records began. This has resulted in the low-flow statistics previously calculated by Greater Wellington Regional Council (GWRC) changing (personal communication M. Gordon, 8 May 2013). The following table is an estimate of what are now the low-flow statistics for the Ruamahunga River at Waihenga Bridge. At Martinborough, with the exception of the November survey, in-river surveys were carried out in flow conditions less than the 28 day mean annual low-flow (MALF).

Table 1: Estimated revised low-flow statistics for the Ruamahunga River at Waihenga Bridge (as of May 2013).

Return Period	1 Day	7 Day	14 Day	28 Day
MALF	8712	10274	12800	17824
2.33	7842	9053	10931	14898
5	6361	7163	8283	10979
10	5537	6134	6893	8969
20	4938	5397	5923	7590
50	4340	4673	4993	6289
100	3983	4245	4456	5549

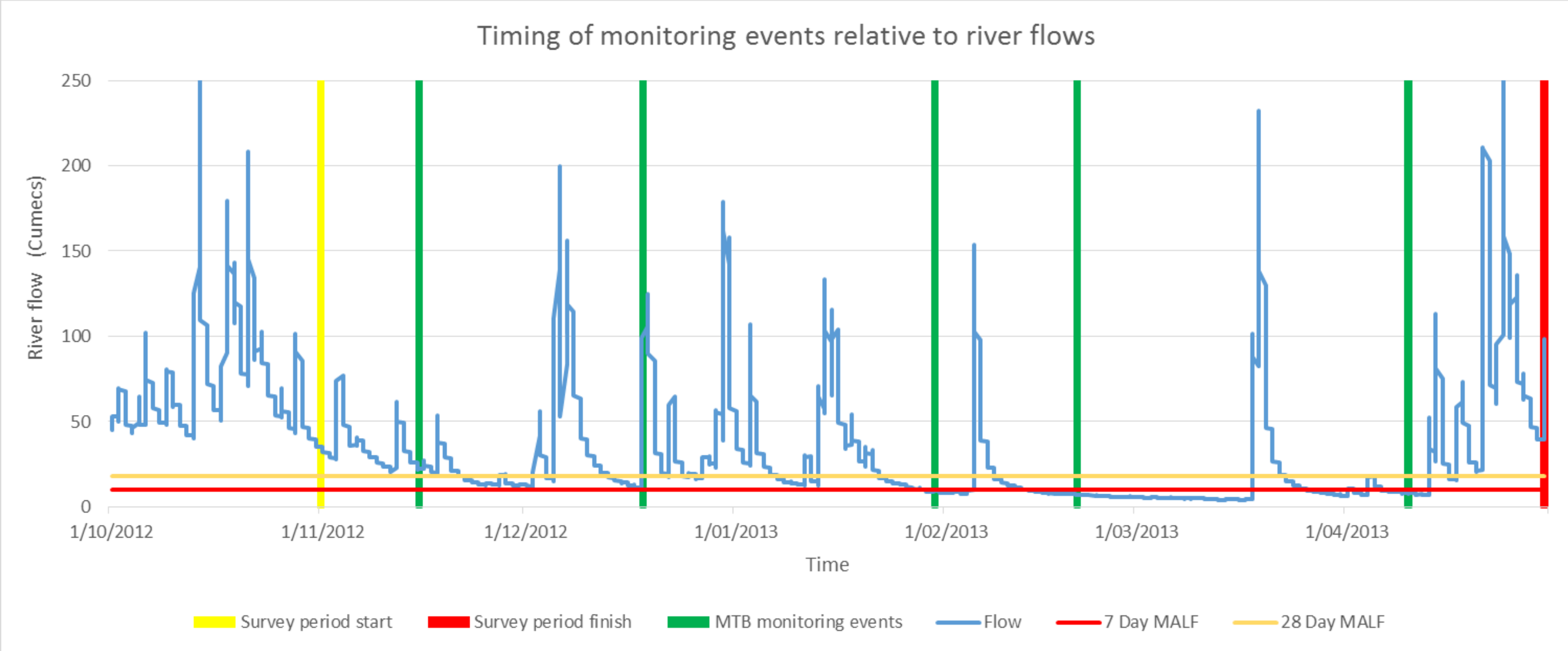


Figure 1: Martinborough: timing of monitoring events in relation to Ruamahunga River flows. 7 day MALF and 28 day MALF shown for context. Note that sampling within the Ruamahunga River at Greytown, when undertaken, occurred on one of the days either before or after the Martinborough monitoring events shown here.

2.2.2 Papawai Stream

While there is some uncertainty associated with the figure, the current 1 day MALF for the Papawai Stream, downstream of the confluence with Tilson's Creek is 340 L/s (Keenan, 2009). Water sampling undertaken during this monitoring programme represents water quality conditions within the Papawai Stream during <1 day MALF conditions.

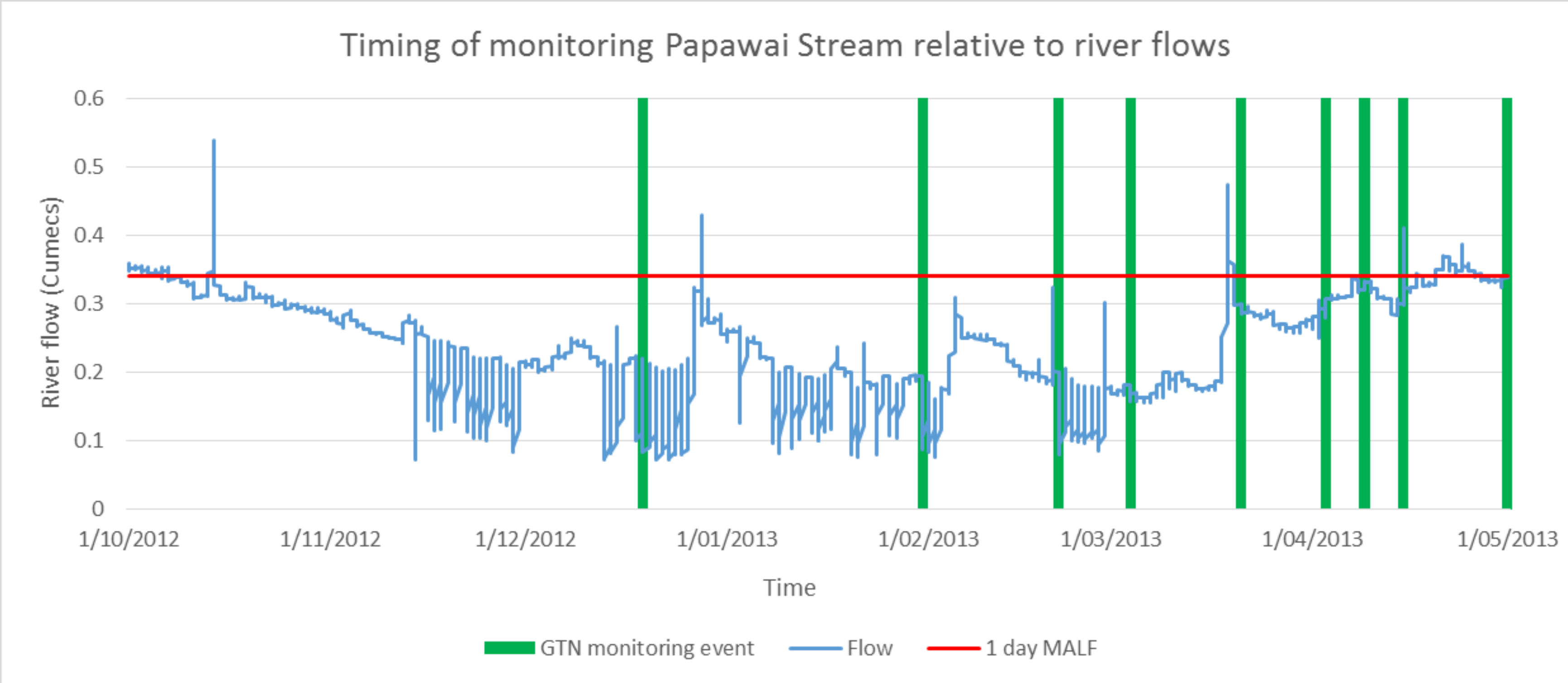
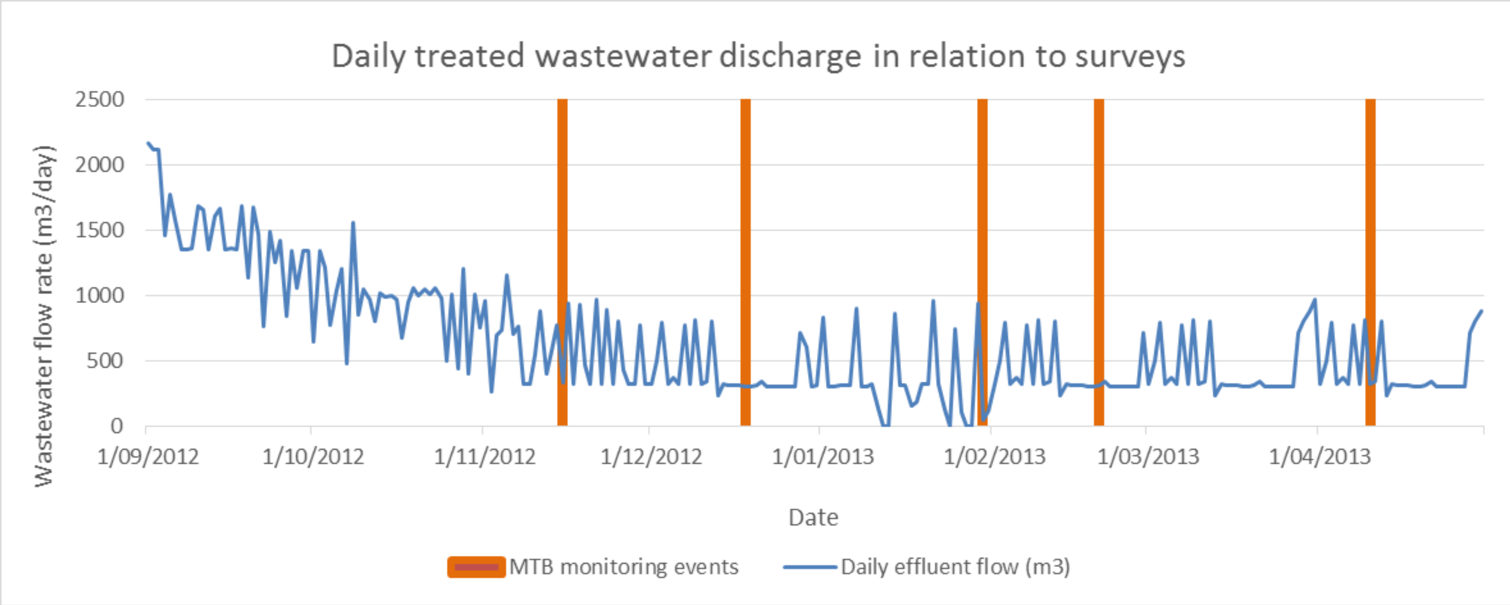


Figure 2: Greytown: timing of monitoring events in relation to Papawai Stream flows. 1 day MALF shown for context.

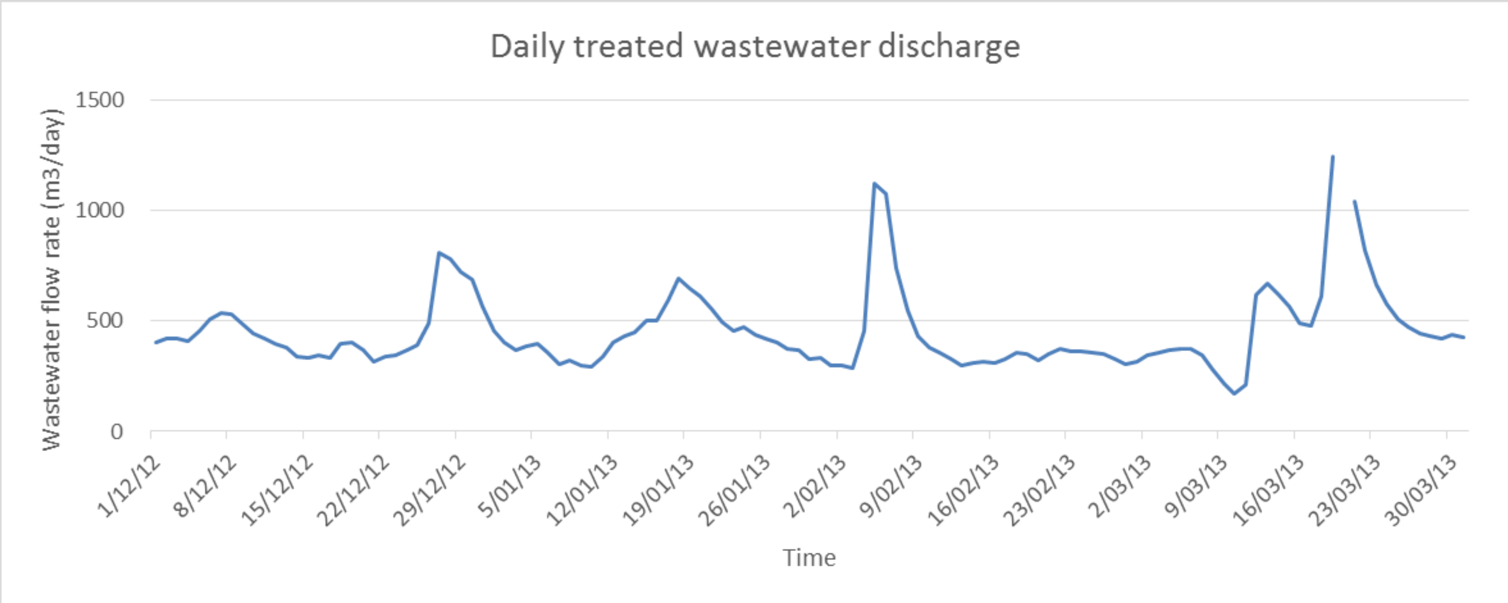
2.3 Treated wastewater flows

Treated wastewater flow rates from each of the three wastewater treatment plants is presented in Figure 3 below.

Martinborough



Greytown


Daily treated wastewater discharge
Wastewater flow rate (m3/day)
1500
1000
500
0
1/12/12
8/12/12
15/12/12
22/12/12
29/12/12
5/01/13
12/01/13
19/01/13
26/01/13
2/02/13
9/02/13
16/02/13
23/02/13
2/03/13
9/03/13
16/03/13
23/03/13
30/03/13
Time

Featherston

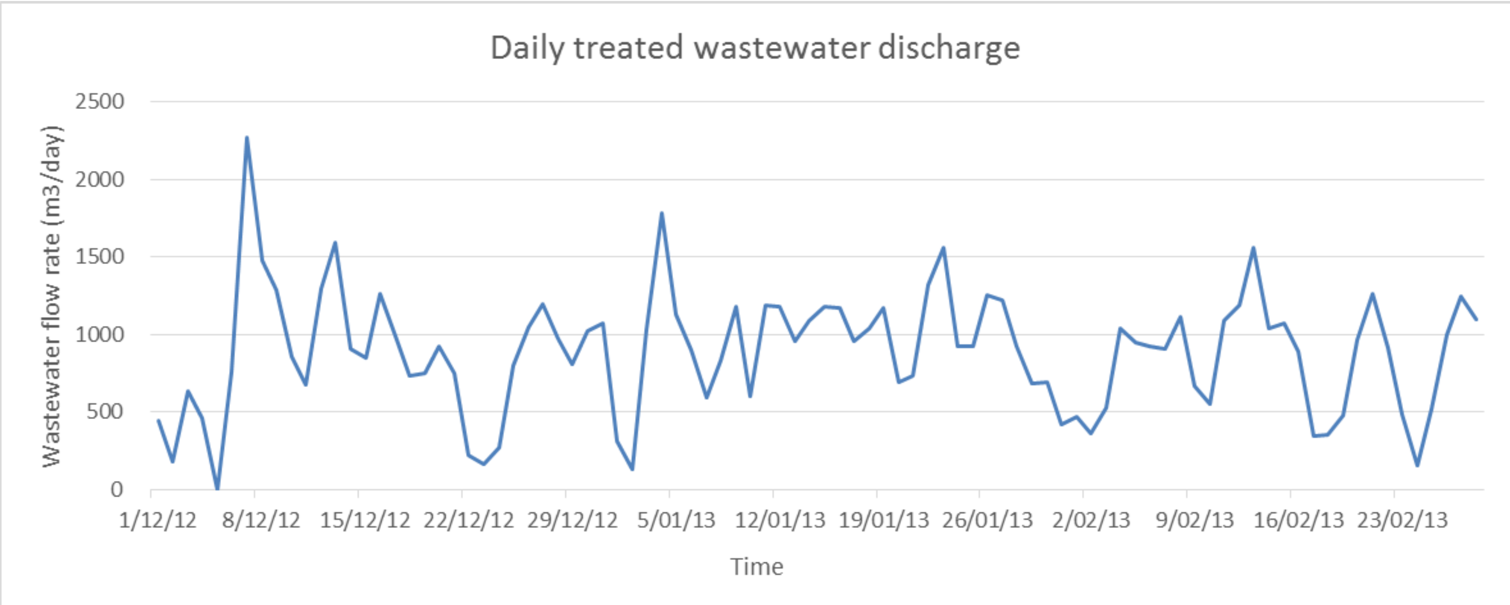


Figure 3: Treated wastewater effluent flow rates for Martinborough, Greytown, and Featherston over the periods of the monitoring period for which data is available.

3.0 METHODS

3.1 Mixing studies

Mixing studies were undertaken within the Ruamahunga River at Martinborough, and within the Papawai Stream at Greytown. At each site sample points were determined in a systematic fashion, being allocated at predetermined intervals (transects) downriver, and at regular intervals laterally across the waterway width (along each transect). At Martinborough transect locations were marked out using 100 m tapes along the rivers length, and transects were positioned directly across river. Intervals across the transect were found using a handheld GPS (Garmin GPSmap 62s) with an accuracy of +/- 3 m. Within the Papawai Stream, due to its narrow width, tape measures were used to find transect locations and the sample points were determined by sight. Samples for the mixing study within the Papawai Stream were collected from a kayak.

Indicators of a treated wastewater plume were (1) dissolved reactive phosphorus (DRP), (2) electrical conductivity (EC), and at Martinborough (3) percentage of the riverbed clean from any periphyton cover other than films.

Results were plotted using the Bubble Plot and Column Plot functions in Microsoft Excel.

3.2 Periphyton

Visual periphyton assessments were undertaken based on the method described by Kilroy, Biggs, and Death (2008). Groups of four transects, set out along each sampling location at 10 m intervals were traversed. Transects extended across the river's width, to a point where either water depth greater than 0.6 m was reached, or the far river bank was reached. Visual observations were made along each transect, at every $^{1}/_{5}$ of the transect length. Therefore, 20 visual observations per sample location were obtained (five for each of the four transects). The number of paces and maximum depth of each transect was recorded.

Periphyton samples were collected in accordance with the method described by Kilroy et al., (2008). Ten subsamples were collected from a uniform sized area of ten randomly selected rocks. Periphyton samples were frozen and dispatched to Ryder Consulting Limited, Dunedin, for processing.

3.3 Water quality

Chemical water quality samples were collected at approximately mid-transect length and dispatched for laboratory analysis. In-situ water quality sampling was carried out using a YSI

Professional Plus hand held water quality probe. Black disk was measured by two people following the standard protocol.

3.4 Fieldwork staff for periphyton surveys

All periphyton surveys were carried out by Adam Forbes (observer) and Rob McDonald (SWDC Environmental Health Officer and data recorder on this project).

3.5 Data analysis

All numerical data was analysed using the statistical software package R (R Development Core Team, 2013). Where significance tests were required, Wilcoxon Rank Sum tests were carried out in R.

3.6 Limitations

While it was intended to sample six times (monthly) over the period November 2012–April 2013, a significant fresh occurred at the time the March survey was about to occur. Therefore, five rather than six surveys were undertaken in total, and no survey could be undertaken in March. During December rain occurring overnight in the Tararura Ranges raised river levels unexpectedly meaning the Ruamahunga River at Greytown could not be sampled.

Leading up to the February survey the effluent discharge from the Martinborough oxidation system was intermittent. This is thought to be due to unusually dry weather conditions, including low groundwater levels, which resulted in less discharge volume than would normally occur at that time of year.

4.0 MARTINBOROUGH

4.1 Results

4.1.1 Mixing study

The EC measurements suggests the concentrated treated wastewater plume remains close to the true left (TL) river bank. Downriver within this most concentrated zone of the plume, EC results were around three times (318 µS/cm) that of upstream levels, and over the course of 90 m downriver, results reduced by about 33% (214 µS/cm) relative to the highest result from adjacent to the outfall. Further downriver— between 90–130 m downstream, EC results reduced to around 60% of the highest result from adjacent to the outfall. From beyond that point results only reduced very gradually, to a level at 370 m downstream where EC results were around half that of the highest result from adjacent to the outfall. Only EC results taken closest to the TL bank showed a sharp response in relation to the treated wastewater plume. Laterally across the river within the zone 50 m downstream of the outfall, but outside of the concentrated plume area identified above, EC results showed a consistent—albeit slight (ca. 3%)—increase in a downstream direction. EC measurements did not appear to detect treated wastewater until somewhere between 50–90 m downriver from the outfall.

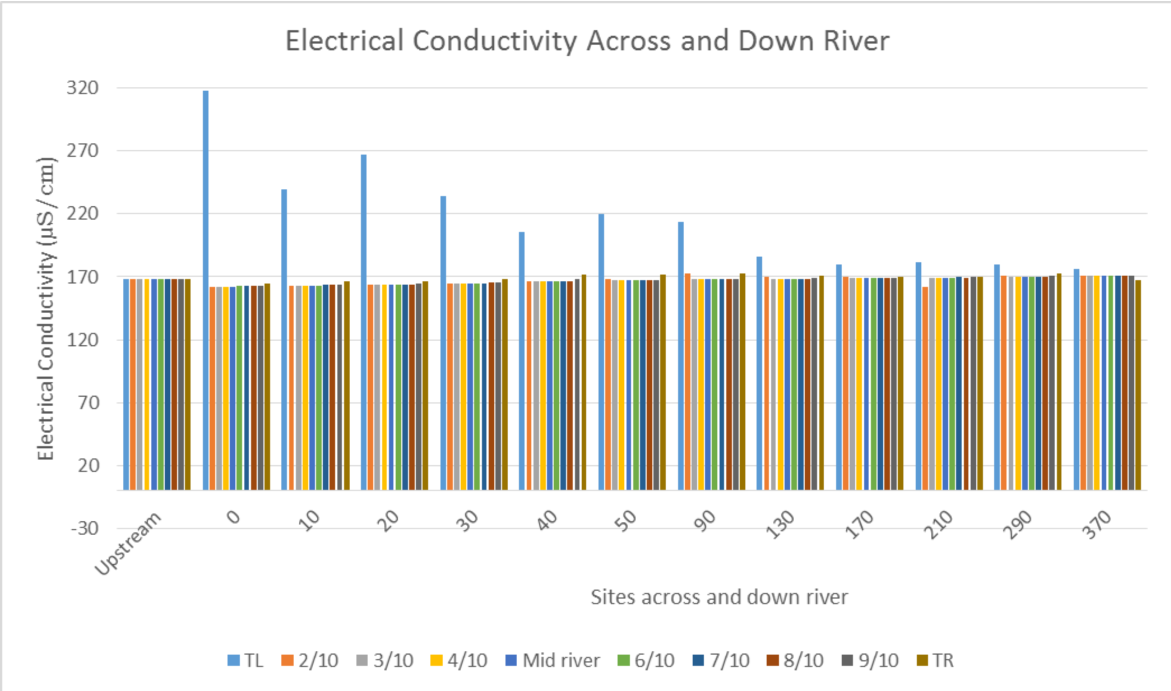
With regard to the concentrated plume, the DRP concentrations show the same spatial pattern as EC—the most concentrated plume being confined to the river's edge, in the zone 0–4.2 m laterally across river from the TL river bank. Within 10 m downstream of the outfall, DRP concentrations within the concentrated plume had reduced four-fold. A more gradual reduction in DRP concentration in the area adjacent to the TL river bank was found to continue for the length of the area surveyed (370 m downstream of the outfall). At the 370 m mark, DRP concentrations at the TL bank were still an order of magnitude higher than in directly adjacent areas of the river width. This shows that, although diminished in concentration, the most concentrated part of the plume is against the TL bank for a distance of 370 m downstream of the outfall. Outside of the area of the plume, DRP concentrations were very nearly identical to upstream concentrations.

Periphyton cover appears to provide a more complete picture of the plume's spatial range of extent. Assessment of periphyton cover suggests the discharge (probably in reduced concentration through mixing with river water) reaches as far as $^{6}/_{10}$ – $^{7}/_{10}$ of the river's width within 30m downstream of the outfall. At the point 90 m downstream of the outfall, 50 % of the river's width closest to the TL side had more than 90 % periphyton cover. Although it appears at this point the discharge still has a relatively small effect on the furthest area (TR $^{4}/_{10}$) of the river's width. From 130–370 m downstream of the outfall, periphyton cover was more uniformly high across the entire river's width and notably the TL most site—against the river's bank consistently held one of the highest percent covers of any of these downstream transects.

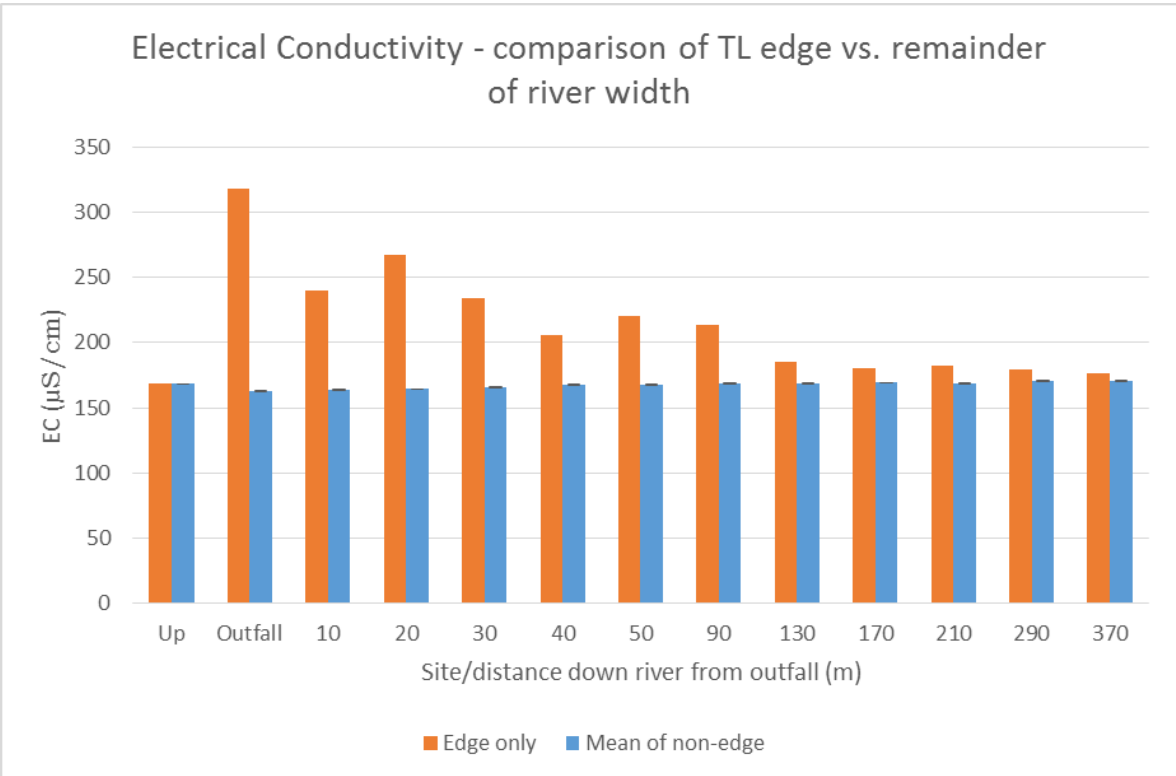
Regarding the spatial extent and relative mixing of treated wastewater at the Martinborough site, it can be concluded that:

1. The most concentrated area of the plume was the area within ca. 3–4 m of the TL river bank. This pattern of relatively high (relative to adjacent areas of the plume, not necessarily relative to near-outfall concentrations) concentration extended up to, and appeared to extend beyond 370 m downstream of the outfall.
2. In a reduced concentration, yet sufficient to stimulate periphyton growth, the plume extended as far as $^{6}/_{10}$ – $^{7}/_{10}$ of the river's width within 30 m downstream of the outfall.
3. Outside of the relatively concentrated area of the plume along the river's LT bank, DRP and EC results show subtle (at most) traces of the plume across the river's width. Periphyton provided a better indicator of plume extent (but not concentration), and showed that by 90–130 m downstream of the outfall the entire river's width was, at least at times, affected by the plume. Outside of the TL zone described herewith, the extent of periphyton cover across the riverbed began reducing from the 130 m mark, in a downriver direction.
4. To represent the most concentrated part of the plume, all future water sampling should be undertaken within 4 m laterally across the river's width, from the TL bank.

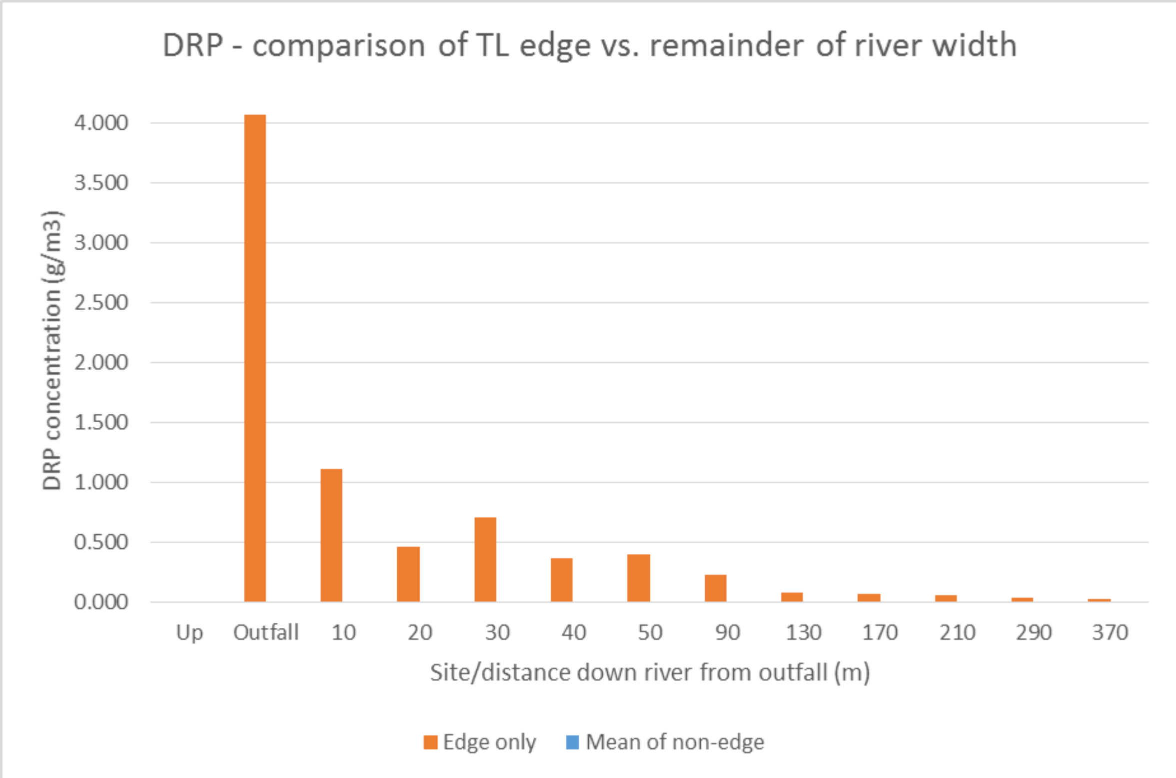
A


Electrical Conductivity Across and Down River
Electrical Conductivity (µS/ cm)
320
270
220
170
120
70
20
-30
Upstream
0
10
20
30
40
50
90
130
170
210
290
370
Sites across and down river
TL
2/10
3/10
4/10
Mid river
6/10
7/10
8/10
9/10
TR

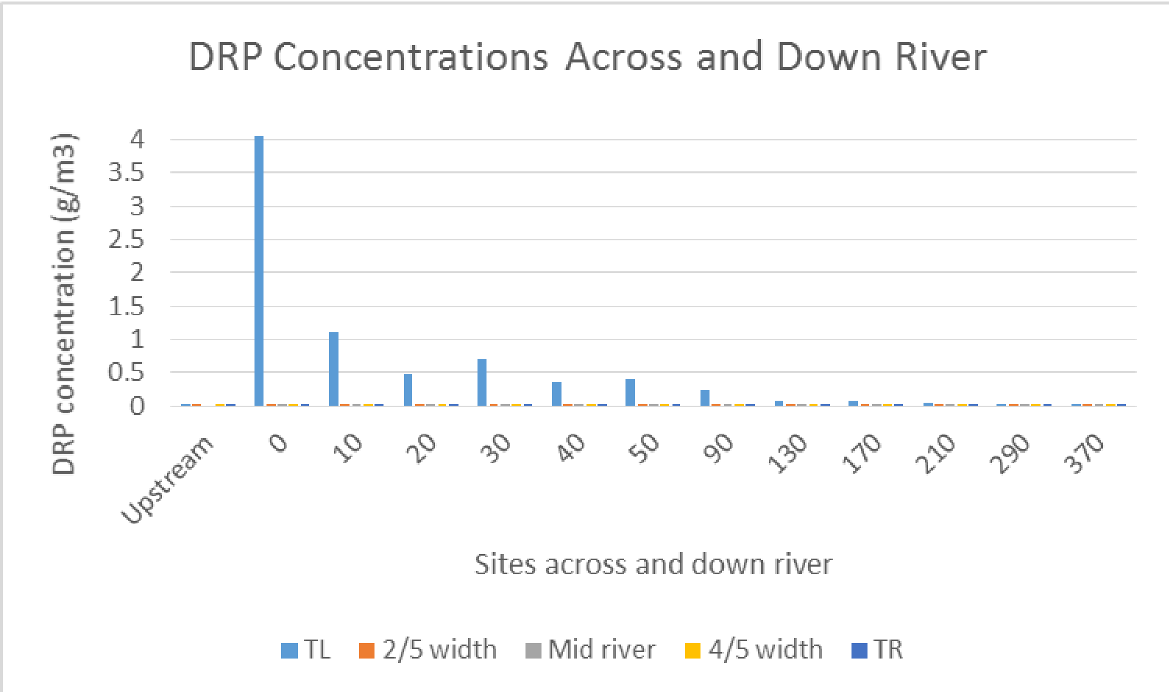
B


Electrical Conductivity - comparison of TL edge vs. remainder of river width
EC (µS/ cm)
350
300
250
200
150
100
50
0
Up
Outfall
10
20
30
40
50
90
130
170
210
290
370
Site/distance down river from outfall (m)
Edge only
Mean of non-edge

C


DRP - comparison of TL edge vs. remainder of river width
DRP concentration (g/m3)
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
Up
Outfall
10
20
30
40
50
90
130
170
210
290
370
Site/distance down river from outfall (m)
Edge only
Mean of non-edge

D


DRP Concentrations Across and Down River
DRP concentration (g/m3)
4
3.5
3
2.5
2
1.5
1
0.5
0
Upstream
0
10
20
30
40
50
90
130
170
210
290
370
Sites across and down river
TL
2/5 width
Mid river
4/5 width
TR

E

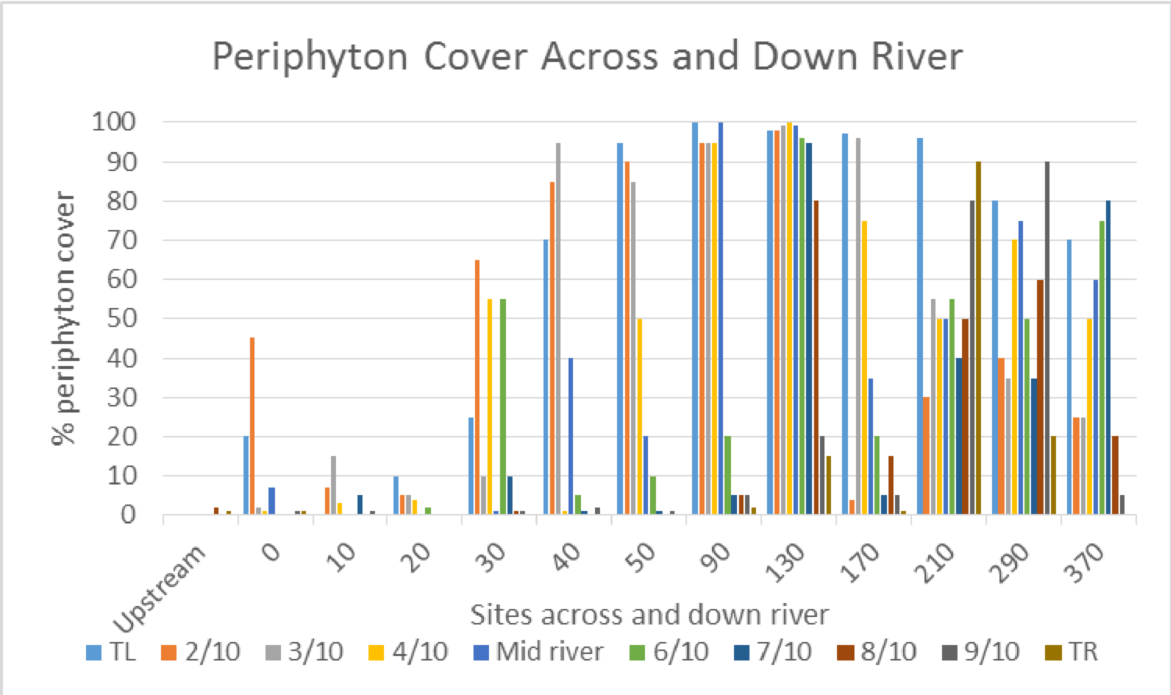


Figure 4: Analysis of treated wastewater mixing at Martinborough with regard to (A) EC across and downriver, (B) Comparison of EC from TL river edge and remainder of river's width (mean; error bars one SEM), (C) Comparison of DRP concentrations from TL river edge and remainder of river's width, (D) DRP concentrations across and downriver, (E) Periphyton cover across and downriver.

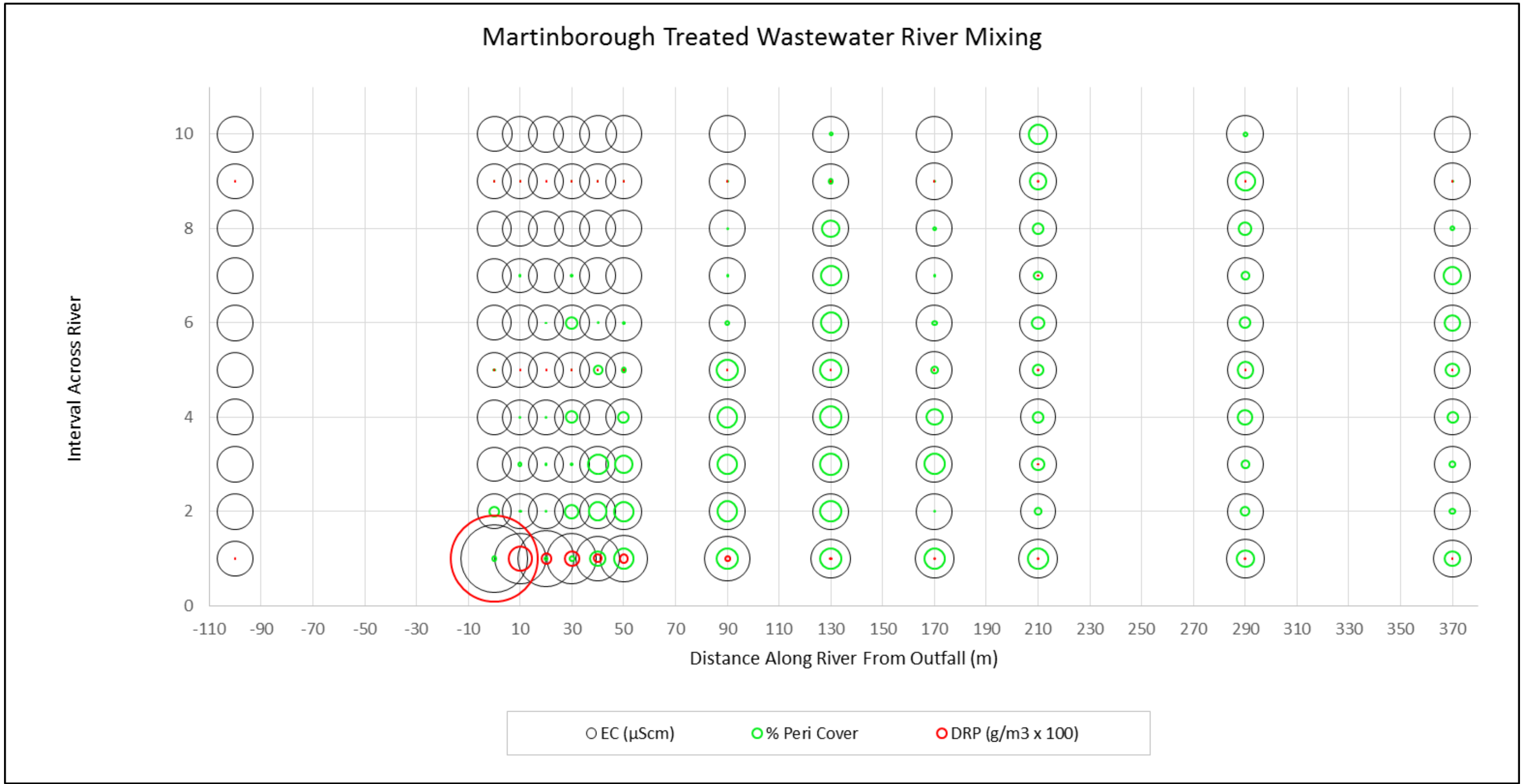


Figure 5: Electrical conductivity, DRP and % periphyton cover results with distance across and downstream of the outfall. Bottom of plot is TL, top is TR. Outfall is at 0 m on TL. Distance downstream is from left to right across page.

4.1.2 Substrate composition

Substrates of the three downstream monitoring sites have similar proportions of gravels and cobbles. The upstream site has a relatively larger proportion of gravel and sand, although it has a considerable proportion of small cobbles. While of a slightly different substrate composition, the upstream site is considered to be representative enough of downstream sites for the monitoring results which follow to be valid.

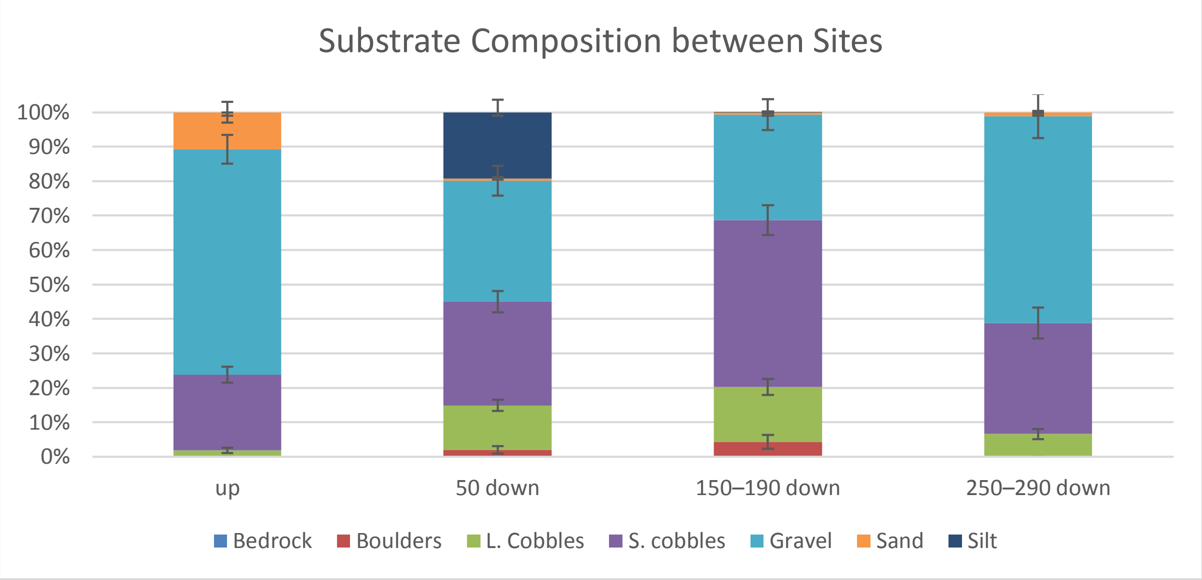


Figure 6: Substrate composition of periphyton monitoring sites within the Ruamahunga River at Martinborough. Plotted values are the mean of all observations and error bars represent one standard error of the mean.

4.1.3 Periphyton

Visual assessment

The percentage of the riverbed which was clean (i.e. free from periphyton and fine sediments) varied considerably at all sites surveyed (upstream and downstream of the outfall). During November the discharge caused a statistically very highly significant[1] reduction in the proportion of clean riverbed at the point 150–190 m downstream, but no significant[2] effect at 250–290 m downstream. In December the proportion of clean riverbed

[1] Significant difference between upstream and 150–190 m downstream (W = 364, p = 0.000008532).
[2] No Significant difference between upstream and 250–290 m downstream (W = 270, p = 0.05675).

within the plume, at 50–90 m[3] and 150–190 m[4], was statistically very highly significantly reduced. However, at the downstream most site the proportion of clean riverbed increased to be comparable with upstream conditions occurring at the time. In January, the proportion of the riverbed clean at 50–90 m downstream of the outfall was 0%. Yet more than 60% upstream was clean. By 250–290 m downstream there was no significant[5] difference in the proportion of clean riverbed, compared to upstream conditions at the time. During February and April no clean riverbed occurred upstream, but in both months clean areas were present at 250–290 m downstream. This makes assessment of the contribution of the discharge on the percent of the riverbed clean not possible for those months.

In all surveys sludge was not an important part of the periphyton community/riverbed cover downstream of the outfall.

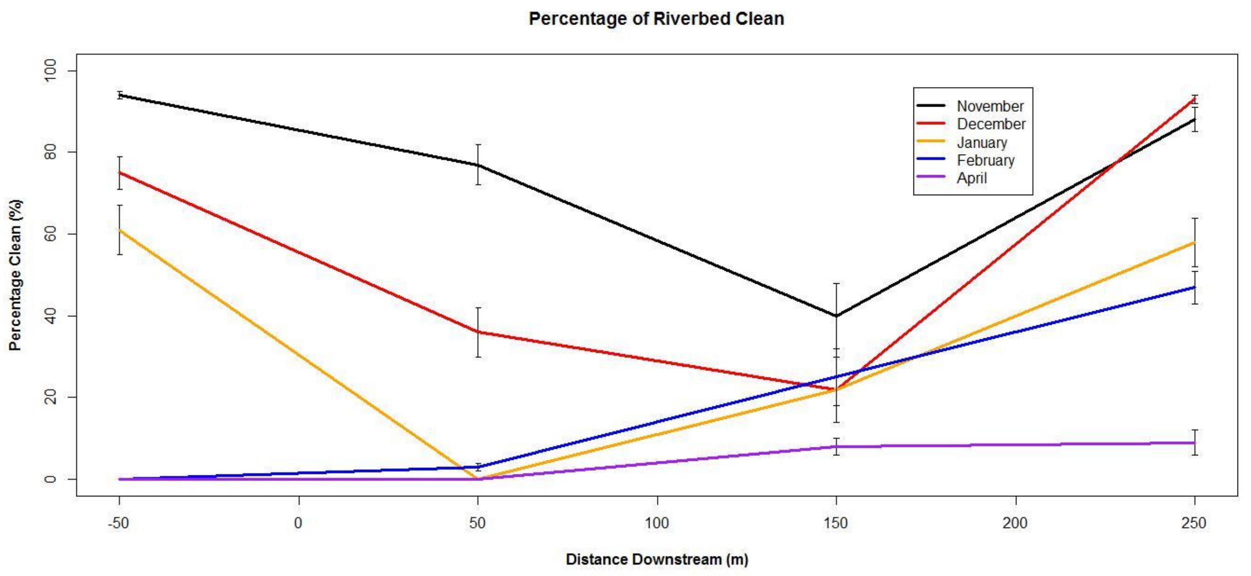
The proportion of the riverbed covered by thick mats was unaffected by the discharge during the months November and December – but was elevated in all later surveys. However, in no survey did the average of any transect exceed 60% cover by thick mats.

Long filamentous algae was less than 30% cover at all sites prior to, and including, the February survey. In April, cover by filamentous algae was around 60% both upstream and 50–90 m downstream of the outfall. At 150–190 m mean cover by long filamentous algae had reduced to just below the 30% cover threshold, and by 250–290 m the mean proportion of cover by long filamentous algae was within <10% of the proportion cover measured in January and February at that downstream most site.

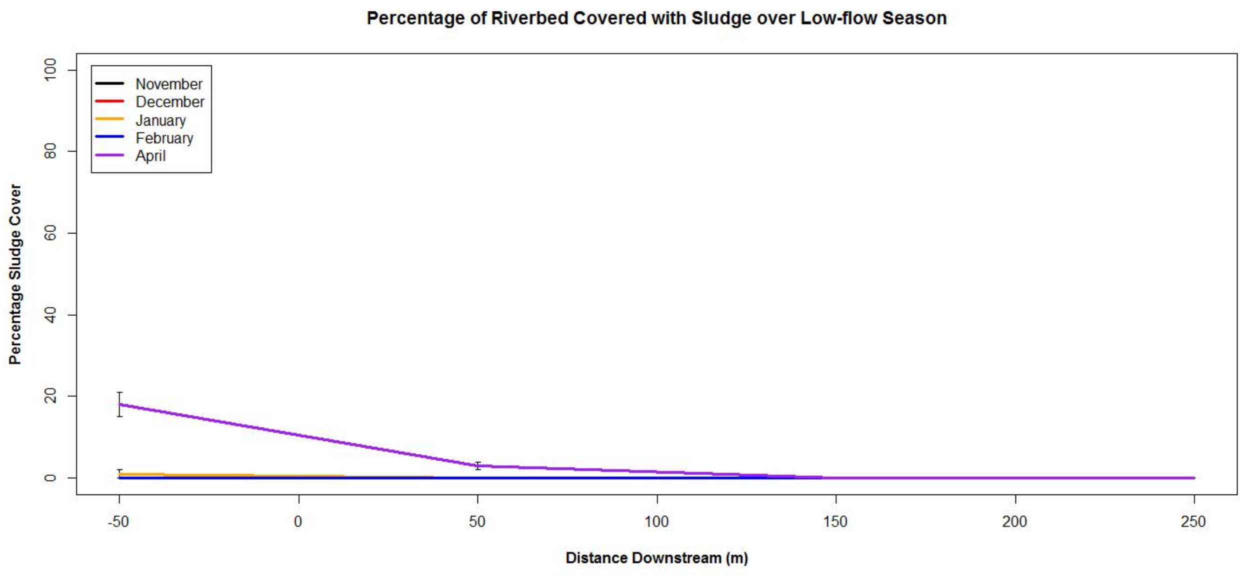
Fine sediment deposition at the point 50–90 m downstream of the outfall increased progressively over the monitoring period. This site was comparatively more depositional (deeper and slower flowing) than the other downstream monitoring sites, which could be a factor leading to this result. Nevertheless, sediment deposition at the point 50–90 m downstream of the outfall was observed to be considerable and the source of sediments would have been the treated wastewater discharge. Proportional cover by sediment consistently reduced by the 150–190 m downstream point, to levels comparable to upstream conditions, and no increases further downstream were detected.

[3] Significant difference between upstream and 50–90 m downstream (W = 365, p = 0.000008415)
[4] Significant difference between upstream and 150–190 m downstream (W = 316, p = 0.001764)
[5] No significant difference between upstream and 250–290 m downstream (W = 218, p = 0.6355).

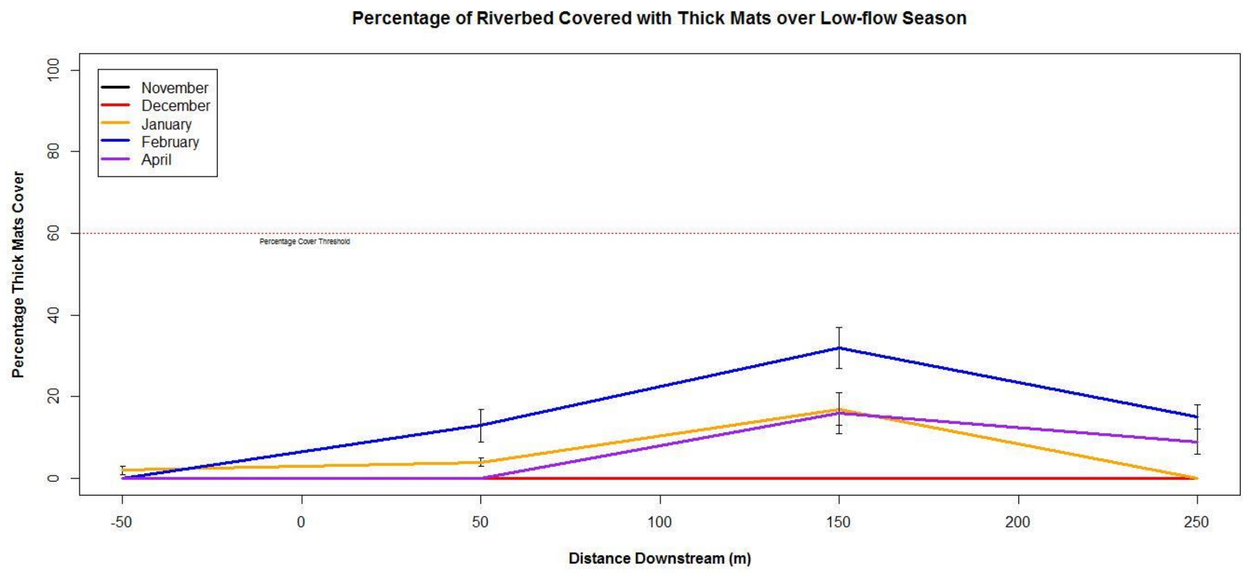
A


Percentage of Riverbed Clean
Percentage Clean (%)
Distance Downstream (m)
November
December
January
February
April
0
20
40
60
80
100
-50
0
50
100
150
200
250

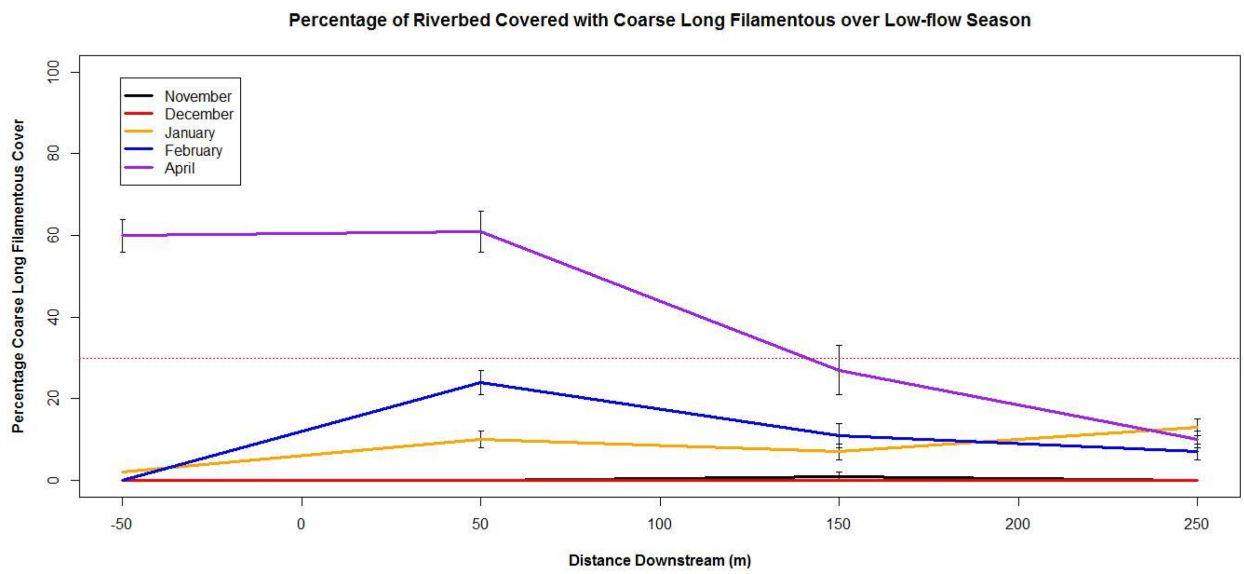
B


Percentage of Riverbed Covered with Sludge over Low-flow Season
Percentage Sludge Cover
Distance Downstream (m)
November
December
January
February
April
0
20
40
60
80
100
-50
0
50
100
150
200
250

C


Percentage of Riverbed Covered with Thick Mats over Low-flow Season
Percentage Thick Mats Cover
Distance Downstream (m)
November
December
January
February
April
Percentage Cover Threshold
0
20
40
60
80
100
-50
0
50
100
150
200
250

D


Percentage of Riverbed Covered with Coarse Long Filamentous over Low-flow Season
Percentage Coarse Long Filamentous Cover
Distance Downstream (m)
November
December
January
February
April
0
20
40
60
80
100
-50
0
50
100
150
200
250

E

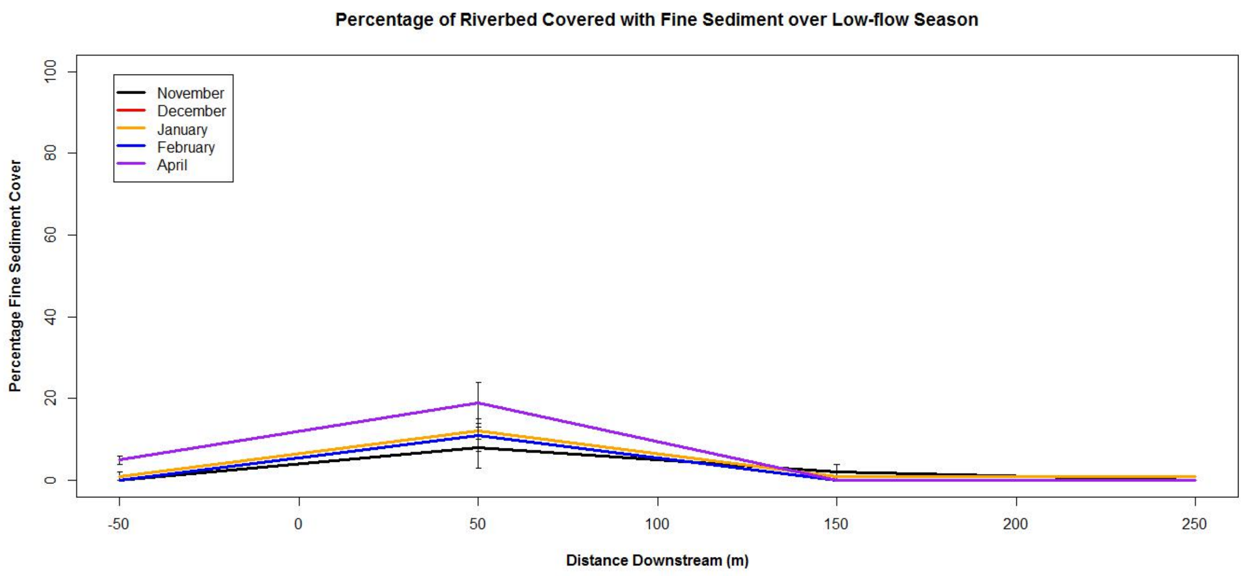


Figure 7: Results from visual assessment of (A) % riverbed clean (B) % cover by sludge (C) % cover by thick mats (D) % cover by coarse long filamentous algae (E) % cover by fine sediment. Error bars represent one standard error of the mean.

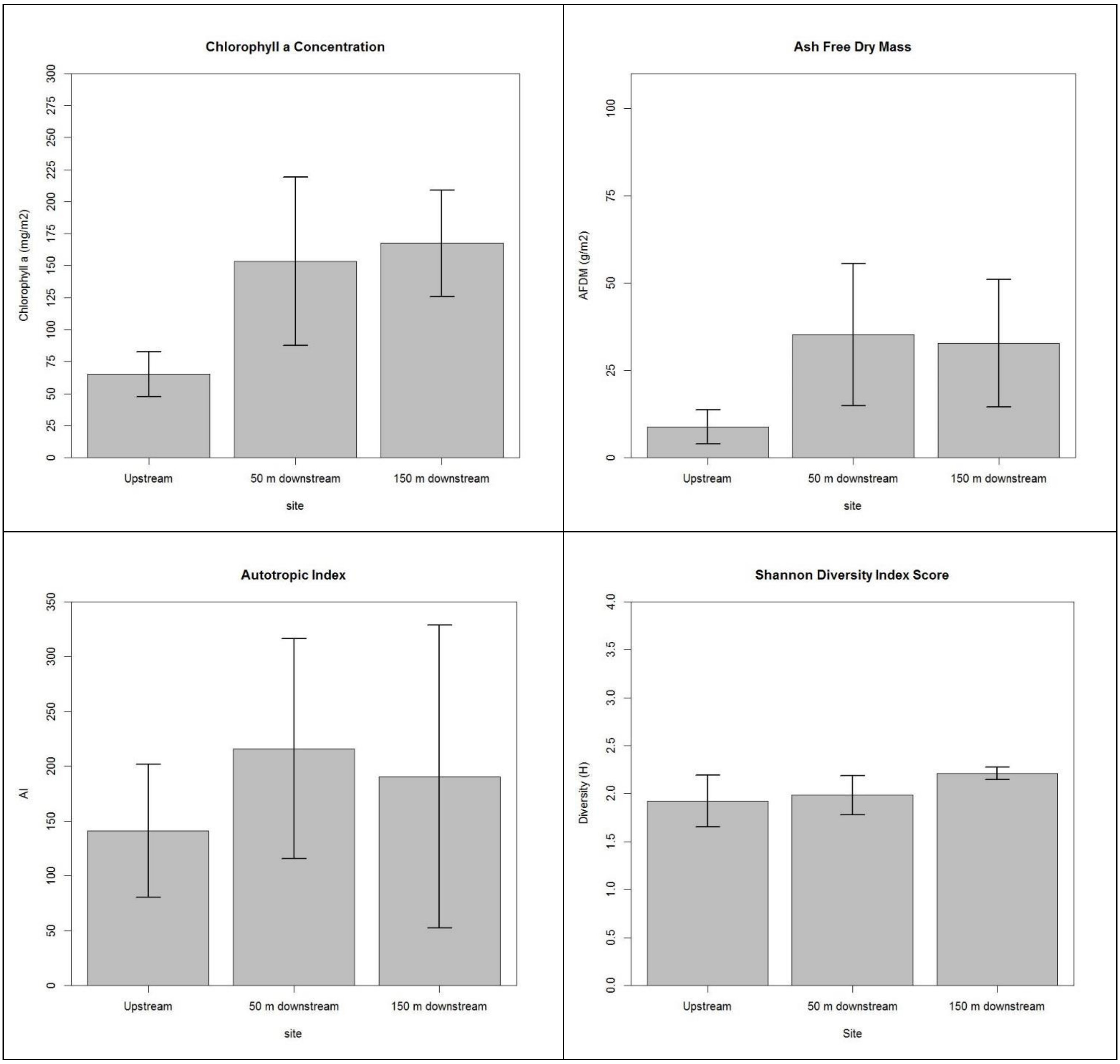
Periphyton Biomass, Autotrophic Index, and Community Composition

Chlorophyll *a* (Chl. *a*) and Ash Free Dry Mass (AFDM), both indicators of periphyton biomass, showed statistically highly significant[6] increases from upstream to 50–90 m downstream of the outfall. Differences relative to upstream concentrations, in these biomass indicators, increased further to be statistically very highly significant[7] at 150–190 m downstream of the outfall.

Autotrophic index (AI) scores at 150–190 m downstream of the outfall were similar at the sample times of February (median AI 194) and April (median AI 196.1). The periphyton biomass sampling during April found a statistically highly significant[8] increase in AI value from upstream to 50–90 m downstream (see Figure 8), while the difference between upstream and 150–190 m downstream AI values was not statistically significant[9]. Diversity

[6] Wilcoxon results for Chlorophyll *a* and AFDM comparison of the upstream results to 50–90 m: Chl. *a* W = 11, $p = 0.002089$; AFDM W = 12, $p = 0.004571$.
[7] Wilcoxon results for Chlorophyll *a* and AFDM comparison of the upstream results to 150–190 m: Chl. *a* W = 1, $p = 0.00002165$; AFDM W = 2.5, $p = 0.0003772$.
[8] Wilcoxon results for AI: comparison of the upstream results to 50–90 m – W = 15, $p = 0.006841$, 150–190 m – W = 33, $p = 0.2176$.

(*H*) index scores from periphyton samples collected in April from upstream, 50–90 m downstream, and 150–190 m downstream showed no statistically significant[9] difference between sampling sites. A statistically highly significant[10] difference was found in periphyton species diversity at 150–190 m downstream between February and April 2013.



[9] Wilcoxon results for *H*: comparison of the upstream results to 50–90 m – W = 13, *p* = 1; 150–190 m – W = 3, *p* = 0.05556.

[10] Wilcoxon results for *H*: comparison of results from 150–190 m, during February and April – W = 25, *p* = 0.007937.

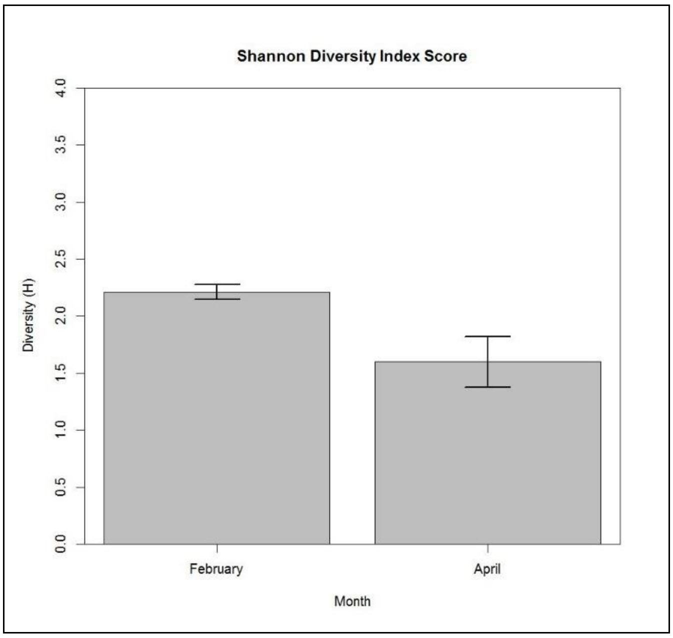


Figure 8: Periphyton biomass, autotrophic index, and diversity index scores for the Martinborough discharge. Plots are median values and error bars represent the interquartile range.

4.1.4 Water quality

Indicator and physical parameters

Although elevated downstream of the outfall, the treated wastewater discharge had no statistically significant effect to EC levels[11].

The discharge had the effect of reducing pH, causing a significant reduction in pH from upstream to 50–90 m downstream, which remained a significant difference at the point 150–190 m downstream, but was not significant at more distant downstream sites[12]. Notably, even with the reduction in pH scores, mean and median pH at all sites was elevated above the ANZECC upper limit default trigger value.

Despite the sediment deposition noted at the area 50–90 m downstream of the outfall, mean suspended sediment concentrations at any downstream monitoring site was not significantly different to the mean upstream concentration[13].

As with suspended sediment concentrations, mean turbidity results showed no significant difference between upstream and mean results at any sites monitored downstream of the outfall[14].

Black disk showed no significant difference between the mean of upstream samples and the mean of any monitoring site located downstream of the outfall[15].

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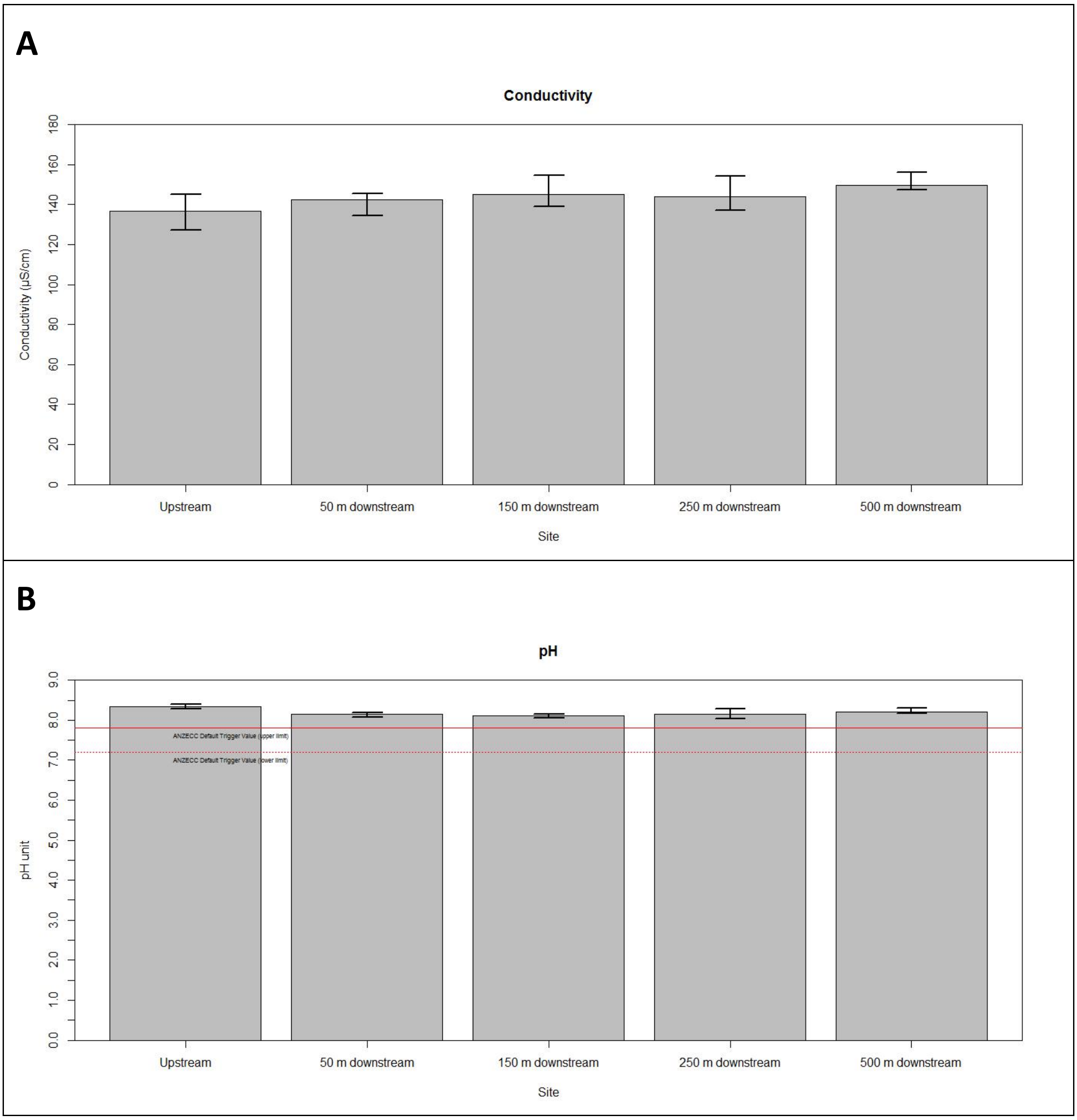
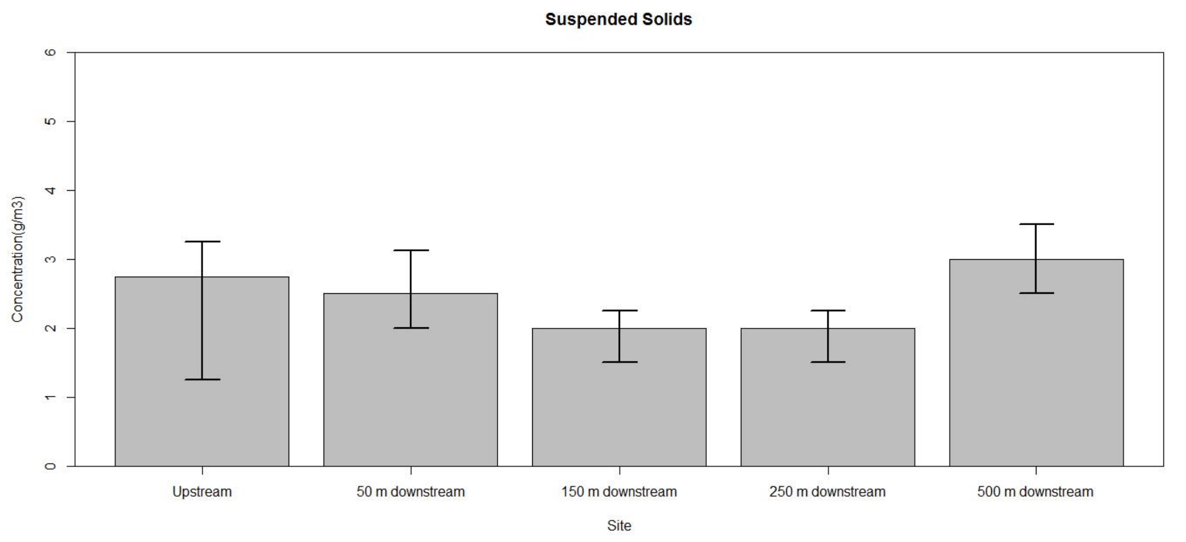
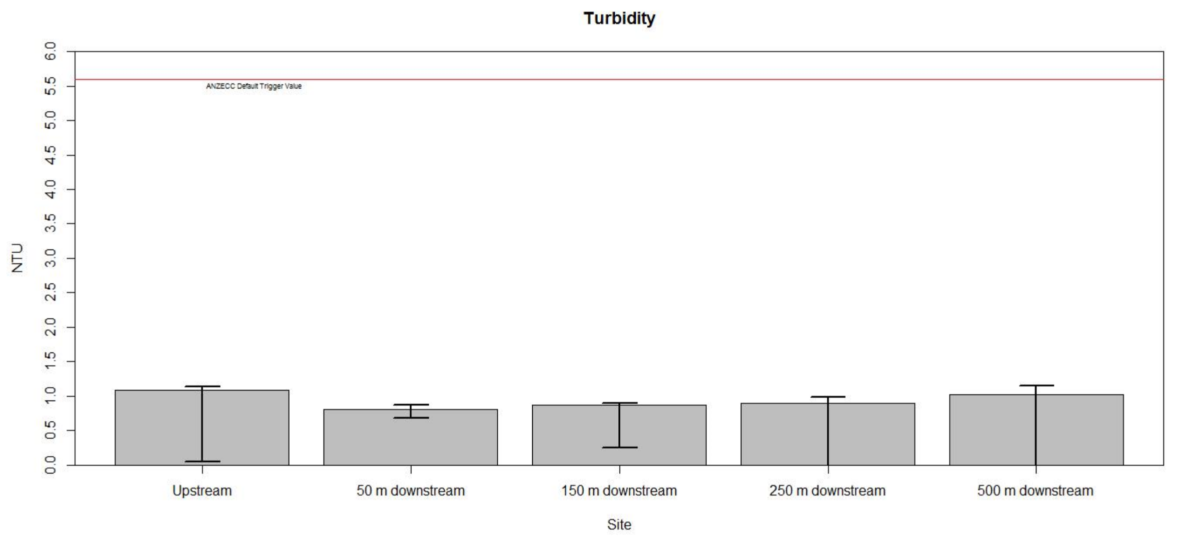
[11] Wilcoxon results for EC: comparison of the upstream results to 50 m – W = 9, p = 0.9048; 150 m – W = 7, p = 0.8857; 250 m – W = 7, p = 0.8857; 500 m – W = 3, p = 0.4.
[12] Wilcoxon results for pH: comparison of upstream results to 50 m – W = 18.5, p = 0.04909; 150 m – W = 16, p = 0.02857; 250m - W = 14, p = 0.1143; 500 – W = 10, p = 0.2076.
[13] Wilcoxon results for SS: comparison of the upstream results to 50 m – W = 9.5, p = 0.766; 150 m – W = 8, p = 0.5892, 250 m – W = 8, p = 0.5892; 500 m – W = 5.5, p = 1.
[14] Wilcoxon results for turbidity: comparison of the upstream results to 50 m – W = 21, p = 0.09524; 150 m – W = 16, p = 0.1905; 250 m – W = 14.5, p = 0.3252; 500 m – W = 9, p = 0.7857.
[15] Wilcoxon results for black disk: comparison of the upstream results to 50 m – W = 5, p = 0.6857; 150 m – W = 6, p = 0.6857; 250 m – W = 6, p = 0.6857, 500 m – W = 9, p = 0.7213.


A
Conductivity
Conductivity (µS/cm)
0
20
40
60
80
100
120
140
160
180
Upstream
50 m downstream
150 m downstream
250 m downstream
500 m downstream
Site
B
pH
pH unit
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
ANZECC Default Trigger Value (upper limit)
ANZECC Default Trigger Value (lower limit)
Upstream
50 m downstream
150 m downstream
250 m downstream
500 m downstream
Site

C


Suspended Solids
Concentration(g/m3)
0
1
2
3
4
5
6
Upstream
50 m downstream
150 m downstream
250 m downstream
500 m downstream
Site

D


Turbidity
NTU
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
ANZECC Default Trigger Value
Upstream
50 m downstream
150 m downstream
250 m downstream
500 m downstream
Site

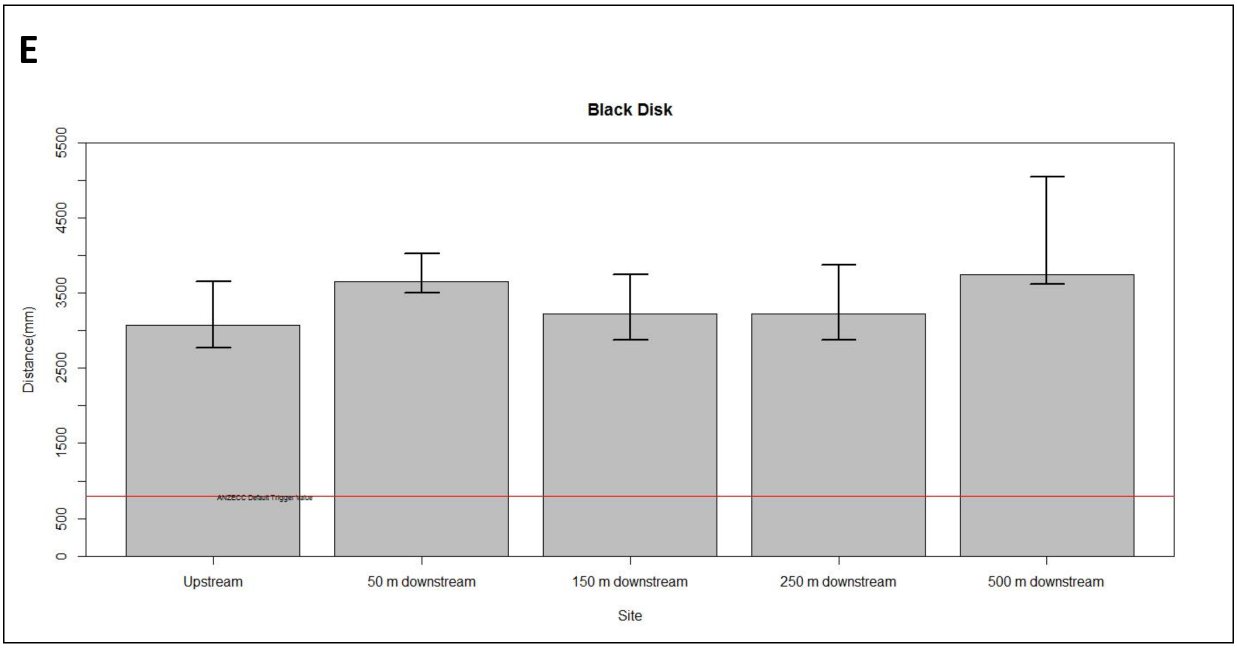


Figure 9: Results from water quality monitoring for (A) electrical conductivity (B) pH (C) suspended solids (D) turbidity (E) black disk. Median values are plotted and error bars represent the interquartile range.

Organic and biological parameters

Total Biological Oxygen Demand (BOD) showed no significant difference between the median of upstream sites and the median at any downstream monitoring site[16]. Mean and median BOD concentrations were less than the GWRC proposed limit of 2 g/m^3, although from the variability observed it would appear BOD downstream of the discharge could exceed the proposed GWRC limit periodically.

No significant difference was found between median *E. coli* concentrations upstream or at any monitoring site downstream of the outfall[17].

[16] Wilcoxon results for BOD: comparison of the upstream results to 50 m – W = 6, *p* = 0.6084, 150 m – W = 3.5, p = 0.4142; 250 m – W = 3.5, *p* = 0.4142; 500 m – W = 3.5, *p* = 0.4142.

[17] Wilcoxon results for *E. coli*: comparison of the upstream results to 50 m – W = 7.5, *p* = 1, 150 m – W = 7.5, p = 1; 250 m – W = 4, *p* = 0.6286; 500 m – W = 6.5, *p* = 1.

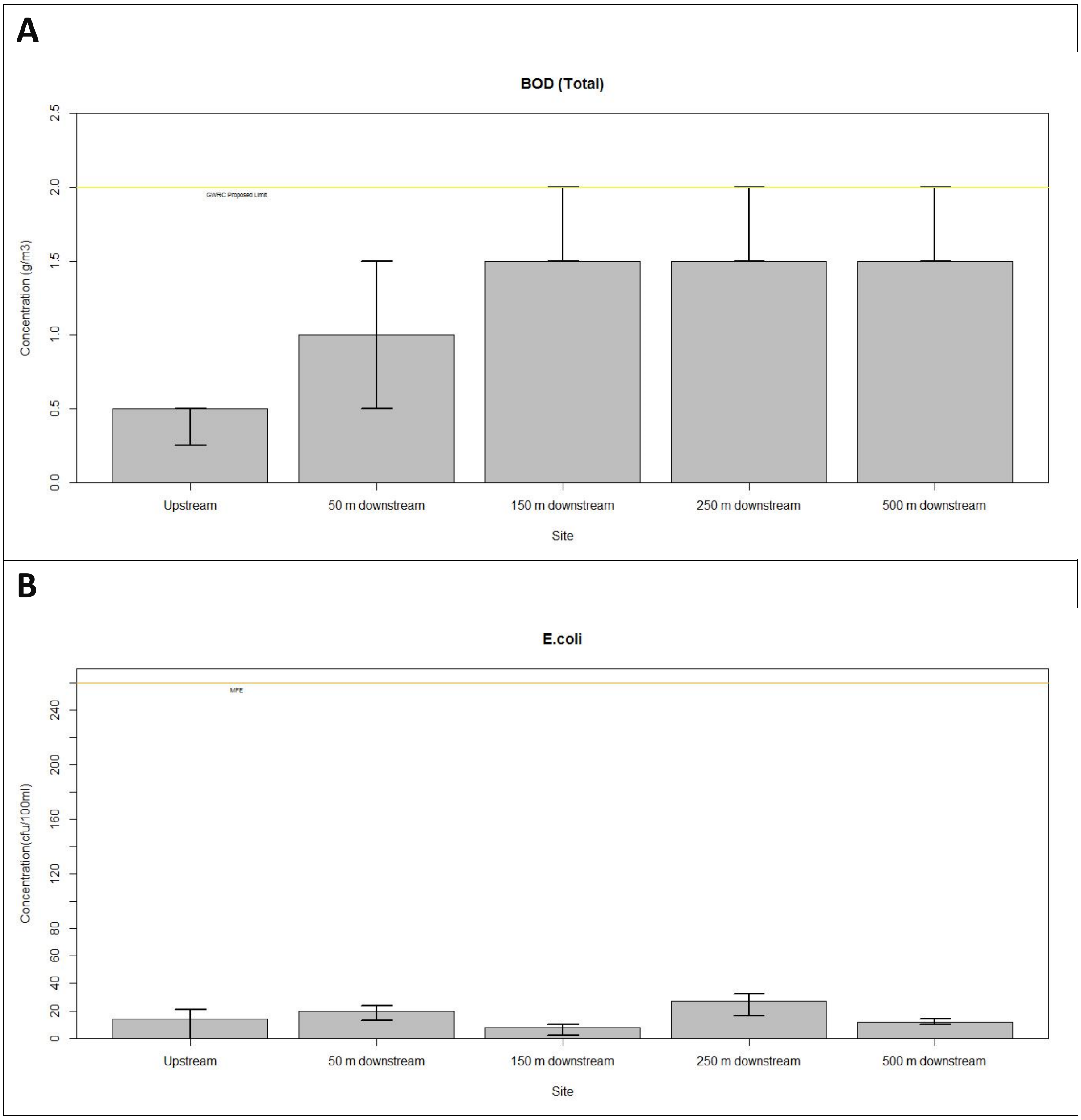


Figure 10: Results from water quality monitoring for (A) total BOD, and (B) *E. coli*. Median values are plotted and error bars represent the interquartile range.

Nutrients

Total nitrogen showed no significant difference in median values between upstream and any of the downstream monitoring sites[18]. Mean and median values were comfortably less than the ANZECC default trigger value of 0.6 g/m^3.

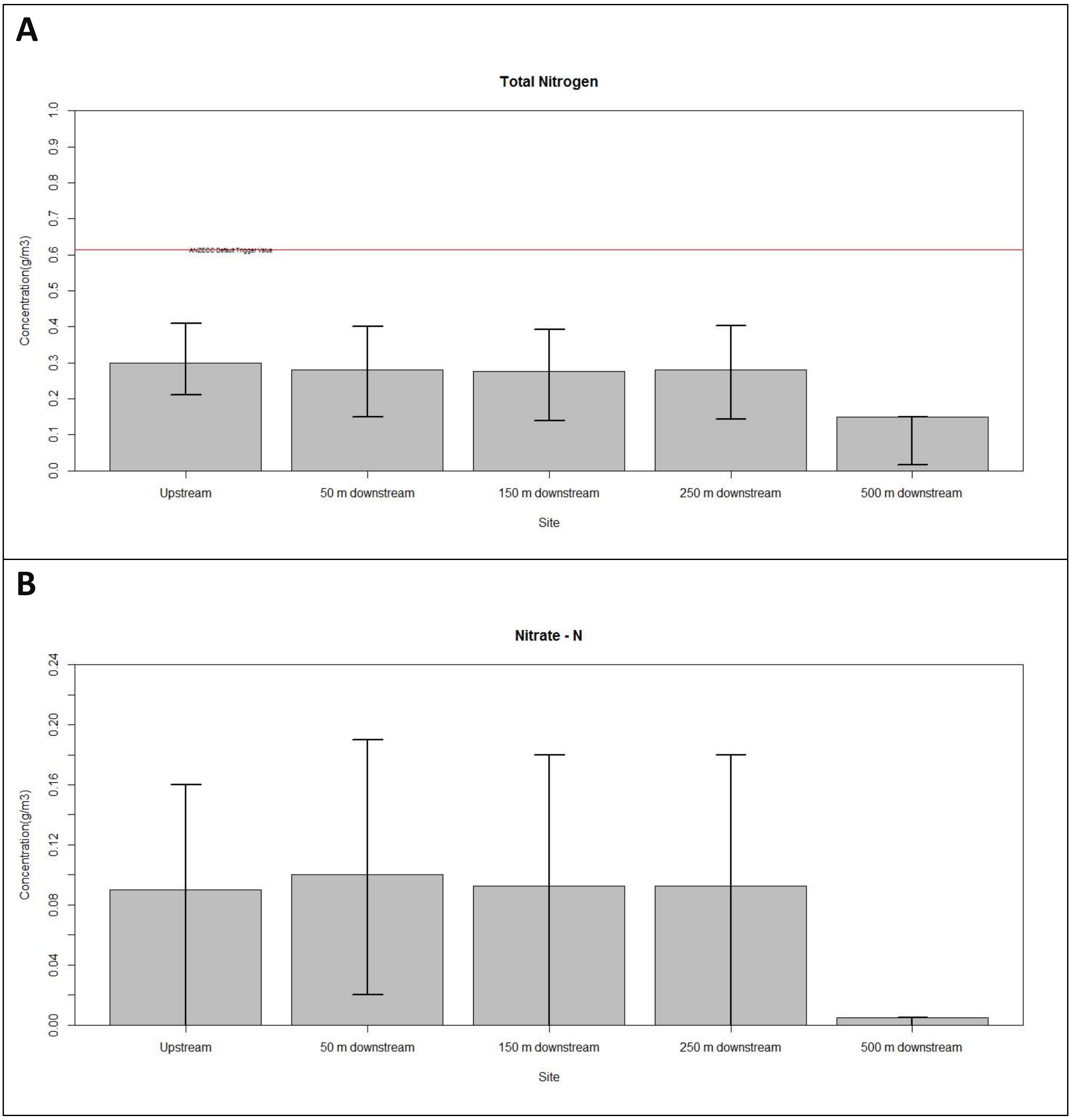
Nitrate-n concentrations showed no significant difference in median values between upstream and any of the downstream monitoring sites[19].

Dissolved Inorganic Nitrogen (DIN) concentrations showed no significant difference in median values between upstream and any of the downstream monitoring sites[20].

Dissolved reactive phosphorus concentrations showed no significant difference in median values between upstream and any of the downstream monitoring sites[21]. However, individual concentrations (both upstream and downstream of the outfall) did exceed both the ANZECC default trigger value and the GWRC proposed limit and median values 150 m downstream were equivalent to the ANZECC default trigger value. It is important to note, these results are likely to represent concentrations outside of the most concentrated area of the mixing zone as at the time they were collected it was not known that the most concentrated area of the plume lay close to, and quite discretely against, the TL riverbank.

All except one result for ammonia were less than laboratory detection limit. Targeted sampling within the most concentrated area of the plume for ammonia is recommended.

[18] Wilcoxon results for TN: comparison of the upstream results to 50 m – W = 14, *p* = 0.834, 150 m – W = 11.5, p = 0.8049; 250 m – W = 11.5, *p* = 0.8049; 500 m – W = 11, *p* = 0.3653.
[19] Wilcoxon results for nitrate: comparison of the upstream results to 50 m – W = 14, *p* = 0.834, 150 m – W = 11.5, p = 0.8049; 250 m – W = 11.5, *p* = 0.8049; 500 m – W = 11, *p* = 0.3653.
[20] Wilcoxon results for DIN: comparison of the upstream results to 50 m – W = 14, *p* = 0.8413, 150 m – W = 13, p = 0.5386; 250 m – W = 13, *p* = 0.5386; 500 m – W = 12, *p* = 0.2302.
[21] Wilcoxon results for DRP: comparison of the upstream results to 50 m – W = 10.5, *p* = 0.7488, 150 m – W = 9.5, p = 1; 250 m – W = 10.5, *p* = 1; 500 m – W = 8.5, *p* = 0.8778.


A
Total Nitrogen
Concentration(g/m3)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
ANZECC Default Trigger Value
Upstream
50 m downstream
150 m downstream
250 m downstream
500 m downstream
Site
B
Nitrate - N
Concentration(g/m3)
0.00
0.04
0.08
0.12
0.16
0.20
0.24
Upstream
50 m downstream
150 m downstream
250 m downstream
500 m downstream
Site

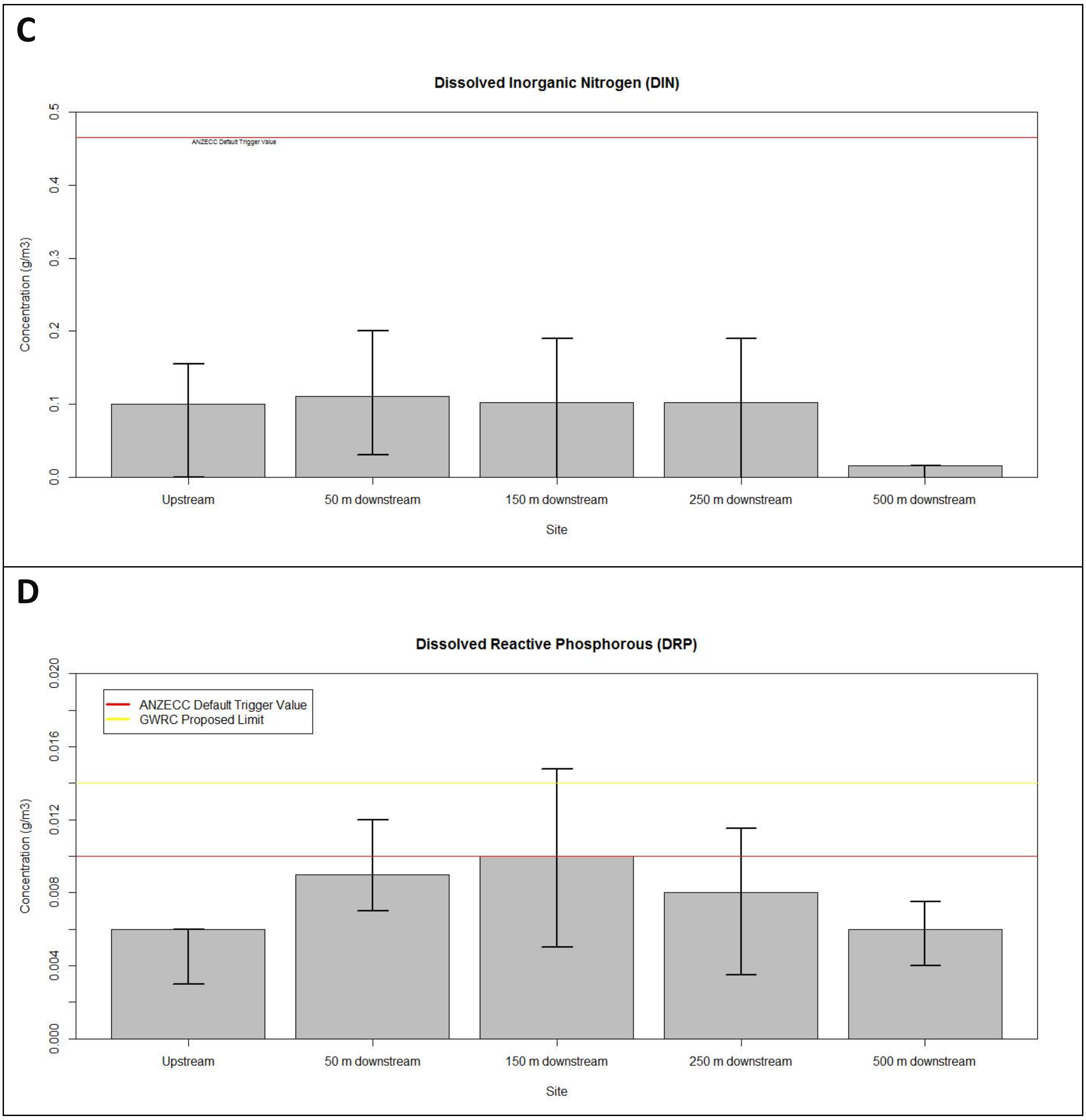


Figure 11: Results from water quality monitoring for (A) total nitrogen, (B) nitrate-n, (C) DIN, (D) DRP. Median values are plotted and error bars represent the interquartile range.

4.2 Discussion and conclusions

During the February mixing study it was found that comparatively high concentrations of DRP occurred within a <4 m lateral TL river edge zone. It is expected that most river water quality monitoring carried out in the past would have occurred beyond that zone, and if that is the case, existing data may well underrepresent contaminant concentrations. This is a point which needs to be confirmed.

As the low-flow season set-in, periphyton cover changes attributable to the treated wastewater discharge occurred. December within the mixing zone 150–190 m downstream periphyton cover relative to upstream cover was significantly increased, but not at 250–290 m. Over subsequent months — January, February, and April — the downstream-most site retained more 'clean' area relative to sites closer to the outfall within the mixing zone, and also compared to the upstream monitoring site. The upstream monitoring site featured comparatively slower water velocities, which is a site-attribute that helps explain the relatively high proportion of cover by periphyton there, compared to sites monitored within the mixing zone. Proportional cover by coarse long filamentous and thick mats was elevated during the months January–April; however this effect was somewhat discrete, which is apparent from the reduction in proportional cover at the point of the downstream-most periphyton site, at 250–290 m downstream of the outfall.

A localised accumulation of fine sediments was observed at the point 50–90 m downstream; this deposition was however not detected at the next closest site down river. At the time of monitoring the treated wastewater discharge reached the river in a relatively deep and slow flowing reach, which is somewhat contrasting other monitoring sites adopted in this programme. Therefore this reach of the river is likely to be more susceptible to deposition and accumulation of fine sediments — which are likely to be in higher concentrations considering the site's close proximity to the outfall.

Periphyton biomass showed somewhat of a similar trend to results from visual assessment of proportional cover. Although no biomass samples were collected at the site 250 m downstream of the outfall, biomass (both Chl. *a* and AFDM) underwent significant increases from upstream to 50–90 m and 150–190 m downstream. Based on the relative decline in proportional cover (from visual assessments described above) from 150–190 m to 250–290 m, it is logical to suggest that periphyton biomass would also peak in concentration within the zone 50–200 m downstream of the outfall, and that concentrations would have been relatively lower at 250–290 m, than at sites closer to the outfall.

On this premise, computation of AI results from data collected within the 50–190 m area of the mixing zone are likely to represent worst case conditions for the treated wastewater discharge. Values for AI of 100–200 represent healthy unpolluted conditions and greater values indicate increasing levels of organic pollution. An AI score of >400 indicates waters are starting to become impaired by pollution. The median score and interquartile range for the upstream site characterises that unaffected site as being 'healthy' in terms of organic pollution; while the consistently higher results, and wide interquartile ranges of results from 50–190 m downstream, suggest the higher levels of organic pollution are occurring. This result is perhaps not surprising, in the context of results from a treated wastewater mixing zone. The decline in AI from 50–90 m to 150–190 m downstream, tends to agree with the visual cover results and the notion that by 250–290 m downstream a lower AI could be anticipated. A difference in periphyton diversity was found between February and April at 150 m downstream, but not in results from upstream to 150–190 m downstream in April.

Biological Oxygen Demand and nitrogen compounds underwent increases, albeit not statistically significant increases, from upstream to downstream. More notably, DRP concentrations to a point where at 150 m downstream of the outfall a median concentration equivalent to the ANZECC default trigger value was returned. Water clarity was not significantly affected by the treated wastewater discharge, after mixing. These water quality results provide only an indication of conditions, as the sample size is small, and samples were collected outside of the most concentrated area of the discharge plume. During the mixing study, where DRP samples were collected at intervals across the plume, both laterally, and longitudinally, DRP concentrations five times that of mid-river concentrations remained 370 m downstream of the outfall.

Of relevance to the wider appraisal of effects to in-stream ecology associated with this treated wastewater discharge is a fish kill noted within the river edge zone around mid-day on 20-02-2013. One koura was found dead in the shallow edge zone at ca. 100 m downstream of the outfall; and at the same time a small eel was found dead, at ca. 200 m downstream of the outfall, in the same edge zone. In response to this find a pair of dusk-dawn DO measurements were taken, the findings of which are being reported separately by Forbes Ecology.

In conclusion, discharge from the Martinborough Wastewater Treatment Plant was found, under low-flow conditions, to result in a concentrated, relatively poorly mixed plume area which extended <4 m laterally across the river from the TL bank. The remainder of the river width at any point appeared to be more uniformly mixed relative to this concentrated edge zone. Given this edge zone’s close proximity to the bank water samples tend to be collected beyond this zone. Therefore, it is possible that data collected to date underestimate concentrations of treated wastewater contaminants within the Ruamahunga River. However, this monitoring programme has investigated patterns in periphyton growth relative to the outfall, over one of the most extreme low-flow seasons on record for this point in the Ruamahunga River. It appears from the periphyton work that the discharge is having a locally significant effect in increasing periphyton cover and biomass. Periphyton surveys show the effect of the treated discharge peaks within an area <190 m downstream of the outfall and reliable signs of diminishing periphyton cover are apparent by 250–290 m downstream of the outfall.

What remains somewhat unaccounted for in this work are those nutrient and other contaminant concentrations held within the most concentrated area of the plume, along the river's TL bank. During the monitoring period a fish kill was noted within two points along the most concentrated edge zone. Cumulatively, considering the sum of upstream concentrations (where they are elevated from other sources, such as in the case of DRP), concentrations rapidly mixed downstream of the outfall, and the relatively high concentrations from the poorly mixed TL area of the mixing zone, there is potential for the discharge to be causing cumulative effects downstream—beyond the reach of this monitoring programme.

5.0 GREYTOWN

5.1 Results – Papawai Stream

5.1.1 Mixing study

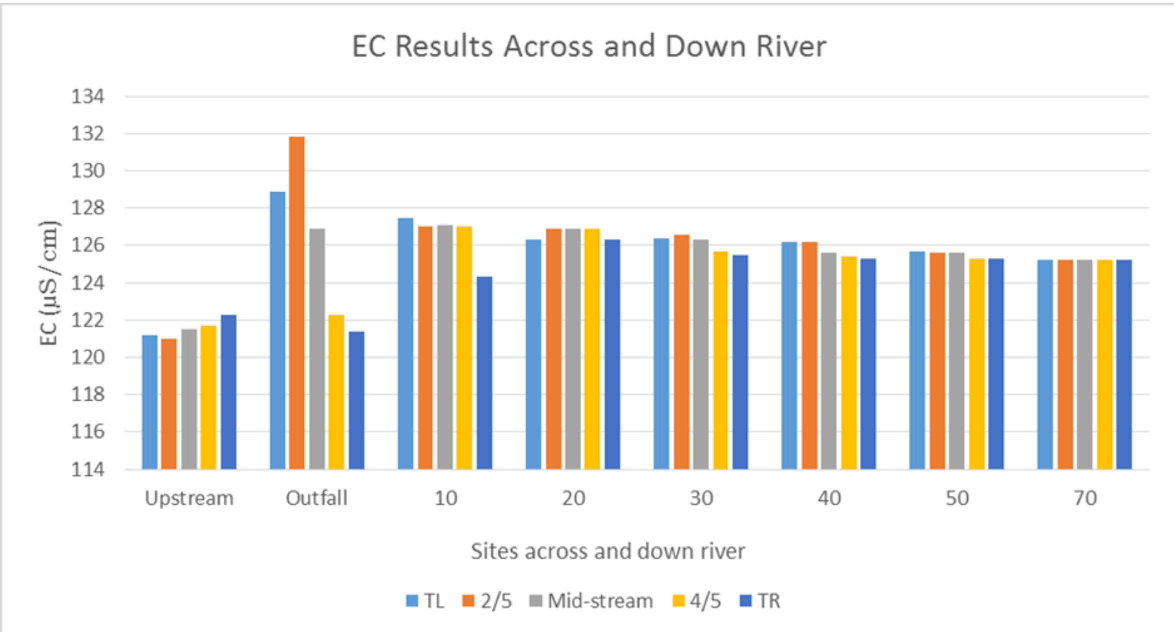
According to both EC and DRP results, lateral mixing across the river was poor, and was not complete at the point 50 m downstream of the outfall.

A more concentrated area of the plume was found to extend along the TL bank for more than 50 m downstream of the outfall. Thereafter, lateral mixing across the river becomes more complete, however at the 70 m mark full lateral mixing had still not occurred for DRP.

From this it can be taken that monitoring results collected from the TR bank at the 50 m downstream mark are likely to underrepresent some parameters of the treated wastewater plume.

Beyond 70 m downstream of the outfall, the Papawai Stream takes on a complex flow pattern, broadening substantially into a multi-channelled wetland complex, before narrowing in a downstream direction into a more singular channel, with abundant macrophytes islands. This latter feature is likely to help ensure mixing has occurred prior to the next downstream monitoring station, located on the 90° bend to the TR at 200 m downstream.

A



B

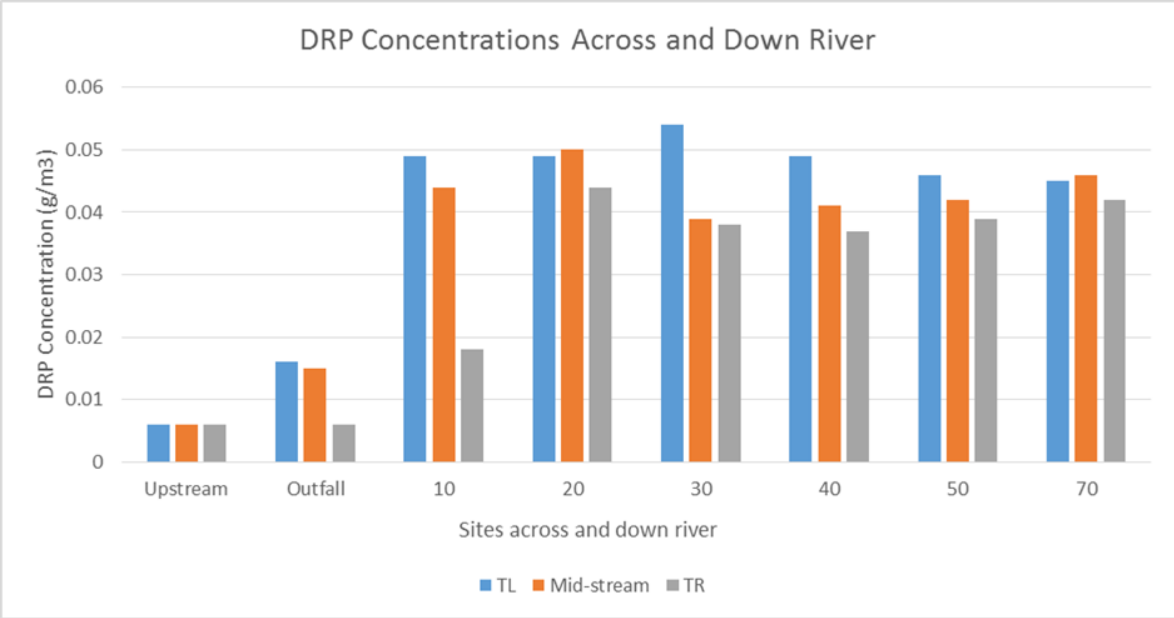


Figure 12: Analysis of treated wastewater mixing at Greytown, within the Papawai Stream, with regard to (A) EC across and downriver, (B) DRP concentrations across and downriver.

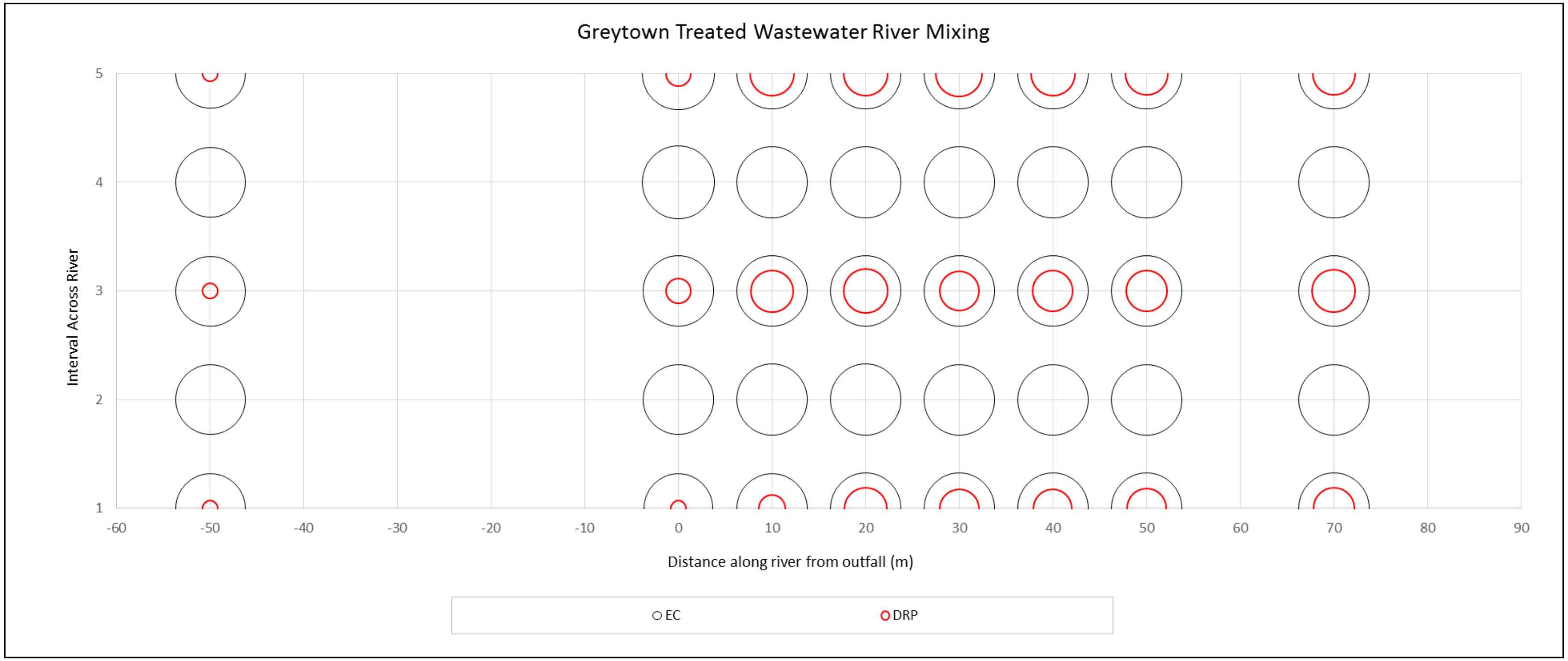


Figure 13: Electrical Conductivity and DRP results with distance across and downstream of the outfall. Bottom of the plot is TR, top is TL. Outfall is located at 0 m on TL. Distance downstream is from left to right across page.

5.1.2 Water quality

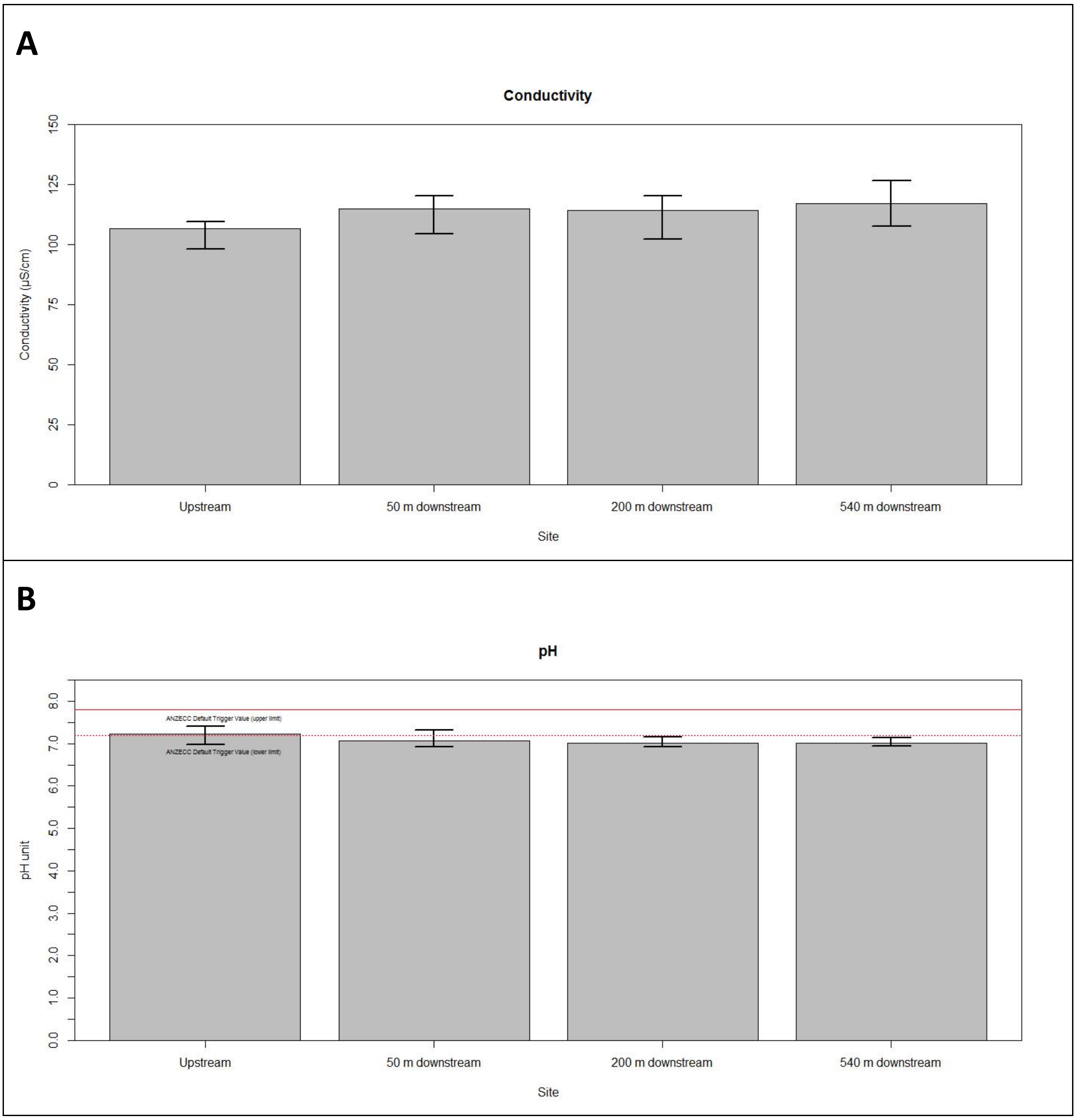
Indicator and physical parameters

No statistically significant difference was found in comparisons of median upstream and any median results for EC at any of the downstream monitoring sites within the Papawai Stream[22].

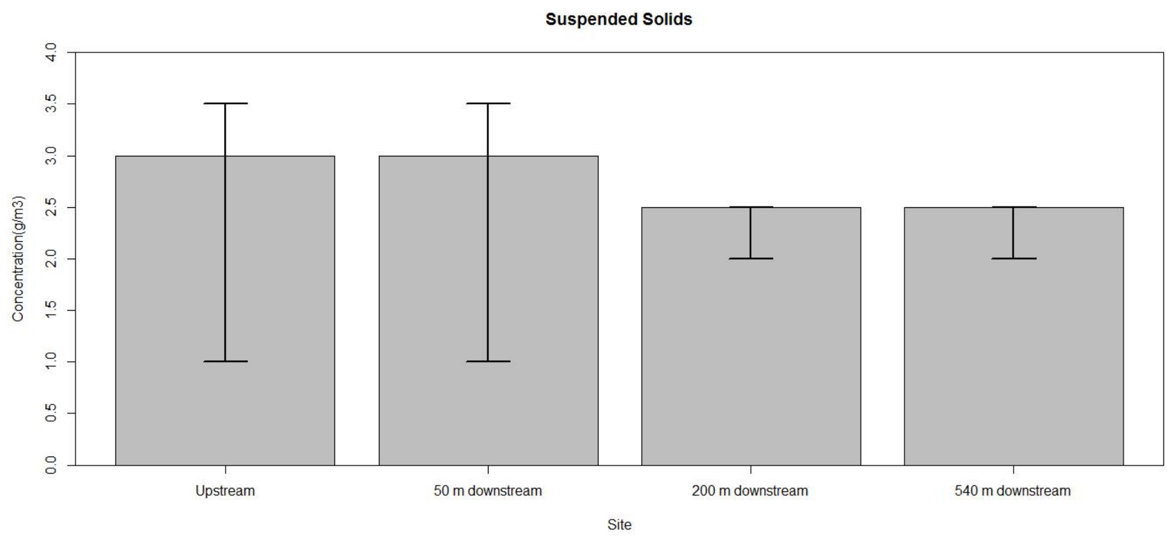
No statistically significant difference was found in comparisons of median upstream and any median results for pH at any of the downstream monitoring sites within the Papawai Stream[23]. The discharge shifted median pH values, downstream of the discharge, from within to marginally below the lower bound of the ANZECC default trigger value range.

The discharge caused no significant difference to suspended sediment concentrations at any of the downstream sites monitored within the Papawai Stream[24]. The discharge caused no significant difference to median turbidity values at monitoring sites downstream of the discharge within the Papawai Stream[25].

[22] Wilcoxon results for EC: comparison of the upstream results to 50 m – W = 18, p = 0.09272, 200 m – W = 19, p = 0.1139; 540 m – W = 17, p = 0.07445.
[23] Wilcoxon results for pH: comparison of the upstream results to 50 m – W = 54, p = 0.09199, 200 m – W = 52.5, p = 0.1234; 540 m – W = 53.5, p = 0.1017.
[24] Wilcoxon results for SS: comparison of the upstream results to 50 m – W = 39.5, p = 0.9638, 200 m – W = 49.5, p = 0.4288; 540 m – W = 49.5, p = 0.4288.
[25] Wilcoxon results for turbidity: comparison of the upstream results to 50 m – W = 22, p = 0.1118, 200 m – W = 50.5, p = 0.4011; 540 m – W = 63, p = 0.05194.


A
Conductivity
Conductivity (µS/cm)
0
25
50
75
100
125
150
Upstream
50 m downstream
200 m downstream
540 m downstream
Site
B
pH
pH unit
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
ANZECC Default Trigger Value (upper limit)
ANZECC Default Trigger Value (lower limit)
Upstream
50 m downstream
200 m downstream
540 m downstream
Site

C



D

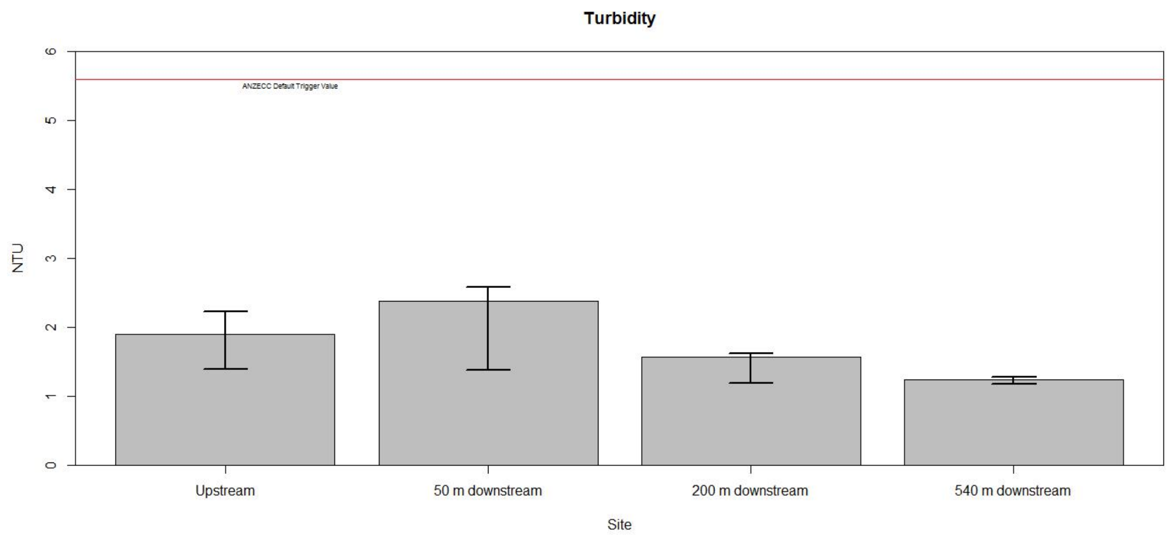
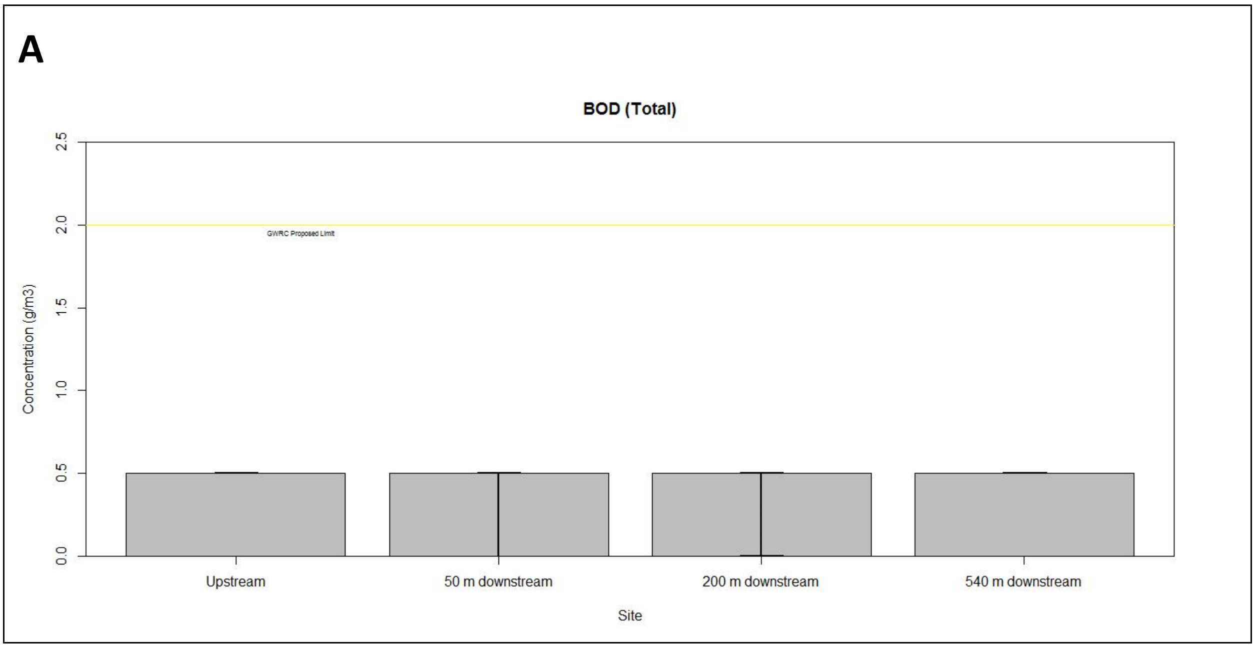


Figure 14: Results from water quality monitoring for (A) EC, (B) pH, (C) suspended solids, and (D) turbidity. Median values are plotted and error bars represent the interquartile range.

Organic and biological parameters

The discharge caused no significant difference to median BOD values at monitoring sites downstream of the discharge within the Papawai Stream[26]. The discharge caused no significant difference to median *E. coli* values at monitoring sites downstream of the discharge within the Papawai Stream[27].



[26] Wilcoxon results for BOD: comparison of the upstream results to 50 m – W = 32.5, p = 0.4295, 200 m – W = 37, p = 0.737; 540 m – W = 40.5, p = 1.
[27] Wilcoxon results for *E. coli*: comparison of the upstream results to 50 m – W = 39, p = 0.9295, 200 m – W = 48.5, p = 0.5067; 540 m – W = 54.5, p = 0.2318.

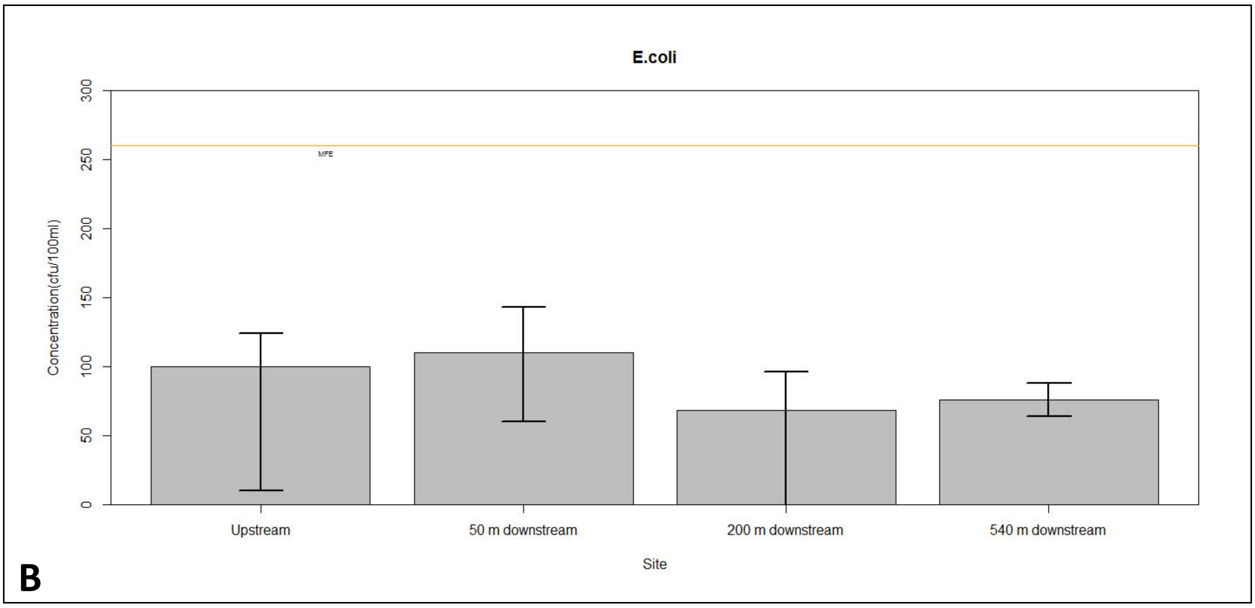


Figure 15: Results from water quality monitoring for (A) total BOD, and (B) E. coli. Median values are plotted and error bars represent the interquartile range.

Nutrients

Median total nitrogen concentrations were found to be greater than the ANZECC default trigger value upstream of the outfall. The discharge had a highly statistically significant ($p = 0.001234$) effect on total nitrogen concentrations at the point 50 m downstream of the outfall and the increase remained significant ($p = 0.01512$) at the point 200 m downstream of the outfall. By 540 m downstream, the difference in median total nitrogen concentrations had reduced to be not statistically significant ($p = 0.1118$). However, both mean and median concentrations, from the outfall to the point 540 m downstream, were found to be well in excess of the respective ANZECC default trigger value for total nitrogen.

The discharge did elevate nitrate-n at monitoring sites downstream of the outfall, however, any difference between median values upstream and downstream was not statistically significant[28].

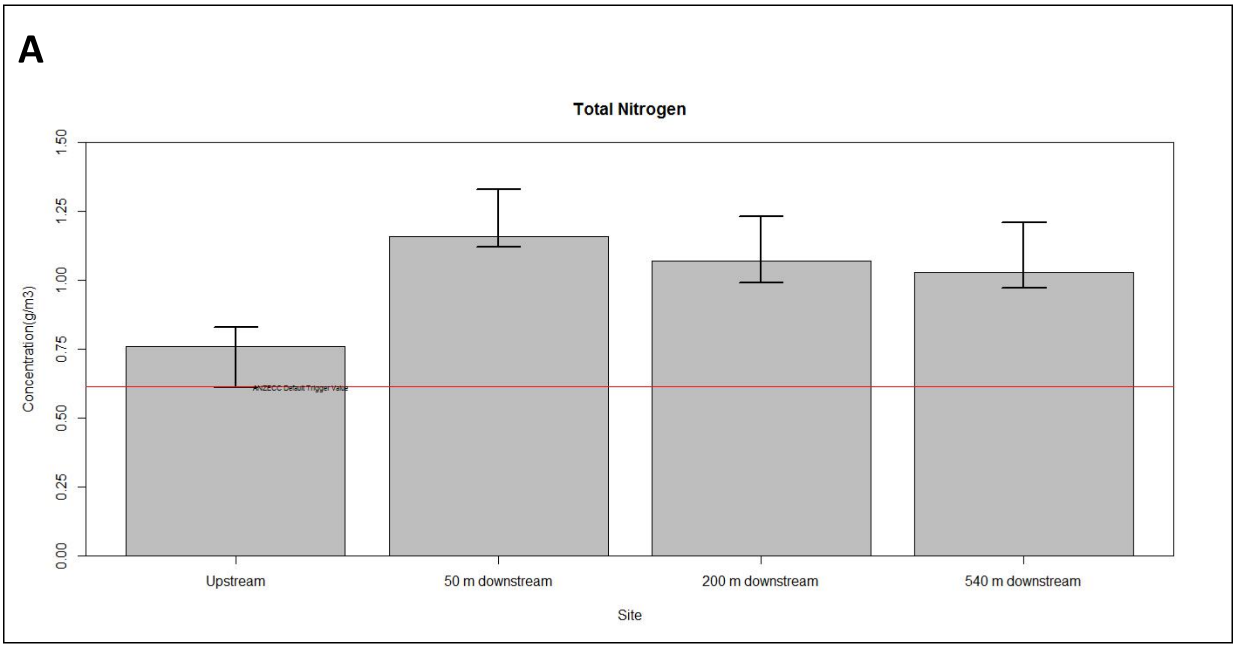
While there was no statistically significant difference between median upstream and any median value from the downstream monitoring sites, DIN values are high in the Papawai

[28] Wilcoxon results for *nitrate-n*: comparison of the upstream results to 50 m – $W = 39$, $p = 0.9294$, 200 m – $W = 32.5$, $p = 0.5074$; 540 m – $W = 31$, $p = 0.4265$.

Stream and the discharge did appear to make a notable contribution to those DIN concentrations[29].

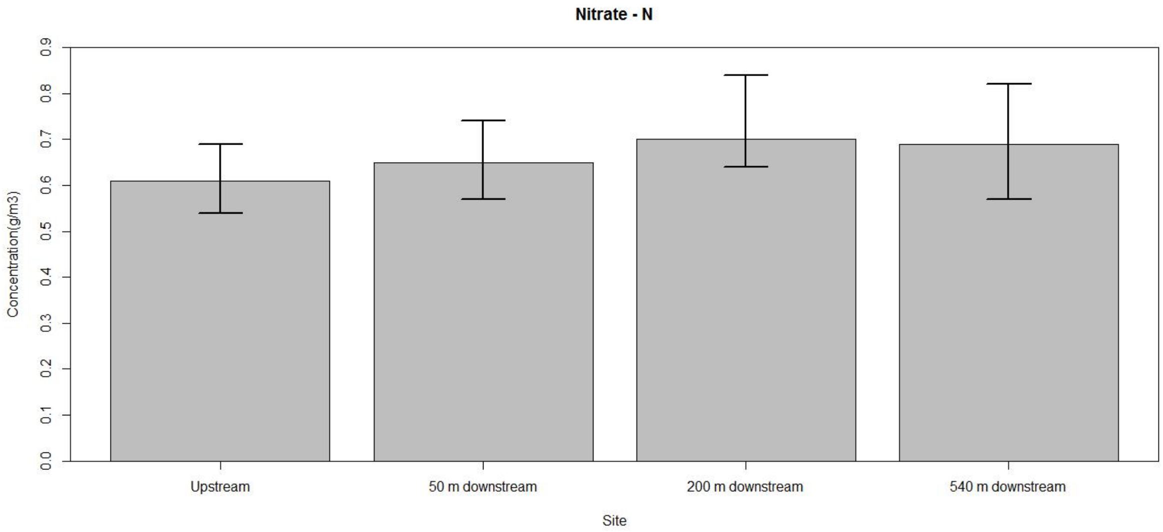
This discharge was found to have a statistically very highly significant (p = 0.0004) effect on DRP concentrations increasing mean and median DRP concentrations well above ANZECC default trigger value and the GWRC proposed limit for DRP. There is a high degree of certainty associated with this result—that the discharge made a very significant contribution of DRP to the Papawai Stream over the monitoring period, in excess of relevant ecological guideline values[30].

Ammonia-nitrogen concentrations at all monitoring sites showed comfortable compliance with the ANZECC acute toxicity trigger value.

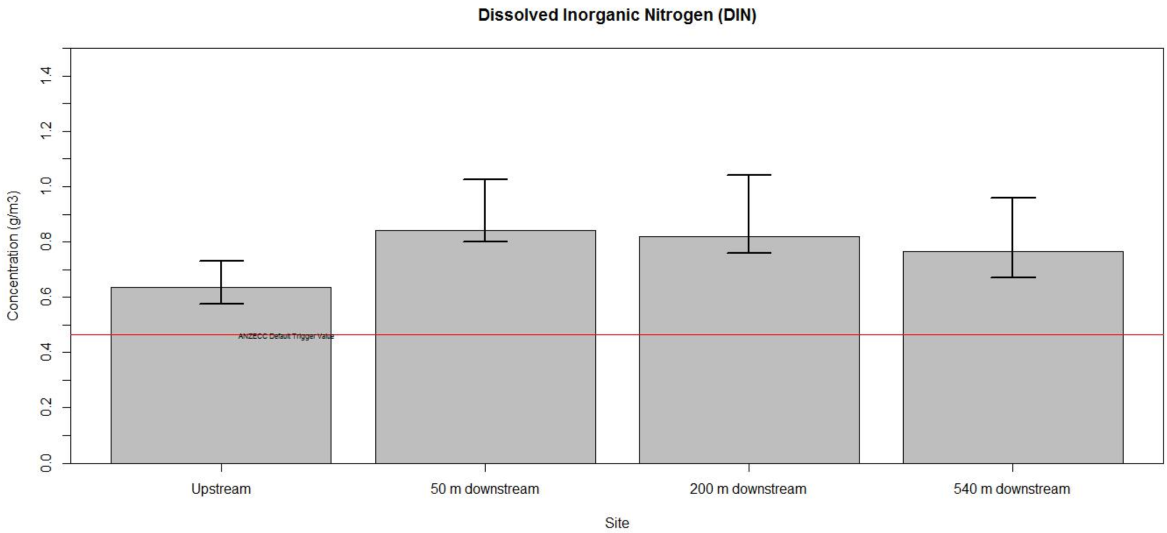


[29] Wilcoxon results for DIN: comparison of the upstream results to 50 m – W = 21, *p* = 0.09391, 200 m – W = 24, *p* = 0.1615; 540 m – W = 29.5, *p* = 0.3536.
[30] Wilcoxon results for DRP: comparison of the upstream results to 50 m – W = 0, *p* = 0.0004095, 200 m – W = 0, *p* = 0.0004066; 540 m – W = 0, *p* = 0.0004066.

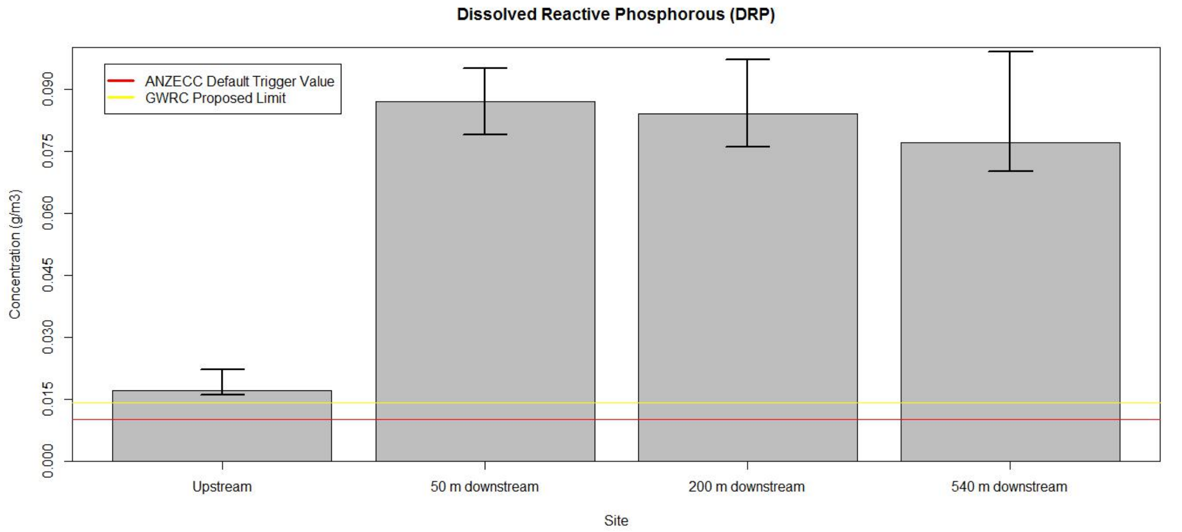
B


Nitrate - N
Concentration(g/m3)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Upstream
50 m downstream
200 m downstream
540 m downstream
Site

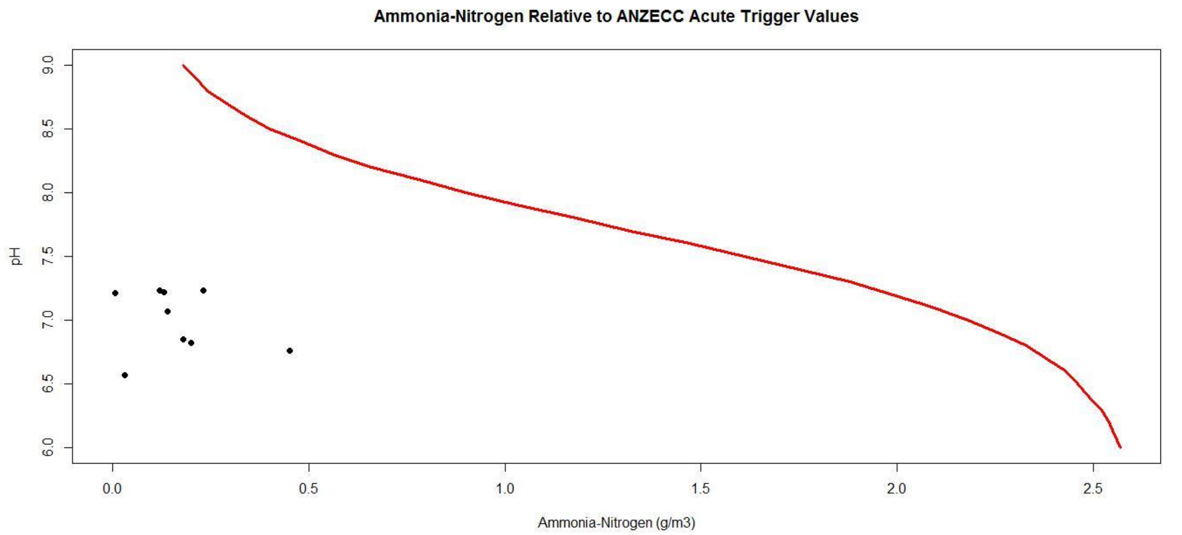
C


Dissolved Inorganic Nitrogen (DIN)
Concentration (g/m3)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
ANZECC Default Trigger Value
Upstream
50 m downstream
200 m downstream
540 m downstream
Site

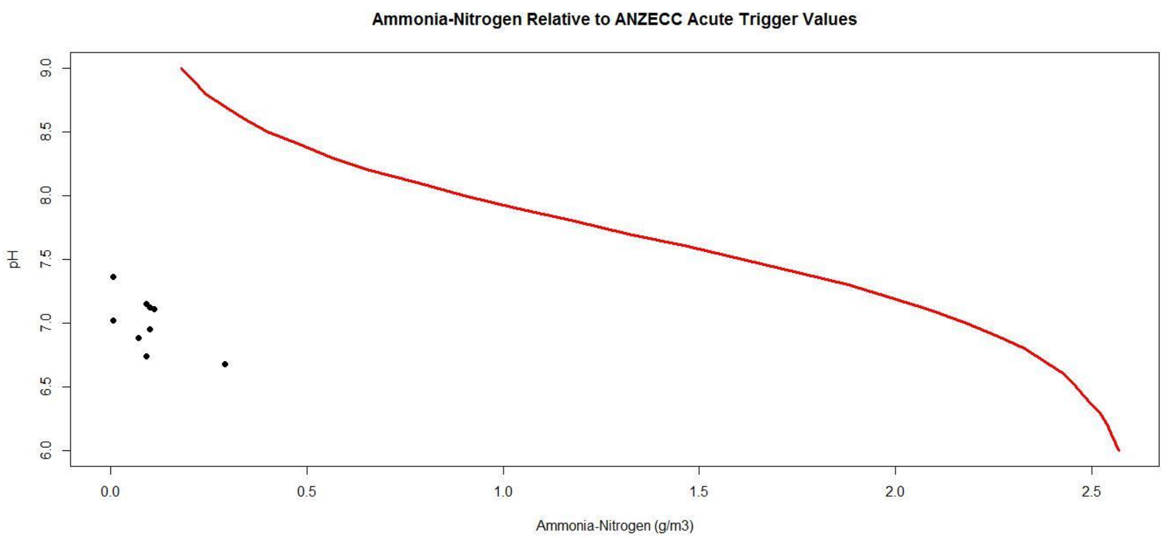
D


Dissolved Reactive Phosphorous (DRP)
ANZECC Default Trigger Value
GWRC Proposed Limit
Concentration (g/m3)
0.000
0.015
0.030
0.045
0.060
0.075
0.090
Upstream
50 m downstream
200 m downstream
540 m downstream
Site

E


Ammonia-Nitrogen Relative to ANZECC Acute Trigger Values
pH
6.0
6.5
7.0
7.5
8.0
8.5
9.0
0.0
0.5
1.0
1.5
2.0
2.5
Ammonia-Nitrogen (g/m3)

F



G

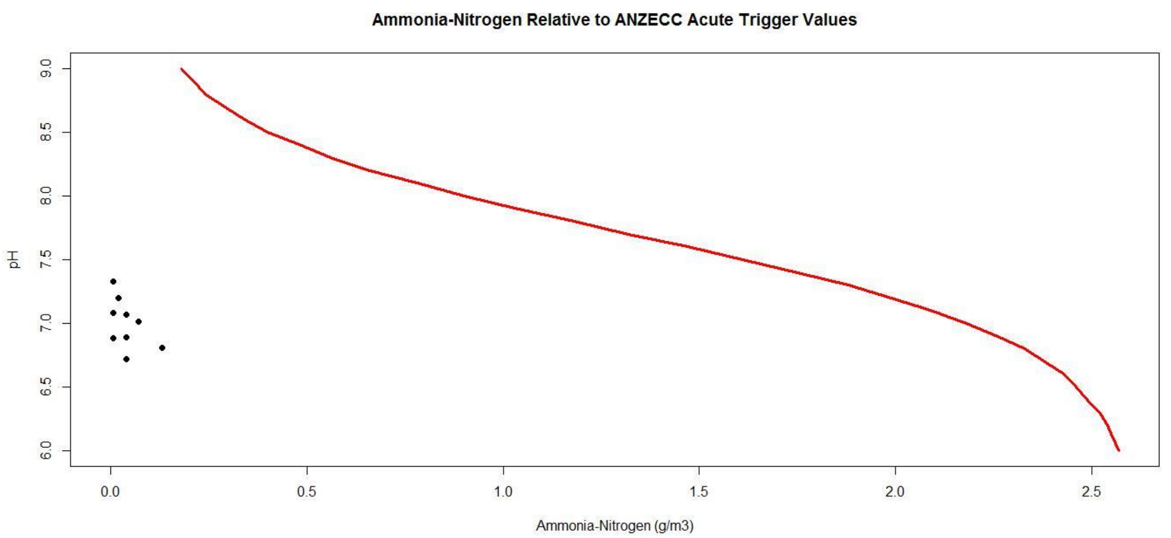


Figure 16: Results from water quality monitoring for (A) total nitrogen, (B) nitrate-n, (C) DIN, (D) DRP, (E) ammonia-nitrogen relative to ANZECC acute toxicity trigger value—50 m, (F) ammonia-nitrogen relative to ANZECC acute toxicity trigger value—200 m, (G) ammonia-nitrogen relative to ANZECC acute toxicity trigger value—540 m. Median values are plotted and error bars represent the interquartile range.

5.2 Results – Ruamahunga River

5.2.1 Substrate composition

Substrates across all sites are reasonably uniform in the context of a periphyton assessment. Substrates at all sites are predominantly gravel, with the next most prominent category being small cobbles.

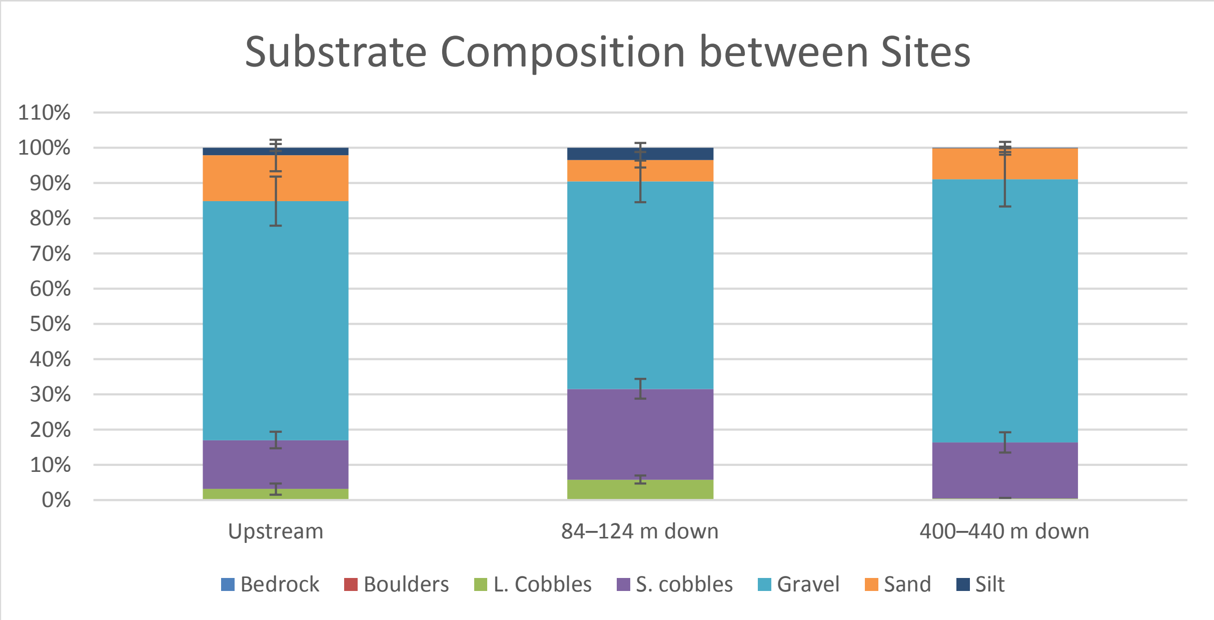


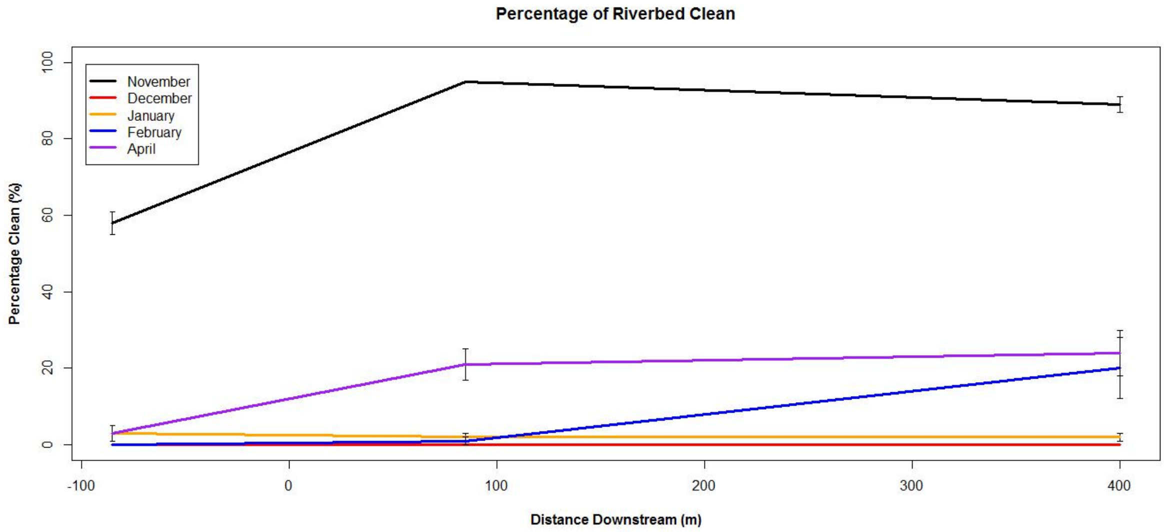
Figure 17: Substrate composition of periphyton monitoring sites within the Ruamahunga River at Greytown. Plotted values are the mean of all observations and error bars represent one standard error of the mean.

5.2.2 Periphyton

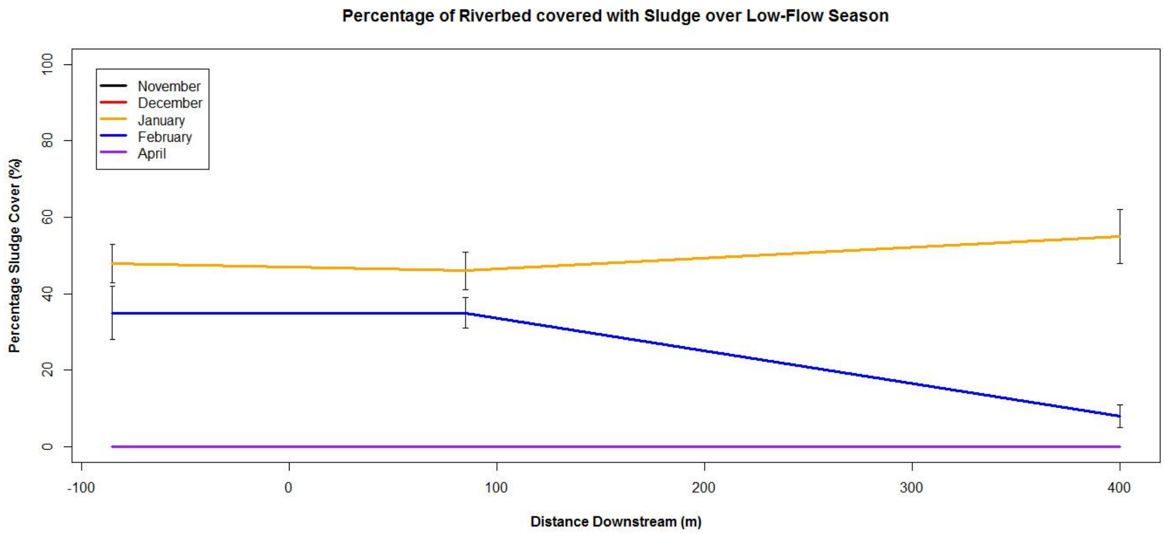
Visual assessment

When upstream and downstream results are compared the contribution of flows from the Papawai Stream to the Ruamahunga River did not appear to cause notable changes in the amount of riverbed clean of algae cover, or the proportion of sludge cover, at either 84–124 m or 400–440 m downstream of the convergence. Riverbed cover by thick mats and coarse long filamentous algae did not exceed the visual assessment cover thresholds of 60 and 30% respectively. Little difference between monitoring sites was observed in the proportion of the riverbed covered with fine sediments.

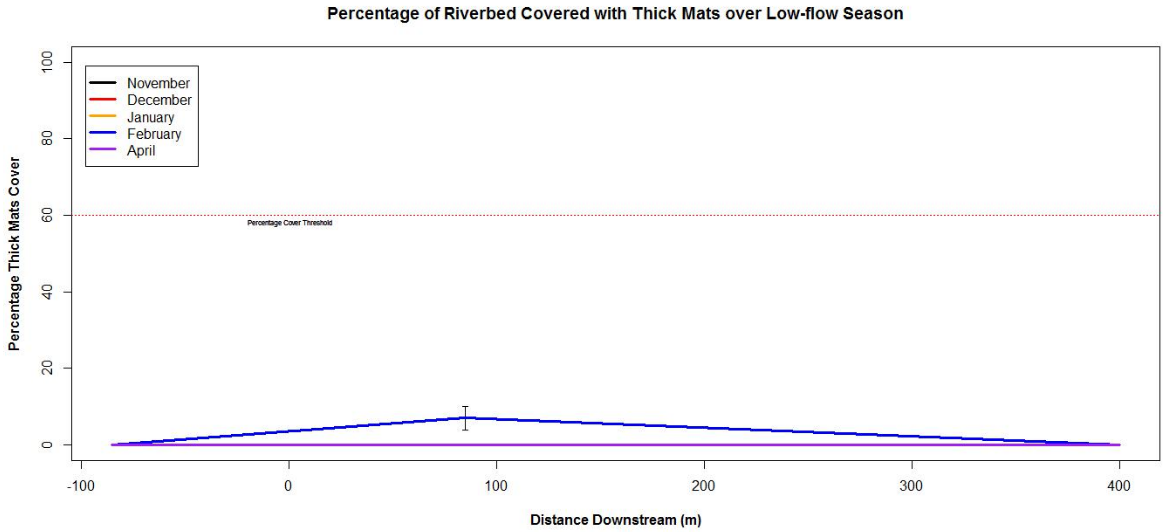
A


Percentage of Riverbed Clean
November
December
January
February
April
Percentage Clean (%)
0
20
40
60
80
100
-100
0
100
200
300
400
Distance Downstream (m)

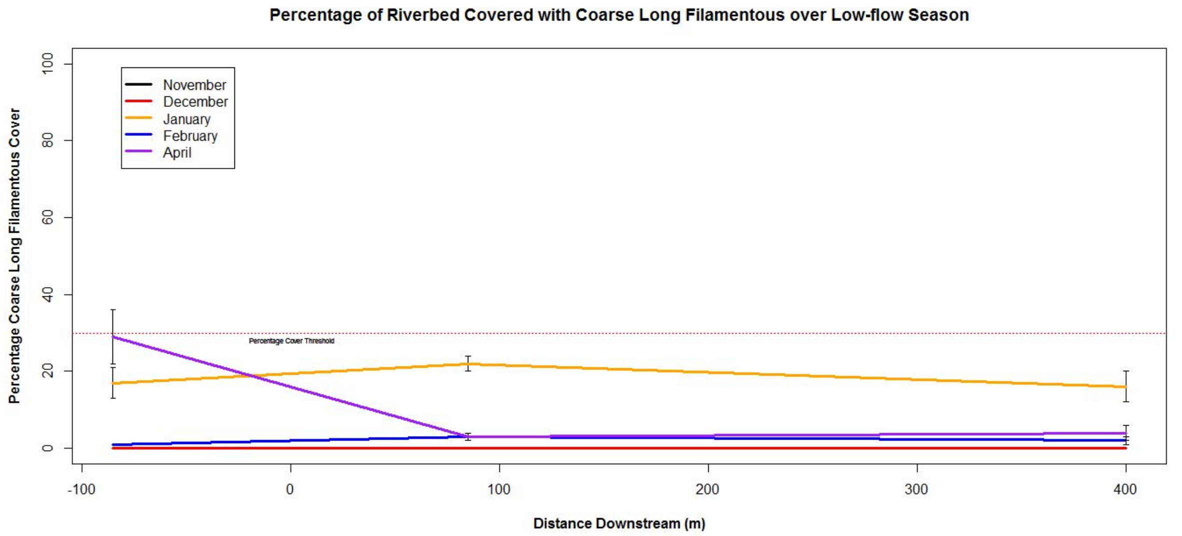
B


Percentage of Riverbed covered with Sludge over Low-Flow Season
November
December
January
February
April
Percentage Sludge Cover (%)
0
20
40
60
80
100
-100
0
100
200
300
400
Distance Downstream (m)

C


Percentage of Riverbed Covered with Thick Mats over Low-flow Season
Percentage Thick Mats Cover
Distance Downstream (m)
November
December
January
February
April
Percentage Cover Threshold
0
20
40
60
80
100
-100
0
100
200
300
400

D


Percentage of Riverbed Covered with Coarse Long Filamentous over Low-flow Season
Percentage Coarse Long Filamentous Cover
Distance Downstream (m)
November
December
January
February
April
Percentage Cover Threshold
0
20
40
60
80
100
-100
0
100
200
300
400

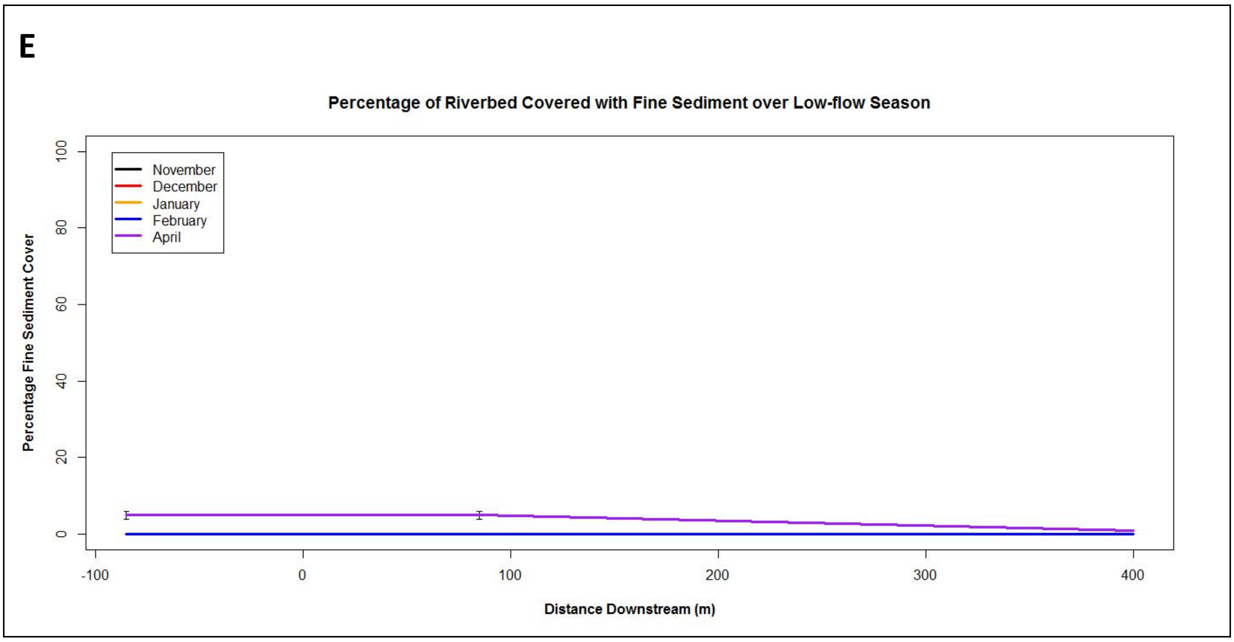


Figure 18: Results from visual assessment of the Ruamahunga River, upstream and downstream of the Papawai confluence, between November 2012 and April 2013 for (A) % riverbed clean (B) % cover by sludge (C) % cover by thick mats (D) % cover by coarse long filamentous algae (E) % cover by fine sediment. Error bars represent standard error of the mean.

5.2.3 Water quality

Indicator and physical parameters

Comparison of EC results collected upstream and at two points downstream of the point of convergence between the Ruamahunga River and the Papawai Stream shows no significant difference in median EC values[31].

No statistically significant difference was found between median pH values in the Ruamahunga River, upstream and 85 m or 400 m downstream, of the Papawai convergence[32]. Median pH results were around the upper bounds of the ANZECC default trigger value range at all sites surveyed.

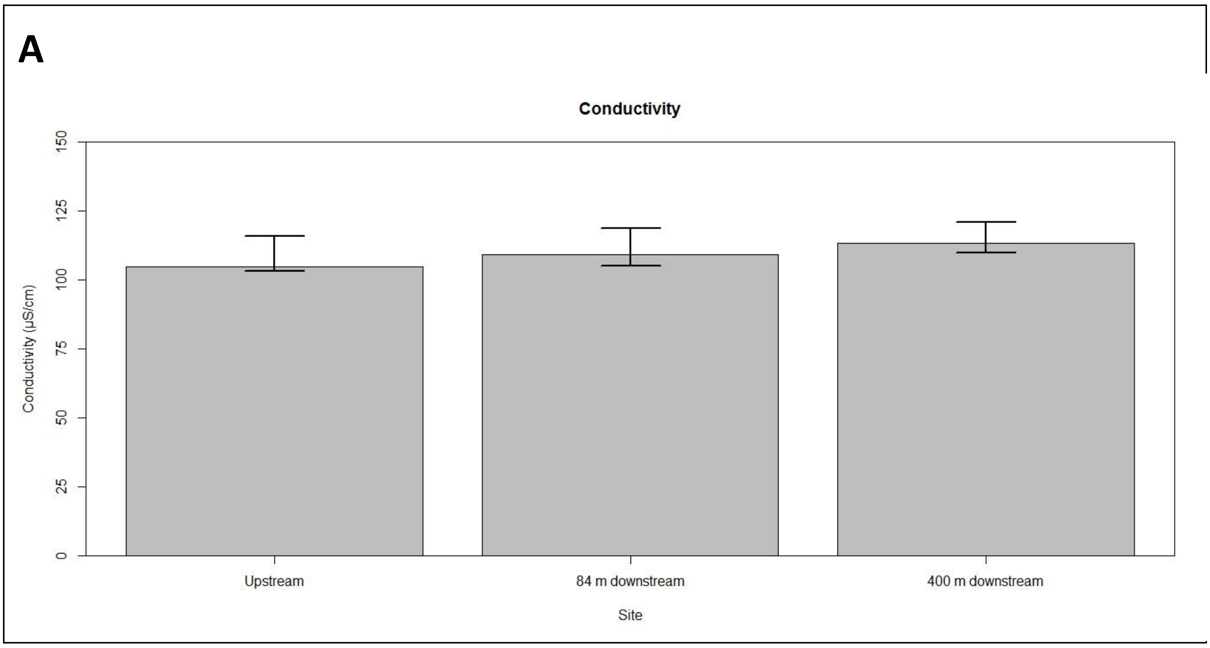
[31] Wilcoxon results for EC: comparison of the upstream results to 85 m – W = 4, p = 0.3429, 400 m – W = 3, p = 0.2.

[32] Wilcoxon results for pH: comparison of the upstream results to 85 m – W = 11, p = 0.4857, 400 m – W = 13, p = 0.2.

No statistically significant difference in suspended solids concentrations was found between sites located upstream and downstream of the Papawai Stream convergence[33].

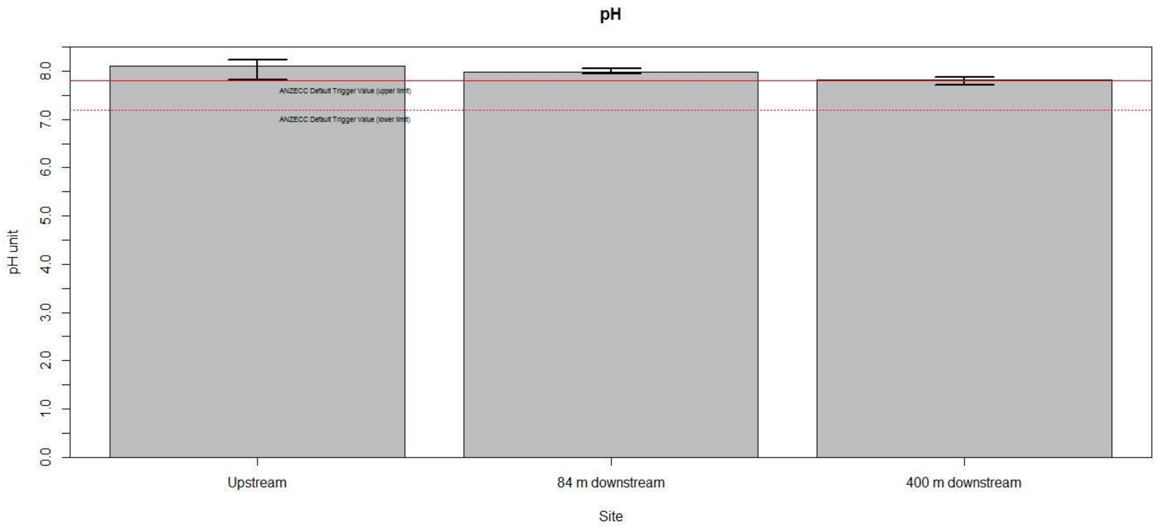
No statistically significant difference in turbidity results was found between monitoring sites located upstream and downstream of the Papawai Stream convergence[34].

No statistically significant difference in black disk results was found between monitoring sites located upstream and downstream of the Papawai Stream convergence[35].

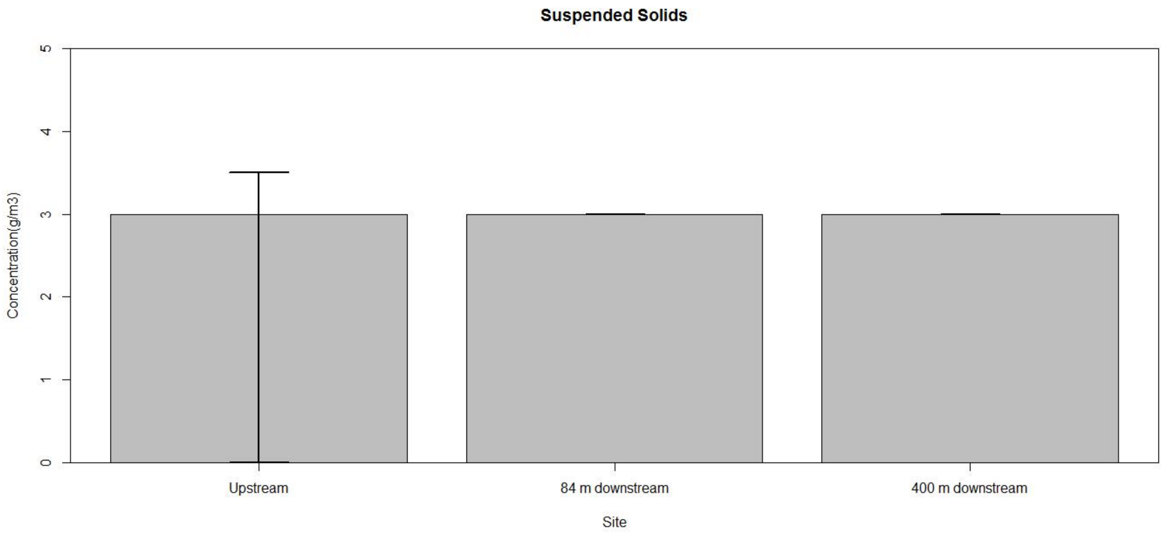


[33] Wilcoxon results for SS: comparison of the upstream results to 85 m – W = 5, p = 1, 400 m – W = 5, p = 1.
[34] Wilcoxon results for turbidity: comparison of the upstream results to 85 m – W = 9, p = 0.8857, 400 m – W = 9, p = 0.8857.
[35] Wilcoxon results for black disk: comparison of the upstream results to 85 m – W = 1, p = 1, 400 m – W = 2, p = 1.

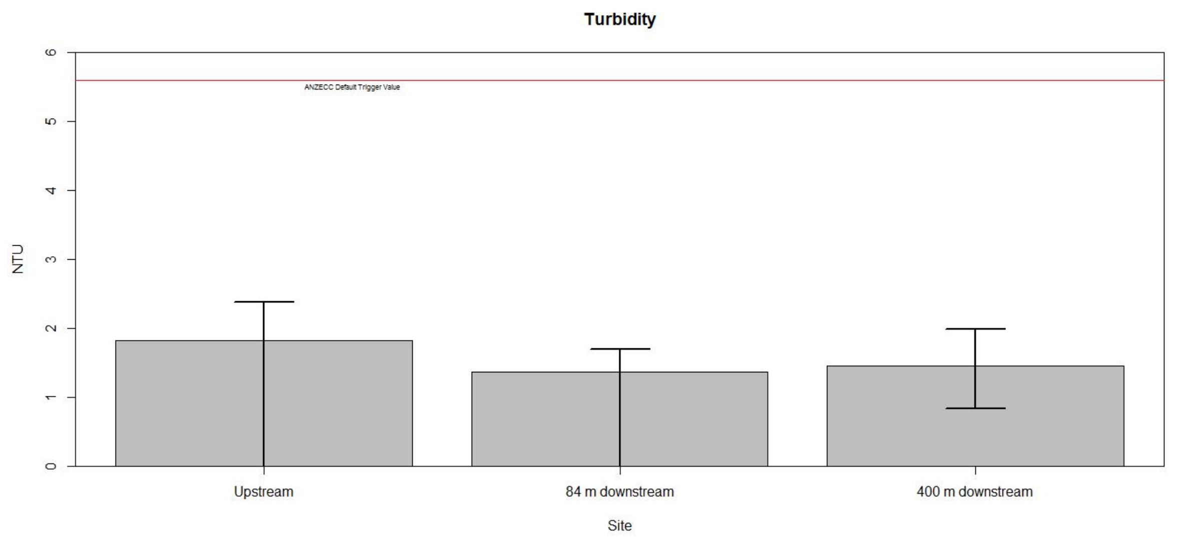
B


pH
pH unit
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
ANZECC Default Trigger Value (upper limit)
ANZECC Default Trigger Value (lower limit)
Upstream
84 m downstream
400 m downstream
Site

C


Suspended Solids
Concentration(g/m3)
0
1
2
3
4
5
Upstream
84 m downstream
400 m downstream
Site

D



E

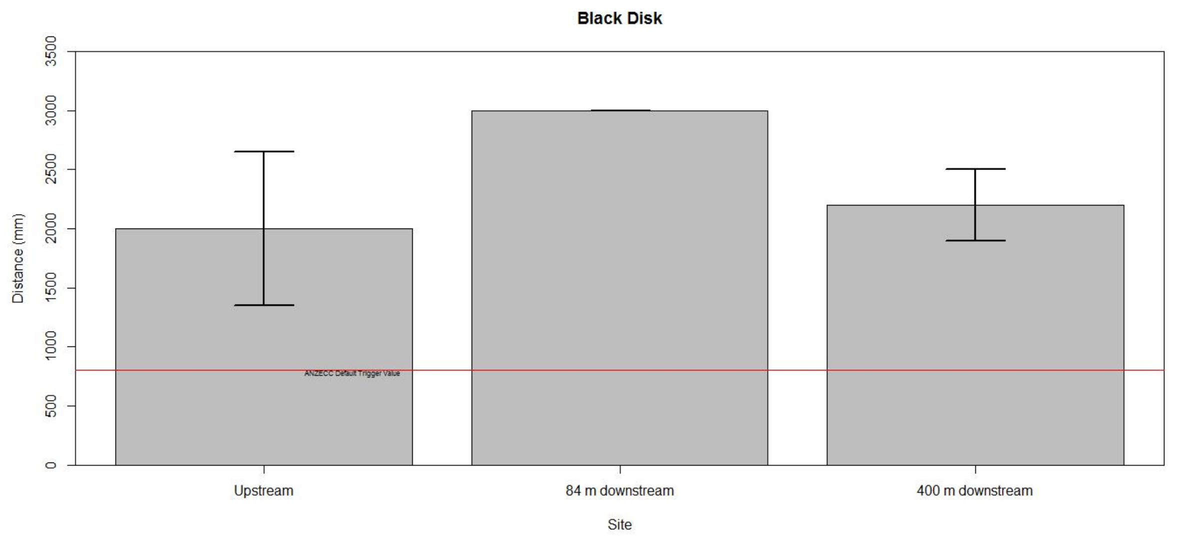


Figure 19: Results from water quality monitoring for (A) EC (B) pH (C) suspended solids (D) turbidity (E) black disk. Median values are plotted and error bars represent the interquartile range.

Organic and biological parameters

Results for BOD were returned as less than laboratory detection limits for all three sites surveyed within the Ruamahunga River, up and downstream of the Papawai Stream convergence.

No statistically significant difference in *E. coli* results was found between monitoring sites located upstream and downstream of the Papawai Stream convergence[36].

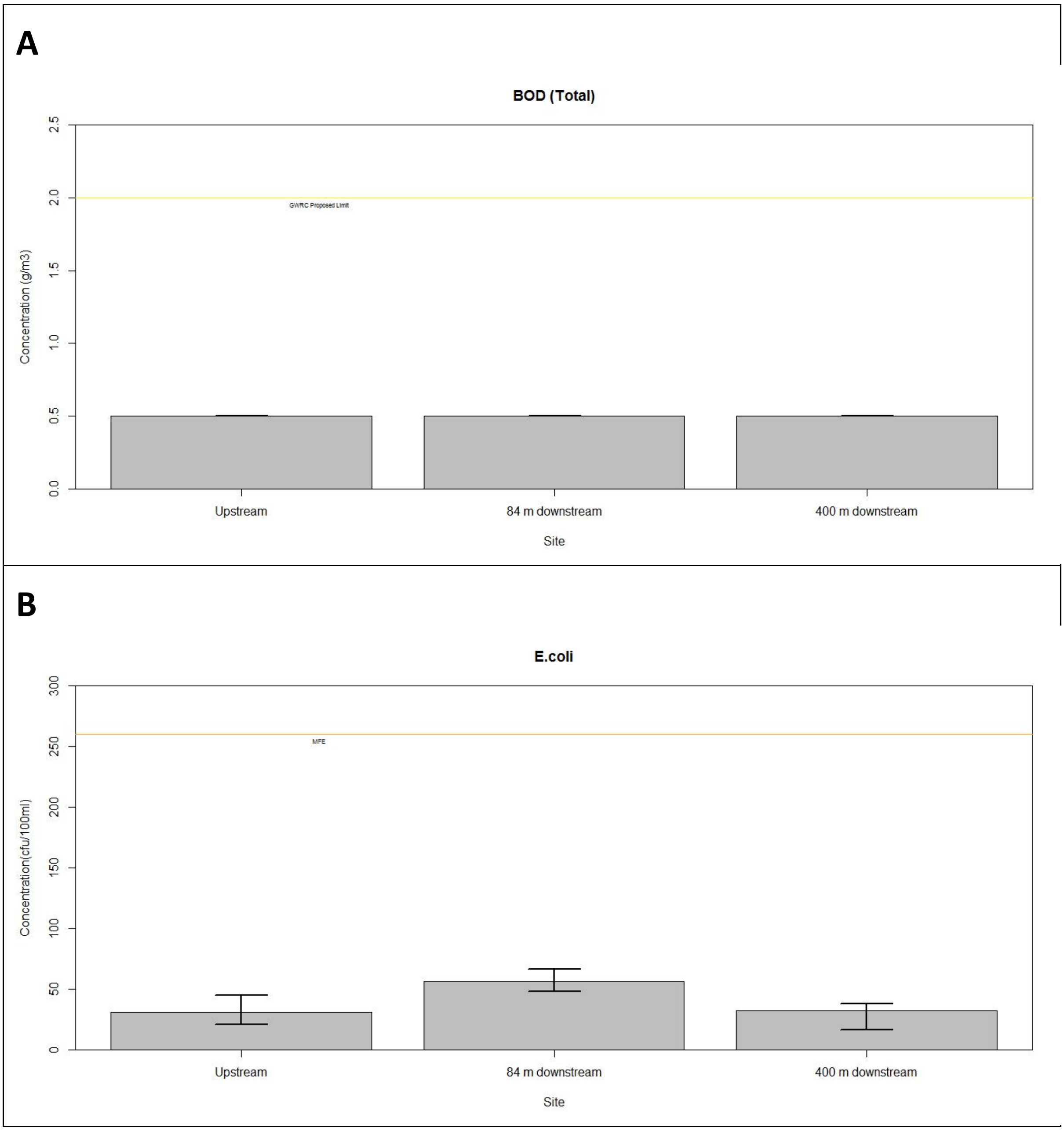


Figure 20: Results from water quality monitoring for (A) total BOD, and (B) *E. coli*. Median values are plotted and error bars represent the interquartile range.

[36] Wilcoxon results for *E. coli*: comparison of the upstream results to 85 m – W = 1, $p = 0.2$, 400 m – W = 3, $p = 0.7$.

Nutrients

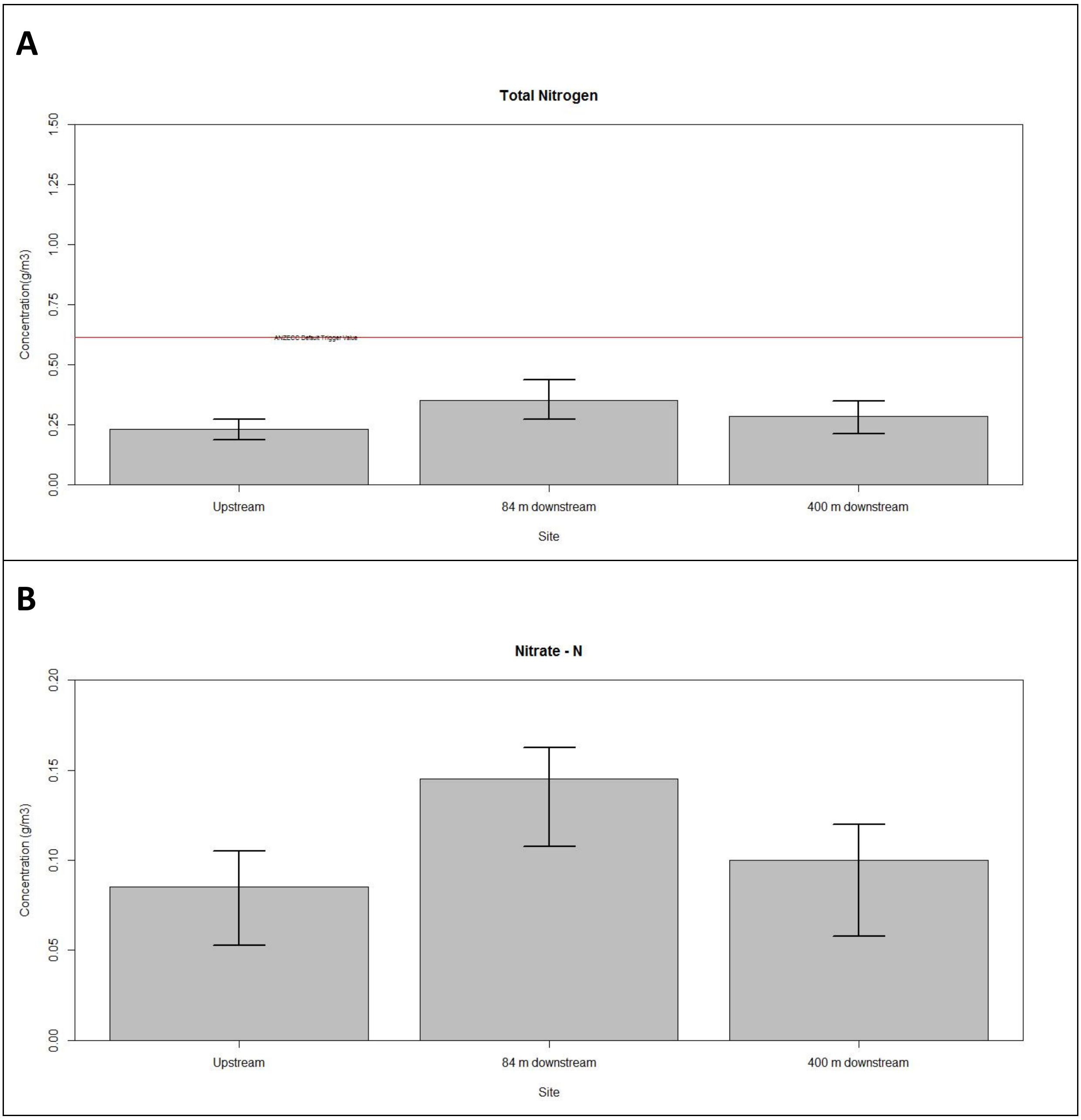
No statistically significant difference in total nitrogen results was found between monitoring sites located upstream and downstream of the Papawai Stream convergence[37].

No statistically significant difference in nitrate-n results was found between monitoring sites located upstream and downstream of the Papawai Stream convergence[38].

Median and mean DIN results were comfortably less than the ANZECC default trigger value for DIN, and no significant difference was detected between the median of the upstream site and median values at either of the two downstream sites[39].

While not statistically significant[40], the Papawai Stream showed increased mean and median DRP concentrations at the two downstream monitoring sites compared to results from upstream of the outfall. At the point 85 m downstream of the Papawai-Ruamahunga convergence, DRP concentrations typically exceeded both ANZECC default trigger level and the GWRC proposed DRP limit. The small DRP low-flow monitoring dataset size (n = 3) could be limiting the statistical precision of the significance test performed here. Nevertheless, the Papawai Stream is making a considerable contribution to DRP concentrations within the Ruamahunga River at the two monitoring sites located downstream of the Papawai Stream convergence.

[37] Wilcoxon results for total nitrogen: comparison of the upstream results to 85 m – W = 3.5, p = 0.2425, 400 m – W = 4, p = 0.3429.
[38] Wilcoxon results for nitrate-n: comparison of the upstream results to 85 m – W = 4, p = 0.3429, 400 m – W = 6.5, p = 0.7715.
[39] Wilcoxon results for DIN: comparison of the upstream results to 85 m – W = 4, p = 0.3429, 400 m – W = 6.5, p = 0.7715.
[40] Wilcoxon results for DRP: comparison of the upstream results to 85 m – W = 4, p = 0.3429, 400 m – W = 6.5, p = 0.7715.


A
Total Nitrogen
Concentration(g/m3)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
ANZECC Default Trigger Value
Upstream
84 m downstream
400 m downstream
Site
B
Nitrate - N
Concentration (g/m3)
0.00
0.05
0.10
0.15
0.20
Upstream
84 m downstream
400 m downstream
Site

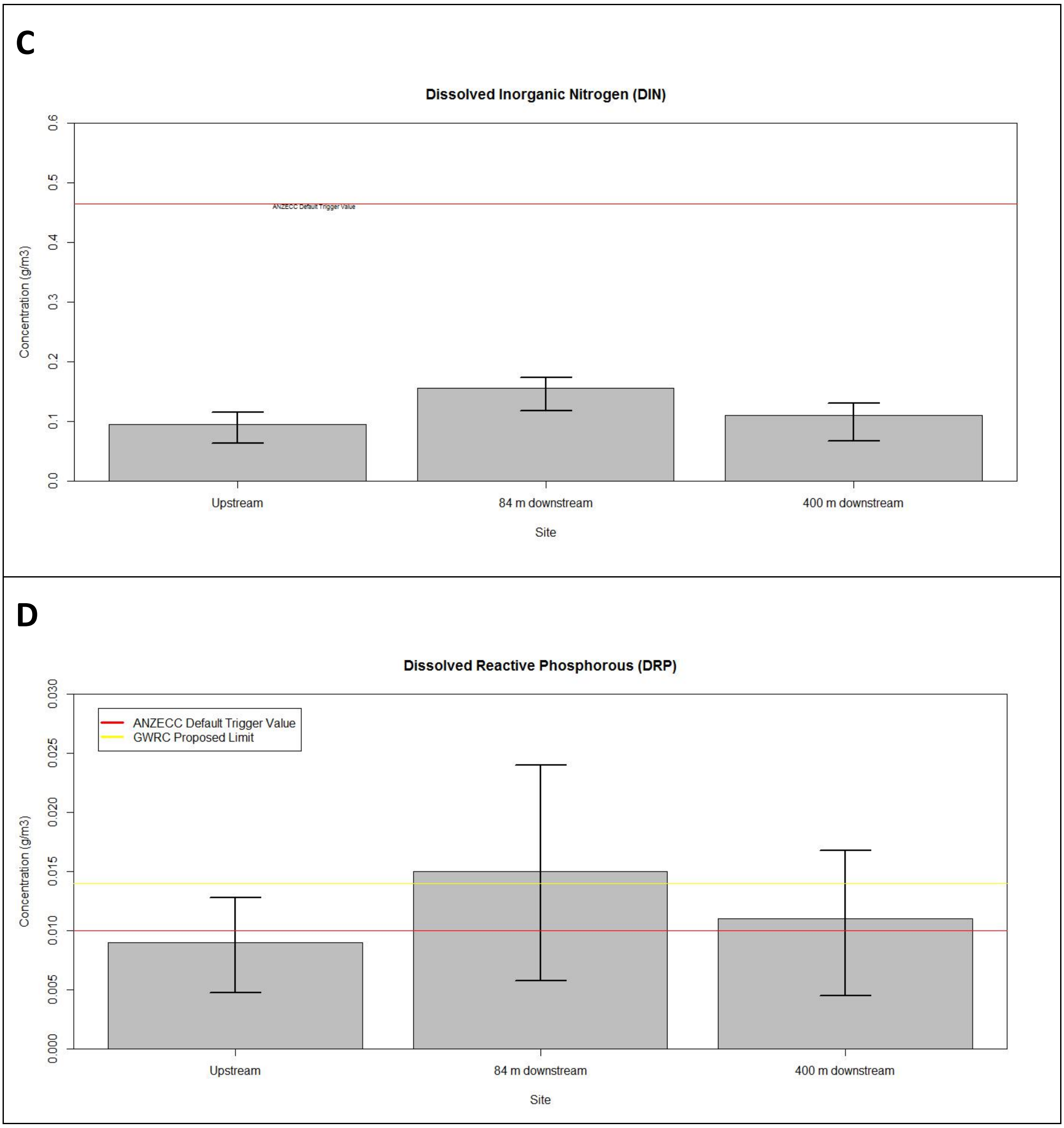


Figure 21: Results from water quality monitoring for (A) total nitrogen, (B) nitrate-n, (C) DIN, (D) DRP. Median values are plotted and error bars represent the interquartile range.

5.3 Discussion and conclusions

5.3.1 Papawai Stream

The mixing study found that the discharge caused higher concentrations of DRP (a nutrient used as a contaminant tracer) toward the TL side of the Papawai Stream. Water quality sample collection within the Papawai Stream is currently collected from the TR bank and therefore, monitoring results collected from the 50 m downstream site are likely to under-represent true contaminant concentrations at that point within the Papawai Stream.

The discharge was found to effect no significant change to pH, EC, suspended sediment, turbidity, BOD or *E. coli* results at the point 50 m downstream of the outfall. However, nutrient concentrations within the Papawai Stream were in many cases significantly affected by the treated wastewater discharge. A highly statistically significant increase in total nitrogen was found from upstream to 50 m downstream of the outfall and the increase remained significant at the next monitoring point 200 m downstream of the outfall. Further downstream, the 540 m below the outfall, total nitrogen concentrations were well in excess of the respective ANZECC default trigger value. Nitrate and DIN were elevated by the outfall, although the change was not statistically significant. The statistically very highly significant increase in DRP concentrations caused by the outfall is a substantial result, with implications for river health, and therefore especially deserving of careful management consideration.

In summary, despite monitoring at the 50 m downstream location probably missing the most concentrated area of the treated wastewater plume, it is clear from the data that nutrients discharged to the Papawai Stream are the central management issue regarding water quality impacts to the Papawai Stream. In many cases nutrient concentrations are well in excess of relevant ecological trigger values, and are therefore, deserving of careful management consideration.

5.3.2 Ruamahunga River

Monitoring upstream and downstream of the Papawai Stream-Ruamahunga River confluence was undertaken to detect effects from the Greytown treated wastewater discharge on the Ruamahunga Stream, via the Papawai Stream. When results from upstream and a short distance downstream (ca. 84 m) of the convergence are compared, no significant differences are detected for EC, pH, suspended solids, turbidity, black disk, BOD, and *E. coli*. These parameters were not significantly affected within the Papawai Stream, downstream of the outfall, therefore these results from the Ruamahunga River can be expected.

However, as with the Papawai Stream, there is evidence that nutrient concentrations within the Ruamahunga River are increased due to the Greytown treated wastewater discharge. Nitrogen compounds are increased downstream of the Papawai Stream-Ruamahunga River convergence, although from the data at hand, any increase in nitrogen compound is not statistically significant, and concentrations remain less than the respective ANZECC default trigger values.

The treated wastewater discharge was found to cause very significant increases in DRP concentrations within the Papawai Stream, and that effect is also apparent within the Ruamahunga River, downstream of the Papawai Stream’s confluence. Median concentrations of DRP at the monitoring site 84 m downstream of the Papawai Stream confluence were increased to a level where both ANZECC default trigger value and the GWRC proposed limit were exceeded. The upper limit of the DRP interquartile range was more than twice the ANZECC default trigger value. Increases in periphyton cover, for the categories long coarse filamentous and thick mats, were detected downstream of the Papawai Stream convergence — although these differences were not statistically significant.

In conclusion, those parameters which were not significantly affected by treated wastewater discharge within the Papawai Stream, were also not significantly affected within the Ruamahunga River. Nitrogen compounds were increased downstream of the convergence and DRP concentrations were increased to levels exceeding ecological management thresholds. Increases in periphyton cover (thick mats and coarse long filamentous algae) were observed within the Ruamahunga River downstream of the Papawai convergence, which can be expected given the increases detected in nitrogen and phosphorus. Results from monitoring within the Ruamahunga confirm that nutrients are a key management consideration for management of Greytown wastewater disposal, as under the current regime effects of increased nutrients are apparent not only within the Papawai Stream, but also within the Ruamahunga River—at least 400 m downstream of the Papawai Stream convergence with the Ruamahunga River.

6.0 FEATHERSTON

6.1 Results

6.1.1 Substrate composition

Substrates are similar in type (predominantly gravel) across monitoring sites with the exception of a greater proportion of fine particle sizes at the two downstream monitoring sites.

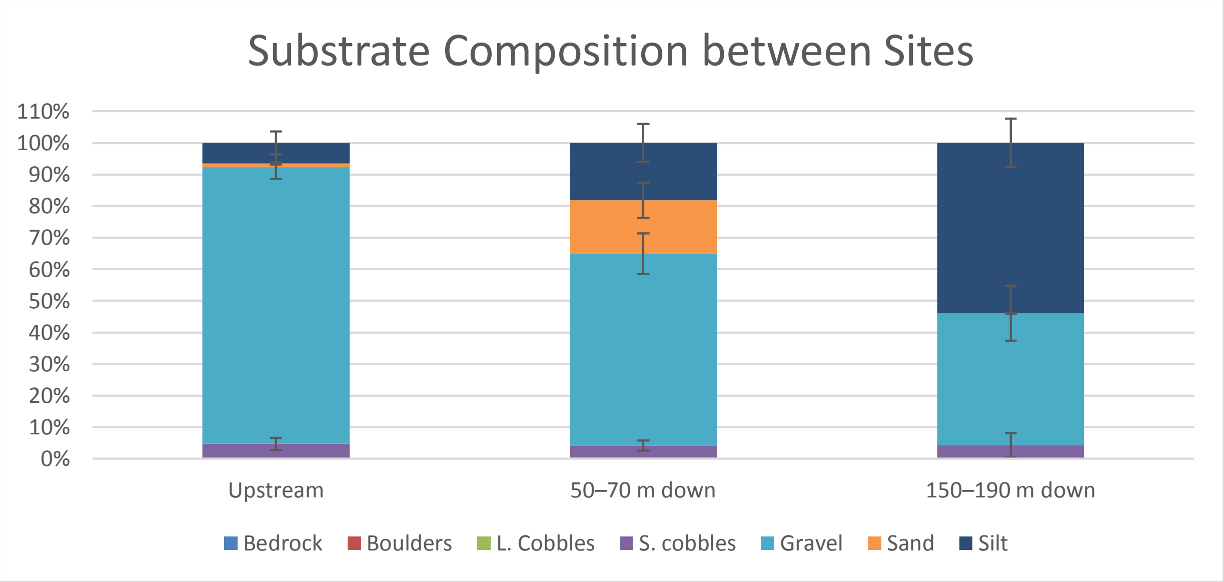
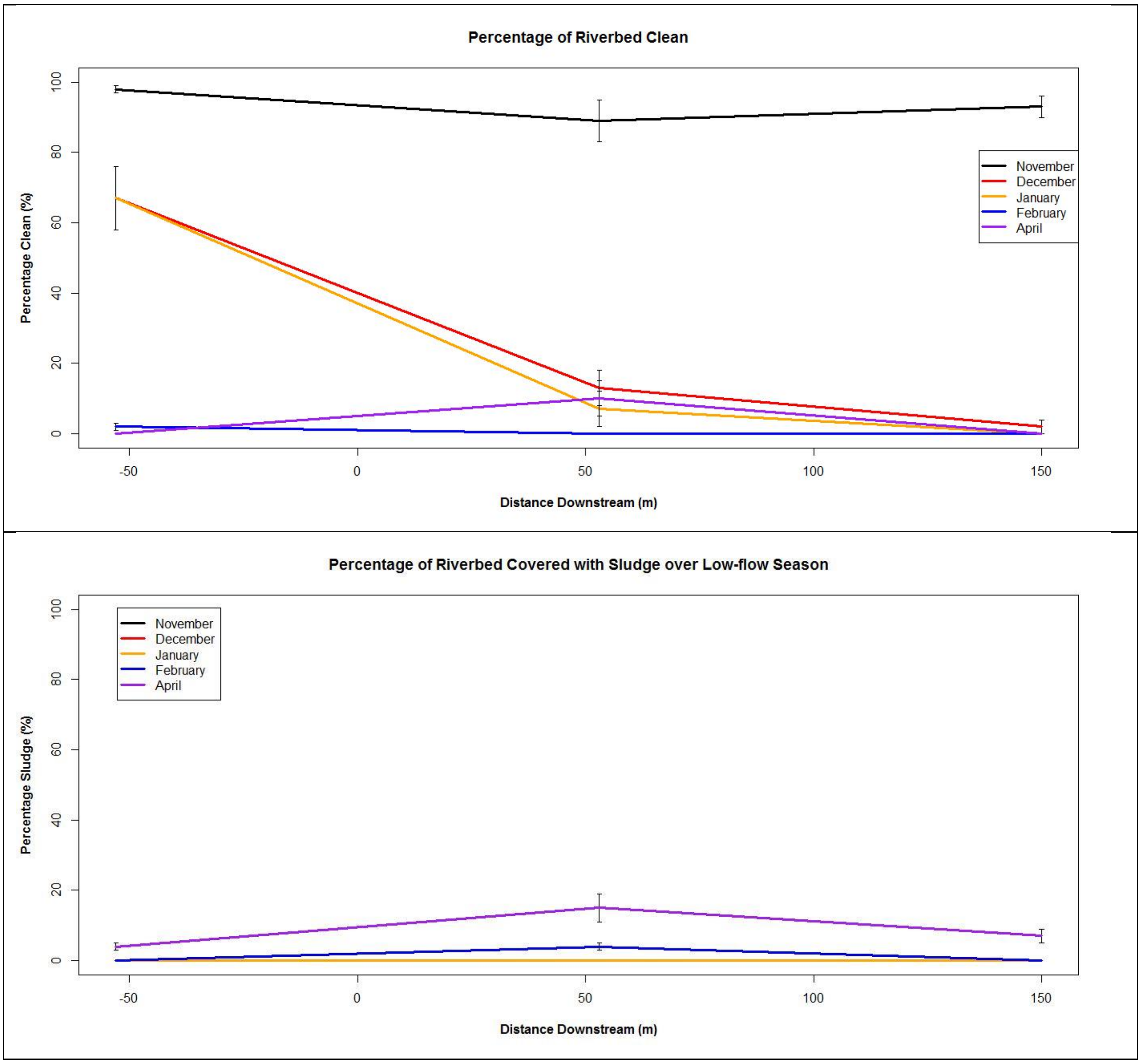


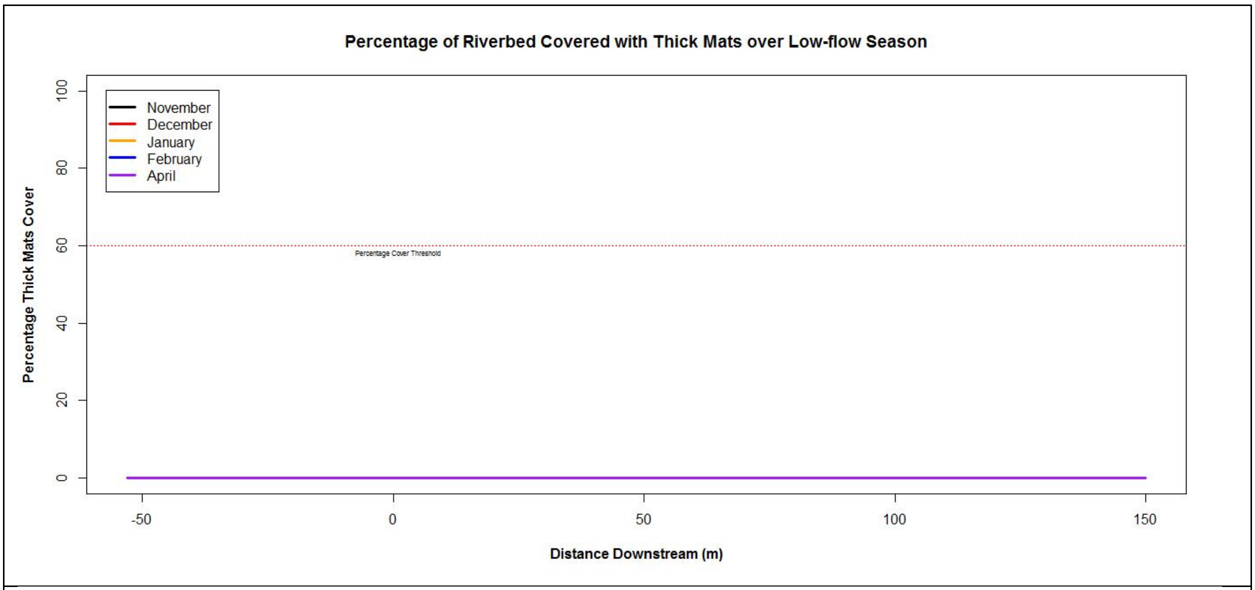
Figure 22: Substrate composition of periphyton monitoring sites within Donald's Creek at Featherston. Plotted values are the mean of all observations and error bars represent one standard error of the mean.

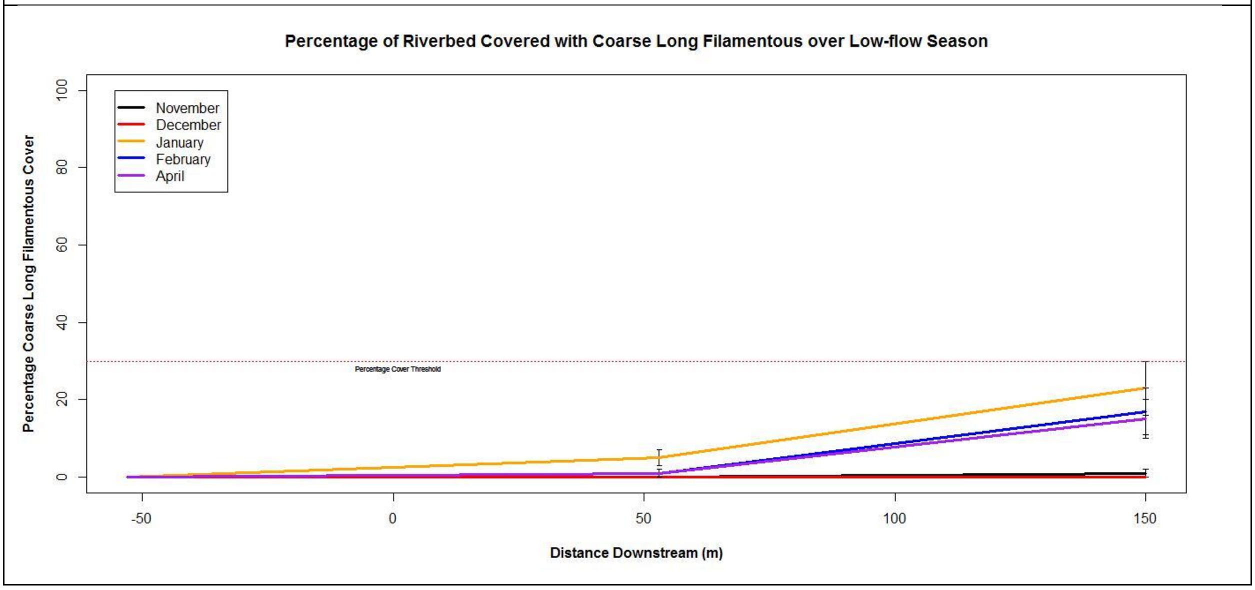
6.1.2 Periphyton

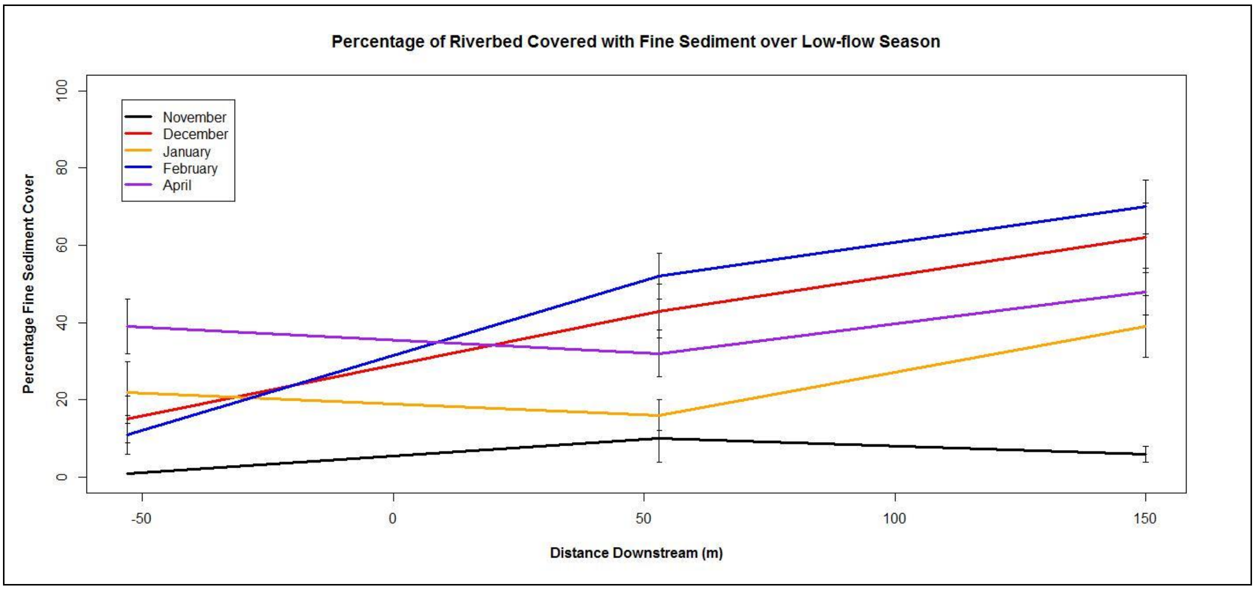
Visual assessment of cover

Over December and January the proportion of the streambed which was clean, downstream of the outfall, was dramatically reduced. In February and April the area of clean streambed upstream of the outfall was reduced to zero, or near zero. The discharge therefore had the most pronounced effect on overall periphyton cover over the December–January period, before upstream conditions deteriorated. Sludge accumulation at 53–73 m downstream became apparent over February–April and long coarse filamentous algae cover increased over the March–April period — although the latter did not exceed the 30% visual cover assessment threshold. Results for fine sediment cover were varied, however in February a clear and substantial increase in fine sediment cover was observed at both monitoring sites located downstream of the outfall. Thick mats were not a feature of the periphyton community at any time, or at any site monitored, and data is therefore not presented here for thick mats.




Percentage of Riverbed Covered with Thick Mats over Low-flow Season
Percentage Thick Mats Cover
Distance Downstream (m)
November
December
January
February
April
Percentage Cover Threshold
0
20
40
60
80
100
-50
0
50
100
150


Percentage of Riverbed Covered with Coarse Long Filamentous over Low-flow Season
Percentage Coarse Long Filamentous Cover
Distance Downstream (m)
November
December
January
February
April
Percentage Cover Threshold
0
20
40
60
80
100
-50
0
50
100
150



Biomass, Autotrophic Index, and Community Composition

Chlorophyll *a* concentrations were assessed at the 150–170 m downstream sampling point in February and April. A median Chl. *a* concentration of 138 mg/m^2 was returned from February sampling, and 91 mg/m^2 from April sampling. The difference in concentration between months is not statistically significant[41]. A statistically significant[42] difference in AFDM at 150–170 m downstream of the outfall occurred between February (median 42 g/m^2) and April (median 17.5 g/m^2). The AI at 150–170 m downstream of the outfall was 277.9. By April the AI score had reduced to 171.6. At the sampling location 150–170 m downstream of the outfall species diversity within the periphyton community as similar[43] between February and April surveys.

[41] Wilcoxon results for Chl. *a*: comparison of samples collected at 150–170 m downstream, in February and April – W = 55, p = 0.2031.
[42] Wilcoxon results for AFDM: comparison of samples collected at 150–170 m downstream, in February and April – W = 64, p = 0.03428.
[43] Wilcoxon results for *H*: comparison of samples collected at 150–170 m downstream, in February and April – W = 18, p = 0.06349.

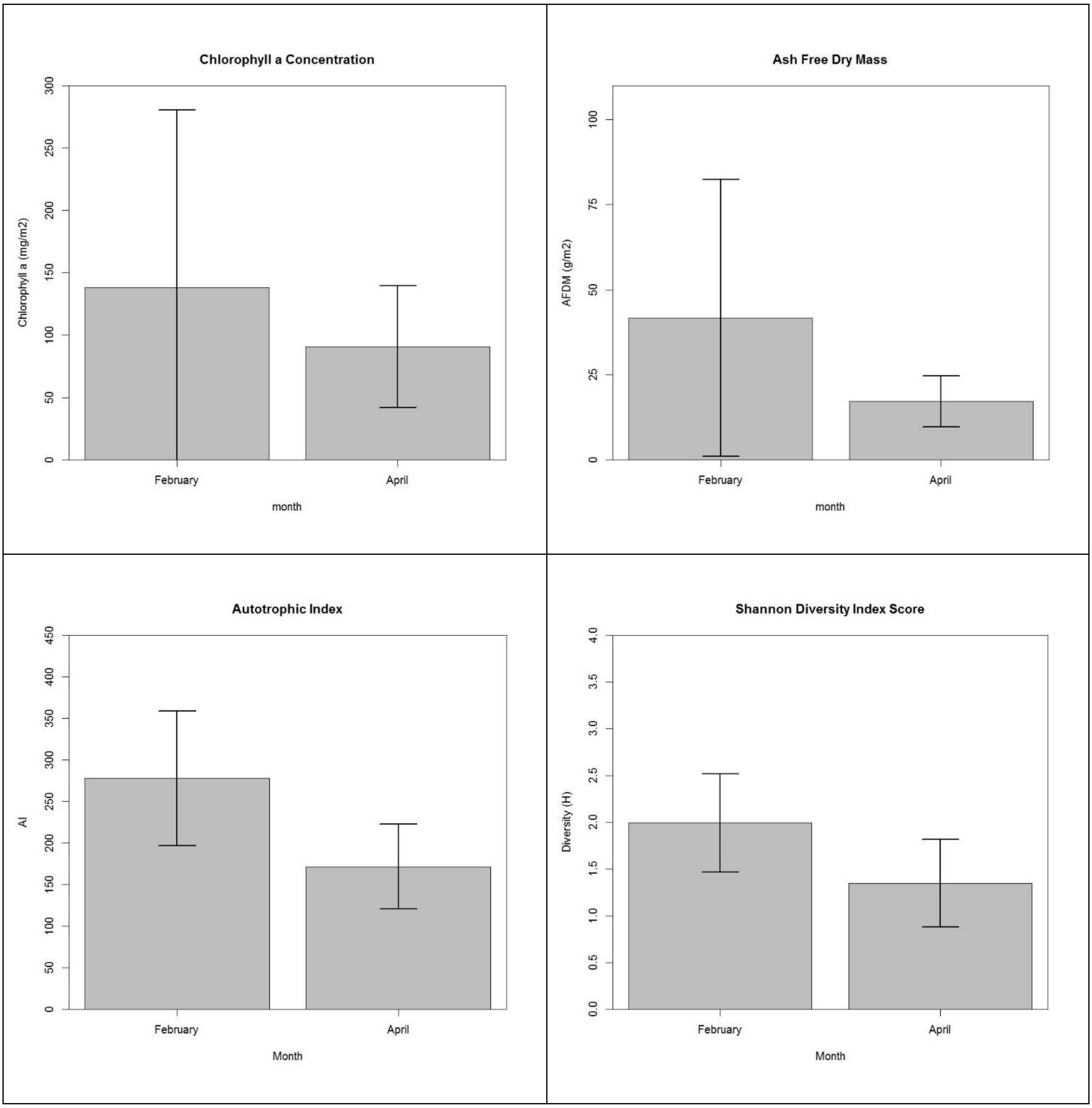


Figure 23: Chlorophyll *a*, ash free dry mass, AI, and diversity index scores for the Featherston discharge. Plots are median values and error bars represent the interquartile range.

6.1.3 Water quality

Indicator and physical parameters

Comparison of median EC results between upstream and monitoring sites located 53 m and 150 m downstream of the outfall showed statistically significant higher results at both downstream monitoring sites[44].

The discharge did not appear to affect pH values significantly and median pH values were within the ANZECC default trigger range[45].

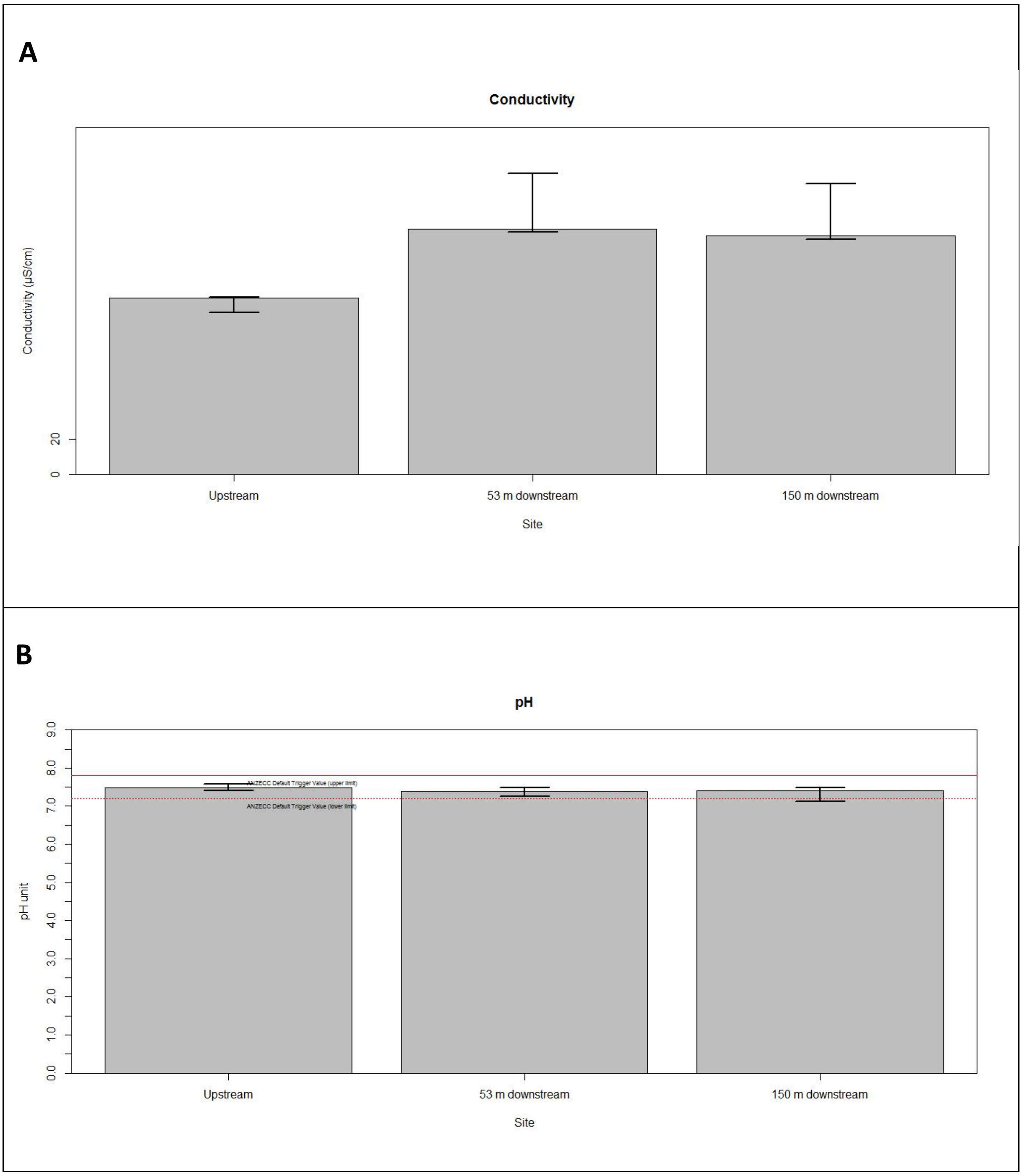
Suspended solid concentrations were elevated downstream of the discharge (relative to upstream concentrations), however, the difference between median values upstream and downstream (at either downstream site) was not statistically significant[46].

Median turbidity showed significant increases, at both downstream monitoring sites, due to the discharge[47]. Although only a small dataset, the variability observed suggests that at times turbidity conditions would exceed the ANZECC trigger value for lowland waterways.

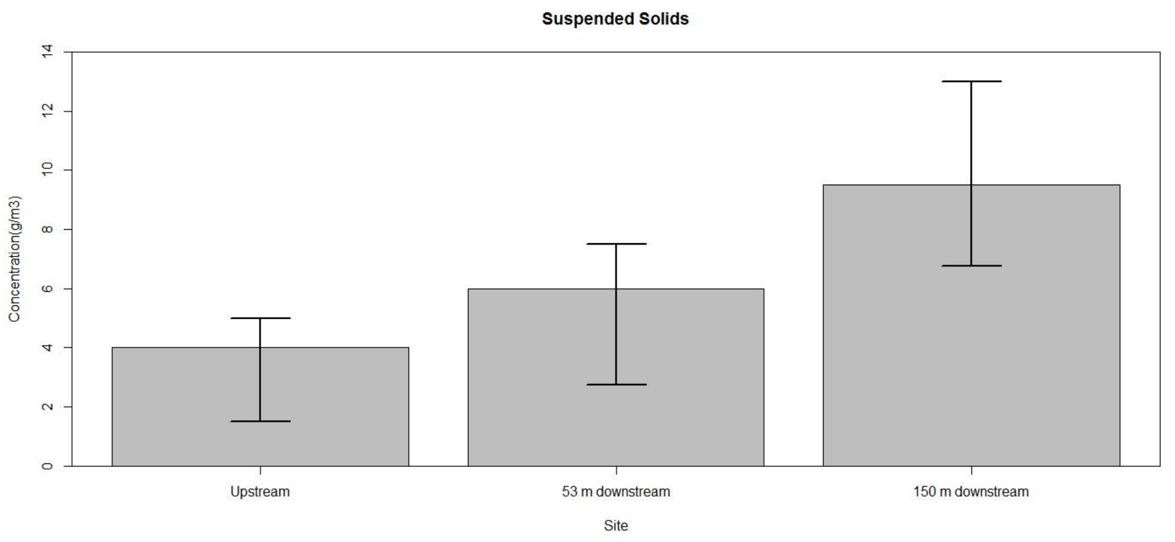
The discharge caused a significant decrease in visual clarity; mean and median black disk sighting distances showed substantial reductions downstream of the discharge[48]. Median black disk sighting range at both downstream monitoring sites was reduced to, and in some cases below, the ANZECC trigger value for lowland waterways.

---

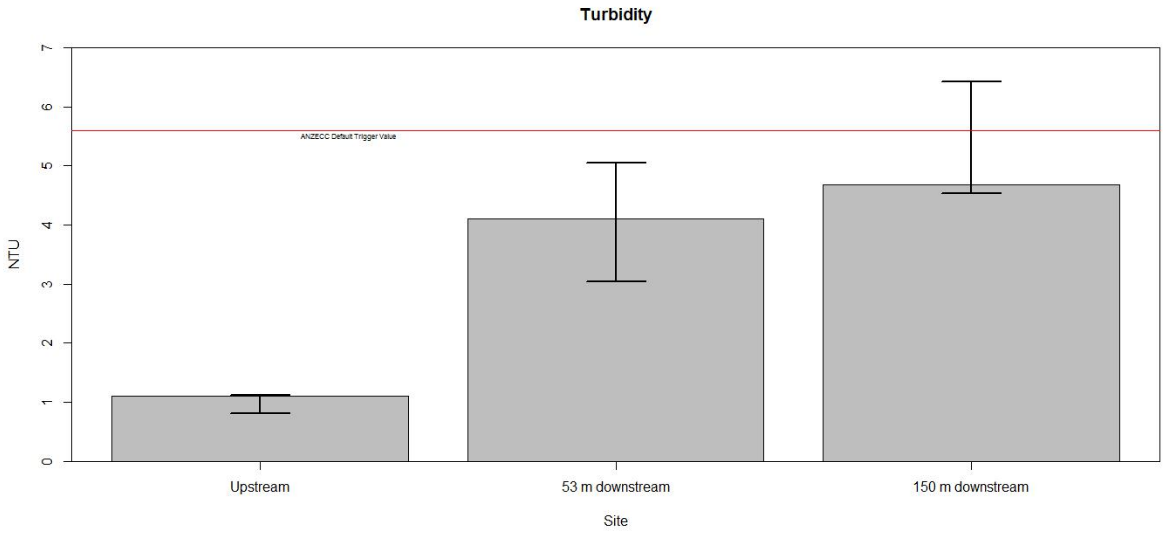
[44] Wilcoxon results for EC: comparison of the upstream results to 53 m – W = 2, p = 0.03175, 150 m – W = 2, p = 0.03175.
[45] Wilcoxon results for pH: comparison of the upstream results to 53 m – W = 16, p = 0.5476, 150 m – W = 11, p = 0.8413.
[46] Wilcoxon results for SS: comparison of the upstream results to 53 m – W = 5.5, p = 0.5516, 150 m – W = 4, p = 0.3005.
[47] Wilcoxon results for turbidity: comparison of the upstream results to 53 m – W = 5.5, p = 0.01587, 150 m – W = 2, p = 0.03175.
[48] Wilcoxon results for black disk: comparison of the upstream results to 53 m – W = 20, p = 0.01587, 150 m – W = 16, p = 0.02857.


A
Conductivity
Conductivity (µS/cm)
0
20
Upstream
53 m downstream
150 m downstream
Site
B
pH
pH unit
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
ANZECC Default Trigger Value (upper limit)
ANZECC Default Trigger Value (lower limit)
Upstream
53 m downstream
150 m downstream
Site

C


Suspended Solids
Concentration(g/m3)
0
2
4
6
8
10
12
14
Upstream
53 m downstream
150 m downstream
Site

D


Turbidity
NTU
0
1
2
3
4
5
6
7
ANZECC Default Trigger Value
Upstream
53 m downstream
150 m downstream
Site

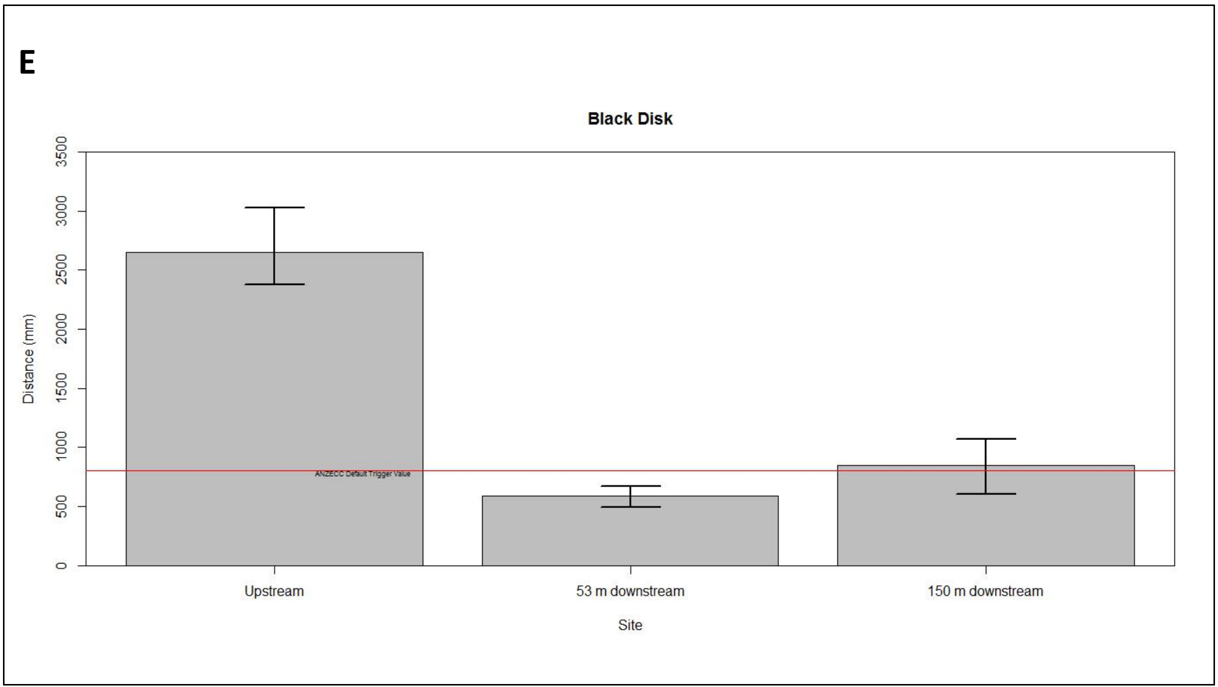


Figure 24: Results from water quality monitoring for (A) EC, (B) pH, (C) suspended solids, (D) turbidity, and (E) black disk. Median values are plotted and error bars represent the interquartile range.

Organic and biological parameters

The discharge resulted in significant increases in median BOD results at both downstream monitoring sites[49].

No significant difference was found between median *E.coli* values, when upstream results were compared to median values for the two downstream monitoring sites[50].

[49] Wilcoxon results for BOD: comparison of the upstream results to 53 m – W = 0, p = 0.02107, 150 m – W = 0, p = 0.02021.

[50] Wilcoxon results for *E.coli*: comparison of the upstream results to 53 m – W = 5, p = 0.4857, 150 m – W = 8, p = 1.

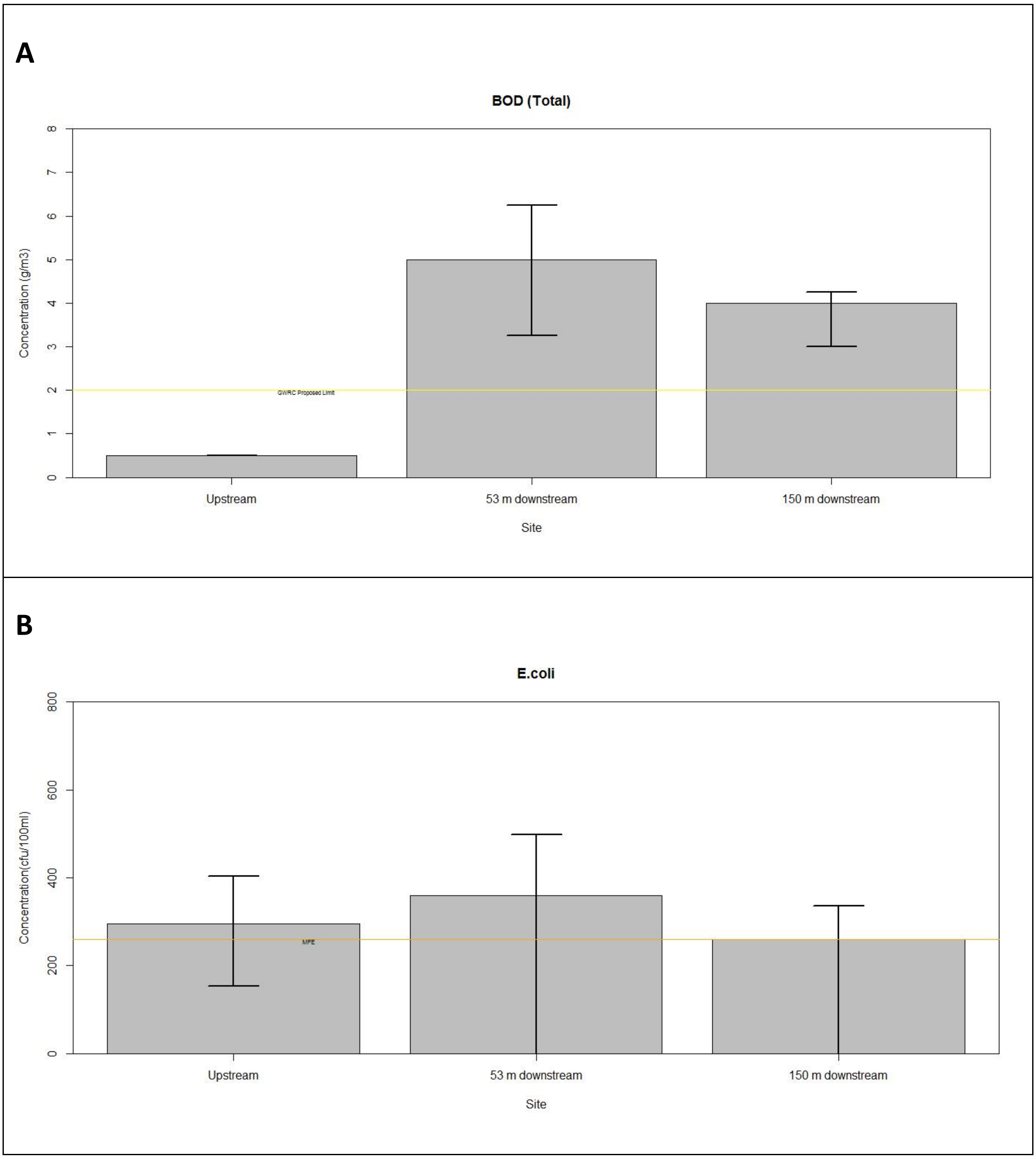


Figure 25: Results from water quality monitoring for (A) total BOD, and (B) *E. coli*. Median values are plotted and error bars represent the interquartile range.

Nutrients

The discharge caused statistically significant increases to total nitrogen concentrations at both downstream monitoring sites[51]. Both mean and median concentrations from the upstream monitoring site were above the ANZECC default trigger value. With the additional contribution of nitrogen from the discharge, mean and median concentrations at both downstream sites were found to be more than four times the ANZECC default trigger concentration for total nitrogen.

No significant difference was found between median values of nitrate-n from upstream compared to either of the two downstream monitoring sites[52].

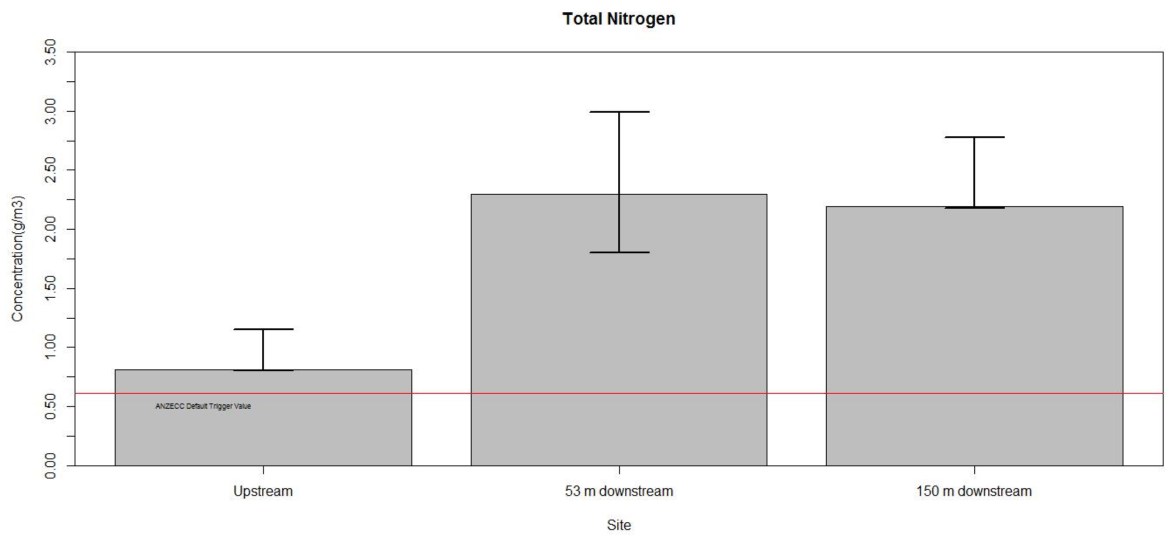
Statistically significant differences were found between median DIN values from the upstream monitoring site and each of the two downstream monitoring sites[53]. Mean and median values for DIN, at both downstream sites were almost threefold the value of the ANZECC default trigger value for DIN.

Highly statistically significant differences were found between median DRP concentrations from the upstream monitoring site and mean values from both of the two downstream monitoring sites[54]. At the monitoring location 53 m downstream from the outfall, the discharge was found to effect more than a 33-fold increase in DRP (based on median statistic), and at 150 m downstream the discharge was found to effect a 26-fold increase in DRP concentrations within Donald's Creek. As upstream concentrations of DRP were close to the ANZECC default trigger level, and also to the GWRC proposed limit, these fold increases are also representative of how far beyond these two management thresholds the discharge increases DRP concentrations within Donald's Creek.

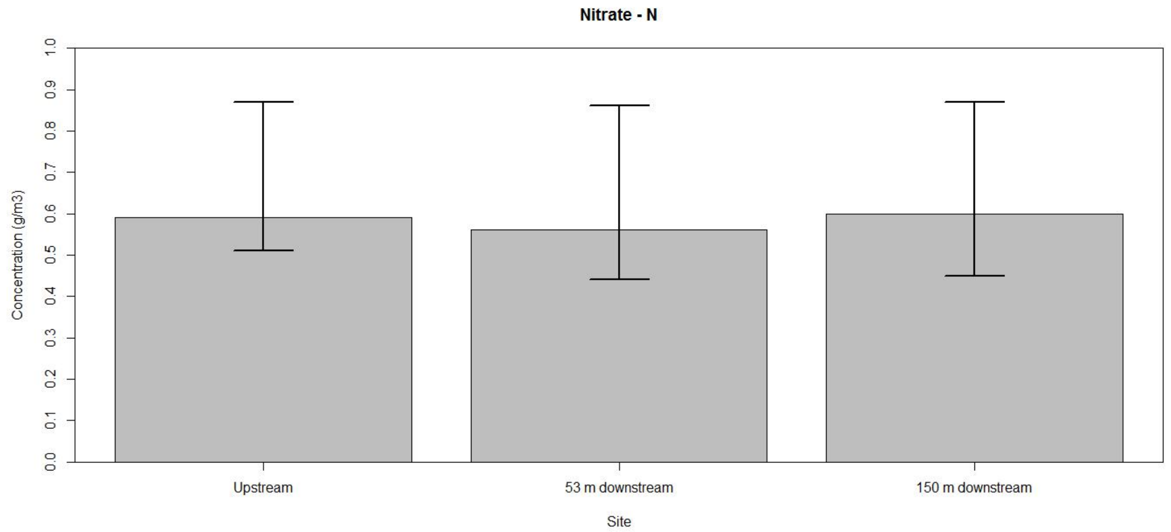
While no evidence is present to show concentrations exceeding, ammonia results are somewhat elevated relative to the ANZECC acute toxicity trigger value.

[51] Wilcoxon results for TN: comparison of the upstream results to 53 m – W = 0, $p = 0.02107$, 150 m – W = 0, $p = 0.02021$.
[52] Wilcoxon results for nitrate-n: comparison of the upstream results to 53 m – W = 11.5, $p = 0.9166$, 150 m – W = 9, $p = 0.5476$.
[53] Wilcoxon results for DIN: comparison of the upstream results to 53 m – W = 0.5, $p = 0.01565$, 150 m – W = 0, $p = 0.01193$.
[54] Wilcoxon results for DRP: comparison of the upstream results to 53 m – W = 0, $p = 0.007937$, 150 m – W = 0, $p = 0.007937$.

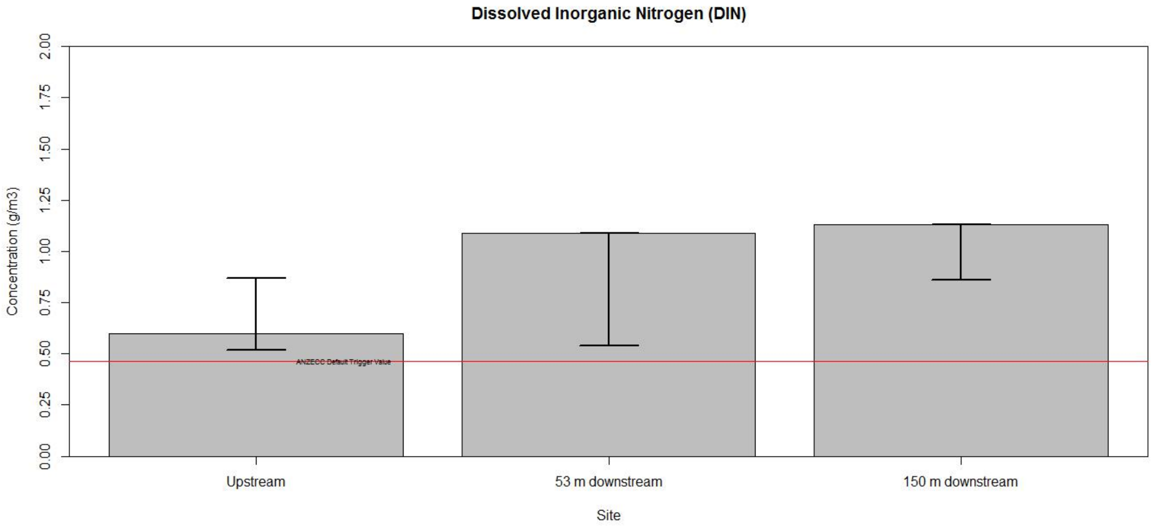
A


Total Nitrogen
Concentration(g/m3)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
ANZECC Default Trigger Value
Upstream
53 m downstream
150 m downstream
Site

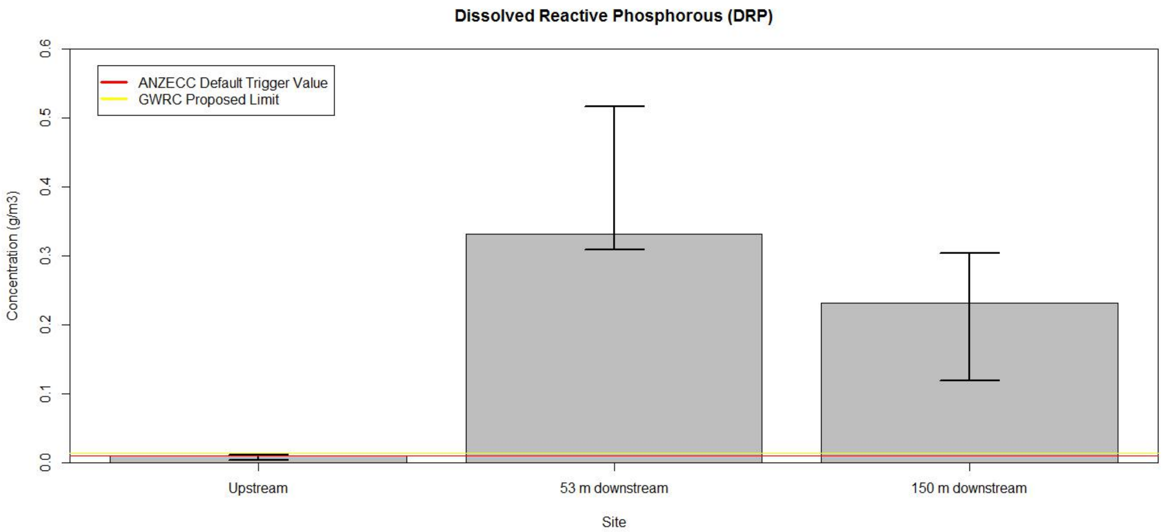
B


Nitrate - N
Concentration (g/m3)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Upstream
53 m downstream
150 m downstream
Site

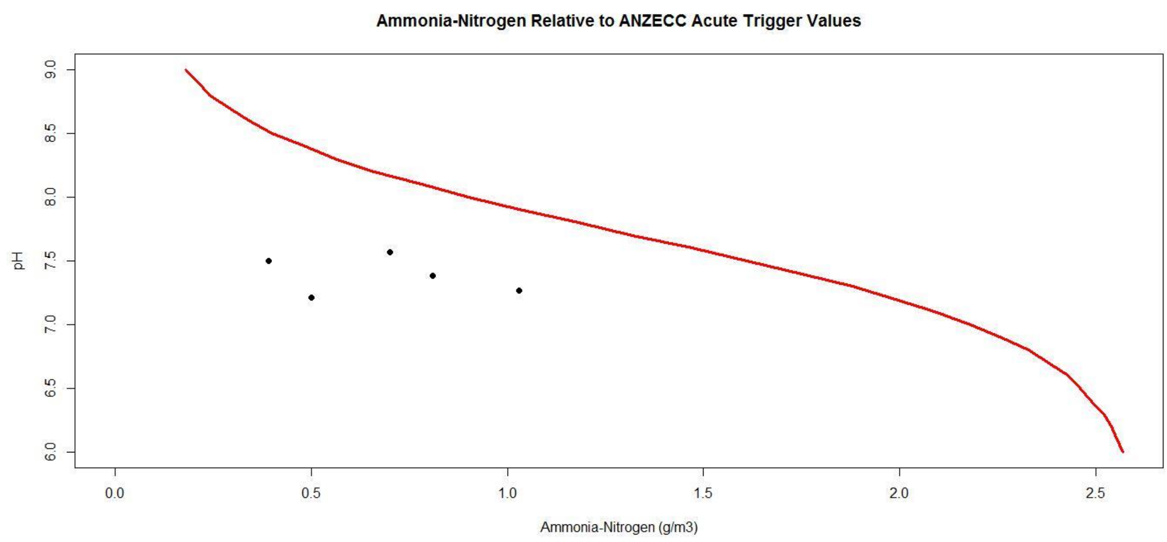
C


Dissolved Inorganic Nitrogen (DIN)
Concentration (g/m3)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
ANZECC Default Trigger Value
Upstream
53 m downstream
150 m downstream
Site

D


Dissolved Reactive Phosphorous (DRP)
ANZECC Default Trigger Value
GWRC Proposed Limit
Concentration (g/m3)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Upstream
53 m downstream
150 m downstream
Site

E



F

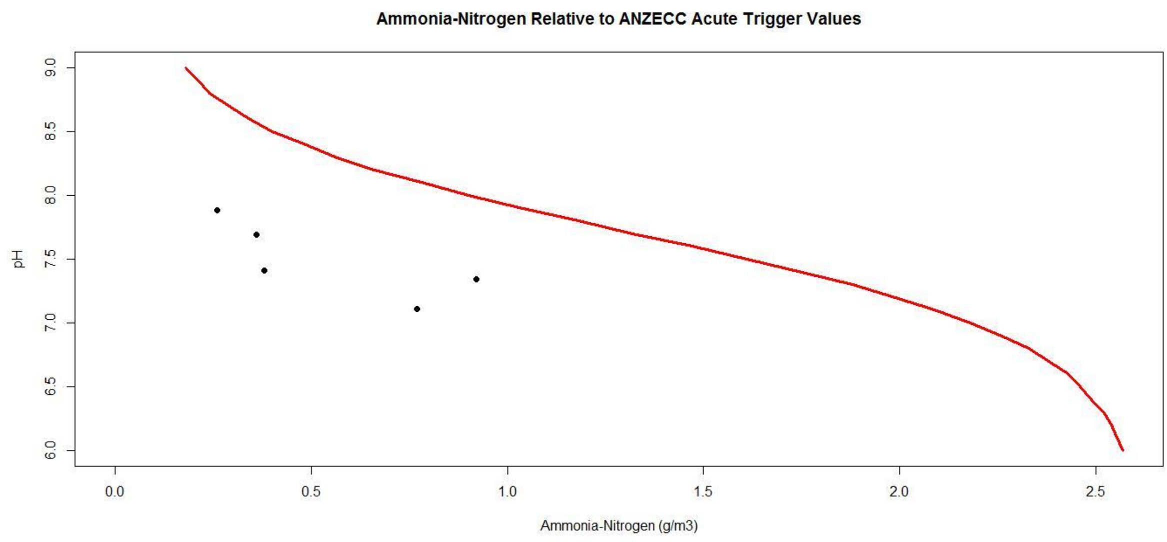


Figure 26: Results from water quality monitoring for (A) total nitrogen, (B) nitrate-n, (C) DIN, (D) DRP, (E) ammonia-nitrogen relative to ANZECC acute toxicity trigger value—53 m, (F) ammonia-nitrogen relative to ANZECC acute toxicity trigger value—150 m. Median values are plotted and error bars represent the interquartile range.

6.2 Discussion and conclusions

The heavy cover by riparian forest downstream of the outfall masks the effect of discharged nutrients on aquatic plant growth. As part of the current monitoring programme, exotic trees surrounding monitoring sites were poisoned to increase light transmission, and blackberry was cleared from areas adjacent to monitoring sites. However, the effect of vegetation clearance by poisoning was slow, and therefore despite these actions the full potential for plant growth was probably not realised during the course of the monitoring programme.

During December and February the discharge caused marked increases in the proportional cover by fine sediments, and in April, cover by coarse long filamentous algae stood-out above results from other sites but did not exceed the 30 % visual assessment threshold. Result for AI at 150–170 m downstream, in February, is characteristic of a site with emerging organic pollution issues.

The discharge was found to effect water clarity significantly, with both turbidity and visual clarity being significantly reduced downstream. Turbidity levels would at times be greater than (poorer clarity) the ANZECC trigger value for lowland waterways, and less than (poorer clarity) the ANZECC visual sighting trigger value for lowland waterways. Suspended solids were elevated by the discharge but the difference between upstream and downstream suspended solids concentrations was not significant.

The discharge increased BOD significantly compared to upstream concentrations. Median *E. coli* results were equivalent to, or greater than, 260 cfu/100 mls.

Electrical conductivity was significantly affected by the discharge, at both downstream monitoring sites, which provides a broad indication of significant ionic contamination from the treated wastewater discharge. The discharge was found to be causing significant increases in nutrient concentrations within Donald's Creek. Both nitrogen (total nitrogen and DIN) and DRP concentrations are well in excess of relevant ecological thresholds. The mean/median result for DIN of three-fold the ANZECC trigger value, and the 33-fold increase in DRP (at the 53 m site, median concentration, relative to median upstream concentration) are results which provide clear evidence that the discharge, in its current form, is unsustainable in ecological terms.

REFERENCES

ANZECC. (2000). Australian and New Zealand guidelines for fresh and marine water quality: Volume 1 — The guidelines. Chapters 1–7.

Keenan, L. (2009). Instream flow assessment for Papawai Stream. Wellington. Greater Wellington Regional Council Environmental Monitoring and Investigations Department. Retrieved from Greater Wellington Regional Council Website: http://www.gw.govt.nz/assets/council-publications/Instream%20Flow%20Assessment%20for%20Papawai%20Stream.pdf

Kilroy, C., Biggs, B., Death, R. (2008). A periphyton monitoring plan for the Manawatu-Wanganui region. A consultant report prepared by National Institute of Water and Atmospheric Research for Horizons Regional Council. Christchurch.

APPENDICIES

All Appendices are provided in an electronic format. See the compact disk attached inside the rear cover of this report.

Forbes Ecology

South Wairarapa District Council WWTP, February 2013

Summary of Freshwater Periphyton Sample Processing & Results

prepared by

Ryder Consulting

April 2013

ryderconsulting
environment + planning + project management

Forbes Ecology

South Wairarapa District Council WWTP, February 2013

Summary of Freshwater Periphyton Sample Processing & Results

prepared by

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1. Introduction

1.1 Background

Frozen periphyton samples were provided to Ryder Consulting by Forbes Ecology. Forbes Ecology staff collected these samples in February 2013. Ryder Consulting Ltd was engaged to process the samples, and report the results of taxonomic composition and biomass.

1.2 Objectives

The objectives of this report are to present the methods and results of the South Wairarapa District Council WWTP sample processing.

2. Laboratory Analysis

2.1 General

In the laboratory each sample was tipped into a glass beaker and blended for about 30 seconds or until the mixture was free of obvious clumps of material. The blended liquid was then made up to a known volume (e.g., 100 ml).

2.2 Chlorophyll *a* analysis

Each sample was shaken and three 5 ml aliquots were withdrawn using an automatic pipette and filtered on to a Microscience MS-GC 47 mm glass fibre filter. The filter was placed in a tube containing 20 ml of 90% ethanol, immersed in a water bath (78 °C for five minutes) and into a refrigerator overnight. The tube was centrifuged for 10 minutes at 6000 rpm before the absorption of a 13.5 ml aliquot of the ethanol homogenate was measured at 665 nm and 750 nm using a 4 cm cuvette in a Shimadzu UV-120-01 spectrophotometer. The ethanol homogenate was then acidified with 0.375 ml of 0.3 M HCl then, following a 30 second delay, absorbances at 665 and 750 nm were re-read. The total amount of chlorophyll *a* was calculated using a standard formula (Biggs and Kilroy 2000) and scaled to the number of milligrams of chlorophyll *a* per m^2 of stream bed.

2.3 Ash-Free Dry Mass (AFDM)

Each sample was shaken and three 5 ml aliquots were withdrawn using an automatic pipette and filtered on to a pre-ashed (400 °C for 2 hours) and pre-weighed Microscience MS-GC 47 mm glass fibre filter. The filter and sample were dried for 24 hours at 105 ºC, cooled in a desiccator then weighed. The filter was ashed at 400 ºC for 4 hours, cooled in a desiccator then reweighed. Values were scaled to calculate grams of AFDM per m^2 of stream bed.

2.4 Algal community composition (Relative abundance)

Five replicates from each site were examined for relative abundance of algae. Each sample was thoroughly mixed and three aliquots removed to an inverted microscope settling chamber then allowed to settle for 10 minutes. Samples were analysed according to the "relative abundance using an inverted microscope" method outlined in Biggs and Kilroy (2000). Samples were inspected under 200-400x magnification to identify algal species present using the keys of Biggs and Kilroy (2000), Entwisle *et al*. (1988) and Moore (2000). Algae were given an abundance score ranging from 1 (rare) to 8 (dominant) based on the protocol of Biggs and Kilroy (2000).

3. Results

Results are included below and have also been forwarded to Forbes Ecology in electronic form.

Site	Sample	Chlorophyll *a* (mg per m^2)	AFDM (g per m^2)
FSTN 150	1	145.8	42.8
	2	130.7	40.6
	3	177.6	54.9
	4	107.8	17.2
	5	275.6	63.7
	6	308.1	104.9
	7	324.1	84.9
	8	56.0	7.2
	9	112.9	25.8
	10	43.7	19.1
MTB 150	1	173.4	54.7
	2	114.2	21.6
	3	329.2	43.3
	4	354.4	84.9
	5	264.6	60.5
	6	292.1	72.2
	7	704.6	76.9
	8	980.8	115.1
	9	1044.0	96.8
	10	419.8	41.2

	FSTN 150					MTB 150				
	1	**3**	**5**	**7**	**9**	**1**	**3**	**5**	**7**	**9**
Filamentous green algae										
Cladophora								1	2	1
Spirogyra							1			
Stigeoclonium		1					1		2	
Filamentous red algae										
Audouinella				1						
Cyanobacteria										
Coleodesmium						2		2		2
Oscillatoria/Phormidium						8	8	7	6	7
Filamentous diatoms										
Melosira	2	2	3	2	2	1				
Tabellaria								1	1	1
Diatoms										
Cocconeis	4	2	2	3	2	1				1
Cyclotella				1						
Cymbella		1	1	3	3		1			1
Gomphonema				1	3		1	1	1	
Naviculoid diatoms	2	2		2	3			1		1
Nitzschia		1	2		2				1	
Surirella						3	1	2		
Synedra	5	6	5	6	7			1		
Planktonic green algae										
Chlorella	2	2		2	2	1				
Closterium					1					
Coelastrum				1	1					1
Cosmarium							1			
Oocystis	1	1	1	2						
Pediastrum					1					
Scenedesmus	8	8	6	6	6		1			1

4. References

Biggs, B.J.F. and Kilroy, K.C. 2000. Stream periphyton monitoring manual. Ministry for the Environment, Wellington.

Entwisle, T.J., Sonneman, J.A. and Lewis, S.H. 1988. Freshwater algae of Australia: a guide to conspicuous genera. Sainty and Associates, Sydney.

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2.4 Algal community composition (Relative abundance)

Five replicates from each site were examined for relative abundance of algae. Each sample was thoroughly mixed and three aliquots removed to an inverted microscope settling chamber then allowed to settle for 10 minutes. Samples were analysed according to the "relative abundance using an inverted microscope" method outlined in Biggs and Kilroy (2000). Samples were inspected under 200-400x magnification to identify algal species present using the keys of Biggs and Kilroy (2000), Entwisle *et al*. (1988) and Moore (2000). Algae were given an abundance score ranging from 1 (rare) to 8 (dominant) based on the protocol of Biggs and Kilroy (2000).

3. Results

Results are included below and have also been forwarded to Forbes Ecology in electronic form.

Site	Sample	Chlorophyll *a* (mg per m^2)	AFDM (g per m^2)
FSTN 150 DS	1	114.6	13.7
	2	182.5	35.8
	3	119.0	20.3
	4	107.0	18.5
	5	74.1	7.8
	6	69.4	15.8
	7	58.0	20.2
	8	58.8	9.6
GTN UP	1	31.2	6.0
	2	40.4	4.5
	3	56.3	7.5
	4	36.3	2.7
	5	51.1	5.4
	6	77.9	10.8
	7	69.8	7.1
	8	57.1	3.2
	9	52.0	5.4
	10	59.3	5.6
MTB 150 DS	1	177.3	37.8
	2	84.7	25.2
	3	273.7	38.6
	4	166.2	27.8
	5	281.3	20.9
	6	143.7	40.9
	7	164.5	41.8
	8	168.7	40.8
	9	194.9	14.2
	10	130.5	13.5
MTB 50 DS	1	179.0	32.5
	2	205.8	38.8
	3	307.6	65.0
	4	97.7	21.5
	5	152.3	37.9
	6	154.3	19.9
	7	139.9	41.3
	8	7.7	2.6
	9	158.4	61.0
	10	87.7	13.4
MTB US	1	46.3	8.9
	2	96.7	13.6
	3	57.6	4.8
	4	72.8	5.1
	5	63.5	9.0
	6	73.2	11.5
	7	66.8	8.8
	8	47.2	4.5
	9	67.7	14.2
	10	52.7	8.8

	FSTN 150 DS				GTN UP					MTB 150 DS					MTB 50 DS					MTB US				
	1	3	5	7	1	3	5	7	9	1	3	5	7	9	1	3	5	7	9	1	3	5	7	9
Filamentous green algae																								
Cladophora										6	7	4			4	2								
Mougeotia					4	4	5	5	4			1	4	2	7	7	5	5	5			2		
Stigeoclonium					2	2	2	1		3	6	6	4	4						6	4	6	4	6
Filamentous red algae																								
Audouinella		3	2						3											2				
Cyanobacteria																								
Oscillatoria/Phormidium														2										
Filamentous diatoms																								
Melosira	2	2		2	3	3	2	1	2	4	5	4	3	4	3	1	2	3	2	4	4	3	4	4
Tabellaria					2	2	3	3	2	4	3	3	6	3	4	3	2	3	2	3	4	3	4	4
Diatoms																								
Achnanthes						1	1																	
Cocconeis			1					1		1					2	1	3	4	3		1			1
Cymbella	1	1	1		4	2	2	5	4	2	2	1	4	3	4	3	1	1	2	3	2	2	2	2
Epithemia															2	1			1					
Frustulia		1		2	1	1						1	2	1						1		1	1	
Gomphoneis	1			1			2	1		3	1	1	2	1								3		
Gomphonema		2				2			3		1		3				2							
Naviculoid diatoms		1			1	2		2	2		1	2	2		1				2	2		1	1	1
Nitzschia					1	2					2	2	1		2					2		2	1	1
Surirella					1					1	1		2	2		1								
Synedra	8	5	7	3	3	2	2	4	5	3	2	2		2	3	2	2	2	2	3	1	1	2	2
Planktonic green algae																								
Cosmarium						2	2	4	2							1				2				
Scenedesmus	1	1		4					2															

4. References

Biggs, B.J.F. and Kilroy, K.C. 2000. Stream periphyton monitoring manual. Ministry for the Environment, Wellington.

Entwisle, T.J., Sonneman, J.A. and Lewis, S.H. 1988. Freshwater algae of Australia: a guide to conspicuous genera. Sainty and Associates, Sydney.

Moore, S.C. 2000. Photographic guide to the freshwater algae of New Zealand. Otago Regional Council, Dunedin.

	Time	Conductivity	Dissolved Oxygen	pH	Temp	Suspended Solids (g/m3)
ANZECC Default Trigger Value				**7.20**		
				7.80		
GWRC Guideline						
MFE						
MTB - Upstream						
15/11/2012	15:58	125.2	10.4	8.29	16.30	
18/12/2012	13:51	150.6	9.9	8.38	20.70	1.5
30/01/2013	15:03	144.2	9.9	8.21	23.10	3.0
20/02/2013	18:30					2.5
10/04/2013	13:15	128.9	11.0	8.44	13.70	8.0
MTB 50m Downstream						
15/11/2012	14:21	123.8	10.4	8.14	15.70	
18/12/2012	12:38	150.4	9.6	8.08	20.30	1.5
30/01/2013	13:44	142.4	9.9	8.24	22.30	3.0
20/02/2013	10:26	156.0	9.7	8.09	19.80	2.0
10/04/2013	11:02	139.3	10.5	8.21	13.10	3.0
MTB 150m Downstream						
15/11/2012	13:25	121.5	10.0	8.13	15.10	
18/12/2012	11:59	149.9	9.6	8.08	20.20	1.5
30/01/2013	13:05	140.3	9.8	8.20	21.80	3.0
20/02/2013	9:34	155.4	9.3	8.04	19.50	2.0
MTB 250m Downstream						
15/11/2012	12:26	120.4	9.9	8.26	14.60	
30/01/2013	12:14	138.6	9.9	8.25	21.30	3.0
18/12/2012	11:06	149.6	9.2	8.03	20.10	1.5
20/02/2013	8:46	154.9	9.0	7.91	19.30	2.0
MTB 500m Downstream						
18/12/2012	10:29	149.8	9.0	8.21	20.10	4.0
30/01/2013	11:16	137.3	9.6	8.29	20.90	3.0
20/02/2013	8:00	154.8	8.2	8.02	19.30	2.0

BOD (Total) (g/m3)	E. coli (cfu/100ml)	Turbidity	Nitrite-N	Nitrate-N	Ammonia-Nitrogen (g/m3)	Total Phosphorus (g/m3)
		5.60			**0.021**	**0.033**
	260					
		1.03	0.005	0.350	0.005	
1.50	20	2.12	0.005	0.190	0.005	
0.50	8	1.08	0.005	0.010	0.030	
0.50	4	0.93	0.005	0.020	0.005	
0.50	56	3.91	0.005	0.090	0.005	
		0.80	0.005	0.350	0.010	
1.50	20	2.41	0.005	0.180	0.005	
0.50	4	0.92	0.005	0.010	0.005	
1.50	20	0.73	0.005	0.005	0.005	0.013
0.50	48	0.66	0.005	0.100	0.005	
		0.86	0.005	0.320	0.005	
1.50	8	3.33	0.005	0.180	0.005	
0.50	4	0.88	0.005	0.005	0.005	
1.50	20	0.79	0.005	0.005	0.005	0.012
		0.93	0.005	0.310	0.005	
0.50	16	0.85	0.005	0.005	0.005	
1.50	27	4.54	0.005	0.180	0.005	
1.50	48	0.66	0.005	0.005	0.005	0.011
1.50	8	6.31	0.005	0.180	0.005	
0.50	12	1.02	0.005	0.005	0.005	
1.50	16	0.76	0.005	0.005	0.005	0.012

Total Dissolved Phosphorus (g/m3)	Dissolved Reactive Phosphorus (g/m3)	Total Nitrogen (g/m3)	Black Disk (mm)	Dissolved Inorgainc Nitrogen (DIN)
	0.010	**0.614**	**800**	**0.465**
	0.014			
0.020	0.019	0.470	3250	0.360
0.011	0.006	0.390	2900	0.200
0.006	0.003	0.190	3750	0.045
0.006	0.006	0.190		0.030
0.010	0.009	0.300	1300	0.100
0.019	0.019	0.500	3270	0.365
0.011	0.011	0.410	2200	0.190
0.007	0.003	0.160	4100	0.020
0.007	0.006	0.150	3650	0.015
0.009	0.009	0.280	3800	0.110
0.019	0.018	0.480	3050	0.330
0.014	0.014	0.390	1650	0.190
0.008	0.003	0.160	4100	0.015
0.008	0.006	0.150	3400	0.015
0.019	0.017	0.470	2950	0.320
0.009	0.003	0.160	3800	0.015
0.011	0.011	0.400	1450	0.190
0.009	0.005	0.150	3500	0.015
0.014	0.010	0.420	1150	0.190
0.007	0.003	0.150	4000	0.015
0.007	0.006	0.150	3750	0.015

			Clean	Film	Sludge	Mats		Fils Slimy		Fils Course		Fine Sediment	
						Thin	Thick	Short	Long	Short	Long	Sand	Silt/Mud
MTB - Upstream	T1		93	2								5	
15/11/2012	Max Depth		93	2								5	
	0.60		90									10	
			93	2								5	
			95									5	
	T2		96	2								2	
	Max Depth		93	5								2	
	0.60		96	2								2	
			93	2								5	
			95									5	
	T3		96	2								2	
	Max Depth		93					2				5	
	0.60		88	2								10	
			98									2	
			97	1								2	
	T4		97	1								2	
	Max Depth		98									2	
	0.60		93	5								2	
			95									5	
			97					1				2	
18/12/2012	T1		98	2									
	Max Depth	% River Width	76	4								20	
	0.60	45	75	5								20	
			80	5								15	
			90	4								5	
	T2		90	10									
	Max Depth	% River Width	36	4								60	
	0.60	50	60	5								35	
			83	2								15	
			90	5								5	
	T3		96	4									
	Max Depth	% River Width	55	10								35	
	0.60	45	70	10								20	
			65	10								25	
			82	8								10	
	T4		96	4									
	Max Depth	% River Width	75	5									
	0.60	50	50	10									
			55	5									
			80	10									
30/01/2013	T1		60	10		10	5					15	
	Max Depth	Paces		2		10					2	20	
	0.60	30	69	4			10				2	15	
			89								1	10	
			84								1	10	
	T2		64	3		3						30	
	Max Depth	Paces	71	2							2	25	
	0.60	25	73	5							2	20	
			78	4							3	15	
			84	4							2	10	
	T3		30	15		15	5					35	
	Max Depth	Paces	64			10	4				2		20
	0.60	30	74	4							2	20	
			33	5							2	20	
				5						1	4	15	
	T4		43	8		8	1				5	35	
	Max Depth	Paces	66			3						30	
	0.60	28	85	5		5	5						
			74	4							2	20	
			78	5							2	15	
20/02/2013	T1	Paces											
	Max Depth												
	T2												
	Max Depth	Paces											
	T3												
	Max Depth	Paces											
	T4												
	Max Depth	Paces											
10/04/2013	T1			35		15					40		10
	Max Depth	Paces		5	30						50		15
	0.60	20		30	10					10	30	5	15
				15						5	75	5	
					20					10	55	5	10
	T2			25	20					5	40		10
	Max Depth	Paces		5	30						45	5	10
	0.4	15		10	20	5					45	5	10
				5	3					5	85	2	
					3						95	2	
	T3			10	30	5					40	5	10
	Max Depth	Paces		5	20					5	70		
	0.40	15		20	30					10	35	5	
				3	5					2	90		
				3	30						65	2	
	T4			5	30					5	60		
	Max Depth	Paces		5	30						65		
	0.35	21		15	10					5	65		5
				5	10						85		
				5	20						70	5	
MTB 50m Downstream	T1		86	10		2				2			
15/11/2012	Max Depth		93	5						2			
	0.60		83	15		2							
			85	15									

			80	20									
	T2		86	10						2	2		
	Max Depth		85	10		5			N				
	0.60		90	10									
			85	15									
			80	20									
	T3		92	5								2	
	Max Depth		68	25						2		5	
	0.60		85	10								5	
			83	10								2	5
			60	15								5	20
	T4		85	10								5	
	Max Depth		60	30								5	5
	0.60		85	10									5
			60	10								5	30
				10									90
18/12/2012	T1		5	85		10							
	Max Depth	% River Width	31	65		4							
	0.60	15	14	80		5				1			
			9	80		10				1			
				85		5							10
	T2		24	70		5				1			
	Max Depth	% River Width	24	60		15				1			
	0.60	15	45	50									5
			30	65									5
				53		2							45
	T3		50	50									
	Max Depth	% River Width	49	40		5				1			5
	0.60	10	43	45									8
			50	30									20
			45	25									30
	T4		73	25									2
	Max Depth	% River Width	70	25									5
	0.60	20	70	20									10
			75	15									10
			10	30									60
30/01/2013	T1			10		53	25				15		2
	Max Depth	Paces		10		77	10				8		5
	0.60	18		40		40	10						10
				20		50	10				20		
				35		40					10		15
	T2			10		60	5				20		5
	Max Depth	Paces		59		15				3	15		8
	0.60	14		52		30					10		8
				77		15					8		10
				70		40	5						15
	T3			15		50					20		15
	Max Depth	Paces		40		47	2				10		5
	0.60	10		50		30	5						15
				55		5				10			30
				75						5			20
	T4			15		30	10				40		5
	Max Depth	Paces		65		10	5			5	10		5
	0.60	12		65				5	5			5	20
				76		5					4		15
				55						5			40
20/02/2013	T1		5	25		30	40				10		
	Max Depth	Paces	10	10		15	65				25		
	0.60	19		10		30	15				35		5
			10	10		50					25		5
			5			5	40				45		
	T2		5	10		45	20				20		
	Max Depth	Paces	10	35		25	5			5	20		
	0.60	16		6		55	15			2	20		2
			5	15		15	40				15		10
				30			5			5	50		10
	T3		2			63	10			5	20		
	Max Depth	Paces		35		15	5				20		25
	0.60	15	5	5		50					35		10
				40		10					30		20
				40		5					15		40
	T4			33		10	2				40		15
	Max Depth	Paces		55		15					20		10
	0.60	13		55							25		20
				80							10		10
				50						10			40
10/04/2013	T1			5		10				20	65		
	Max Depth	Paces		5						10	85		
	0.60	18		5		5					90		
				5							90		5
				5						5	50		40
	T2				5					30	50		15
	Max Depth	Paces			5						90		5
	0.60	15			5					5	80		10
					10	5				10	75		
				20	10						45		25
	T3				10					20	45		25
	Max Depth	Paces		5	5					10	75		10
	0.60	16		5	5						80		10
				10						5	50		35
				10							20		70
	T4									35	55		10
	Max Depth	Paces		20	5					20	40		15
	0.60	13		30						5	45		20
				15						5	60		20

				5							25		70
MTB 150m Downstream	T1		94	5						1			
15/11/2012	Max Depth		86	10						4			
	0.60		93	5						2			
			98	2									
			46	20				4					30
	T2		65	30						5			
	Max Depth		45	40							10		5
	0.60		65	30							5		
			88	10						2			
			53	45						2			
	T3		66	30						2	2		
	Max Depth		35	60						5			
	0.58		80	15						5			
			88	10						2			
			88	20		4							
	T4		55	30						10	5		
	Max Depth		50	40						5	5		
	0.60		80	15						5			
			88	10						2			
			88	10						2			
18/12/2012	T1		10									90	
	Max Depth	% River Width	98	2									
	0.45	100	98	2									
			53	40		5				2			
			12	80									8
	T2		7	3								80	
	Max Depth	% River Width	98	2									
	0.45	100	54	15		30				1			
			6	30		60				4			
			20	80									
	T3		60									40	
	Max Depth	% River Width	61	20		15				4			
	0.55	100	16	40		40				4			
			20	40		35				5			
			62	30		4				4			
	T4		39	50		10				1			
	Max Depth	% River Width	69	35		4				2			
	0.60	60		60		35				2			
			9	80		10				1			
				35		4							
30/01/2013	T1		94									6	
	Max Depth	Paces	62	5		30					3		
	0.50	50	55	5		20	5			15			
						70	10				18		2
			3	90						2	5		
	T2		93								1	6	
	Max Depth	Paces	33	40		15				3	5		4
	0.50	60		5		30	50				5		10
				3		30	40				7		
				47		40	10				3		
	T3		80	4		4	4				1	7	
	Max Depth	Paces	11	5		30	50				4		
	0.50	55		5		50	40				5		
				30		60	5				5		
				48		40	2				10		
	T4					40	55				5		
	Max Depth	Paces		10		50	20				20		
	0.60	34		5		73	15				7		
				5		45	20				30		
				15		78	5						2
20/02/2013	T1		68	5						2			
	Max Depth	Paces	66	20		5	5				4		
	0.30	73	5	10		10	70				5		
						5	55				40		
				5		10	70				15		
	T2		80	10									
	Max Depth	Paces	30	15		5	40				20		
	0.40	70		15		30	25			5	25		
				5		40	40				15		
				10		20	40			5	20		
	T3		55	5									
	Max Depth	Paces	69			5	20			2	4		
	0.50	80		5		30	45			5	20		
				5		30	35				30		
			5	5		39	45			2	4		
	T4		76	4			15				5		
	Max Depth	Paces	43	5		5	45				2		
	0.50	61				22	70				8		
				5		75	10				10		
			5	10		73	10				2		
10/04/2013	T1		38	30							2	30	
	Max Depth	Paces	10	83		2				5			
	0.35	80	15	25		10	30				20		
			20	60			5			5	10		
			10	10						10	70		
	T2			84							1	15	
	Max Depth	Paces	15	72		5				4	4		
	0.30	85		40			55				5		
			20	30		5	35				10		
				20						40	40		
	T3			85								15	
	Max Depth	Paces	10	50			25				15		
	0.45	76	5	5			45				45		
			10	20		5	20			5	40		

				40		20					40		
	T4			88		5				5		2	
	Max Depth	Paces		15			70			4	50		
	0.55	72		10		10	30			5	45		
			10			10				5	75		
				10		20				10	60		
MTB 250m Downstream	T1		90	10									
15/11/2012	Max Depth		94	5						1			
	0.60		93	5						2			
			89	10						1			
			95	5									
	T2		61	35						4			
	Max Depth		40	40						20			
	0.60		80							20			
			84	15						1			
			90	10									
	T3		96	4									
	Max Depth		93	5						2			
	0.60		92	8									
			96	4									
			95	5									
	T4		95	5									
	Max Depth		95	5									
	0.60		93	5						2			
			95	5									
			98	2									
18/12/2012	T1		83	15								2	
	Max Depth		95	5									
	0.60		95	5									
			95	5									
			85	15									
	T2		95	5									
	Max Depth		96	4									
	0.60		95	5									
			96	4									
			83	15								2	
	T3		96	4									
	Max Depth		98	2									
	0.60		96	4									
			98	2									
			78	20								2	
	T4		96	5									
	Max Depth		97	3									
	0.60		92	8									
			96	4									
			88	10								2	
30/01/2013	T1		57	5		30					8		
	Max Depth	Paces	75			20					5		
	0.60	20	75	10		5					10		
			60	15		5					20		
			15	50							35		
	T2		79	5		8					8		
	Max Depth	Paces	70	10							20		
	0.60	13	65	10							25		
			75	5							20		
			20								5		5
	T3		85	5		5					5		
	Max Depth	Paces	50	10		10					30		
	0.60	15	70	15		5					10		
			70	5		5					20		
			17	5		70					5		3
	T4		53	10		25					5	2	
	Max Depth	Paces	75	5		15					5		
	0.60	24	80	5		8					5		
			70	15		5					10		
				10		3					8		2
20/02/2013	T1			83						2			
	Max Depth		23	20			40				2	15	
	0.55	Paces	68	10			20			2		15	
		52	60	10			15				5		
			35	30							35		
	T2		69	10		5	5				1	15	
	Max Depth	Paces	53	5		5	30				2	5	
	0.55	48	57	15		5	15				4	4	
			50	25		5	10				10		
			53	30		2					15		
	T3		40	40								20	
	Max Depth	Paces	42			10	40				8		
	0.55	50	58	15		5	20				2		
			41	20		20	5			4	10		
			64	30							6		
	T4		49	25		15					1	10	
	Max Depth	Paces	38	10		5	40				2	5	
	0.55	48	55	5		5	35						
			55	15		5	10				15		
			35	20		5	20				20		
10/04/2013	T1			87			5				8		
	Max Depth	Paces		80			5			5	10		
	0.60	19		60			5				35		
				86		10					4		
				70		5	5			5	15		
	T2		5	70			15			2	8		
	Max Depth	Paces	15	75		5					5		
	0.60	28	5	70		5	15				5		
			5	30		10	40			5	15		

				50		5				10	35		
	T3			80		10						10	
	Max Depth	Paces	10	11			25			4	15	30	
	0.58	60	20	71			4				5		
			15	40			20			5	10		
			5	86			5			2	2		
	T4		51	20			4				2	5	
	Max Depth	Paces	15	65			35				10	5	
	0.58	62	15	35		40				5	5		
			5	60		20				5	10		
			15	60		5	5			5	10		

	Substrate						
MTB - Upstream	**Bedrock**	**Boulders**	**L. Cobbles**	**S. cobbles**	**Gravel**	**Sand**	**Silt**
15/11/2012				15	83	2	
			2	20	76	2	
				10	88	2	
				10	85	5	
				10	88	2	
18/12/2012			5	15	60		
				10	80	20	
			5	20	35	40	
				20	40	40	
				20	70	10	
30/01/2013			10	30	40	20	
				30	40	30	
			10	40	50		
				40	40	20	
			5	25	55	15	
10/04/2013				30	70		
				40	60		
				15	80		
				20	80		
				15	80	5	
MTB 50m Downstream			15	60	20	5	
15/11/2012			20	40	30	5	5
			20	20	55		5
			5	60	25	5	30
			10	40	20		30
18/12/2012			10	20	68		2
			10	10	75		5
			15	10	65		10
			10	10	70		10
			10	10	15		65
30/01/2013		20	10	30	35		5
			25	20	50		5
		15	5	30	30		20
			15	40		3	15
			10	50			40
20/02/2013			15	50	20		15
			5	25	60		10
			20	25	35		20
			20	40	30		10
				30	30		40
10/04/2013			35	45	10		10
			10	25	50		15
		10	5	30	35		20
		5	20	15	30		20
				15	15		70
MTB 150m Downstream			10	60	25	2	
15/11/2012			10	75	15		
			15	70	15		
			15	75	10		
18/12/2012			5	20	75		
			30	50	15	5	
			10	60	30		
			30	60	10		
			15	10	75		
30/01/2013		15	20	60	5		
		10	5	75	10		
		35	5	40	20		

		5	30	45	20		
		2	5	71	20		2
20/02/2013				35	61	4	
		35	20	20	25		
			30	40	30		
			20	30	50		
10/04/2013				60	38	2	
			25	40	35		
			5	65	30		
			5	20	75		
			30	30	40		
MTB 250m Downstream				40	60		
15/11/2012				80	20		
			5	40	55		
				30	70		
			5	70	25		
18/12/2012				10	90		
				15	85		
				25	70		
			5	20	75		
			5	15	73	2	
20/02/2013			20	60	15	5	
			15	30	50	5	
			15	10	55		
			10	20	70		
				10	90		
10/04/2013			25	40	30	5	
			15	45	35	5	
				30	70		
			10	35	55		
				10	90		

	Time	Conductivity	Dissolved Oxygen	pH	Temp	Suspended Solids (g/m3)	BOD (Total) (g/m3)	E. coli (cfu/100ml)	Turbidity	Nitrite-N	Nitrate-N	Ammonia-Nitrogen (g/m3)	Total Phosphorus (g/m3)	Total Dissolved Phosphorus (g/m3)	Dissolved Reactive Phosphorus (g/m3)	Total Nitrogen (g/m3)	Black Disk (mm)	Dissolved Inorgainc Nitrogen (DIN)
ANZECC Default Trigger Value				**7.20**					**5.60**			**0.021**	**0.033**		**0.010**	**0.614**	**800**	**0.465**
				7.80														
GWRC Guideline															**0.014**			
MFE								**260**										
Papawai - Upstream																		
19/12/2012	10:01	114.8	2.89	7.30	15.6	2.0	0.5	76	0.54	0.005	0.53	0.005		0.016	0.013	0.73		0.540
31/01/2013	15:18	126.0	2.49	7.16	17.4	3.0	0.5	16	1.15	0.005	0.28	0.005		0.013	0.005	0.65		0.290
21/02/2013	13:30					5.0	0.5	40	2.04	0.005	0.66	0.005		0.009	0.006	0.76		0.670
4/03/2013	12:30	104.2	6.50	6.88	15.4	2.5	0.5	190	1.80	0.005	0.35	0.005		0.015	0.012	0.69		0.360
21/03/2013	10:23	115.7	6.61	6.87	13.0	5.0	0.5	100	1.90	0.005	0.78	0.005		0.016	0.019	1.01		0.790
3/04/2013	9:19	109.0	5.78	7.44	14.8	2.5	1.5	190	3.02	0.005	0.68	0.010		0.018	0.018	0.91		0.695
9/04/2013	10:33	103.7	8.52	7.76	13.1	3.0	0.5	170	2.41	0.005	0.61	0.020		0.019	0.018	0.92		0.635
15/04/2013	11:11	103.3	9.08	7.63	13.5	6.5	3.0	92	1.57	0.005	0.61	0.010		0.015	0.017	0.81		0.625
1/05/2013	10:19	102.50	7.17	7.10	13.20	2.5	0.5	190	2.70	0.005	0.73	0.03		0.019	0.020	0.09		0.765
Papawai - 50 Down																		
19/12/2012	10:44	120.0	4.18	7.07	16.0	2.0	0.5	110	1.08	0.005	0.56	0.140		0.084	0.079	0.96		0.705
31/01/2013	15:45	130.2	4.28	7.21	17.9	3.0	0.5	28	2.18	0.010	0.28	0.005		0.094	0.087	0.79		0.295
21/02/2013	13:03	125.5	5.32	6.57	17.2	5.0	0.5	52	2.53	0.005	0.62	0.030		0.048	0.038	0.99		0.655
4/03/2013	12:39	114.9	7.20	7.23	15.7	2.5	2.0	140	2.38	0.005	0.27	0.120		0.145	0.140	1.03		0.395
21/03/2013	10:38	127.6	6.80	6.76	13.2	6.0	1.0	390	2.18	0.005	0.75	0.450		0.191	0.184	1.67		1.205
3/04/2013	9:34	114.7	6.11	6.82	14.9	2.5	1.5	160	3.38	0.005	0.66	0.200		0.100	0.095	1.23		0.865
9/04/2013	10:49	109.4	7.94	7.23	13.2	3.0	0.5	81	3.81	0.010	0.73	0.230		0.099	0.092	1.20		0.970
15/04/2013	11:26	108.5	8.59	6.85	13.6	6.5	3.0	77	2.26	0.010	0.65	0.180		0.068	0.081	1.16		0.840
1/05/2013	10:30	107.20	7.03	7.22	13.30	2.5	0.5	270	3.68	0.020	0.73	0.13		0.084	0.078	1.19		0.880
Papawai - 200 Down																		
19/12/2012	10:34	120.5	4.50	7.11	16.2	2.0	0.5	150	1.19	0.010	0.56	0.110		0.074	0.071	0.91		0.680
31/01/2013	15:37	129.9	4.76	7.36	18.4	3.0	0.5	38	1.52	0.005	0.29	0.005		0.083	0.071	0.72		0.300
21/02/2013	14:34	126.6	4.83	7.02	17.8	2.5	0.5	68	1.57	0.005	0.59	0.005		0.062	0.045	0.88		0.600
4/03/2013	12:51	114.4	5.21	7.15	15.8	2.5	1.0	40	1.63	0.010	0.31	0.090		0.122	0.116	0.94		0.410
21/03/2013	10:48	126.5	4.44	6.68	12.9	2.5	0.5	180	1.44	0.040	0.86	0.290		0.175	0.169	1.59		1.190
3/04/2013	9:47	113.9	4.36	6.95	15.0	2.5	1.5	130	1.96	0.020	0.76	0.100		0.093	0.092	1.14		0.880
9/04/2013	10:58	108.6	6.37	7.12	13.1	3.0	0.5	36	2.61	0.020	0.70	0.100		0.094	0.087	1.23		0.820
15/04/2013	11:36	107.7	7.13	6.74	13.4	6.5	3.0	64	1.54	0.020	0.73	0.090		0.079	0.084	1.07		0.840
1/05/2013	10:43	106.90	6.26	6.88	13.30	2.5	0.5	2200	1.96	0.010	0.81	0.07		0.089	0.082	1.15		0.890
Papawai - 540 Down																		
19/12/2012	10:25	121.1	3.43	7.08	16.2	2.0	0.5	120	1.24	0.005	0.56	0.005		0.061	0.055	0.85		0.570
31/01/2013	15:27	127.6	3.83	7.33	18.4	3.0	0.5	84	1.14	0.005	0.17	0.005		0.071	0.048	0.64		0.180
21/02/2013	14:41	126.3	4.25	6.88	17.4	2.5	0.5	76	1.21	0.005	0.57	0.005		0.059	0.042	0.63		0.580
4/03/2013	12:59	117.0	4.30	7.20	15.3	2.5	0.5	110	1.78	0.005	0.37	0.020		0.083	0.077	0.87		0.395
21/03/2013	10:59	126.7	5.08	6.81	13.1	2.5	0.5	64	1.34	0.030	0.91	0.130		0.156	0.144	1.44		1.070
3/04/2013	10:02	114.3	3.68	7.07	15.2	2.5	1.5	64	1.16	0.010	0.81	0.040		0.091	0.088	1.08		0.860
9/04/2013	11:07	106.4	5.38	7.01	12.7	3.0	0.5	50	1.31	0.005	0.69	0.070		0.087	0.084	1.09		0.765
15/04/2013	11:50	107.0	5.63	6.72	13.2	6.5	3.0	88	1.29	0.005	0.77	0.040		0.062	0.075	1.03		0.815
1/05/2013	10:55	107.50	5.05	6.89	13.40	2.5	0.5	68	1.24	0.005	0.82	0.04		0.082	0.077	1.09		0.865

	Time	Conductivity	Dissolved Oxygen	pH	Temp	Suspended Solids (g/m3)	BOD (Total) (g/m3)	E. coli (cfu/100ml)	Turbidity	Nitrite-N	Nitrate-N	Ammonia-Nitrogen (g/m3)	Total Phosphorus (g/m3)	Total Dissolved Phosphorus (g/m3)	Dissolved Reactive Phosphorus (g/m3)	Total Nitrogen (g/m3)	Black Disk (mm)	Dissolved Inorgainc Nitrogen (DIN)
ANZECC Default Trigger Value				**7.20**					**5.60**			**0.021**	**0.033**		**0.010**	**0.614**	**800**	**0.465**
				7.80														
GWRC Guideline															**0.014**			
MFE								**260**										
GTN - Upstream																		
16/11/2012	14:14	63.80	11.90	7.98	14.2				0.60	0.005	0.170	0.005		0.019	0.017	0.290		0.180
31/01/2013	14:20	103.80	11.81	8.85	23.1	9	0.5	4	10.20	0.005	0.050	0.005		0.010	0.003	0.180	700	0.060
21/02/2013	10:53	109.00	10.81	7.93	18.8	2	0.5	52	1.49	0.005	0.100	0.005		0.006	0.006	0.190	3300	0.110
9/04/2013	14:19	105.90	10.90	8.22	14.4	3	0.5	31	2.15	0.005	0.070	0.005		0.015	0.012	0.270		0.080
GTN 85m Downstream																		
16/11/2012	14:41	80.00	11.38	7.97	13.7				0.67	0.005	0.280	0.005		0.027	0.025	0.430		0.290
31/01/2013	13:24	111.90	9.51	8.05	21.2	3	0.5	72	6.57	0.005	0.090	0.005		0.016	0.006	0.240		0.100
21/02/2013	10:06	118.80	9.45	7.69	17.9	3	0.5	56	1.14	0.005	0.150	0.005		0.011	0.006	0.270	3000	0.160
9/04/2013	13:31	106.70	10.56	7.99	14.2	3	0.5	36	1.58	0.005	0.140	0.005		0.024	0.024	0.430		0.150
GTN 400m Downstream																		
16/11/2012	13:15	85.80	11.66	7.85	14.0				0.61	0.010	0.240	0.005		0.022	0.022	0.410		0.255
31/01/2013	12:18	114.10	11.75	8.23	20.8	3	0.5	20	2.64	0.005	0.050	0.005		0.008	0.003	0.200	1600	0.060
21/02/2013	9:48	125.70	9.68	7.72	18.1	3	0.5	64	1.02	0.005	0.110	0.005		0.008	0.006	0.230	2800	0.120
9/04/2013	12:55	112.60	11.01	7.81	14.1	3	0.5	32	1.88	0.005	0.090	0.005		0.019	0.016	0.340		0.100

			Clean	Film	Sludge	Mats		Fils Slimy		Fils Course		Fine Sediment	
						Thin	Thick	Short	Long	Short	Long	Sand	Silt/Mud
GTN - Upstream	T1	Paces	65	30								5	
16/11/2012	Max Depth		68	30				2					
	0.60		55	40				2				3	
			66	30								4	
			80	15		1						4	
	T2	Paces	66	30				1				3	
	Max Depth		69	25				2				4	
	0.60		55	35								10	
			58	30								8	
			82	10								8	
	T3	Paces	42	50				3				5	
	Max Depth		49	45				1				5	
	0.60		33	50				1				15	
			53	45								2	
			76	15								8	
	T4	Paces	50	45				1				4	
	Max Depth		42	50				4				4	
	0.60		35	55				4				6	
			33	55				1	2			4	
			77	15								8	
31/01/2013	T1				85						15		
	Max Depth	Paces		5	50					15	30		
	0.60	28		10	70					10	10		
			35	50	10						5		
			20	65	13						2		
	T2				60						40		
	Max Depth	Paces			60						40		
	0.60	22		20	45					20	15		
				30	58						5	2	
				55	30							15	
	T3				80						20		
	Max Depth	Paces			60						40		
	0.60	23		10	70						20		
				20	68					10	2		
				70	15							15	
	T4				45					15	40		
	Max Depth	Paces		5	40					10	45		
	0.60	22		10	36					40	10	4	
				45	40						5	10	
				75	15							10	
21/02/2013	T1			100									
	Max Depth	Paces		90	5					5			
	0.55	80		54	45						1		
				10	90								
				80	20								
	T2			91	5						4		
	Max Depth	Paces		55	40					5			
	0.55	85		40	60								
				10								90	
				60	40								
	T3			34	65					1			
	Max Depth	Paces		19	80						1		
	0.60	45		5								95	
				40	60								
				90	10								
	T4			8	65		2				5		
	Max Depth	Paces		9						1		20	
		37		15	15							90	
				24	75						1	70	
				80	20								
9/04/2013	T1		35	20							40		5
	Max Depth	Paces		10						5	85		
	0.50	92		10						5	80		5
				20						20	60		
				76						2	2	30	
	T2			5						5	90		
	Max Depth	Paces		15						5	80		
	0.60	40	10	75						5	10		
				91							4		5
				65							5	30	
	T3		10	72							8		10
	Max Depth	Paces		87						8			5
	0.60	25		80						5	5		10
				65						5	5	20	5
				66							4	30	
	T4			80						5	5		10
	Max Depth	Paces		55						5	20		20
	0.60	20		85							10		5
				40							30	20	10
				55							15	20	10

GTN 85m Downstream	T1		98	2									
16/11/2012	Max Depth	Paces	95	5									
	0.60		95	5									
			95	5									
			93	5								2	
	T2		94	5				1					
	Max Depth	Paces	98	2									
	0.60		97	2				1					
			96	4									
			100										
	T3		93	2								5	
	Max Depth	Paces	94	1								5	
	0.60		96	2								2	
			95	1								4	
			93	5								2	
	T4		96	2								2	
	Max Depth	Paces	97	2								1	
	0.60		92	4								4	
			94	4								2	
			96	2								2	
31/01/2013	T1				90	4				5	1		
	Max Depth	Paces			88	4					8		
	0.60	15		5	60					20	15		
				5	40		4			20	35		
				10	20	40				20	10		
	T2			5	80						15		
	Max Depth	Paces		5	61	4				20	10		
	0.60	11	2	5	49	4					40		
			5	10	40					20	25		
			8	10	32					20	25	5	
	T3			10	25	5				20	40		
	Max Depth	Paces		5	60	5				15	15		
	0.60	5		5	33	20				15	25	2	
			5		40	5				20	20	10	
					25	10				20	20	25	
	T4			10	51	4					35		
	Max Depth	Paces	16	15	20					20	25	4	
	0.60	6		10	50	10				15	15		
				5	39	4				20	30	2	
			5	5	20	5				25	25	15	
21/02/2013	T1			58	30		12						
	Max Depth	Paces		62	30		8						
	0.60	30	25		10		40				25		
				60	30					10			
				30	40		10			10	10		
	T2			40	55		5						
	Max Depth	Paces		31	50		25			4			
	0.60	34		10	40		35			10	5		
				45	45					5	5		
				25	60		5			10			
	T3			35	65								
	Max Depth	Paces		30	50					5	15		
	0.60	6		65	30					5			
				85	15								
				75	25								
	T4			36	60						4		
	Max Depth	Paces		65	30	5					4		
	0.60	7		70	30								
				100									
				90	10								
9/04/2013	T1		55	30							15		
	Max Depth	Paces	50	30						10	10		
	0.60	16	15	66		4					10	5	
			20	66							10	4	
				91		4				5			
	T2		65	30						5			
	Max Depth	Paces	35	50						10	5		
	0.60	15	10	66						15	2	4	4
			55	30								10	5
			10	70								15	5
	T3		10	83						2			5
	Max Depth	Paces	20	45						20		10	5
	0.60	11	5	75						5		5	10
			10	80								5	5
			10	70								20	
	T4		20	65		5							10
	Max Depth	Paces	5	65						5			25
	0.60	8	10	53							2	25	10
			5	44						1		50	
			5	65								20	10
GTN 400m Downstream	T1	Paces	79	8				8				5	
16/11/2012	Max Depth		88	10				2					
	0.60		93	5								2	
			95	4								1	

			97	1								2	
	T2	Paces	86	10				4					
	Max Depth		87	8				4				1	
	0.60		83	15								2	
			80	10								4	
			97	1								2	
	T3	Paces	87	8				3				2	
	Max Depth		77	15				6				2	
	0.60		93	5								2	
			95	4								1	
			98	2									
	T4	Paces	75	20				5					
	Max Depth		91	5				2				2	
	0.60		87	8				1				4	
			96	3								1	
			91	5		1						3	
31/01/2013	T1		3	85							10	2	
	Max Depth	Paces	2		90						8		
	0.55		2		88		2			2	6		
					92						4	4	
					97					2	1		
	T2			95							5		
	Max Depth	Paces			75	5				5	15		
	0.50				60					10	30		
					82	10					5	3	
					68	2				15	15		
	T3			90						4	2	4	
	Max Depth	Paces			28	2				20	50		
	0.46			4	34	2					60		
			10		82	4				2		2	
			2		82	2				10	4		
	T4		13	60	25					1	1		
	Max Depth	Paces		5	56	4				20	15		
	0.42			4	21					10	65		
				53	40					4	1	2	
					76	4					20		
21/02/2013	T1		97	3									
	Max Depth	Paces	14	40	25					2	4	15	
	0.45	60		78	15	2					5		
				69		4					10	15	
				75	10							15	
	T2		95	4						1			
	Max Depth	Paces		73	10						2	15	
	0.45	60	6	75	15					4			
			10	70							10	10	
				90		2				4		4	
	T3		88	10	2								
	Max Depth	Paces		98						2			
	0.45	60		80	15					5			
			5	70		5				10		10	
				80	5							15	
	T4		5	90		5							
	Max Depth	Paces	4	65	5					1		25	
	0.45	70		53	15					2		30	
			76	15	45						4	5	
				25		5						25	
9/04/2013	T1		72	20						2	2	4	
	Max Depth	Paces		84						2	4	10	
	0.50	62	10	80							8	2	
			58	40								2	
			26	70								4	
	T2		20	66						6	8		
	Max Depth	Paces	10	61						2	2	15	
	0.50	64		84		1				2	8	5	
			73	25						2			
				86		5				2		5	4
	T3		10	78						4	6	2	
	Max Depth	Paces	5	60						2	8	25	
	0.45	65	52	35						4	4	5	
			76	20						4			
				92						2		2	4
	T4		5	60							30	5	
	Max Depth	Paces		72		2				2	4	20	
	0.45	69	55	40						5			
				20						2		5	
			10	82								4	4

	Substrate						
GTN Ruamahanga - Upstream	**Bedrock**	**Boulders**	**L. Cobbles**	**S. cobbles**	**Gravel**	**Sand**	**Silt**
16/11/2012			3	7	88	2	
				20	78	2	
			4	16	76	4	
			4	30	65	1	
			40		52	8	
31/01/2013				10	88	2	
				5	95		
				10	90		
				30	60	10	
				10	80	10	
21/02/2013				10	70	20	
					10	90	
					30	70	
					100		
				20	80		
9/04/2013			10	13	67		10
				35	45		20
				5	90		5
				30	40	20	10
				25	45	20	10
GTN 85m Downstream							
16/11/2012			10	15	70	5	
			5	30	60	5	
			2	15	80	3	
			2	15	80	3	
			2	15	75	5	
31/01/2013			15	10	70	5	
			20	30	60		
			15	45	40		
				40	58	2	
			5	35	45		15
21/02/2013			5	40	55		
			10	30	60		
			5	15	80		
				15	85		
				20	80		
9/04/2013			5	30	65		10
			5	30	40		25
			10	30	25	25	10
				30	20	50	
				30	40	20	10
GTN 400m Downstream							
16/11/2012				15	82	3	
				15	80	5	
				30	68	2	
				40	59	1	
				55	44	1	
21/02/2013			5	5	90		
					75	25	
				5	65	30	
				5	90	5	
				10	65	25	
9/04/2013				5	90	5	
				20	60	20	
				10	90		
				5	90	5	

				20	72	4	4

	Time	Conductivity	Dissolved Oxygen	pH	Temp	Suspended Solids (g/m3)	BOD (Total) (g/m3)	E. coli (cfu/100ml)	Turbidity	Nitrite-N	Nitrate-N	Ammonia-Nitrogen (g/m3)	Total Phosphorus (g/m3)	Total Dissolved Phosphorus (g/m3)	Dissolved Reactive Phosphorus (g/m3)	Total Nitrogen (g/m3)	Black Disk (mm)	Dissolved Inorgainc Nitrogen (DIN)
ANZECC Default Trigger Value				**7.20**					**5.60**			**0.021**	**0.033**		**0.010**	**0.614**	**800**	**0.465**
				7.80														
GWRC Guideline															**0.014**			
MFE								**260**										
FSN - Upstream																		
16/11/2012	11:00	101.80	9.59	7.58	12.90				1.11	0.005	0.670	0.005		0.01	0.007	0.82		0.680
19/12/2012	12:52	117.30	7.44	7.40	18.00	11.0	0.5	550	1.10	0.005	0.680	0.005		0.01	0.009	0.82	1900	0.690
31/01/2013	10:44	115.70	6.39	7.49	15.90	3.0	0.5	190	1.42	0.005	0.170	0.005		0.02	0.006	0.45	2900	0.180
22/02/2013	10:26	105.00	6.27	7.02	14.90	3.0	0.5	180	0.86	0.005	0.310	0.010		0.02	0.017	0.47	3000	0.325
12/04/2013	14:32	86.70	8.10	7.63	16.00	5.0	0.5	400	2.98	0.005	0.590	0.005		0.016	0.015	0.81	2400	0.600
FSTN 53m																		
16/11/2012	10:14	108.70	8.89	7.50	12.90				1.95	0.020	0.680	0.390		0.14	0.130	1.43		1.090
19/12/2012	12:23	158.30	6.22	7.27	19.20	5.0	9.0	230	5.16	0.080	0.560	1.030		0.72	0.634	3.05	530	1.670
31/01/2013	10:06	141.20	5.13	7.21	16.40	7.0	3.0	490	4.10	0.010	0.180	0.500		0.41	0.353	1.61	650	0.690
22/02/2013	9:54	141.60	5.67	7.38	16.00	3.0	4.0	200	3.15	0.020	0.260	0.810		0.18	0.146	2.30	800	1.090
12/04/2013	14:19	143.90	7.49	7.57	15.80	16.0	6.0	12000	10.50	0.050	0.890	0.700		0.370	0.331	2.80	450	1.640
FSTN 150m Downstream																		
16/11/2012	9:40	107.60	8.92	7.69	12.70				1.55	0.020	0.750	0.360		0.14	0.129	1.35	1620	1.130
19/12/2012	12:06	157.10	5.83	7.34	18.70	12.0	8.0	320	4.68	0.090	0.600	0.920		0.69	0.626	2.92	630	1.610
31/01/2013	8:03	138.70	4.73	7.41	15.60	7.0	3.0	140	4.82	0.030	0.290	0.380		0.41	0.345	1.60	1100	0.700
22/02/2013	9:09	141.20	5.17	7.11	16.00	3.0	4.0	200	2.94	0.030	0.330	0.770		0.19	0.160	2.19	850	1.130
12/04/2013	14:08	137.70	7.73	7.88	15.60	13.0	4.0	7000	8.22	0.040	1.100	0.260		0.262	0.232	2.20	600	1.400

		Clean	Film	Sludge	Mats		Fils Slimy		Fils Course		Fine Sediment	
					Thin	Thick	Short	Long	Short	Long	Sand	Silt/Mud
FSN - Upstream	T1	90									5	5
16/11/2012	Max Depth	90									5	5
	0	100										
		100										
		100										
	T2	93										5
	Max Depth	95									5	
	0	100										
		100										
		95										5
	T3	95										5
	Max Depth	100										
	0	98										2
		100										
		100										
	T4	100										
	Max Depth	100										
	0	100										
		98									2	
		100										
19/12/2012	T1	85	5									10
	Max Depth	88	4									8
	0	93	5									2
		91	5								2	2
		80	8								2	10
	T2	20										80
	Max Depth	15										85
	0	94	4								2	
		95	2								2	1
		43	10								2	45
	T3	100										
	Max Depth	95							1		4	
	0	98									2	
		96										4
		55										45
	T4	98									2	
	Max Depth		2								2	
	0	98	2									
			1								2	
			2								1	
31/01/2013	T1		2									98
	Max Depth		5									95
	0	10										90
		20	5									75
		85										15
	T2	90									5	5
	Max Depth	40							10			20
	0	98									2	
		94	4								2	
		55	10						15			20
	T3	92	4									
	Max Depth	96									4	
	0	98									2	
		98	2								2	
		100										
	T4	92										8
	Max Depth										4	
	0	96								2	2	
		91	2						2			5
		90	5									5
22/02/2013	T1	5										95
	Max Depth											20
	0											40
		10										15
		10										10
	T2	2										8
	Max Depth										2	
	0										10	
		2									10	5
											5	5
	T3											4
	Max Depth	1										
	0	4										
	T4	2										5
	Max Depth	2										
	0											
												2
												2
12/04/2013	T1		30									70
	Max Depth		40									60

	0		75									25
			70									30
			60									40
	T2		50									50
	Max Depth		65	10								25
	0		40	20								40
			20	15								65
				5								95
	T3		25									75
	Max Depth		40	15								45
	0		75	5								20
			85									5
			85								5	
	T4		15									85
	Max Depth		72								3	10
	0		90								10	
			80									
			47								3	35
FSTN 53m	T1	100										
16/11/2012	Max Depth	100										
	0	100										
		100										
		98										2
	T2	100										
	Max Depth	100										
	0	85										15
		19							1			80
												100
	T3	98							2			
	Max Depth	98	2									
	0	98									2	
		98									2	
		90										10
	T4	98	2									
	Max Depth	100										
	0	100										
		98									2	
		98									2	
19/12/2012	T1		5						70			25
	Max Depth		5						65			30
	0		10						70			20
			10						50			40
		70							10			20
	T2		50						5			45
	Max Depth		30						10			60
	0	25	10						15			40
			5						5			90
									5			95
	T3		5						20			75
	Max Depth		10						10			80
	0	55	10						5			30
		60	10						10			20
		40	5						25			30
	T4		5						5			90
	Max Depth								25		10	
	0		10						5		15	
			5						5		5	10
			25						15			60
31/01/2013	T1		30						45	5		20
	Max Depth		52						20	8		20
	0		40						40	10		10
			10						45	25		20
			30						40	15		15
	T2		25									75
	Max Depth		30						30			40
	0		2						98			
			5						95			
			2						88			10
	T3		35						10	15		40
	Max Depth		20						60	10		10
	0		30						55	5		10
			10						70			20
			2						98			
	T4	90	5								5	
	Max Depth	50	30						10			10
	0		5						95			
			10						90			
			5						80			15
22/02/2013	T1		36									60
	Max Depth		48	5						4		45
	0		35	5						2		60
			60									40
			10							10		80
	T2		25									75

	Max Depth		30	10							60
	0		10	10							80
				5							95
											100
	T3		5	20							75
	Max Depth		65								35
	0		80					5			15
			70	10							20
			50								50
	T4		80								20
	Max Depth		95								5
	0		80								20
			15	10							75
			70	10							20
12/04/2013	T1		10	30							60
	Max Depth		20	40							40
	0		20	50							30
			20	20					5	5	50
			55	5					5	10	25
	T2		50	5						5	40
	Max Depth		75	10						15	
	0		20							50	30
			10								90
			5								95
	T3		30							30	40
	Max Depth	60	30						5	5	
	0	50	20	25						5	5
			50	25						5	20
			25	35							40
	T4	78	10						2	10	
	Max Depth	5								95	
			3	2						90	5
			45	30							25
			30	30							40
FSTN 150m Downstream	T1	100									
16/11/2012	Max Depth	100									
		98						2			
		100									
		100									
	T2	63	2					5	15		15
	Max Depth	93						5			2
		96	2								2
		100									
		100									
	T3	60									40
	Max Depth	100									
		100									
		98									2
		95									5
	T4	100									
	Max Depth	100									
		85									15
		90									10
		76									30
19/12/2012	T1		20					80			
	Max Depth		5					95			
	0		5					95			
			3					95		2	
			5					95			
	T2	30	5					45			20
	Max Depth		5					55			40
	0							40			60
								30			70
			2								98
	T3							5			95
	Max Depth		5					5			90
	1							10			90
								10			90
								5			95
	T4										100
	Max Depth										100
	1							5			95
								5			95
								4			96
31/01/2013	T1		20					10	70		
	Max Depth		10					30	60		
	0		50					40	10		
			20					30	30		20
			20					20	30		30
	T2		5						75		20
	Max Depth		5						80		15
	0		20						60		20
			75					5	5		15
			70						2		25

	T3		15							40		45
	Max Depth		75									25
	0		80									20
			68							2		30
			74							1		25
	T4		5									95
	Max Depth		2									98
	1		5									100
			5									95
												95
22/02/2013	T1		25							20		55
	Max Depth		10							30		60
	0		5							85		10
			5							75		20
			20							50		30
	T2		5									95
	Max Depth		10									90
	0		35						5			60
			50							10		40
			5							70		25
	T3		10									90
	Max Depth		5									95
	1		5									95
			10									90
			30									70
	T4		15									85
	Max Depth		5									95
	1		10									90
												100
												100
12/04/2013	T1		35	30						10	5	20
	Max Depth		25	15						25	5	30
	0		35	20						30		15
			20	30						25	5	20
			20							65		15
	T2		60									40
	Max Depth		65									35
	0		20							30		50
			10	10						70		10
			15	10						35		40
	T3		50	15								35
	Max Depth		40									60
	0		50									50
			15									85
			45								15	40
	T4		20									80
	Max Depth		10									90
	1		20									80
			20									80
			20									80

	Substrate						
FSTN- Upstream	**Bedrock**	**Boulders**	**L. Cobbles**	**S. cobbles**	**Gravel**	**Sand**	**Silt**
16/11/2012					98	2	
				5	90	5	
				40	60		
					100		
				5	95		
19/12/2012					98	2	
					98	2	
				3	97		
					98	2	
				3	96	2	
31/01/2013				4	88		8
				4	92	4	
				5	93	2	
				2	93		5
			5		90		5
22/02/2013					95		5
					100		
				5	95		
					100		
				2	96		
12/04/2013					15		85
					87	3	10
				30	60		10
				5	95		
					60	3	35
FSTN 53m				20	40	40	
16/11/2012			10	20	60	10	
				30	60	10	
					25	75	
				5	70	10	15
19/12/2012					100		90
					90	10	
					85	15	
					85	5	10
					90		60
31/01/2013					85	15	
					65	5	30
					100		
					95	5	
							100
22/02/2013				5	75		20
					75	20	5
				5	55	20	20
				5	10	10	75
				10	80		10
12/04/2013					90	10	
					5	95	
					5	90	5
					100		
					60		40
FSTN 150m Downstream				80	17		3
16/11/2012				60	38		2
					100		
				10	88		2
					100		
19/12/2012					100		100
					100		100

					100		100
					100		100
					100		100
31/01/2013					100		100
					100		100
					100		100
					100		100
					100		100
22/02/2013					15		85
					5		95
					10		90
							100
							100
12/04/2013					20		80
					10		90
					20		80
					20		80
					20		80