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Report

Annual Waikanae River and River Recharge Report 2016/17 (Consents WGN130103 [34399] and [34400])

Prepared for Greater Wellington Regional Council

On behalf of Kāpiti Coast District Council

Prepared by CH2M Beca Ltd

22 September 2017

Revision History

Revision Nº	Prepared By	Description	Date
1	Simon Newton, Tracy Clode	Draft for client review	27 July 2017
2	Simon Newton	Draft for Adaptive Management Group review	02 August 2017
3	Simon Newton	Final for Council Approval	05 September 2017
4	Simon Newton	Final for Submission to Greater Wellington Regional Council	22 September 2017

Document Acceptance

Action			
Prepared by	**Simon Newton & Tracy Clode**		
Reviewed by	**Malory Osmond** **Kirsten Fraser** **Tracy Clode**		
Approved by	**Andrew Watson**		**Date:** 22 September 2017
on behalf of	CH2M Beca Ltd		

Highlights

This 2016/17 annual report has been prepared for Kāpiti Coast District Council (Council) as part of the consenting requirements for the River Recharge with Groundwater scheme. It reports on operational aspects and monitoring undertaken in relation to the Council's water take from, and discharge of groundwater to, the Waikanae River during the year 1 July 2016 to 30 June 2017. This annual report completes year three of the baseline monitoring period for the Waikanae River.

Because of the relatively wet summer experienced on the Kāpiti Coast the flow in the Waikanae River remained high enough that recharge of groundwater from the Waikanae Borefield to the river was not required this year. The lowest river flow recorded over the 2016/17 was 1431L/s, well above the minimum flow threshold of 750L/s.

There was a comprehensive programme of monitoring in the Waikanae River during the months of December to February at sites upstream and downstream of the water treatment plant. The monitoring involved regular water quality measurements, assessments of the numbers and types of algae, and two fish surveys were undertaken in the river between March and April to monitor migrating fish as agreed with Greater Wellington Regional Council (GWRC). There were no triggers exceeded in this period.

The collated baseline monitoring data from the three years of baseline monitoring is being used to develop on-going management trigger levels and cease abstraction compliance limits as part of the On-going Mitigation Plan for the Waikanae River. The On-going Mitigation Plan will take effect from 1 December 2017 (pending GWRC approval), otherwise the River BMP will be used to monitor river abstraction and recharge activities next summer.

The Adaptive Management Group which comprises representatives of the Council, GWRC and Te Ati Awa ki Whakarongotai met in August 2017 to discuss this report, alongside representatives of key stakeholder groups. The key recommendation from the Adaptive Management Group was to progress with the development of the Waikanae River OMP. The Adaptive Management Group believes baseline monitoring has achieved the required outcomes and sufficient data has been collected for setting an ongoing mitigation regime.

Executive Summary

This annual report for the Waikanae River take and river recharge has been prepared on behalf of Kāpiti Coast District Council (Council) in accordance with Condition 24 of consent WGN130103 [34399] and Condition 26 of consent WGN130103 [34400]. This is the fourth annual Waikanae River and River Recharge report, and covers the period from 1 July 2016 to 30 June 2017.

The maximum daily abstraction was 17,361 m^3/day on 26 May 2017. The average daily abstraction of 11,783 m^3/day for 2016/17 is slightly lower than in last year's (2015/16) annual report. This can be attributed to the wetter summer than in the 2015/16 period. The maximum instantaneous rate of abstraction was 244 L/s on 18 July 2016.

River Recharge with Groundwater was not used this year as the river flow remained well above the limits as set by the consent. Should recharge have been required the limitation of no more than 20% of downstream flow would have been applicable. Twelve short term discharges for operations and maintenance purposes occurred during the year (one per month) and a total volume of 22,758 m^3 of bore water was discharged into the river.

Baseline monitoring of the Waikanae River was carried out during the period December 2016 to February 2017 in in accordance with the certified Waikanae River Baseline Monitoring Plan (River BMP). Fish surveys were undertaken in March and April 2017. The results of this monitoring are documented in Appendix A.

A new fish monitoring methodology was approved by Greater Wellington Regional Council (GWRC) earlier this year (2017). Small (young) fish were surveyed both above and below the Waikanae Water Treatment Plant (WTP). The majority of fish in terms of abundance were below the Waikanae WTP.

The baseline monitoring data collected during the 2016/17 year is part of a three year programme of monitoring and adds to the data collected in March and April 2014 and the data collected in the 2014/15 and 2015/16 monitoring periods. This data includes water quality, periphyton measurements and fish surveys. The data collected over the 3-year baseline monitoring period is being used to develop an on-going monitoring regime for the Waikanae River and inform the development of management trigger levels, monitoring locations and cease abstraction compliance limits as part of the On-going Mitigation Plan (OMP) for the Waikanae River.

The 2016/17 summer had very limited cover of periphyton through December to February and algae did not begin to accrue until the March measure. There were no visual (WCC) periphyton trigger exceedances during the 2016/17 monitoring period. Macroinvertebrates were not sampled in this period due to the level of periphyton growth not reaching the required moderate or high periphyton level as agreed with GWRC on 24 May 2016.

The intentions of the consents in regard to the Waikanae River baseline monitoring have been met. Baseline monitoring is therefore concluded with three years of baseline monitoring completed. With three years of baseline monitoring completed, the 20% recharge limit will no longer be applicable and will be removed from the consent following confirmation from GWRC.

Looking ahead to the coming year (2017/18), there is no additional mitigation or adaptive management that is anticipated at this stage, other than the development of management trigger levels and cease abstraction compliance limits and a review of the monitoring locations as part of the OMP for the Waikanae River. River recharge may be used if required due to low flows in the Waikanae River. The recharge will be undertaken in accordance with the approved Bore Preference Hierarchy Plan and approved River OMP (pending approval from GWRC).

Contents

Appendices

1 Introduction

The Kāpiti Coast District Council (Council) holds resource consents WGN130103 [34399] and [34400] to take water from the Waikanae River for public water supply and to discharge groundwater to the Waikanae River for the purpose of river recharge.

This is the fourth annual Waikanae River and River Recharge report to Greater Wellington Regional Council (GWRC), and covers the period from 1 July 2016 through to 30 June 2017. This report is required by Condition 24 of consent WGN130103 [34399], Condition 26 of consent WGN130103 [34400] and Condition 22 of consent WGN130103 [34400]. The requirements of these conditions are listed in the tables below (Table 1, Table 2) with cross-references to the relevant section in this report.

Table 1: Requirements for Annual Waikanae River report

Condition 24 of consent WGN130103 [34399]	Section in this annual report
The consent holder shall, by 30th September each year, submit an Annual Waikanae River report to the Manager, or by another date as agreed with the Manager. The annual Waikanae River report shall report on the year 1 July to 30 June inclusive, and include the following information:	
a) Records of the instantaneous rate of take (L/s), and total daily volumes (m^3);	Section 2.1.2
b) Flow and river recharge information to demonstrate compliance with Condition 6 (Waikanae River low flow);	Section 2.1
c) Provide information to demonstrate compliance with Condition 18 of this consent	Sections 2.1 and 2.2
d) Results of all monitoring undertaken that year required by Conditions 19, 20 and 21 of this consent (if applicable), including a comprehensive analysis of the monitoring results, assessment against any relevant guidelines and comparison with previous years' results (i.e. trend analysis);	Section 3
e) Details of any trigger levels or compliance limits that were reached (if occurred that year);	Section 3.1
f) Details of any actions and/or mitigation/adaptive management taken in response to trigger levels or compliance limits being reached, including an assessment of the effectiveness of these actions and/or mitigation/adaptive management;	Section 3
g) Any recommendations for changes to the Waikanae River Baseline Monitoring Plan or the On-going Mitigation Plan (as relevant), including triggers, compliance limits or actions and/or mitigation measures or changes to the operations and maintenance manual, including recommendations of the Adaptive Management Group (referred to in Condition 26 of this consent);	Section 3.3, Section 2.3, Section 3.4, Section 4 and Section 5,
h) A discussion on any mitigation/adaptive management that may be required in the coming year;	Section 4
i) Summary of any maintenance undertaken.	Section 2.2
The annual Waikanae River report can be combined with the annual River Recharge report required by the conditions of discharge permit WGN130103 [34400]. The annual Waikanae River report shall be made available	Refer www.kapiticoast.govt.nz

Condition 24 of consent WGN130103 [34399]	Section in this annual report
to the public on the Kāpiti Coast District Council website no later than 30th September each year, or by another date as agreed with the Manager. *Note: The consent holder is only required to report on the listed requirements of this condition if they have occurred during that compliance year (1 July to 30 June inclusive).* *Note: The consent holder may request, with the Manager's approval, an extension of time to submit the annual report to the Manager and make it available to the public on the website, if the Adaptive Management Group requires more time to consider the draft annual report and provide their recommendations as required by part (g) of this condition.*	

Table 2: Requirements for Annual River Recharge report

Condition 26 of consent WGN130103 [34400]		Section in this annual report
The consent holder shall, no later than 30th September each year that a discharge to the River occurs, submit an annual River Recharge report to the Manager, or by another date as agreed with the Manager. The annual River Recharge report shall report on the year 1 July to 30 June inclusive, and include the following information:		
a)	Records of the instantaneous rate of discharge (L/s), and total daily volumes (m^3) of discharge	Section 2.1.3
b)	Dates, times and duration of discharge	Section 2.1.3
c)	Information to demonstrate compliance with the rate of discharge specified in Condition 5	Section 2.1.3
d)	Flow and river recharge information to demonstrate compliance with the Waikanae River low flow specified in Condition 12 of this consent	Section 2.1.3
e)	Results of all monitoring undertaken that year required by Conditions 22 or 23 of this consent (if applicable), including a comprehensive analysis of the monitoring results, assessment against any relevant guidelines and comparison with previous years' results (i.e. trend analysis)	Section 3
f)	Details of any trigger levels or compliance limits that were reached (if occurred that year)	Section 3.1
g)	Details of any actions and/or mitigation/adaptive management taken in response to trigger levels or compliance limits being reached, including an assessment of the effectiveness of these actions and/or mitigation/adaptive management	Section 3
h)	Any recommendations for changes to the Waikanae River Baseline Monitoring Plan or the On-going Mitigation Plan as relevant), including triggers, compliance limits or actions and/or mitigation measures or changes to the operations and maintenance manual, required by Condition 17 to be discussed with the Adaptive Management Group (as required by Condition 27 of this consent)	Section 3.3, Section 2.3, Section 4 and Section 5
i)	A discussion on any mitigation/adaptive management	Section 4

Condition 26 of consent WGN130103 [34400]	Section in this annual report
that may be required in the coming year	
j) Summary of any maintenance undertaken	Section 2.2
The annual River Recharge report may be combined with the annual Waikanae River report required by consent WGN130103 [34399]. The annual River Recharge River report shall be made available to the public on the Kāpiti Coast District Council website by 30 September each year, or by another date as agreed with the Manager. *Note: The consent holder may request, with the Manager's approval, an extension of time to submit the annual report to the Manager and make it available to the public on the website, if the Adaptive Management Group requires more time to consider the draft annual report and provide their recommendations as required by part (g) of this condition.*	Refer www.kapiticoast.govt.nz

There are a number of plans and manuals required by the River Recharge with Groundwater (RRwGW) suite of consents and various reports have been produced from the 2016/17 monitoring. These documents are set out in the following figure (Figure 1).

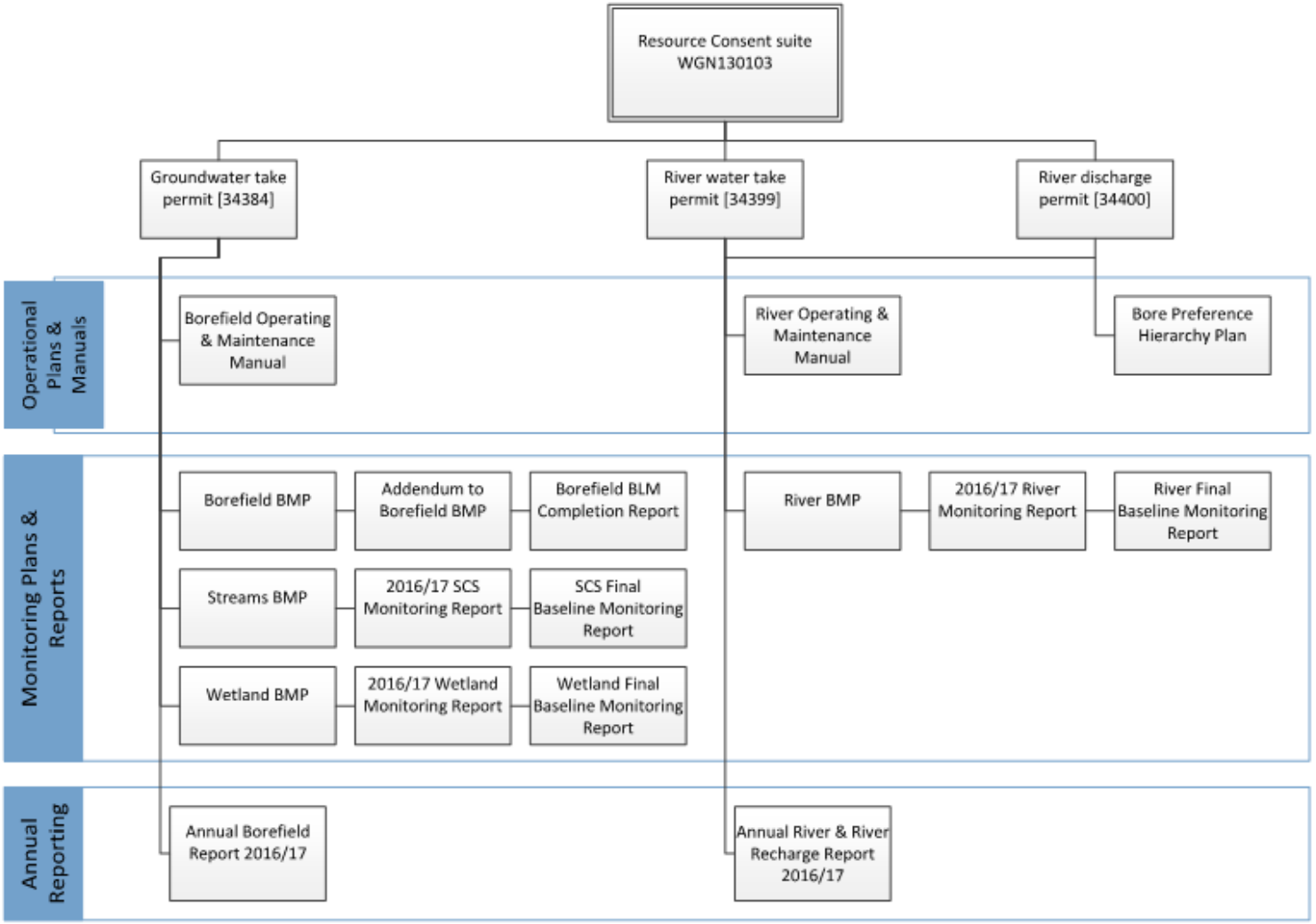

Figure 1: Key documents for RRwGW consents and 2016/17 monitoring

2 Operation of River Take and River Recharge

2.1 River Flows, Abstraction and Recharge

2.1.1 Waikanae River Flows

The Waikanae River flow is monitored by GWRC at a gauging station approximately 200 m upstream of the Waikanae Water Treatment Plant (WTP) intake. Rainfall is also measured by GWRC at this site. River flow data, recorded at 15 minute intervals, for the reporting period is presented in Figure 2 together with weekly rainfall totals.

Council's SCADA system receives river flow data from GWRC's SCADA system on an approximately 15 minute basis. The river flow data received and stored by Council is used for managing the water supply abstraction and this data is not back-corrected if GWRC subsequently updates the rating curve for the gauging station. Daily rainfall data for the whole 2016/17 year was sourced from GWRC's Environmental Monitoring and Research website[1] .

Rainfall throughout the summer period kept the river flows above 1400 L/s for the monitoring period. The peak flow occurred on 2 February 2017 with flows reaching 270,000 L/s. The start of the summer flow recession commenced in the first week of February and continued until a major rainfall event in mid-March. Frequent rainfall for the remainder of the monitoring period kept the river flows well above the required minimum flow (750 L/s).

[1] http://graphs.gw.govt.nz/?siteName=Waikanae River at Water Treatment Plant&dataSource=Rainfall&interval=1%20Hour, sourced 1 July 2017

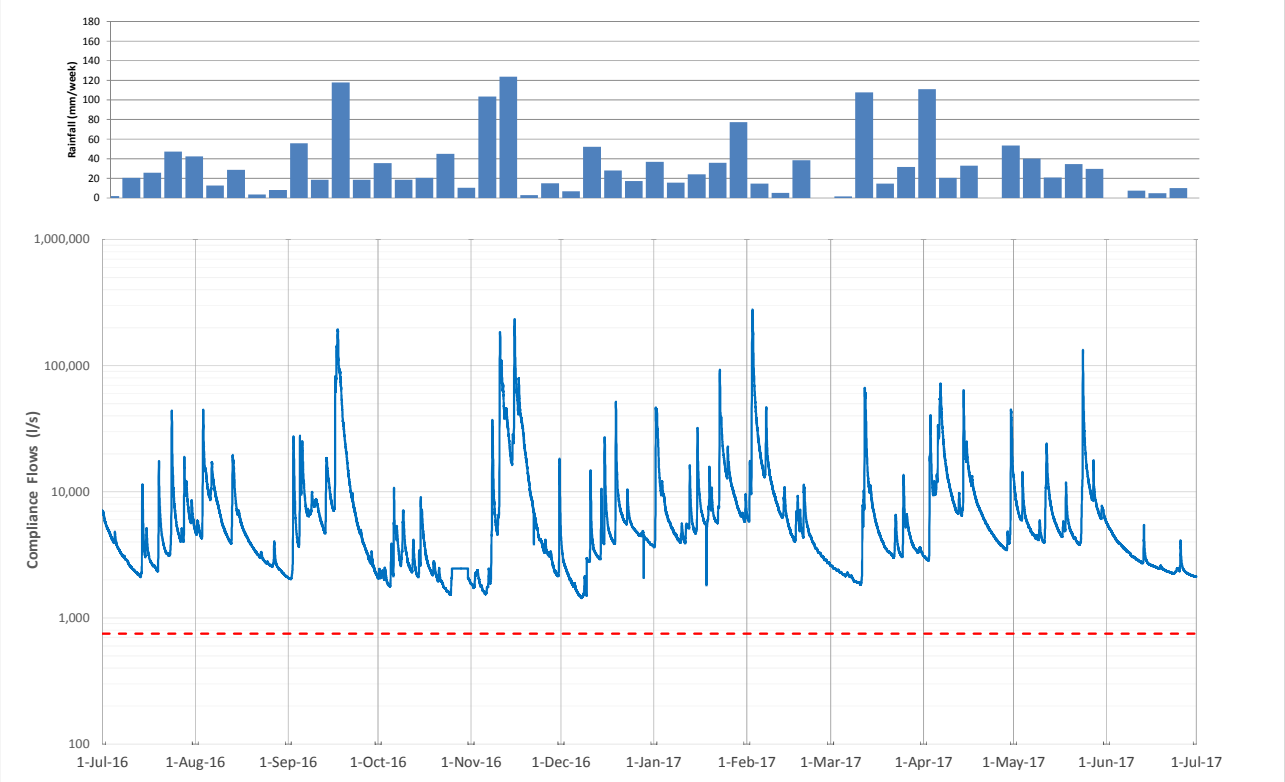

Figure 2: Waikanae River Flow and Rainfall at Water Treatment Plant (July 2016 – June 2017)

2.1.2 River Abstraction

Council measures and records the flow rates and volumes of water abstracted from the Waikanae River by way of a flow meter at the WTP intake. Council regularly submits its river abstraction records to GWRC, as per Condition 13 of consent WGN130103 [34399]; this is done automatically from Council's SCADA to GWRC's Water Use Data Management System (Hydrotel). A summary of the abstraction data is provided below.

The daily abstraction volumes for the reporting period are summarised in Figure 3. The maximum daily abstraction was 17,361 m^3/day on 26 May 2017 (the peak abstraction occurred outside of the summer period). This is less than the maximum allowable daily volume of 30,700 m^3/day specified by Condition 5 of consent WGN130103 [34399]. The maximum daily abstraction volume for 2016/17 was slightly higher than the volume reported in last year's (2015/16) annual report.

The total volume abstracted in the period 1 July 2016 to 30 June 2017 was 4,300,806 m^3. This is equivalent to an average daily abstraction of 11,783 m^3/day. The average daily abstraction volume for 2016/17 is slightly lower than in last year's (2015/16) annual report.

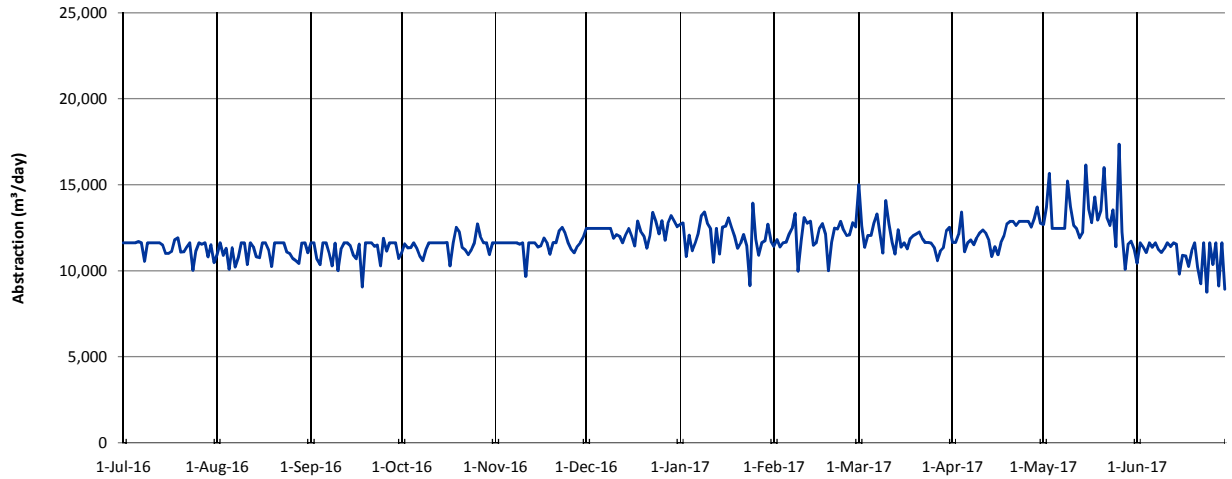

Figure 3: Waikanae WTP River Abstraction Volumes (m^3/day)

The instantaneous rates of abstraction (recorded at 15 minute intervals) for the reporting period are shown in Figure 4. The maximum abstraction rate was 244L/s on 18 July 2016. Condition 5 of consent WGN130103 [34399] sets the maximum instantaneous abstraction rate of 355L/s (when the flows in the river are below 1,400 L/s). The instantaneous abstraction rate was less than 355L/s at all times during 2016/17 (and the river flow did not drop below 1,400L/s during 2016/17).

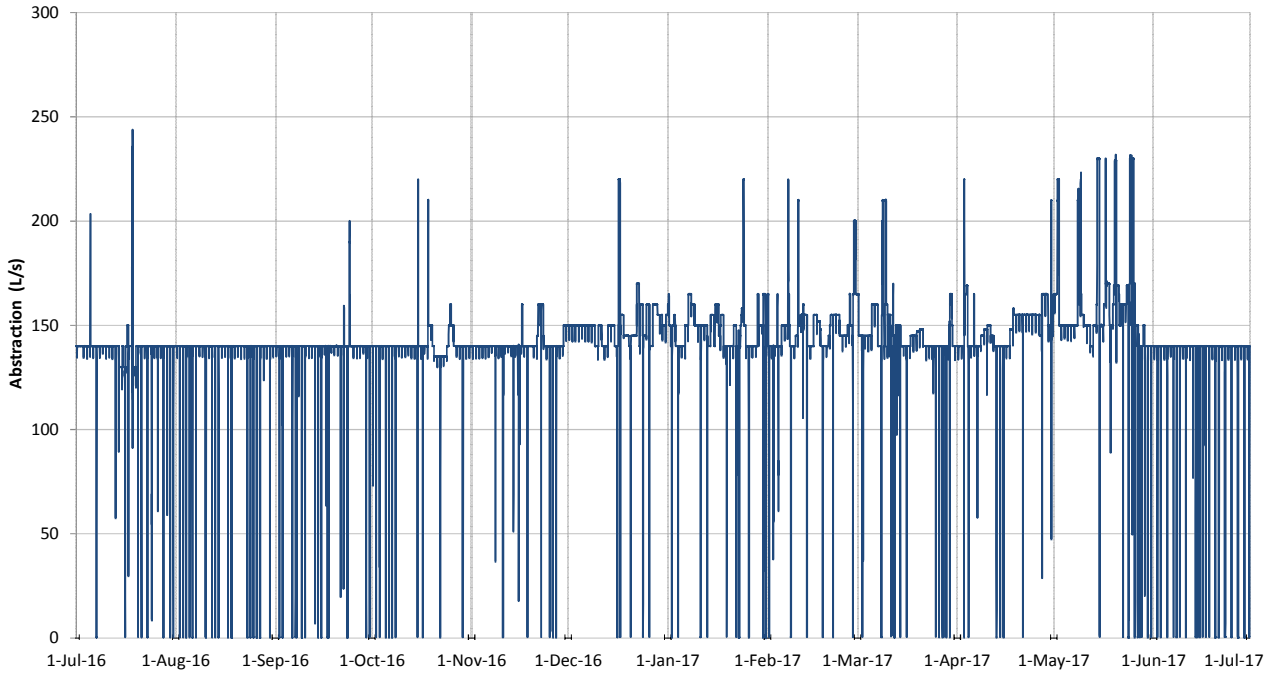

Figure 4: Waikanae WTP River Abstraction Rates (L/s)

2.1.3 River Recharge

River recharge was not used for the 2016/17 period.

Short Duration Discharges of groundwater to the Waikanae River associated with routine bore testing and maintenance occurred during the 2016/17 period as shown on

Figure 5 and Figure 6 and detailed in Table 3 below. Short duration discharges (of a few hours) of groundwater to the Waikanae River via the swale have taken place 12 times in the 2016/17 monitoring period. A total volume of 19,950m³ of bore water was discharged to the Waikanae River as a result of these short term discharges over the year. The discharges were all in relation to testing and maintenance of the bores (and hence the approximate monthly periods between discharges). All of the discharges fell within the constraints for Short Duration Discharges as outlined by Consent WGN130103 [34400].

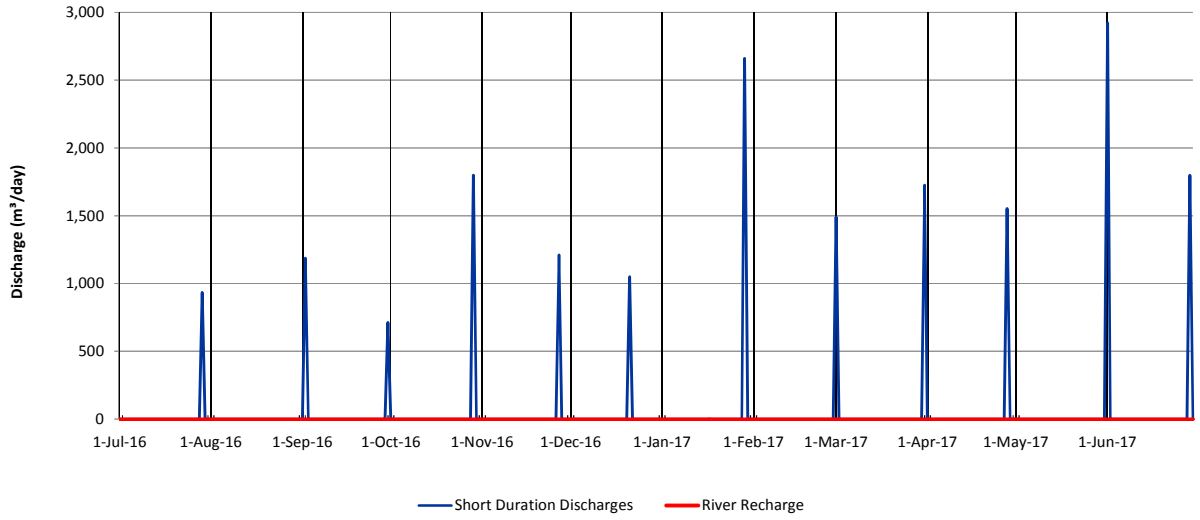

Figure 5: Daily Waikanae River Recharge (and Short Duration Discharges) for 2016/17 (m³/day)

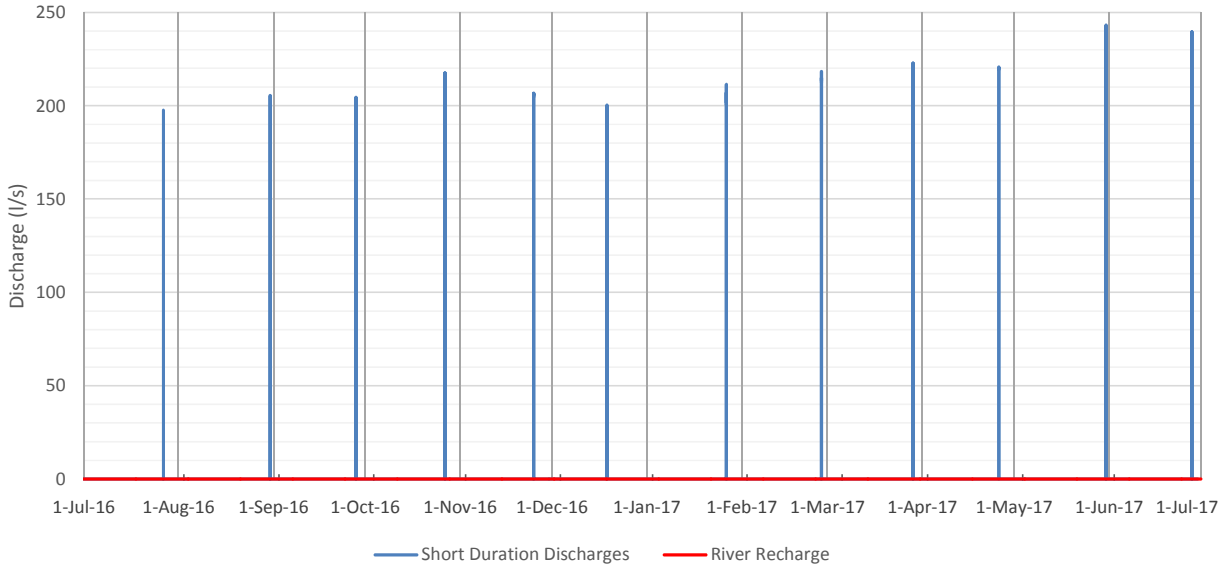

Figure 6: Instantaneous Waikanae River Recharge (and Short Duration Discharges) 2016/17 (L/s)

Table 3: Waikanae River Recharge – Short Duration Discharges

Date	Discharge volume (m^3)	Discharge Duration (hrs)	Max Instantaneous Discharge (L/s)
July 27, 2016	1073	1.5	197.2
August 31, 2016	1505	2	205.4
September 28, 2016	1031	1.5	204.5
October 27, 2016	1910	2.75	217.4
November 25, 2016	1232	2	206.5
December 19, 2016	1034	2	200.5
January 27, 2017	2749	4	206.5
February 27, 2017	1788	2.5	218
April 29, 2017	1805	2.5	222.7
March 26, 2017	1656	2.5	220
May 31, 2017	4489	5.25	249
June 28, 2017	1980	2.5	239

Council requested confirmation from GWRC on 7 July 2017 that condition 18 of consent WGN130103 [34400] “Limit on River Recharge for the Purposes of Baseline Monitoring” is now complete; i.e., that the limit on the recharge flow to no more than 20% of the total river flow downstream of the recharge is no longer applicable now that three years of Baseline Monitoring has been undertaken and the requirement for one year of non-atypical hydrological conditions was met in the 2014/15 year as approved by GWRC on 7 October 2015.

2.2 Operations Log and Maintenance Undertaken

Council has confirmed that its upgraded SCADA system together with the NCS system are an ‘electronic data management system’ which records and stores the information required by Condition 18 of consent WGN130103 [34399]. Council is also using WaterOutlook to store and report data and operational information relating to the Waikanae River take and recharge.

The WTP operators carry out an inspection of the intake every day and clear accumulated debris from the intake screens, such as leaves and twigs, as required. No further maintenance tasks were undertaken on the river intake during this reporting period.

Twelve short term discharges were passed through the river recharge structure as detailed in section 2.1.3.

2.3 Operations and Maintenance Manual

The Waikanae River Take Operations and Maintenance Manual (ROMM) was approved by GWRC on 24 May 2017, in accordance with Condition 17 of consent WGN130103 [34399].

There are no recommended changes to the ROMM at this time. Once the River Ongoing Mitigation Plan (OMP) is approved by GWRC the ROMM will be updated to reflect the changes and resubmitted to GWRC for approval.

3 River Monitoring

3.1 Aquatic Monitoring

Baseline monitoring of the Waikanae River was carried out during the period December 2016 to the start of March 2017 in accordance with the certified Waikanae River Baseline Monitoring Plan (River BMP) and as agreed with GWRC, subsequent to this period, fish surveys were undertaken in March and April. The results of this monitoring are documented in the report "Waikanae River Aquatic Baseline Monitoring Data" by Boffa Miskell, which is included as Appendix A.

The river baseline monitoring generally involved collection of periphyton data, macroinvertebrate samples, fish samples and water quality measurements at two sites upstream of the Waikanae WTP and three downstream sites.

The 2016/17 summer had very limited cover of periphyton (even thin cover) through December to February and algae did not begin to accrue until the March measure. We assume this is due to the more regular floods and generally higher river flows this year. Cyanobacteria did not feature markedly this year and only the later measures noted its occasional presence.

There were no visual (WCC) periphyton trigger exceedances during the 2016/17 monitoring period. Most sites throughout the season had WCC weighting between 2-20% ("excellent" ecological condition). No sites breached the fair or poor ecological condition of the Mathieson 2000 methodology.

Macroinvertebrates were not sampled in this period due to the level of periphyton growth not reaching the required moderate or high periphyton level as agreed with GWRC on the 24 May 2017.

A new fish monitoring methodology was proposed for the 2016/17 monitoring period approved by GWRC on 7 February 2017. The approved fish methodology is detailed in the latest River BMP and the results can be found in in Appendix A. Small (young) fish were surveyed both above and below the Waikanae WTP. The majority of fish in terms of abundance were below the Waikanae WTP.

The baseline monitoring data collected during the 2016/17 summer adds to the data collected in March and April 2014 and the 2014/15, and 2015/16 monitoring periods. The data collected over the three year baseline monitoring period is being used to develop an on-going monitoring regime for the Waikanae River and inform the development of management trigger levels and cease abstraction compliance limits as part of the OMP for the Waikanae River.

3.2 Bore Water Quality Monitoring

The Bore Preference Hierarchy Plan, which is required by Condition 16 of consent WGN130103 [34400], was approved by GWRC on 07 December 2016. This plan included full water quality results for the production bores Kb4, K4, K5, K6, K10, KB7, K12, N2 from monthly sampling carried out between October 2013 and April 2016. All eight production bores could have been used for recharge in the 2016/17 year.

Blended bore water was not sampled due to no blended bore water being discharged to the Waikanae River for river recharge and so no records of bore water testing are included in this year's report.

3.3 Changes to River Baseline Monitoring Plan

The River BMP was updated earlier this year to include all of the changes that have occurred since the February 2014 River BMP issue. The changes and alternative methodologies have been approved by

GWRC. The latest River BMP, dated 29 May 2017, incorporates all of the agreed changes in methodologies which have occurred since the approval of the February 2014 River BMP. GWRC approved the latest updated River BMP on 6 June 2017.

The River BMP is set to be replaced by the Waikanae River OMP which will take effect on December 1 2017 (pending GWRC approval).

4 Mitigation/Adaptive Management in the Coming Year

Looking ahead to the coming year (2017/18) there is no additional mitigation or adaptive management that is anticipated at this stage, other than the development of management trigger levels and cease abstraction compliance limits as part of the OMP for the Waikanae River.

Activities on The Waikanae River for the 2017/18 summer/autumn will be in accordance with the OMP which is due to GWRC by 31 October 2017. If the OMP is not approved by 1 December 2017, the approved River BMP will remain in place to assess activities occurring on the Waikanae River (subject to GWRC approval) until the OMP is approved.

5 Recommendations of the Adaptive Management Group

The Adaptive Management Group (AMG) for the RRwGW scheme comprises three members who are representatives of GWRC, Council and Te Āti Awa ki Whakarongotai. Figure 7 shows the stages of AMG and key stakeholder involvement in the lead up to the submission of this annual report to GWRC.

Council held a briefing session with the AMG and key stakeholders on 4 May 2017. Representatives of Wellington Fish and Game Council, The Kāpiti Fly Fishing Club, Department of Conversation, Friends of the Waikanae River and Regional Public Health were present at the briefing. The purpose of this briefing session was to discuss the observations from the baseline monitoring undertaken to date, as well as any observations of the AMG and key stakeholders during the 2016/17 period. The briefing was also to make an early start in the process of considering the potential for adaptive management in regards to these observations ahead of the AMG meeting in August 2017.

The AMG met on 30 August 2017 to discuss the draft version of this report, and the proposed triggers and monitoring sites based on the data gathered during the three year baseline monitoring period to meet condition 22 of the consent. The draft version of the annual Waikanae Borefield report was also discussed.

Friends of the Waikanae River were the only key stakeholder to attend this meeting. Apologies were received from the other key stakeholders.

The key recommendation from the Adaptive Management Group was to progress with the development of the River OMP. The Adaptive Management Group believes baseline monitoring has achieved the required outcomes and sufficient data has been collected for setting an ongoing mitigation regime.

The OMP process is being conducted in parallel with the annual reporting process as detailed in Figure 7.

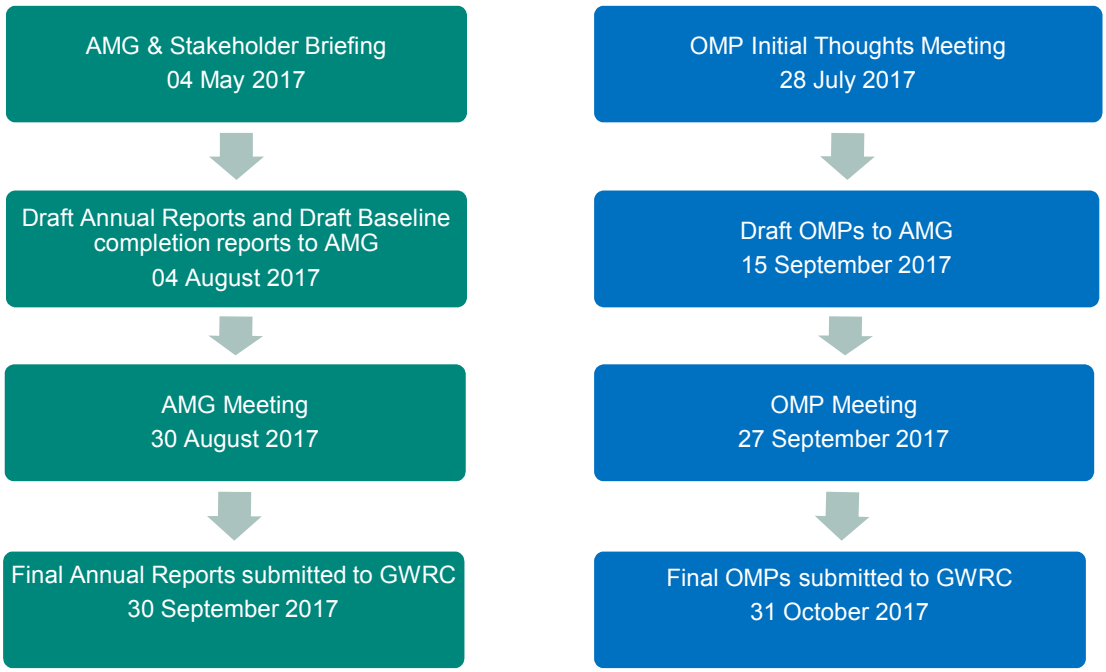

Figure 7: AMG activities associated with this year's RRwGW activities (*Annual Reports –Green, OMP - Blue)*

Appendix A

Waikanae River Aquatic Baseline Monitoring Report

Waikanae River Annual Aquatic Baseline Monitoring Report

A report on 2016/2017 aquatic data collection for water permits WGN130103 [34399] & [34400]

Prepared for Kāpiti Coast District Council

1 September 2017

Document Quality Assurance

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Cover photograph: Waikanae River © Boffa Miskell 2017

Contents

Appendices

1.0 Introduction

1.1 Background

Resource consent conditions 19 (Consent WGN130103 [34399]) and 21 (Consent WGN130103 [34400]) for Kāpiti Coast District Council's River Recharge with Groundwater Project (RRwGW Project) required the preparation of a '*Waikanae River Baseline Aquatic Monitoring Plan'* (Waikanae River BMP). That plan (as prepared by Boffa Miskell Ltd (BML) and certified by GWRC) required the collection of:

- Periphyton data – including visual cover and community composition assessments, algal biomass and chlorophyll-*a* over summer periods at frequencies that depend on the river's flow;
- Macroinvertebrate samples that are dependent on periphyton levels (i.e. sample periods target each of a low, medium and high periphyton period);
- Water quality samples each fortnight (or flow depending, weekly);
- A set of velocity measures taken at each periphyton visual cover estimation; and
- Fish data – including the location of fish monitoring, sampling methodologies and sampling frequencies.

These requirements were updated following completion of the annual report and review of the 2014/2015 summer data and again after completion of the 2015/16 data sets. Some elements of the original BMP have changed as a result of that monitoring analysis and review. GWRC received a draft of the Waikanae River BMP (dated 21st December 2015) on 3rd February 2016 for comment. A meeting was held with GWRC on 11th February 2016 and it was agreed that the "final" updated Waikanae River BMP could be submitted after the 2015/16 annual reporting period to include any recommendation from the Adaptive Management Group. Meeting notes were issued to GWRC on the 15th March 2016.

In addition to earlier changes, the following changes were made to the 2016/2017 monitoring season requirements[1]:

- Council have been working with GWRC and the AMG to agree a way forward with migratory fish sampling. Given that the recharge is outside the peak upward migration period, further testing for this aspect via the method set out in the agreed river BMP was removed. GWRC requested further monitoring via an alternative method. This consisted of up to 4 EFM surveys (in February-April 2017 (river flow permitting)) in riffle habitat at each site. The monitoring methodology was chosen to illustrate the species present with a focus on young fish (which are potentially moving). This data however, will not form any sort of metric to indicate adverse effects and will simply provide information on fish presence at the time of survey.
- Periphyton samples were taken at each survey for chlorophyll-a, and once for periphyton species assemblage and relative abundance (December).
- The 2016/17 monitoring season focused on moderate to high periphyton and the relationship with the macroinvertebrate community. Sampling for macroinvertebrates were required to only be undertaken if periphyton levels reached moderate to high at any site.
- Following agreement with GWRC the updated River BMP was issued on 03 May 2017 for approval and included the attached fish methodology as agreed with GWRC.

[1] Note the revised fish survey procedure (below) was approved prior to the 2017 BMP update

Data is collected from two upstream “control” and three downstream “receiving” monitoring sites on the Waikanae River. The data this monitoring season is: visual periphyton cover, chlorophyll a data from 10 pooled samples per site, per sampling event, one (February) periphyton community assemblage assessment, the standard water quality data from each sampling event at each site, and spot temperature measures at sampling. The WCC and PSI periphyton indices (calculated without inclusion of the “thin” class as suggested by the GWRC reviewer) are calculated and presented.

Full details of the consent conditions and the parameters and requirements for monitoring can be found in the BML “Waikanae River Baseline Aquatic Monitoring Plan” report dated 12 April 2017 submitted to GWRC on 03 May 2017.

This report presents the findings from three months of data collection spanning December 2016 through to 3rd March 2017 (a late February measure) and completes the 3 years of baseline monitoring data collection which ended on 28 February 2017. It also includes the fish survey data following the new survey procedures in February-April 2017. We note that due to high river flows only 2 of the possible 4 sample periods in this time were able to be sampled. This data adds to previous data sets collected from March and April 2014, December 2014 to April 2015 and December 2015 to May 2016. This monitoring season is the second season in which consented river recharge is allowed to occur, but no recharge did occur in the monitoring period. Raw data is provided in the appendices.

This baseline monitoring data completes the set that will inform the development of ongoing trigger levels.

2.0 Methods

2.1 Monitoring sites

The monitoring locations have been determined in the Waikanae River BMP, and in summary they are:

- Two ‘control’ sites, (C1 and C2) located upstream of the Waikanae Water Treatment Plant (WTP); and
- Three ‘receiving’ sites, located at predetermined intervals downstream of the Waikanae WTP (R1, R2 and R3).

The locations of these sites are described in full in the Waikanae River BMP and shown in Map 1. At each site, a wooden stake was driven into the bank so that the site location (in addition to GPS location) can be re-sampled over time. The stakes driven into the banks in 2014 have since been removed or the river has removed them, nevertheless the GPS location and site photos, along with sampler familiarity, has allowed an accurate transect location each survey.

Currently, and for the purpose of this report, the control and receiving sites are replicate sites until such time as bore water is introduced. Following that time, the upper sites (C1 and C2) become control sites that could be used to examine effects of bore water discharge on the parameters measured.

Flow gauging sites are shown for information on Map 1 (NIWA 1, 2, 3).

Map 1: Waikanae River Monitoring locations (C1, C2, R1, R2 and R3) and NIWA sites where flow gauging was undertaken.

2.2 Site Photos

Photo 1: Site C1, taken on 11th January 2016

Photo 2: Site C2, taken on 14th March 2016

Photo 3: Site R1, taken on 29th March 2016

Photo 4: Site R2, taken on 18th April 2016

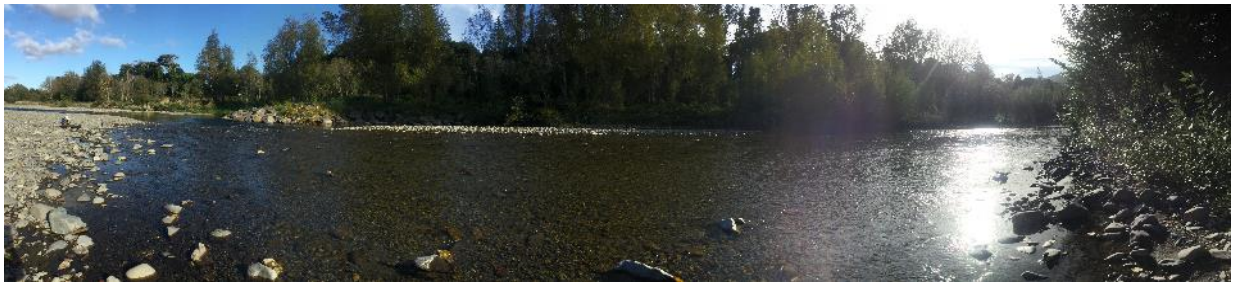
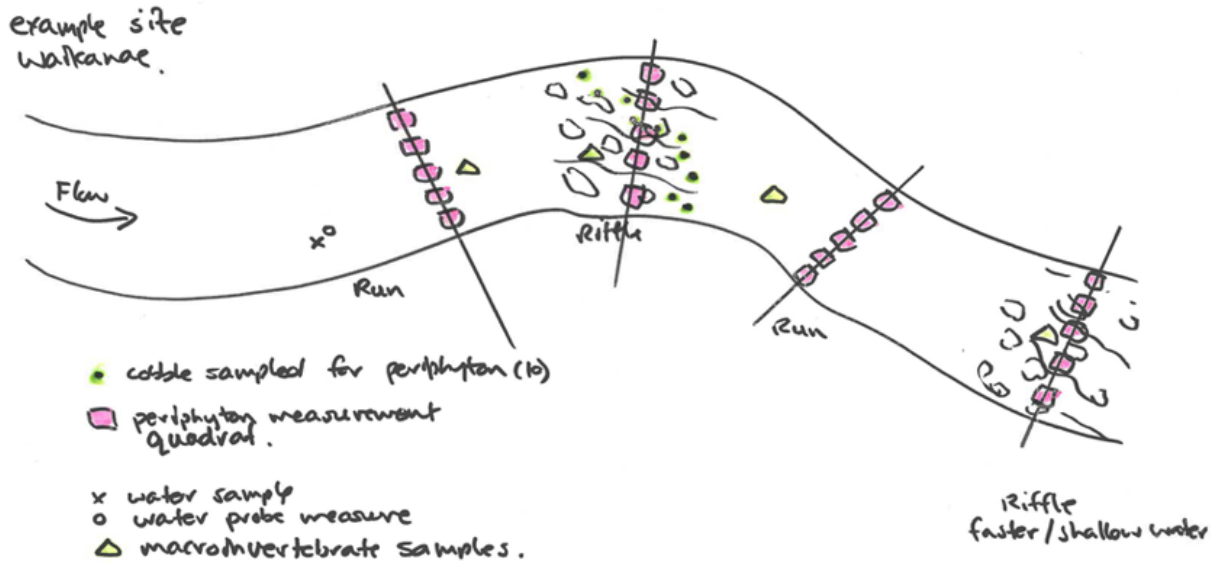


Photo 5: Site R3, taken on 18th April 2016

2.3 Survey Transect setup

A diagrammatic representation of the measurements undertaken at a site.



2.4 Monitoring methods

At each of the two control and three receiving sites the following parameters were measured, generally during fine weather and low-flow conditions (i.e., post-raised or flushing flow events). After a health and safety event when flows were over 5 cumecs, a maximum of 4 cumecs was placed as a survey limit for surveyor safety. Full methods for this sampling programme are provided in Waikanae River BMP. In summary, the following parameters are required to be measured at each site in a set timetable (see Table 1) which is flow related (fortnightly sampling when river has a flow >1100L/s or else weekly when flows were <1100L/s).

1. Water chemistry and temperature:
    - pH;
    - Temperature (°C);
    - Conductivity (µS/cm);
    - Dissolved reactive phosphorus (DRP, g/m^3);
    - Total phosphorus (TP, g/m^3);
    - Soluble inorganic nitrogen (SIN, g/m^3);
    - Total nitrogen (TN, g/m^3);
    - Nitrite nitrate nitrogen (g/m3)
    - Total ammonia (NH_4, g/m^3); and
    - Dissolved calcium (g/m^3).

2. Periphyton:
    - Potential hard bottom substrate available for periphyton growth is assessed;
    - Visual observations of percentage cover of periphyton at each site according to the Rapid Assessment Method (RAM) 1 & 2 methods of Biggs and Kilroy 2000; and
    - Periphyton biomass, based on chlorophyll *a* measurements (B. J. Biggs & Kilroy, 2000), from multiple rock scrapings is collected from each site.
3. Benthic macroinvertebrates: Further sampling is only required in this season if periphyton cover levels reach moderate/high. It did not.
4. Fish: The new method involved 4 survey periods from February to end of March (where flows allow), typically at fortnightly intervals. At each period a standard EFM single pass was conducted in a riffle at the standard monitoring sites. The riffle was fished across the wetted width of the river, resetting the trap (stop) net each 2m. The length of the river fished was measured for each transect. Three or 4 such transects were fished at each period at each site. We assume that the EFM process fishes 3m of habitat in front of the stop net. We spaced (therefore) the transects down the riffle 4m apart. Generally, 3 or 4 transects were undertaken at each riffle of a site (covering most of the riffle). Flows in the Waikanae River had to be below 4 cumecs to be fishable and an absence of rain was also required. Fish caught were measured for size and the species & related sizes recorded. The fish were released beyond the sampling area.

   Site R2, after exploration, did not receive fish survey as the flows (being a narrow deeper section than other sites) and footing was not conducive to safe EFM method at the flows encountered. Nevertheless, the surveys include 2 downstream (of the Waikanae WTP) and 2 upstream site riffles.

Table 1: Sample activity.

Period	Water Quality	Visual periphyton	Pooled Periphyton Chloro A	Pooled Periphyton Chloro A & Assemblage	Fish
2nd December 2016	✓	✓	✓	Not required	Not required
12th December 2016	✓	✓	Not required	✓	Not required
29th December 2016	✓	✓	✓	Not required	Not required
14th January 2016	✓	✓	✓	Not required	Not required
17th January 2017	River flow too high to sample				
31th January 2017	River flow too high to sample				
17th February 2017	✓	✓	✓	Not required	✓
3rd March 2017	✓	✓	✓	Not required	
9th March 2017	Not required	Not required	Not required	Not required	✓

2.5 Data analyses

Tables and charts (graphic plots) were prepared to examine the differences in water quality, and periphyton results between sites and over time (monitoring period).

3.0 Water Quantity through the Monitoring Period

The Waikanae River BMP specifics the frequency of summer sampling relative to the 7-day average flow for the Waikanae River. Fortnightly sampling is undertaken when the 7-day average flow is above 1100l/s. Weekly sampling is required when the 7-day average flow is below 1100l/s.

3.1 Rainfall and river flow

Figure 1 details GWRC collected rainfall and River flow data at the Water Treatment Plant The figure illustrates a wet summer with high flow periods especially in February. The flow during the monitoring period averaged above the 1100l/s 7 day average flow and thus weekly flow monitoring was not required.

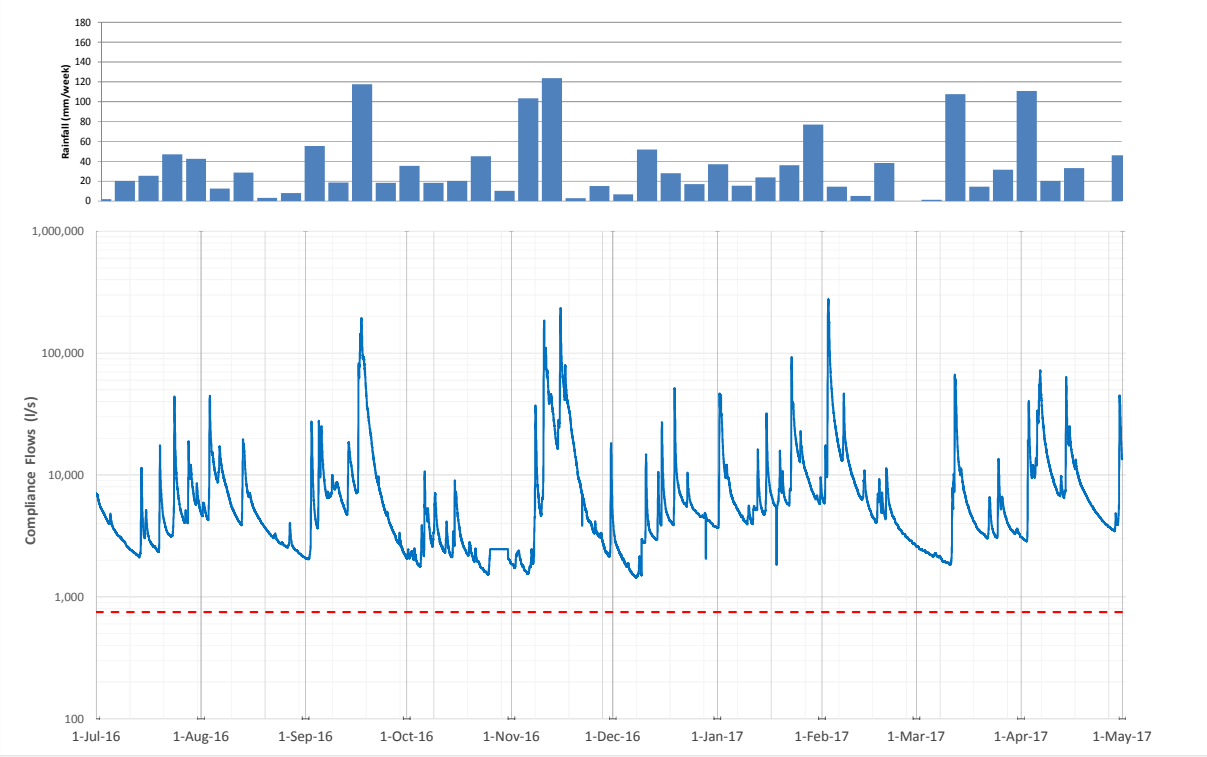


Figure 1 : GWRC flow record at the Water Treatment plant site between 1 July 2016 and 1 May 2017

Regular rainfall through the summer period helped to maintain river flows above the minimum flow threshold of 750 L/s. Indeed, the preceding spring and summer was one of the wetter seasons recorded and flows were generally above 2000 L/s and often above 4000 L/s.

There were 5 notably large rainfalls which resulted in 5 high flow periods in the River, the largest being being 280 cumec on 02 February.

There was a no typical seasonal flow recession, flows “peaking” in February and only starting to recede in March.

Due to the high river flows and no river recharge activities, flow gauging was not undertaken by NIWA this summer as per condition 19 of consent WGN130103 [34400] *“Flow gauging may not be required during times when River Recharge is not in operation if the flow is known based on existing flow information”.*

3.2 Abstraction

Figure 2 shows daily average abstraction from 1 July 2016 to 1 May 2017. During this period, the average abstraction was 11,735 m^3/day (141 L/s daily average), with a peak of 15,016 m^3/day. The peak abstraction occurred on 01 March 2015. The peak instantaneous abstracted flow was 244 L/s and occurred on 18 July 2016.

The 2016/2017 abstraction was similar to the 2015/2016 season and possibly reflects, the generally higher river flows and at no time upstream flows below the abstraction threshold of 750 L/s. The peak abstraction during 2016/2017 was lower than the previous years. This is likely to a wetter summer reducing demand for activities such as garden watering.

Figure 3 shows the calculated flow downstream of the Waikanae Water Treatment Plant. It demonstrates that the flow throughout the 2016/17 monitoring period is well above the required 750l/s. The total daily abstraction is demonstrated on Figure 2.

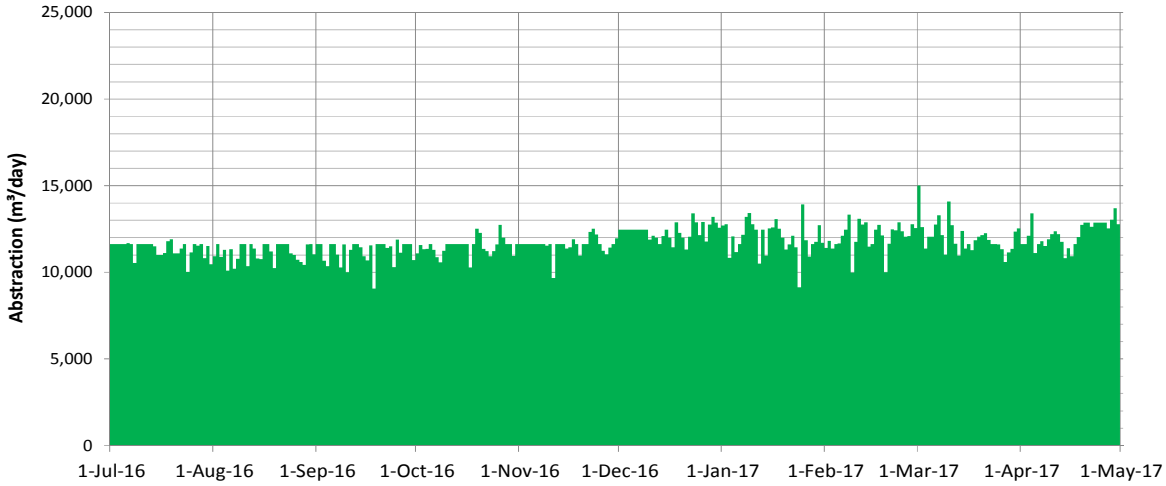


Figure 2: Waikanae River daily abstraction

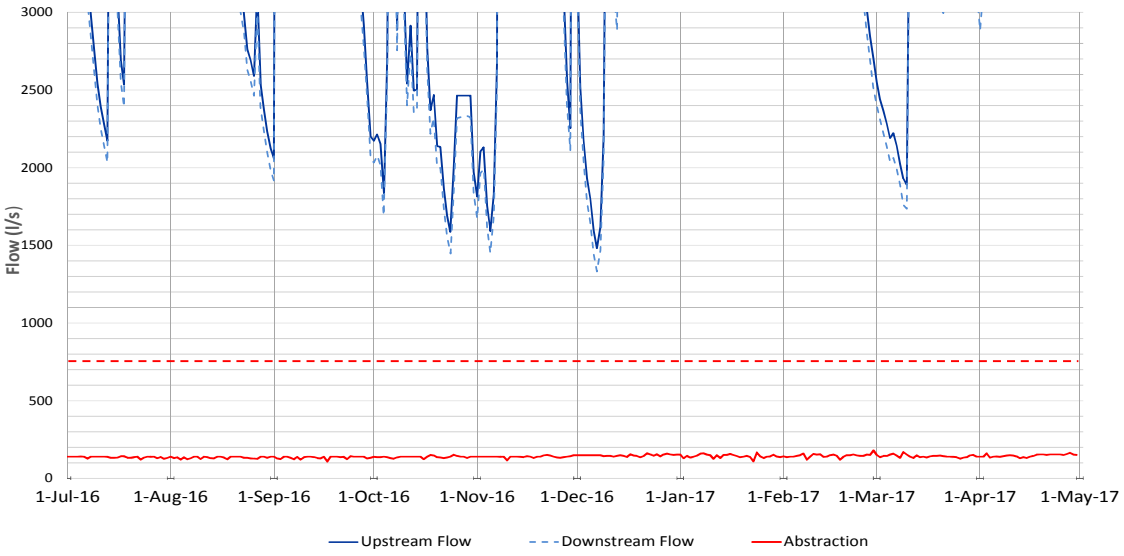


Figure 3: Waikanae River daily abstraction and calculated downstream flow vs minimum 750 L/s consented flow (dashed red line)

3.3 River Recharge

There was no river recharge during the 2016/17 monitoring period (December 2016 to February 2017) or from March to April 2017 when triggers are still applicable.

4.0 Shade and Substrate Quantity

This year (2016-2017) an average of 82% of the substrate within each 1m^2 quadrate along each of the five site transects were of sufficient size and hardness to support periphyton growth. This is a 3% decline on the 2015/16 summer period. The other 17% of the substrate was generally sands and/ or gravel.

Shading is as it was last season (no change), being largely absent at all monitoring sites. Despite there being native (and exotic) shrub and forest generally near the river. Most tall vegetation is set well back from the active water channel sufficiently so that no actual direct shade is provided except in early morning and late evening.

5.0 Results

Throughout this report the sites are labelled as C1, C2, R1, R2 and R3. Reference to Map 1 may be required, but it should be remembered that C1 is the control site closest to the water treatment plant and C2 the upstream control site. R1, R2 and R3 are the sequence of downstream effect sites.

5.1 Water chemistry and temperature

Summary charts of water quality data are contained within the following sub-sections. Note that the data is not continuous, they are one point in time measures and plots are generally given as bar graphs.

5.1.1 pH

A raised pH was recorded in March (similar to last year) with a preceding month depression (Figure 4). There are no discharging side streams, instream rubbish or other obvious source for change. Generally, the values are within (even considering the raised values) “normal” levels. The remainder of the data shows a relatively stable pH at around 7.4.

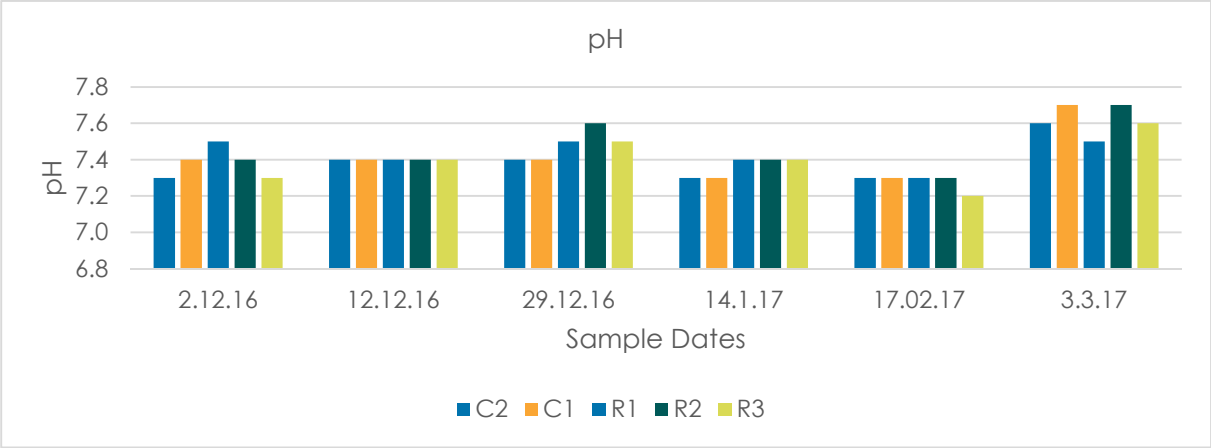


Figure 4: pH lab results across monitoring sites from December 2016 to early March 2017 in the Waikanae River

5.1.2 Temperature

Water temperature varies throughout the day and the spot measures taken between 9 and 4 pm are indicative of the warmest period of the day. The averaged trend from December through to March shows March to be the warmest month this season at around 16°C. Last year the warmest month (February) was 18 - 20°C. Figure 5 below illustrates the spot temperature ranges.

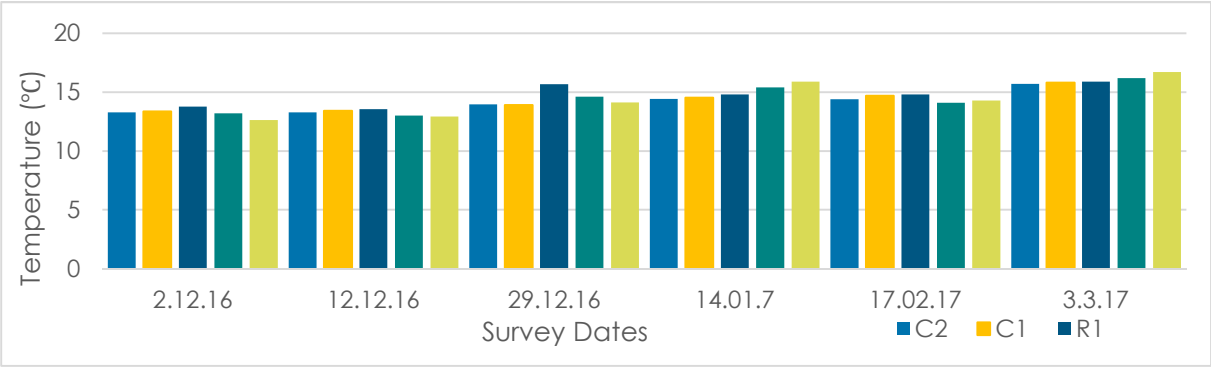


Figure 5: Temperature spot measures from December 2016 to March 2017 in the Waikanae River.

5.1.3 Conductivity

Results between sites at any one sampling time were generally similar. Between times of sampling (i.e. across the season) there is an “ebb and rise” in conductivity, independent of any river recharge (Figure 6). That said the range of the variance is small and not ecologically significant.

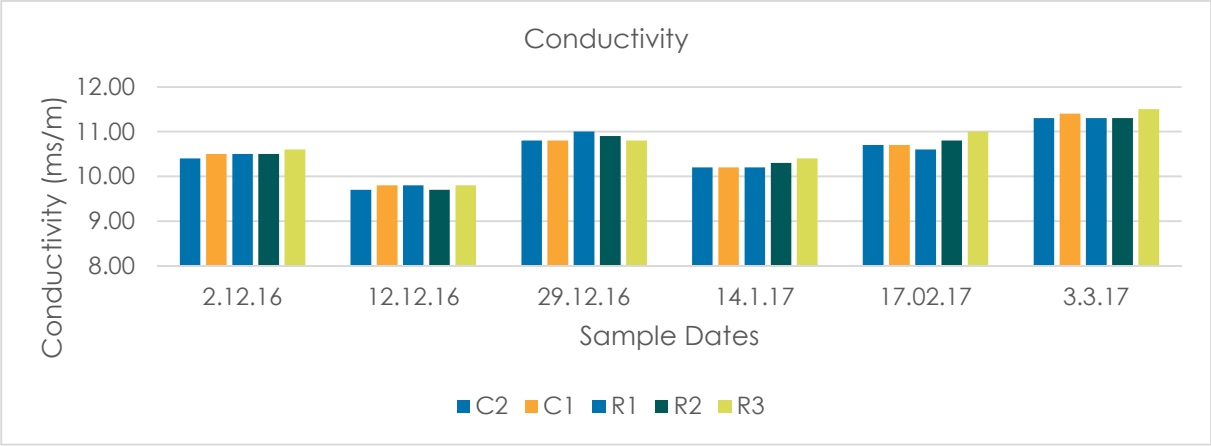


Figure 6: Conductivity spot measures from December 2016 to March 2017 in the Waikanae River

5.1.4 Total phosphorus

Total phosphorus showed two "peak" periods -early December and middle of February. In the first seasons measures, R1 had a reduced and different level than the other sites.

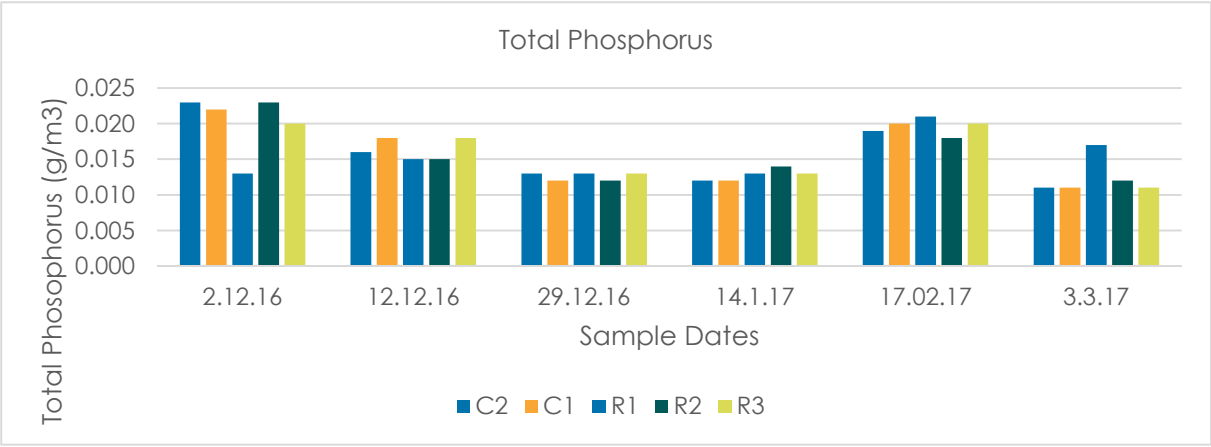


Figure 7: Total phosphorus measures from December 2016 to March 2017 in the Waikanae River.

5.1.5 Dissolved reactive phosphorus (DRP)

DRP (Figure 8) shows a reasonable consistency across the sites and throughout the monitoring period. There was a slight rise in February and a reduction in early March. The only "unusual" result was a reduced level in the February measure at C2, a result not reflected in the Total Phosphorous result.

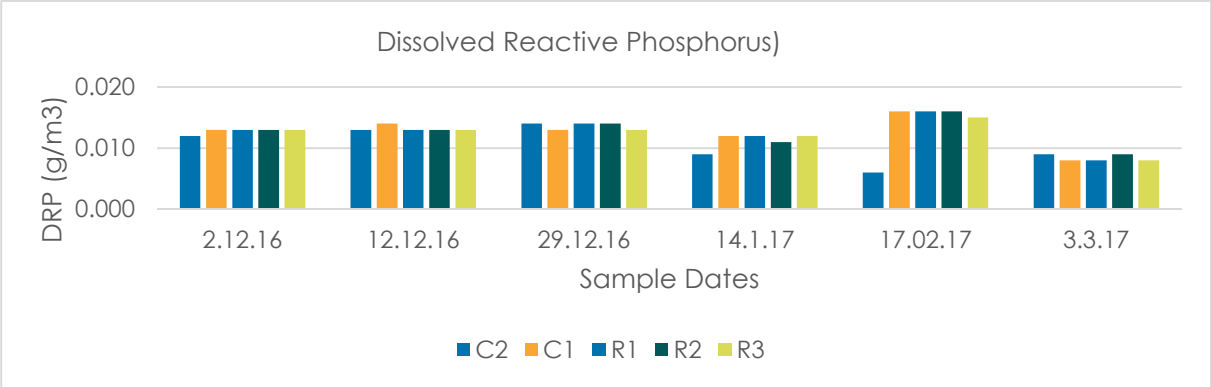


Figure 8: Dissolved reactive phosphorus results from December 2016 to March 2017 in the Waikanae River

5.1.6 Total Nitrogen

Total Nitrogen levels oscillated throughout the season, dropping in January and peaking in February. There were no unusual results this year. See Figure 9.

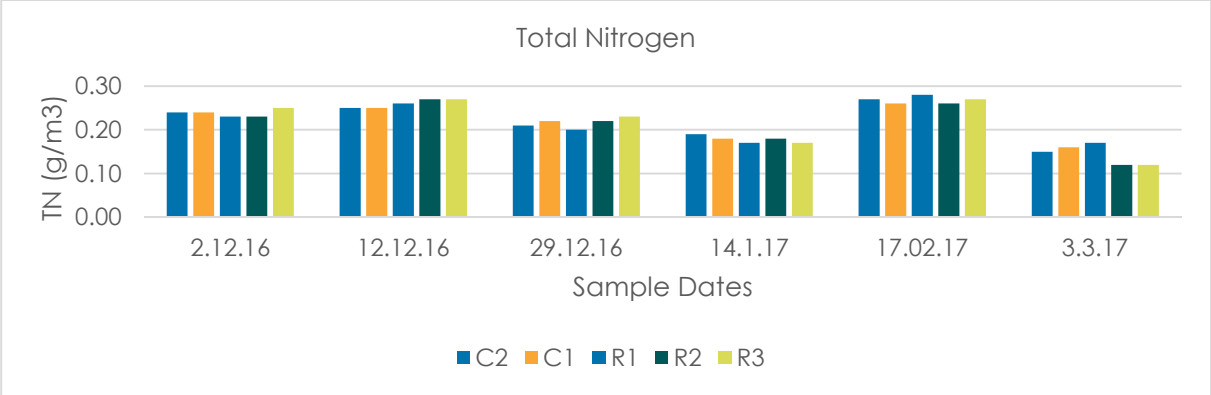


Figure 9: Total Nitrogen results across monitoring sites from December 2016 to March 2017 in the Waikanae River.

5.1.7 Nitrite/Nitrate Nitrogen

A general decline in nitrite-nitrate nitrogen is observable from December to January. February levels rose to drop back to January levels in March. There were no unusual measures this season (Figure 10).

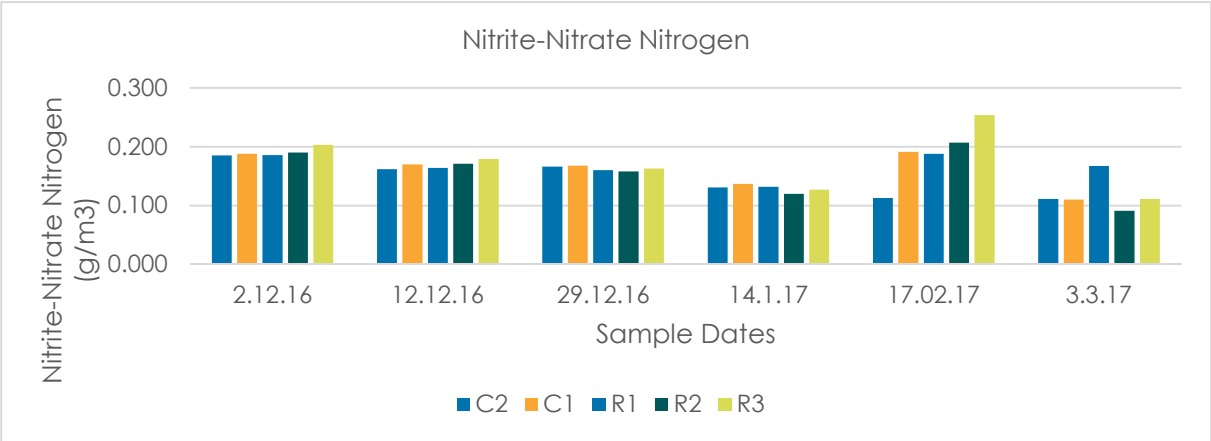


Figure 10: Nitrite/Nitrate Nitrogen measures from December 2016 to March 2017 in the Waikanae River.

5.1.8 Soluble Inorganic Nitrogen

Soluble inorganic nitrogen followed the same pattern as the nitrite/ nitrate nitrogen results above. There were no unusual results and February saw a slight rise in SIN (Figure 11).

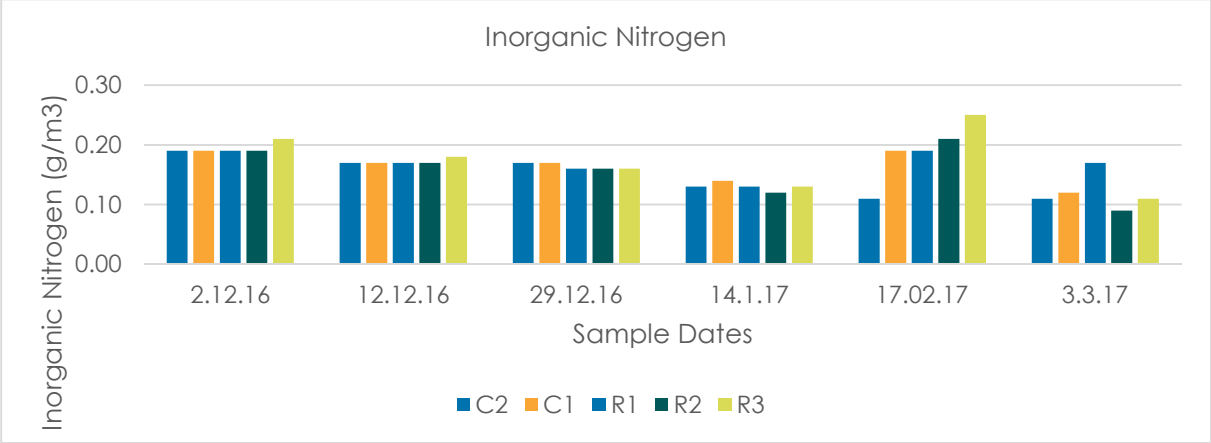


Figure 11: Soluble inorganic nitrogen measures from December 2016 to March 2017 in the Waikanae River.

5.1.9 Ammonia-Nitrogen

All measurements of ammonia nitrogen were <0.01, below the laboratory detection level.

5.1.10 Dissolved Calcium

Dissolved calcium was relatively stable throughout the monitoring period at around 5.0 g/m^3 (Figure 12).

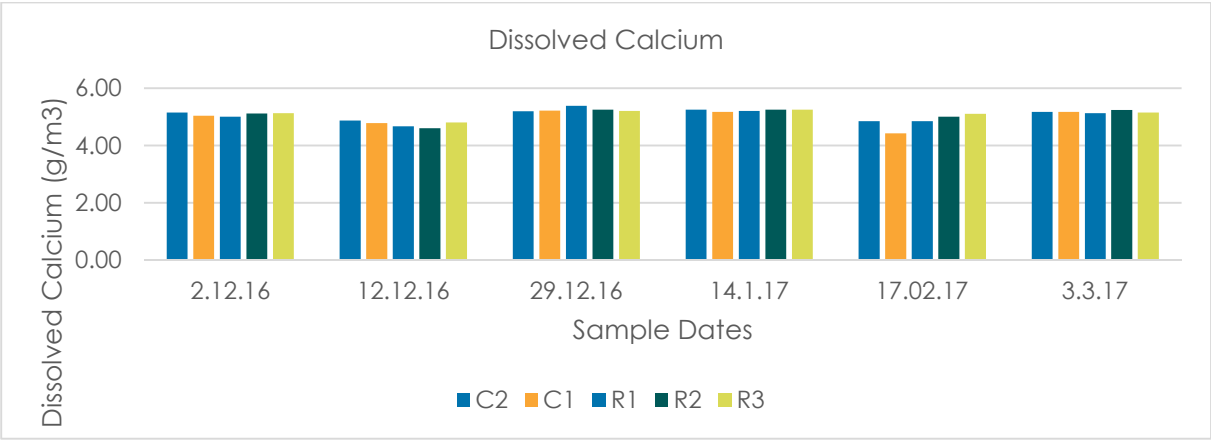


Figure 12: Dissolved calcium results from December 2016 to March 2017 in the Waikanae River.

5.1.11 Summary

Water chemistry across the sites was similar in general and there were no control and reaction site variances of note. Generally, there is a minor visible oscillation across the three months of monitoring.

The key differences were in January with lower measures of some elements and in February with higher measures in some elements. There were however, no unusual measures or obvious patterns.

5.2 Periphyton

5.2.1 Periphyton Visual Assessments

This year there was a very limited cover of periphyton (even thin cover) through December to February and algae did not begin to accrue until the March measure. We assume this is due to the more regular floods and higher general river flows this year.

Cyanobacteria did not feature this year and only the later measures noted its occasional presence.

Historically the annual report has produced five graphs: the averaged cover of thin periphyton growth; the averaged medium periphyton mat cover per site; the averaged thick periphyton growth; the averaged filamentous periphyton growth; and periphyton average cover in riffle and run habitat.

Given the low numbers we have graphed WCC and PSI indices to illustrate the general lack of periphyton this year. This varies from previous reports showing five graphs: the averaged cover of thin periphyton growth; the averaged medium periphyton mat cover per site; the averaged thick periphyton growth; the averaged filamentous periphyton growth; and periphyton average cover in riffle and run habitat. These data is presented in Appendix 1,

Periphyton Indices

Weighted Composite Cover (WCC) is a measure of periphyton abundance in terms of the stream bed covered (%) by two forms of periphyton; mats and filaments (Matheson, Quinn, & Hickey, 2012). While the New Zealand Periphyton Guideline (B. J. F. Biggs, 2000) provides separate aesthetic impact guidelines for identifying nuisance periphyton filamentous (≥30%) and mat (≥60%) cover, a composite cover guideline is useful for instances where both filamentous growths and mats occur (Matheson et al., 2012).

The WCC was calculated as %filamentous cover + (%mat cover/2). We have accepted GWRC expert's direction to remove the thin algae class from the equation and see this as a reasonable approach (Figure 13). Provisional general guidelines of <20%, 20-39%, 40-55% and >55% periphyton weighted composite cover are recommended as indicators of 'excellent', 'good', 'fair' and 'poor' ecological condition, respectively, at sites where other stressors are minimal (Matheson et al., 2012).

Most sites throughout the season had WCC weighting between 2-20% ("excellent" ecological condition). No sites breeched the fair or poor ecological condition.

The PSI is a biomass indices called periphyton "Sliminess" indices (Figure 14). The formula is based on percent cover for each thickness category (i.e., all colour categories combined). The PSI was calculated as PSI = {(%Thin mat/film) + (%Short filaments * 2) + (%Medium mat * 3) + (%Long filaments * 4) + (%Thick mat * 5)} / 5.

PSI flowed a very similar level and pattern as the WCC and is as expected in the absence generally of periphyton.

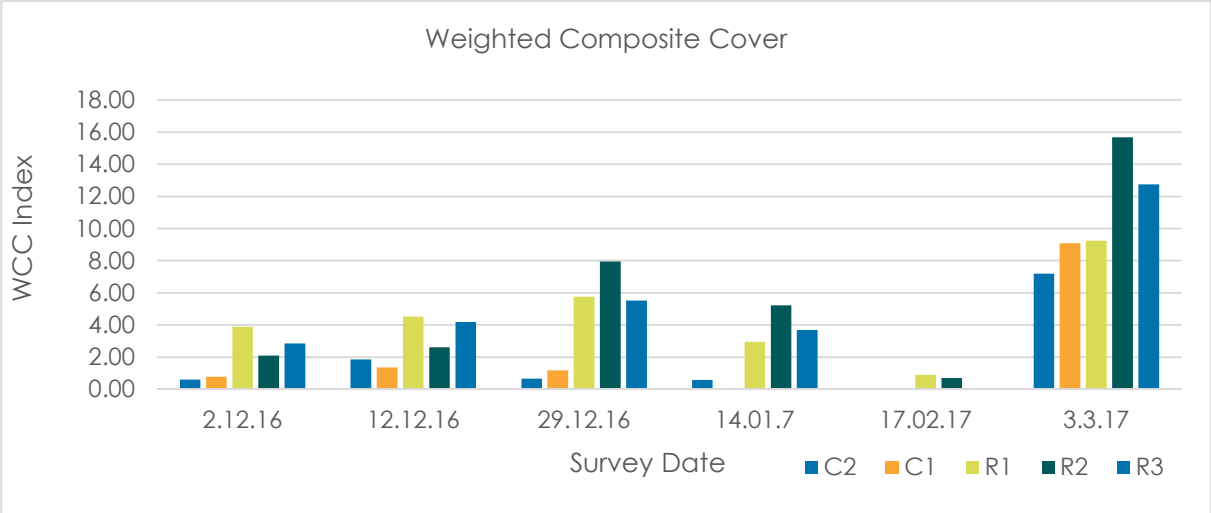


Figure 13: Weighted composite cover at all monitoring sites throughout the monitoring period December to March

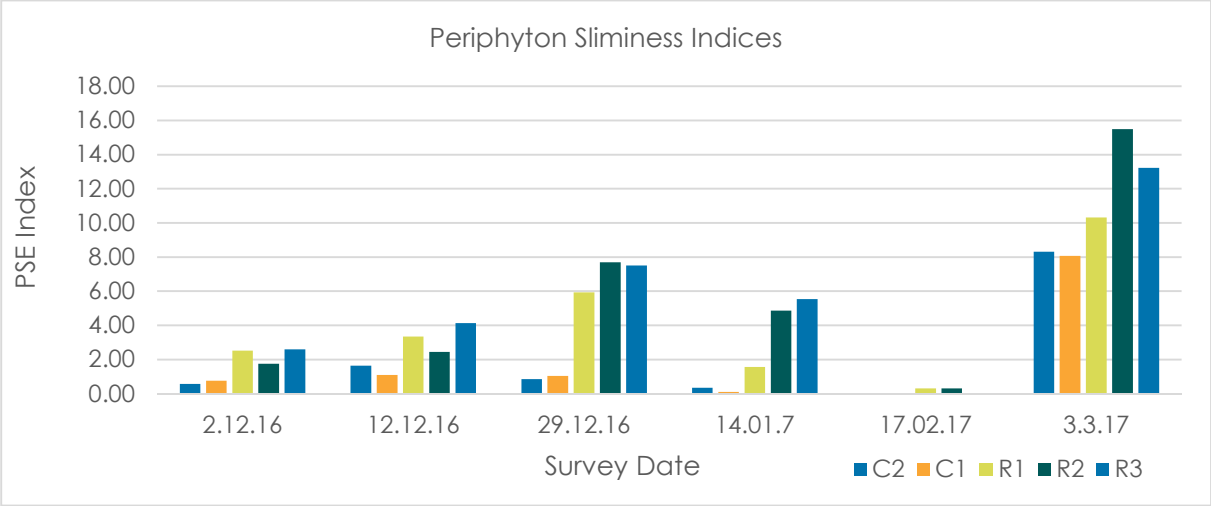


Figure 14: Periphyton sliminess indices at all monitoring sites throughout the monitoring period December to March

5.2.2 Quantitative Periphyton Measure – Chlorophyll-*a*

Chlorophyll-*a* is a pigment present in large quantities in most algae to enable photosynthesis. Chlorophyll-*a* is extracted from periphyton samples using an organic solvent (usually ethanol or acetone), and the concentration of chlorophyll *a* is then measured in a spectrophotometer. This gives a relative measure of autotrophic biomass (Matheson et al, 2012).

The Biggs (2000) guide delimits oligotrophic and eutrophic waterbodies as containing chlorophyll *a* bounds of 60mg/m^2 and 200 mg/m^2. No result measured this year was in excess of 151 mg/m^2. The Manawatu Wanganui Regional Council recommends periphyton biomass standards of < 100mg/m^2. Figure 15 shows that through most of the monitoring period the levels were below 50 mg/m^2. The high flows of February kept levels very low. There were some differences at each sampling period between sites, with R2 having higher level of chlorophyll-a on three sampling occasions. Notable as flows receded to under 4 cumecs (March) periphyton abundance and biomass increased.

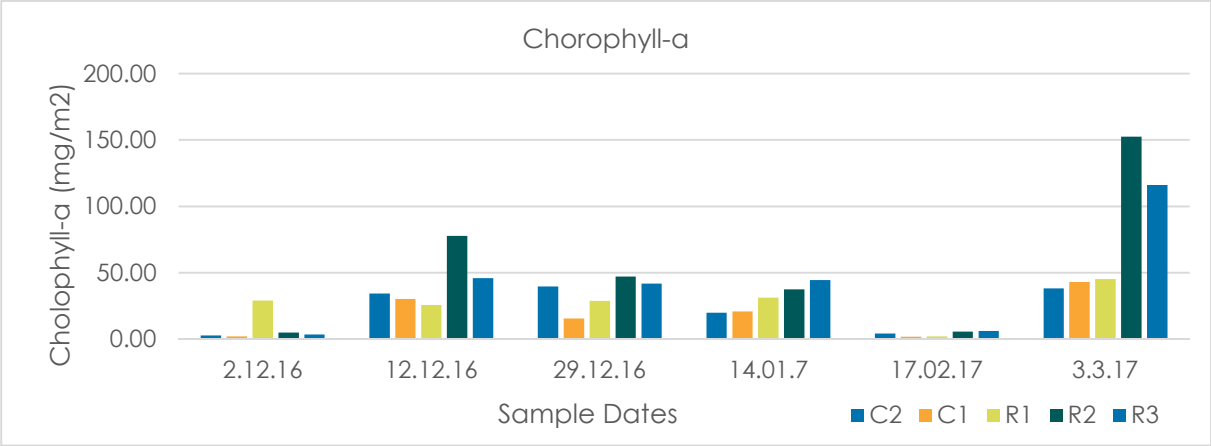


Figure 15: Average chlorophyll a (mg/m^2) at each site from December 2016 to March 2017 at Waikanae River

5.2.3 Periphyton Species Richness & Community Composition

Only one period was sampled for periphyton community assemblage and relative abundance this year (as per agreed position with GWRC). That period was December and the results are shown in Table 2.

The periphyton group which causes most human and animal health issues (Cyanobacteria) were represented in the Waikanae River monitoring sites by two taxa (*Oscillatoria/ Phormidium* and *Rivularia*). These two taxa had the highest relative abundance (noting that the abundance/cover was still very low) at every site including controls. No filamentous algae were in samples taken.

Table 2: Averaged relative abundance data for each site for 9th February 2017 sample.

Al	C2	C1	R1	R2	R3
Mougeotia	2.5	2.5	3	3	2.7
Cyanobacteria					
Oscillatoria/Phormidium	5.4	4.4	4	4.8	4.6
Rivularia	2	3	3	4	3
Filamentous diatoms					
Melosira	1.8	1.75	1.7	1.5	1.75
Diatoms					
Cocconeis			1		
Cymbella	1.67	1.3	1.4	1.6	1.5
Frustulia	1	1	1	1	1
Gomphoneis	2	2	2	2	2
Nitzschia	1	1	1	1	1
Pinnularia	1	1	1	1	1
Synedra			1		

5.2.1 Macroinvertebrates

Macroinvertebrates were not sampled this year due to periphyton in the river not reaching high or very high levels.

The relationship between macroinvertebrates and periphyton when the level of periphyton is low and moderate has been demonstrated and quantified in previous years of baseline monitoring. The relationship determined reflects and is reinforced by literature. No further monitoring of macroinvertebrates was agreed as necessary at low and moderate periphyton levels due to sufficient data. Monitoring of the macroinvertebrates if moderate or high periphyton levels were reached in the 2016/2017 monitoring period was agreed as the approach to further macroinvertebrate community data by the AMG at the 2016 meeting and GWRC agreed on this approach in their review of the 2015/16 Annual Report.

5.3 Fish

Two of the four surveys were completed (high river flow and weather conditions meant no further surveys could be done in the agreed period). Surveys occurred on the 17.2.2017 and 9.3.2017. Where flows were 1.9 and 4.1 cumecs respectively. Appendix 4 presents the raw data.

From the two surveys 186 fish were caught in the riffles. 123 (66%) of those fish were sampled downstream of the Waikanae WTP (twice as many as above (63)). Longfin eel where the most commonly sampled species both above and below the Waikanae WTP (Figure 16). Redfin bully and torrent fish were much more abundant below the Waikanae WTP than above. Shortfin eel, blue-gilled bully and banded kokopu were only sampled above the Waikanae WTP but all in abundances less than 5 fish.

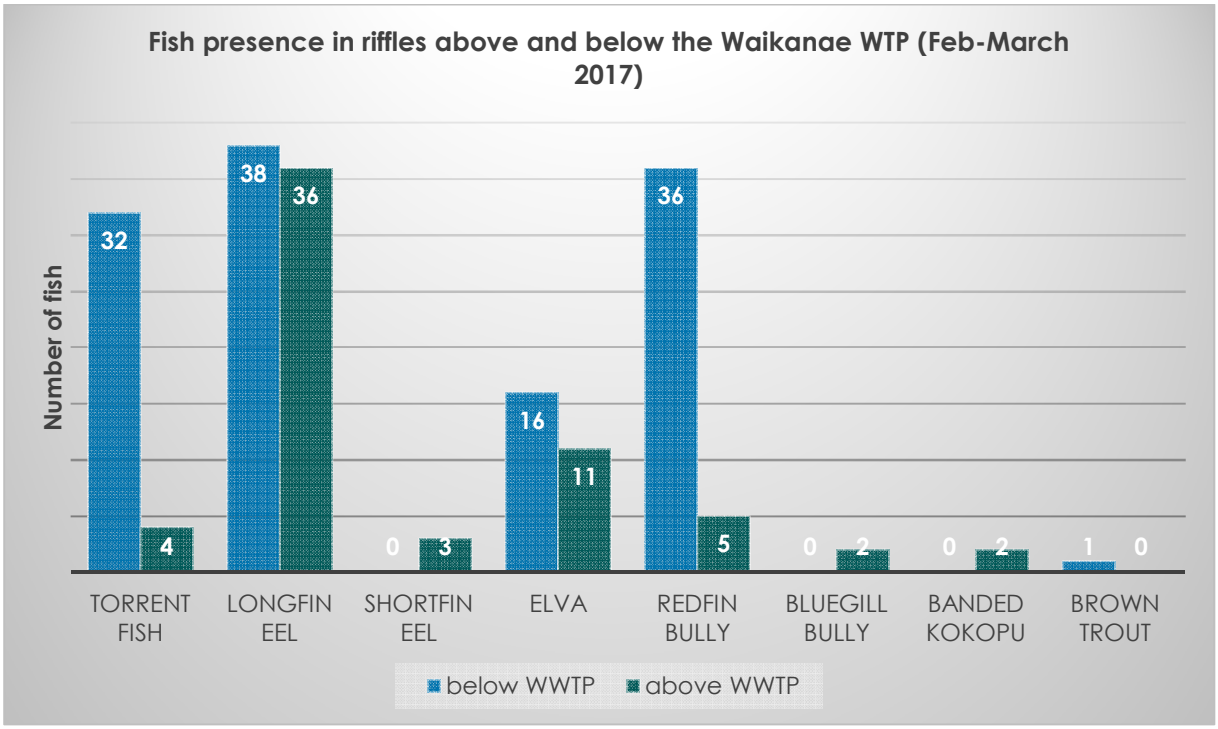


Figure 16: Number of fish caught in the Waikanae River.

When abundances were set against the total area of the survey in each riffle the density of fish was greatest downstream of the Waikanae WTP (sample sites R1 and R3) (Figure 17).

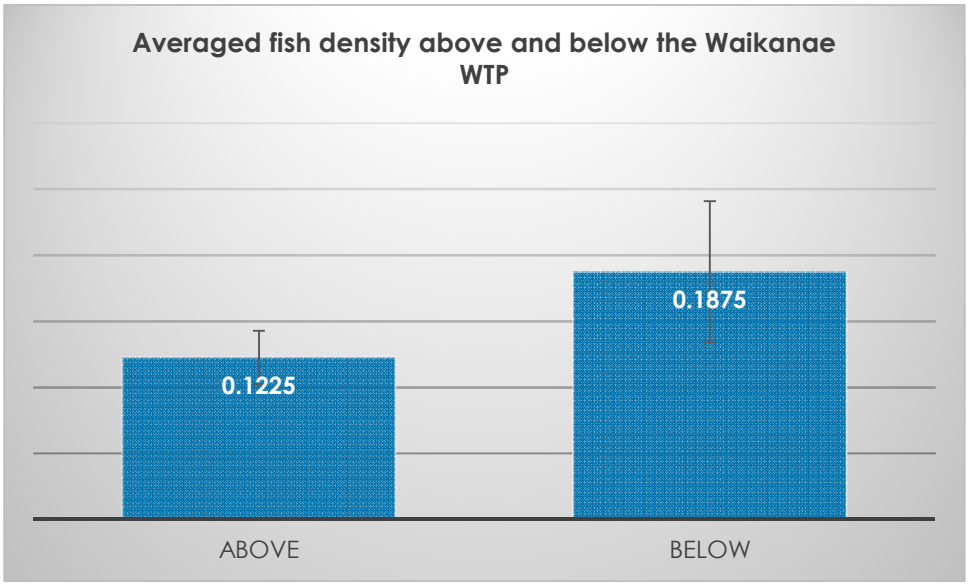


Figure 17: Density of fish caught in the Waikanae River above (C1 & C2) and below (R1 & R3) the Waikanae WTP.

In terms of sizes the largest fish sampled were eel (short and long fin) but these were still generally of small to moderate size fish (average - 50mm). Generally, only small torrent and redfin bully were caught (Figure 18). A number of elva (eel <100mm) where present both above and below the Waikanae WTP (Figure 17).

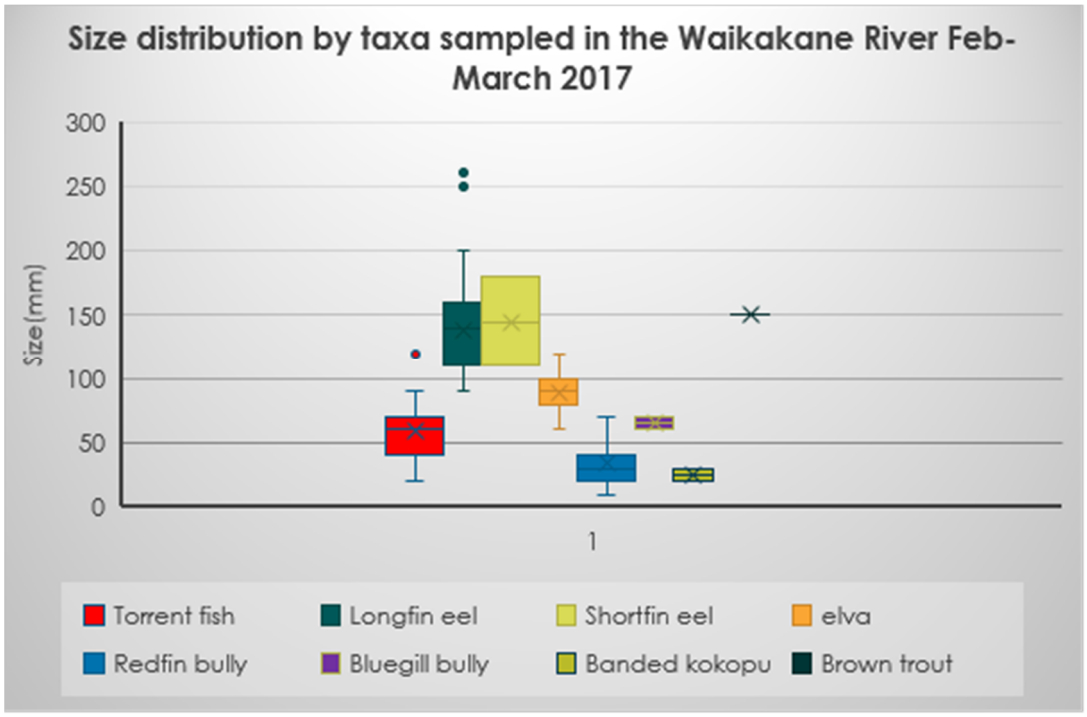


Figure 18: Box plot of sizes of fish caught in the Waikanae River.

6.0 Flow Gauging

Due to the high river flows and no river recharge activities, flow gauging was not undertaken by NIWA this summer as per condition 19 of consent WGN130103 [34400] *"Flow gauging may not be required during times when River Recharge is not in operation if the flow is known based on existing flow information".*

7.0 Summary

This report builds on the previous season's data collection experiences and completes the 15 months total of summer baseline monitoring. This season's monitoring represents a wet season. There are now 15 months in total of aquatic baseline monitoring data, 2 months of this data is following recharge activity.

The data reported here, in a wet spring-summer period - as well as the early analysis, indicate that the Waikanae River, by and large, has a stable water quality with a small but seasonally predictable temperature regime. Nutrient status can be described as generally being between oligotrophic and mesotrophic (i.e. a medium nutrient status, with DRP being the higher nutrient).

Periphyton cover was very low this monitoring season and this can be attributed to the high flows and more frequent small and large floods experienced. Cover did not start to accrue until late February / early March.

There were no visual (WCC) periphyton trigger exceedances during the monitoring period. Macroinvertebrates were not sampled in this period due to the level of periphyton growth not reaching the required high or very high level.

Small (young) fish were surveyed both above and below the Waikanae WTP, but the majority of fish in terms of abundance were below the Waikanae WTP.

No recommendations for future monitoring are provided in this report as the data from the past 3 years will now be collated and analysed for the setting of the ongoing triggers for monitoring going forward, in consultation with the AMG and GWRC.

8.0 References

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Appendix 1: Visual periphyton cover data 2nd Decemebr-2016 to March 3rd 2017

2nd December 2016		CONTROL B (C2)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		92	90	95	95	80	98	95	92	98	80	85	95	92	95	95	48	58	50	82	85
Thin mat/film	Green	20	5	10	5	8	25	20	30	35	28	5	3	1	3	1	2	1	0	0	0
	Light Brown	30	25	30	23	25	15	10	8	15	10										
	Dark Brown/ Black					2															
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black			1	1	1	1	1	1	2	2										
Filaments, short	green			1	1	1	1		1	1	1										
	brown reddish																				
Filaments, long	green																				
	brown reddish																				

Total algal cover	**WCC**	25	15	21.5	15.5	19	21.5	15.5	20.5	27	21	2.5	1.5	0.5	1.5	0.5	1	0.5	0	0	0
	PSI	10	6	9.4	7	8.4	9.4	7	9	12.4	10	1	0.6	0.2	0.6	0.2	0.4	0.2	0	0	0
Without thin mat/film	**WCC**	0	0	1.5	1.5	1.5	1.5	0.5	1.5	2	2	0	0	0	0	0	0	0	0	0	0
	PSI	0	0	1.2	1.2	1.2	1.2	1	1.2	2.2	2.2	0	0	0	0	0	0	0	0	0	0

Without thin mat/ thin & Averaged across site	**WCC**			0.9					1.5					0					0		
	PSI			0.72					1.56					0					0		

2nd December 2016		CONTROL A (C1)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		85	80	95	98	100	75	65	70	60	65	90	95	92	95	98	90	95	88	90	90
Thin mat/film	Green	2	2	0	1	0	2	1	5	5	5		0	2	0	0	2	0	0	5	3
	Light Brown		4		1			5	25	15	18										
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown								4		4										
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black				1				2	1	5										
Filaments, short	Green								3	1	3										
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				

Total algal cover	**WCC**	1	3	0	1.5	0	1	3	21	11.5	19	0	0	1	0	0	1	0	0	2.5	1.5
	PSI	0.4	1.2	0	1.4	0	0.4	1.2	11.6	5.4	13.2	0	0	0.4	0	0	0.4	0	0	1	0.6
Without thin mat/film	**WCC**	0	0	0	0.5	0	0	0	6	1.5	7.5	0	0	0	0	0	0	0	0	0	0
	PSI	0	0	0	1	0	0	0	5	1.2	8	0	0	0	0	0	0	0	0	0	0
Without thin mat/ fim & Averaged across site	**WCC**			0.1					3					0					0		
	PSI			0.2					2.84					0					0		

2nd December 2016		SITE R1																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		82	90	90	60	92	92	90	84	90	100	75	82	70	65	90	40	86	89	91	90
Thin mat/film	Green	10	5	5	5	5	4	5	3	12	9	1	1	1	1	12	0	0	0	1	1
	Light Brown	30	42	15	37	36	28	32	32	26	41	5	5	1	15	40	2	2	1	3	1
	Dark Brown/ Black					1		3													
Medium mat	Green																				
	Light Brown						1									7					
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown										4										
Cyanobacteria	Dark Brown/ Black		5	3	8		5			4	1					1					
Filaments, short	green	1	5	1	2	15	6	1	1	8	12					1					
	brown reddish																				
Filaments, long	green		1		1						3										
	brown reddish																				
Total algal cover	**WCC**	21	32	12.5	28	36	25	21	18.5	29	42.5	3	3	1	8	31	1	1	0.5	2	1
	PSI	8.4	17.2	7.4	18	14.4	14.4	8.4	7.4	14.8	22.2	1.2	1.2	0.4	3.2	16	0.4	0.4	0.2	0.8	0.4
Without thin mat/film	**WCC**	1	8.5	2.5	7	15	9	1	1	10	17.5	0	0	0	0	5	0	0	0	0	0
	PSI	0.2	6.8	3.2	9.2	3	6.8	0.2	0.2	5.6	9.8	0	0	0	0	5.4	0	0	0	0	0
Without thin mat/ fim & Averaged across site	**WCC**			6.8					7.7					1					0		
	PSI			4.48					4.52					1.08					0		

2nd December 2016		SITE R2																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		85	92	95	100	95	95	85	90	85	85	90	60	95	60	90	92	82	65	75	90
Thin mat/film	Green	45	45	40	65	35	15	40	40	5	10	5	2	2	2	10	1	1	2	5	20
	Light Brown	5	5	5	5	1	2	5	5	2	15					10					25
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown						2		10	1											
	Dark Brown/ Black	5																			5
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Thick Brown/ black								7	2	6										2
Filaments, short	Green	1	2	2	5				4	1	5										2
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				
Total algal cover	**WCC**	28.5	27	24.5	40	18	9.5	22.5	35	6	20.5	2.5	1	1	1	10	0.5	0.5	1	2.5	28
	PSI	13.4	10.8	9.8	16	7.2	4.6	9	23.6	4.4	13	1	0.4	0.4	0.4	4	0.2	0.2	0.4	1	14.8
Without thin mat/film	**WCC**	3.5	2	2	5	0	1	0	12.5	2.5	8	0	0	0	0	0	0	0	0	0	5.5
	PSI	3.2	0.4	0.4	1	0	1.2	0	13.8	2.8	7	0	0	0	0	0	0	0	0	0	5.4
Without thin mat/ fim & Averaged across site	**WCC**	2.5					4.8					0					1.1				
	PSI	1					4.96					0					1.08				

2nd December 2016		SITE R3																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		98	98	100	95	70	85	92	92	90	60	100	98	80	100	100	70	75	85	100	100
Thin mat/film	Green	0	0	5	18	0	20	10	2	2	10	0	0	0	0	0	0	0	0	2	5
	Light Brown		0				25	20	3	15	5										
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black							20	25	5	2										
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Thick Dark Brown/ Black						2	10	2	1	1										
Filaments, short	Green						1	10	10	2											
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				

Total algal cover	**WCC**	0	0	2.5	9	0	24.5	40	26	13.5	9	0	0	0	0	0	0	0	0	1	2.5
	PSI	0	0	1	3.6	0	11.4	32	22	8.2	5.2	0	0	0	0	0	0	0	0	0.4	1
Without thin mat/film	**WCC**	0	0	0	0	0	2	25	23.5	5	1.5	0	0	0	0	0	0	0	0	0	0
	PSI	0	0	0	0	0	2.2	24	19	4.4	2.2	0	0	0	0	0	0	0	0	0	0

Without thin mat/ thin & Averaged across site	**WCC**			0					11.4					0					0		
	PSI			0					10.36					0					0		

12th December 2016		CONTROL B (C2)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		90	86	88	90	90	90	95	95	95	85	80	90	90	95	100	45	50	45	75	80
Thin mat/film	Green	15	1	5	10	2	15	10	25	25	10	1	5	5	5	1	5	1	5	5	1
	Light Brown	35	25	25	20	20	20	15	10	25	20	5		5	5		1	1	5	5	
	Dark Brown/ Black					2															
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																	1			
Cyanobacteria	Dark Brown/ Black	1		5	5	1	5	5	1		1				1	1		1			
Filaments, short	green	5		1	1	5	1	5	5												
	brown reddish																				
Filaments, long	green																				
	brown reddish																				

Total algal cover	**WCC**	30.5	13	18.5	18.5	17.5	21	20	23	25	15.5	3	2.5	5	5.5	1	3	2	5	5	0.5
	PSI	13	5.2	11.4	11.4	7.8	12.4	12	10	10	7	1.2	1	2	3	1.2	1.2	2.4	2	2	0.2
Total algal cover not including thin mat/film	**WCC**	5.5	0	3.5	3.5	5.5	3.5	7.5	5.5	0	0.5	0	0	0	0.5	0.5	0	1	0	0	0
	PSI	2	0	5.2	5.2	2	5.2	6	2	0	1	0	0	0	1	1	0	2	0	0	0

algal cover without thin mat/ thin & Averaged across site	**WCC**			3.6					3.4					0.2					0.2		
	PSI			2.88					2.84					0.4					0.4		

12th December 2016		CONTROL A (C1)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		85	90	90	95	98	72	70	68	65	70	86	95	90	90	100	85	85	90	87	95
Thin mat/film	Green	5	5	1	5	1	5	5	5	1	5	5	5	5	10	1	5	5	1	5	1
	Light Brown		1		15	15	1	10	20	10	20	20	1	5				15	10		1
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown								4												
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black		1	1	1		1		1	1	5		1		1			1			
Filaments, short	Green							5		5	5										
	Brown Reddish																				
Filaments, long	Green									1	1							1			
	Brown Reddish																				

Total algal cover	**WCC**	2.5	3.5	1	10.5	8	3.5	12.5	15	12	21	12.5	3.5	5	5.5	0.5	2.5	11.5	5.5	2.5	1
	PSI	1	2.2	1.2	5	3.2	2.2	5	8.4	6	12.8	5	2.2	2	3	0.2	1	5.8	2.2	1	0.4
Total algal cover not including thin mat/film	**WCC**	0	0.5	0.5	0.5	0	0.5	5	2.5	6.5	8.5	0	0.5	0	0.5	0	0	1.5	0	0	0
	PSI	0	1	1	1	0	1	1	3.4	2.8	6.8	0	1	0	1	0	0	1.8	0	0	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			0.3					4.6					0.2					0.3		
	PSI			0.6					3					0.4					0.36		

12th December 2016		SITE R1																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		80	85	85	70	90	89	85	85	80	90	80	85	78	60	85	45	85	80	95	95
Thin mat/film	Green	15	8	1	5	8	4	5	3	12	9	1	1	1	1	12	0	0	0	1	1
	Light Brown	10	25	15	28	40	30	32	32	26	41	5	5	1	15	40	2	2	1	3	1
	Dark Brown/ Black		1	1			1	3													
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown		1	5	1				5	5											
Cyanobacteria	Dark Brown/ Black	1	6	5	5		1		1	5			1		1		1		1		
Filaments, short	green	1	8	5		12	5			5	10	1		5				1	1		
	brown reddish																				
Filaments, long	green	1	1	1	1	1		1	1	5							2				
	brown reddish																				
Total algal cover	**WCC**	15	29.5	19.5	20.5	37	23	21	21.5	34	35	4	3.5	6	8.5	26	3.5	2	2	2	1
	PSI	7.2	17.8	16.2	13.4	15.2	10	8.8	13.8	23.6	14	1.6	2.2	2.4	4.2	10.4	3	0.8	1.6	0.8	0.4
Total algal cover not including thin mat/film	**WCC**	2.5	12.5	11	4	13	5.5	1	4	15	10	1	0.5	5	0.5	0	2.5	1	1.5	0	0
	PSI	2	9.4	11.8	6.8	3.2	2	0.8	6.8	15	2	0.2	1	1	1	0	2.6	0.2	1.2	0	0
algal cover without thin mat/ fim & Averaged across site	**WCC**			8.6					7.1					1.4					1		
	PSI			6.64					5.32					0.64					0.8		

12th December 2016		SITE R2																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		82	90	91	100	85	90	87	92	80	89	90	85	70	60	90	85	79	58	69	92
Thin mat/film	Green	45	30	35	50	25	20	35	45	20	10						1	5	5	1	15
	Light Brown	5	5	1	1	5	5	10	1	1	10	40	30	20	5	10					15
	Dark Brown/ Black											46	35			5					
Medium mat	Green																				
	Light Brown							5	5		1	1		5		5					
	Dark Brown/ Black	1		5	1												5			5	
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Thick Brown/ black						5		2	5	5		1		1			1	1		
Filaments, short	Green	1	1	5		5	2		5		3										
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				
Total algal cover	**WCC**	26.5	18.5	25.5	26	20	17	25	31.5	13	16	43.5	33	12.5	3	10	3	3	3	3	15
	PSI	11	7.4	12.2	10.8	8	10.8	12	16.2	9.2	10.8	17.8	14	7	2	6	3.2	2	2	3.2	6
Total algal cover not including thin mat/film	**WCC**	1.5	1	7.5	0.5	5	4.5	2.5	8.5	2.5	6	0.5	0.5	2.5	0.5	2.5	2.5	0.5	0.5	2.5	0
	PSI	0.8	0.2	4	0.6	1	5.4	3	6	5	6.2	0.6	1	3	1	3	3	1	1	3	0
algal cover without thin mat/ fim & Averaged across site	**WCC**			3.1					4.8					1.3					1.2		
	PSI			1.32					5.12					1.72					1.6		

12th December 2016		SITE R3																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		SITE R3	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		95	100	100	95	90	98	98	98	80	92	65	88	92	95	100	80	92	92	92	95
Thin mat/film	Green	3											5	2	5	5	40	45	25	15	10
	Light Brown	30	19	65	30	36	38	30	40	60	56	45	60	65	65	95	10	8	15	15	50
	Dark Brown/ Black		40	30	15	20	56	45	25	5	22										
Medium mat	Green								5												
	Light Brown	5																			
	Dark Brown/ Black	10	5																		
Thick mat	Green																				
	Light Brown									1											
Cyanobacteria	Thick Dark Brown/ Black	15	8					5	5												
Filaments, short	Green	5	3					5	2	1											
	Brown Reddish																				
Filaments, long	Green	10	18					5	4	1											
	Brown Reddish																				

Total algal cover	**WCC**	46.5	57	47.5	22.5	28	47	50	43.5	35	39	22.5	32.5	33.5	35	50	25	26.5	20	15	30
	PSI	40.6	38.4	19	9	11.2	18.8	26	25	15.2	15.6	9	13	13.4	14	20	10	10.6	8	6	12
Total algal cover not including thin mat/film	**WCC**	30	27.5	0	0	0	0	12.5	11	2.5	0	0	0	0	0	0	0	0	0	0	0
	PSI	33	26	0	0	0	0	10	11.6	2	0	0	0	0	0	0	0	0	0	0	0
algal cover without thin mat/ fim & Averaged across site	**WCC**			11.5					5.2					0					0		
	PSI			11.8					4.72					0					0		

29th December 2016		CONTROL B (C2)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		90	87	90	85	92	75	70	40	85	100	98	92	25	15	95	92	78	65	75	50
Thin mat/film	Green	2	5		5	7	10	20	5	5	10							1			
	Light Brown	70	73	10	55	80	68	50	30	70	80	10	10			5	35	40	40	50	10
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black	1	1			1	3	10													
Filaments, short	green							5													
	brown reddish																				
Filaments, long	green																				
	brown reddish																				

Total algal cover	**WCC**	36.5	39.5	5	30	44	40.5	45	17.5	37.5	45	5	5	0	0	2.5	17.5	20.5	20	25	5
	PSI	15.4	16.6	2	12	18.4	18.6	26	7	15	18	2	2	0	0	1	7	8.2	8	10	2
Total algal cover not including thin mat/film	**WCC**	0.5	0.5	0	0	0.5	1.5	10	0	0	0	0	0	0	0	0	0	0	0	0	0
	PSI	1	1	0	0	1	3	11	0	0	0	0	0	0	0	0	0	0	0	0	0
algal cover without thin mat/ fim & Averaged across site	**WCC**			0.3					2.3					0					0		
	PSI			0.6					2.8					0					0		

29th December 2016		CONTROL A (C1)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		85	85	90	95	95	90	78	85	85	85	98	90	90	80	90	70	85	90	95	90
Thin mat/film	Green	5	5	10	10	5		20	10	5	1								8	10	
	Light Brown	65	58	60	30	45	50	35	65	60	65	15	12	12	35	26	38	40	65	60	70
	Dark Brown/ Black				20	20															
Medium mat	Green																				
	Light Brown	1			1					1											
	Dark Brown/ Black			1		1	1	1													
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black	1	2	2	2	1													2	4	
Filaments, short	Green			2	3	2		1	1	1										3	
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				

Total algal cover	**WCC**	36	32.5	38.5	34.5	38	25.5	29	38.5	34	33	7.5	6	6	17.5	13	19	20	37.5	40	35
	PSI	15.6	14.6	17.4	15.8	16.4	10.6	12	15.4	14	13.2	3	2.4	2.4	7	5.2	7.6	8	16.6	19.2	14
Total algal cover not including thin mat/film	**WCC**	1	1	3.5	4.5	3	0.5	1.5	1	1.5	0	0	0	0	0	0	0	0	1	5	0
	PSI	1.6	2	3	3.2	2	0.6	0.8	0.2	0.8	0	0	0	0	0	0	0	0	2	4.6	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			2.6					0.9					0					1.2		
	PSI			2.36					0.48					0					1.32		

29th December 2016		SITE R1																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		98	98	90	85	80	100	80	98	95	80	70	90	85	90	95	60	50	95	98	97
Thin mat/film	Green				5	3	5	5	5									1	12	10	1
	Light Brown	60	35	20	35	40	50	25	10	61	60	40	40	60	60	70	10	8	30	40	45
	Dark Brown/ Black	15	20	30	30	20	10	15	10	21	20					5					1
Medium mat	Green																				
	Light Brown		5		5		10	15	20		2										
	Dark Brown/ Black		15	10				5	20												
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black						4	11	15	3	5					1					
Filaments, short	green	1	1	1	1	1	8	1	10	1	3								1	1	
	brown reddish																				
Filaments, long	green	1	1	1	1	1	1	2		1	1								1	1	
	brown reddish																				

Total algal cover	**WCC**	39.5	39.5	32	39.5	33.5	48.5	41	50	44.5	47.5	20	20	30	30	38	5	4.5	23	27	23.5
	PSI	16.2	24.2	17.2	18.2	13.8	27	34	48	20.6	24.2	8	8	12	12	16	2	1.8	9.6	11.2	9.4
Total algal cover not including thin mat/film	**WCC**	2	12	7	4.5	2	16	18.5	37.5	3.5	7.5	0	0	0	0	0.5	0	0	2	2	0
	PSI	1	13	7	4	1	12.4	24.8	41	4	7.6	0	0	0	0	1	0	0	1	1	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			5.5					16.6					0.1					0.8		
	PSI			5.2					17.96					0.2					0.4		

29th December		SITE R2																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		78	85	85	80	88	80	85	80	70	80	87	70	60	50	70	80	65	75	90	85
Thin mat/film	Green	10	10	8	10	15	13	20	2	25	30			5	15	15	5	15	20	5	
	Light Brown	25	20	30	45	55	35	20	25	20	20	80	65	65	40	60	50	40	40	30	65
	Dark Brown/ Black	25	25	25	20	15	20	5	15	10	20	5	8	10	10	5	15	20	20	40	5
Medium mat	Green																				
	Light Brown	8	5	5	2		8	20	35	5								10			
	Dark Brown/ Black	10	5		2			2		15	10					5	3		5		
Thick mat	Green																				
	Light Brown																5			10	
Cyanobacteria	Thick Brown/ black	8	7	1			1										1				
Filaments, short	Green	2	5	1	4	1	1	5	1	3	5				1		1	2	3	5	
	Brown Reddish																				
Filaments, long	Green	2	8	1	1	1	1	1	1	5	1						1	1		1	
	Brown Reddish																				

Total algal cover	**WCC**	47	49	36.5	44.5	44.5	40.5	39.5	40.5	45.5	46	42.5	36.5	40	33.5	42.5	41.5	45.5	45.5	48.5	35
	PSI	33.2	32.4	17.8	19.8	18.2	20.6	25	30.6	28.2	22.8	17	14.6	16	13.4	19	23	22.6	20.2	27.8	14
Total algal cover not including thin mat/film	**WCC**	17	21.5	5	7	2	6.5	17	19.5	18	11	0	0	0	1	2.5	6.5	8	5.5	11	0
	PSI	20.8	20.4	5	4	1	6.8	15	22	16.6	7.8	0	0	0	0.2	3	8.8	7.2	3.6	11.8	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			10.5					14.4					0.7					6.2		
	PSI			10.24					13.64					0.64					6.28		

29th December 2016		SITE R3																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		SITE R3	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		80	75	90	87	95	98	87	95	90	90	95	70	73	70	60	60	50	78	60	60
Thin mat/film	Green	5	5	5	2	1	10	5		5		10									
	Light Brown	45	35	45	55	37	70	60	65	45	25	30	30	55	45	45	40	55	50	15	5
	Dark Brown/ Black		25	15	16	25		5	10	5	5	2	1								
Medium mat	Green																				
	Light Brown	5			2	4					20										
	Dark Brown/ Black	5	3	1	1	2		1													
Thick mat	Green																				
	Light Brown	15		5	1	8		2													
Cyanobacteria	Thick Dark Brown/ Black	5	8	5	4	5	1	10	5	5	30										
Filaments, short	Green	1	5	3	3	1	3	2	1	1	1										
	Brown Reddish																				
Filaments, long	Green	1	1	1	1	1	1	2	1	1	3										
	Brown Reddish																				

Total algal cover	**WCC**	42	44	42	44.5	43	44.5	45.5	42	32	44	21	15.5	27.5	22.5	22.5	20	27.5	25	7.5	2.5
	PSI	37.2	25.6	25.6	23.4	30.4	19	29	21.2	17.2	50.8	8.4	6.2	11	9	9	8	11	10	3	1
Total algal cover not including thin mat/film	**WCC**	17	11.5	9.5	8	11.5	4.5	10.5	4.5	4.5	29	0	0	0	0	0	0	0	0	0	0
	PSI	27	11.6	12	8.2	17.6	2.4	14.6	6	6	44.6	0	0	0	0	0	0	0	0	0	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			11.5					10.6					0					0		
	PSI			15.28					14.72					0					0		

14th January 2017		CONTROL B (C2)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		90	85	85	70	82	90	75	70	90	92	95	60	70	70	95	98	85	85	75	92
Thin mat/film	Green	15	10	5	5	1	15	2	2	5	5						5	1	1	2	1
	Light Brown	40	40	45	30	20	30	20	30	25	50	15	12	10	10	15	15	15	18	20	12
	Dark Brown/ Black	1	15	20	15	2	20	5	10	5	12						5	1	1	5	1
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black			2	1				1		1										
Filaments, short	green		2	3	1				1	1	1										
	brown reddish																				
Filaments, long	green																				
	brown reddish																				

Total algal cover	**WCC**	28	34.5	39	26.5	11.5	32.5	13.5	22.5	18.5	35	7.5	6	5	5	7.5	12.5	8.5	10	13.5	7
	PSI	11.2	13.8	17.2	11.4	4.6	13	5.4	9.8	7.4	14.8	3	2.4	2	2	3	5	3.4	4	5.4	2.8
Total algal cover not including thin mat/film	**WCC**	0	2	4	1.5	0	0	0	1.5	1	1.5	0	0	0	0	0	0	0	0	0	0
	PSI	0	0.4	2.6	1.2	0	0	0	1.2	0.2	1.2	0	0	0	0	0	0	0	0	0	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			1.5					0.8					0					0		
	PSI			0.84					0.52					0					0		

14th January 2017		CONTROL A (C1)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		90	80	80	80	90	90	85	85	75	90	90	70	70	75	80	65	70	90	85	85
Thin mat/film	Green																				
	Light Brown	35	30	50	40	50	40	25	40	15	35	10	5	5	5	5	5	10	30	20	25
	Dark Brown/ Black			20	10	15	5	15	10	10	15										
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black			1	1																
Filaments, short	Green																				
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				

Total algal cover	**WCC**	17.5	15	35.5	25.5	32.5	22.5	20	25	12.5	25	5	2.5	2.5	2.5	2.5	2.5	5	15	10	12.5
	PSI	7	6	15	11	13	9	8	10	5	10	2	1	1	1	1	1	2	6	4	5
Total algal cover not including thin mat/film	**WCC**	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PSI	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
algal cover without thin mat/ fim & Averaged across site	**WCC**			0.2					0					0					0		
	PSI			0.4					0					0					0		

14th January 2017		R1																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		75	75	80	80	95	80	90	80	90	95	95	92	92	85	70	70	70	50	85	80
Thin mat/film	Green	15	5	5	10	5		15	5	15	10										1
	Light Brown	25	35	40	45	45	40	30	30	40	30	20	15	30	15	25	5	5	1	5	5
	Dark Brown/ Black	5	10	8	15	15	5	20	20	10	15										
Medium mat	Green																				
	Light Brown							5	15												
	Dark Brown/ Black							8													
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black				1	1		2	1	1											
Filaments, short	green	5	5	5	10	2	1	5	2	3	2	1	1								
	brown reddish																				
Filaments, long	green																				
	brown reddish																				

Total algal cover	**WCC**	27.5	30	31.5	45.5	35	23.5	45	37.5	36	29.5	11	8.5	15	7.5	12.5	2.5	2.5	0.5	2.5	3
	PSI	11	12	12.6	19	14.8	9.4	24.8	21.8	15.2	11.8	4.4	3.4	6	3	5	1	1	0.2	1	1.2
Total algal cover not including thin mat/film	**WCC**	5	5	5	10.5	2.5	1	12.5	10	3.5	2	1	1	0	0	0	0	0	0	0	0
	PSI	1	1	1	3	1.4	0.2	10.8	10.4	1.6	0.4	0.2	0.2	0	0	0	0	0	0	0	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			5.6					5.8					0.4					0		
	PSI			1.48					4.68					0.08					0		

14th January 2017		SITE R2																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		90	90	85	92	90	85	90	85	80	92	85	85	90	90	85	85	80	40	85	85
Thin mat/film	Green	5	10	5	25	15			10	15	5			10	10	10	5				
	Light Brown	15	40	25	10	30	65	40	30	40	40	20	20	30	40	50	70	40	10	70	60
	Dark Brown/ Black	10	15	10		20		20	5	5	10			10	15	10					
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black																				
Thick mat	Green																				
Cyanobacteria	Thick Brown/ black		2			15		8	20	10	20				5	5					
Filaments, short	Filaments, short		2	5	10	10		5	5	5	5			5	5	5					
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				

Total algal cover	**WCC**	15	35.5	25	27.5	50	32.5	39	37.5	40	42.5	10	10	30	40	42.5	37.5	20	5	35	30
	PSI	6	15.8	10	11	32	13	22	31	24	33	4	4	12	20	21	15	8	2	14	12
Total algal cover not including thin mat/film	**WCC**	0	3	5	10	17.5	0	9	15	10	15	0	0	5	7.5	7.5	0	0	0	0	0
	PSI	0	2.4	1	2	17	0	9	21	11	21	0	0	1	6	6	0	0	0	0	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			7.1					9.8					4					0		
	PSI			4.48					12.4					2.6					0		

14th January 2017		SITE R3																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		100	98	100	98	100	100	80	80	70	90	65	30	80	90	92	75	50	70	98	95
Thin mat/film	Green									10	5			10	10	5					
	Light Brown	35	40	60	50	65	60	70	40	50	60	5	5	20	50	50	5	5	15	10	15
	Dark Brown/ Black	40	20	5	20	10	5		5	5	5			5		10					
Medium mat	Green																				
	Light Brown								10												
	Dark Brown/ Black																				
Thick mat	Green																				
															1	10					
Cyanobacteria	Thick Dark Brown/ Black	10	20	2	8	5	10	8	15	5	1				1	5					
Filaments, short	Green	2	3	1	2	5	1	1	2		1										
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				

Total algal cover	**WCC**	44.5	43	34.5	41	45	38.5	40	37	35	36.5	2.5	2.5	17.5	31	40	2.5	2.5	7.5	5	7.5
	PSI	25.8	33.2	15.4	22.8	22	23.4	22.4	30.8	18	15.4	1	1	7	14	28	1	1	3	2	3
Total algal cover not including thin mat/film	**WCC**	7	13	2	6	7.5	6	5	14.5	2.5	1.5	0	0	0	1	7.5	0	0	0	0	0
	PSI	10.4	20.6	2.2	8.4	6	10.2	8.2	21.4	5	1.2	0	0	0	2	15	0	0	0	0	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			7.1					5.9					1.7					0		
	PSI			9.52					9.2					3.4					0		

17th Feb 2017		CONTROL B (C2)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		90	80	95	80	90						95	90	80	90	65	90	85	85	70	90
Thin mat/film	Green																				
	Light Brown	5	10	1	1	1								1		1		2			
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black																				
Filaments, short	green																				
	brown reddish																				
Filaments, long	green																				
	brown reddish																				

Total algal cover	**WCC**	2.5	5	0.5	0.5	0.5	0	0	0	0	0	0	0	0.5	0	0.5	0	1	0	0	0
	PSI	1	2	0.2	0.2	0.2	0	0	0	0	0	0	0	0.2	0	0.2	0	0.4	0	0	0
Total algal cover not including thin mat/film	**WCC**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PSI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
algal cover without thin mat/ fim & Averaged across site	**WCC**			0					0					0					0		
	PSI			0					0					0					0		

17th Feb 2017		CONTROL A (C1)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		85	70	65	85	90	95	90	80	75	50	80	80	15	95	100	90	25	60	70	65
Thin mat/film	Green																				
	Light Brown	15	5	1	15	5		5	30	25	2	1					1	1	1		
	Dark Brown/ Black								1	2											
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black																				
Filaments, short	Green																				
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				

Total algal cover	**WCC**	7.5	2.5	0.5	7.5	2.5	0	2.5	15.5	13.5	1	0.5	0	0	0	0	0.5	0.5	0.5	0	0
	PSI	3	1	0.2	3	1	0	1	6.2	5.4	0.4	0.2	0	0	0	0	0.2	0.2	0.2	0	0
Total algal cover not including thin mat/film	**WCC**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PSI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
algal cover without thin mat/ fim & Averaged across site	**WCC**			0					0					0					0		
	PSI			0					0					0					0		

17th Feb 2017		R1																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		80	80	85	90	95	95	90	90	92	85	100	100	100	90	80	98	85	65	50	65
Thin mat/film	Green																				
	Light Brown	5	15	1	30	25	5	5	10	10	5		1	1			1	5	5	1	
	Dark Brown/ Black				1																
Medium mat	Green																				
	Light Brown				5																
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black																				
Filaments, short	green			15	1																
	brown reddish																				
Filaments, long	green																				
	brown reddish																				

Total algal cover	**WCC**	2.5	7.5	15.5	19	12.5	2.5	2.5	5	5	2.5	0	0.5	0.5	0	0	0.5	2.5	2.5	0.5	0
	PSI	1	3	6.2	9.6	5	1	1	2	2	1	0	0.2	0.2	0	0	0.2	1	1	0.2	0
Total algal cover not including thin mat/film	**WCC**	0	0	15	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PSI	0	0	3	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
algal cover without thin mat/ fim & Averaged across site	**WCC**			3.7					0					0					0		
	PSI			1.24					0					0					0		

17th Feb 2017		SITE R2																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		85	80	80	75	90	92	90	75	92	95	85	70	70	65	60	65	55	65	55	90
Thin mat/film	Green		5	15	15	5	1	1	5		1	3	2	10	1	2					
	Light Brown	5	35	30	25	5	1	1	20	30	15	8	5	35	25	10	5	1	1	8	1
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown			5											1						
	Dark Brown/ Black			1																	
Thick mat	Green																				
Cyanobacteria	Thick Brown/ black																				
Filaments, short	Filaments, short		5	5										1							
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				

Total algal cover	**WCC**	2.5	25	30.5	20	5	1	1	12.5	15	8	5.5	3.5	23.5	13.5	6	2.5	0.5	0.5	4	0.5
	PSI	1	10	14.6	8	2	0.4	0.4	5	6	3.2	2.2	1.4	9.4	5.8	2.4	1	0.2	0.2	1.6	0.2
Total algal cover not including thin mat/film	**WCC**	0	5	8	0	0	0	0	0	0	0	0	0	1	0.5	0	0	0	0	0	0
	PSI	0	1	4.6	0	0	0	0	0	0	0	0	0	0.2	0.6	0	0	0	0	0	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			2.6					0					0.3					0		
	PSI			1.12					0					0.16					0		

17th Feb 2017		SITE R3																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		70	80	90	80	100	90	90	80	80	20	30	30	80	90	95	30	40	70	80	70
Thin mat/film	Green		1					1													
	Light Brown					1	1			1									1		
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown																				
	Dark Brown/ Black																				
Thick mat	Green																				
Cyanobacteria	Thick Dark Brown/ Black																				
Filaments, short	Green																				
	Brown Reddish																				
Filaments, long	Green																				
	Brown Reddish																				

Total algal cover	**WCC**	0	0.5	0	0	0.5	0.5	0.5	0	0.5	0	0	0	0	0	0	0	0	0.5	0	0
	PSI	0	0.2	0	0	0.2	0.2	0.2	0	0.2	0	0	0	0	0	0	0	0	0.2	0	0
Total algal cover not including thin mat/film	**WCC**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PSI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
algal cover without thin mat/ fim & Averaged across site	**WCC**			0					0					0					0		
	PSI			0					0					0					0		

3-Mar-17		CONTROL A (C1)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		70	80	80	70	80	95	70	80	70	95	90	85	50	25	30	70	60	80	50	0
Thin mat/film	Green																				
	Light Brown	80	60	70	50	40	30	90	70	70	99	80	90	70	50	50	30	20	20	15	
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown	20	30	10	10	20	40					5	1			5		5	30	80	
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black																				
Filaments, short	Green																				
	Brown Reddish																				
Filaments, long	Green	5	1	1		5		1		1	1								1		
	Brown Reddish																				

Total algal cover	**WCC**	55	46	41	30	35	35	46	35	36	50.5	42.5	45.5	35	25	27.5	15	12.5	26	47.5	0
	PSI	32	30.8	20.8	16	24	30	18.8	14	14.8	20.6	19	18.6	14	10	13	6	7	22.8	51	0
Total algal cover not including thin mat/film	**WCC**	15	16	6	5	15	20	1	0	1	1	2.5	0.5	0	0	2.5	0	2.5	16	40	0
	PSI	16	18.8	6.8	6	16	24	0.8	0	0.8	0.8	3	0.6	0	0	3	0	3	18.8	48	0

algal cover without thin mat/ fim & Averaged across site	**WCC**			11.4					4.6					1.1					11.7		
	PSI			12.72					5.28					1.32					13.96		

3-Mar-17		CONTROL B (C2)																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		70	75	75	80	100	80	75	50	80	70	90	90	80	60	70	90	20	0	50	60
Thin mat/film	Green																				
	Light Brown	75	60	20	70	80	90	90	50	60	50	40	80	75	80	80	70	80	0	80	80
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown		10	50	5	5	10	5	5	15	10	20					1				5
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black		5							1											
Filaments, short	green													10	10	5		1			
	brown reddish																				
Filaments, long	green	15	15	25	10	1		1	10	5											
	brown reddish																				

Total algal cover	**WCC**	52.5	52.5	60	47.5	43.5	50	48.5	37.5	43	30	30	40	47.5	50	45	35.5	41	0	40	42.5
	PSI	27	35	54	25	19.8	24	21.8	21	26	16	20	16	19	20	18	14.6	16.4	0	16	19
Total algal cover not including thin mat/film	**WCC**	15	22.5	50	12.5	3.5	5	3.5	12.5	13	5	10	0	10	10	5	0.5	1	0	0	2.5
	PSI	12	23	50	11	3.8	6	3.8	11	14	6	12	0	2	2	1	0.6	0.2	0	0	3

algal cover without thin mat/ fim & Averaged across site	**WCC**			20.7					7.8					7					0.8		
	PSI			19.96					8.16					3.4					0.76		

3-Mar-17		SITE R3																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		90	100	90	60	75	95	50	100	80	80	60	50	50	95	100	20	20	70	80	100
Thin mat/film	Green																				
	Light Brown	60	30	19	20	70	60	80	50	40	80	70	80	80	65	90	90	90	50	30	85
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown	10	60	40	50	20	10		10	20	5	1	1	1	20	1			30	20	
	Dark Brown/ Black																				
Thick mat	Green																				
Cyanobacteria	Thick Dark Brown/ Black			1																	
Filaments, short	Green																				
	Brown Reddish																				
Filaments, long	Green	1	1	20	5	1	5	1	30	10	1	1	1	1	10	5			10	1	1
	Brown Reddish																				

Total algal cover	**WCC**	36	46	50	40	46	40	41	60	40	43.5	36.5	41.5	41.5	52.5	50.5	45	45	50	26	43.5
	PSI	18.8	42.8	44.8	38	26.8	22	16.8	40	28	19.8	15.4	17.4	17.4	33	22.6	18	18	36	18.8	17.8

Total algal cover not including thin mat/film	**WCC**	6	31	40.5	30	11	10	1	35	20	3.5	1.5	1.5	1.5	20	5.5	0	0	25	11	1
	PSI	6.8	36.8	41	34	12.8	10	0.8	30	20	3.8	1.4	1.4	1.4	20	4.6	0	0	26	12.8	0.8

algal cover without thin mat/ fim & Averaged across site	**WCC**			23.7					13.9					6					7.4		
	PSI			26.28					12.92					5.76					7.92		

3-Mar-17		SITE R2																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		95	90	95	70	80	90	95	90	90	95	70	95	80	70	95	80	90	80	80	90
Thin mat/film	Green																				
	Light Brown	75	30	70	19	40	80	85	60	70	85	90	85	80	75	70	90	70	65	70	70
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown	10	40	10	80	30	10	10	10	10		5	5	5	10	15	10	10	10	10	5
	Dark Brown/ Black																				
Thick mat	Green																				
Cyanobacteria	Thick Brown/ black																				
Filaments, short	Filaments, short																				
	Brown Reddish																				
Filaments, long	Green	15	1	20	1	1	1	1	25	10	5	1	10	10	10	10		5	20	15	5
	Brown Reddish																				

Total algal cover	**WCC**	57.5	36	60	50.5	36	46	48.5	60	50	47.5	48.5	55	52.5	52.5	52.5	50	45	57.5	55	42.5
	PSI	33	30.8	36	52.6	26.8	22.8	23.8	38	28	21	21.8	28	27	29	31	24	24	35	32	21
Total algal cover not including thin mat/film	**WCC**	20	21	25	41	16	6	6	30	15	5	3.5	12.5	12.5	15	17.5	5	10	25	20	7.5
	PSI	18	24.8	22	48.8	18.8	6.8	6.8	26	14	4	3.8	11	11	14	17	6	10	22	18	7
algal cover without thin mat/ fim & Averaged across site	**WCC**			24.6					12.4					12.2					13.5		
	PSI			26.48					11.52					11.36					12.6		

3-Mar-17		R1																			
		Riffle 1					Riffle 2					Run 1					Run 2				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potential		70	80	90	100	100	70	90	90	80	95	100	70	90	100	100	90	90	80	90	95
Thin mat/film	Green																				
	Light Brown	70	90	80	80	60	60	60	70	70	40	90	70	75	60	70	60	40	80	60	85
	Dark Brown/ Black																				
Medium mat	Green																				
	Light Brown	5		1	5	5	5	25	20	10	40	5	10	20	5	10	30	50	10	20	10
	Dark Brown/ Black																				
Thick mat	Green																				
	Light Brown																				
Cyanobacteria	Dark Brown/ Black			1										1							
Filaments, short	green																				
	brown reddish																				
Filaments, long	green		1	1	5	5		1	1	1	1	10	1	1	1	5		1	1	5	
	brown reddish																				

Total algal cover	**WCC**	37.5	46	42	47.5	37.5	32.5	43.5	46	41	41	57.5	41	49	33.5	45	45	46	46	45	47.5
	PSI	17	18.8	18.4	23	19	15	27.8	26.8	20.8	32.8	29	20.8	28.8	15.8	24	30	38.8	22.8	28	23
Total algal cover not including thin mat/film	**WCC**	2.5	1	2	7.5	7.5	2.5	13.5	11	6	21	12.5	6	11.5	3.5	10	15	26	6	15	5
	PSI	3	0.8	2.4	7	7	3	15.8	12.8	6.8	24.8	11	6.8	13.8	3.8	10	18	30.8	6.8	16	6

algal cover without thin mat/ fim & Averaged across site	**WCC**			4.1					10.8					8.7					13.4		
	PSI			4.04					12.64					9.08					15.52		

Appendix 2 – Water quality data. 2nd December 2016 to 3rd March 2017.

Parameters	Date	R1	R2	R3	C1	C2
Ph	2.12.16	7.5	7.4	7.3	7.4	7.3
Conductivity (ms/m)		10.50	10.50	10.60	10.50	10.40
Inorganic Nitrogen (g/m³)		0.19	0.19	0.21	0.19	0.19
Nitrite Nitrate Nitrogen (g/m3)		0.186	0.190	0.203	0.188	0.185
Amonia Nitrogen (g/m3)		0.010	0.010	0.010	0.010	0.010
Dissolved Calcium (g/m3)		5.00	5.12	5.13	5.04	5.15
Total Phosphorus (g/m3)		0.013	0.023	0.020	0.022	0.023
Dissolved Reactive Phosphorus (g/m3)		0.013	0.013	0.013	0.013	0.012
Total Nitrogen (g/m3)		0.23	0.23	0.25	0.24	0.24
Ph	12.12.16	7.4	7.4	7.4	7.4	7.4
Conductivity (ms/m)		9.80	9.70	9.80	9.80	9.70
Inorganic Nitrogen (g/m³)		0.17	0.17	0.18	0.17	0.17
Nitrite Nitrate Nitrogen (g/m3)		0.164	0.171	0.179	0.170	0.162
Amonia Nitrogen (g/m3)		0.010	0.010	0.010	0.010	0.010
Dissolved Calcium (g/m3)		4.67	4.60	4.80	4.78	4.87
Total Phosphorus (g/m3)		0.015	0.015	0.018	0.018	0.016
Dissolved Reactive Phosphorus (g/m3)		0.013	0.013	0.013	0.014	0.013
Total Nitrogen (g/m3)		0.26	0.27	0.27	0.25	0.25
Ph	29.12.16	7.5	7.6	7.5	7.4	7.4
Conductivity (ms/m)		11.00	10.90	10.80	10.80	10.80
Inorganic Nitrogen (g/m³)		0.16	0.16	0.16	0.17	0.17
Nitrite Nitrate Nitrogen (g/m3)		0.160	0.158	0.163	0.168	0.166
Amonia Nitrogen (g/m3)		0.010	0.010	0.010	0.010	0.010
Dissolved Calcium (g/m3)		5.38	5.25	5.20	5.22	5.19
Total Phosphorus (g/m3)		0.013	0.012	0.013	0.012	0.013
Dissolved Reactive Phosphorus (g/m3)		0.014	0.014	0.013	0.013	0.014

Parameters	Date	R1	R2	R3	C1	C2
Total Nitrogen (g/m3)		0.20	0.22	0.23	0.22	0.21
Ph	14.1.17	7.4	7.4	7.4	7.3	7.3
Conductivity (ms/m)		10.20	10.30	10.40	10.20	10.20
Inorganic Nitrogen (g/m^3)		0.13	0.12	0.13	0.14	0.13
Nitrite Nitrate Nitrogen (g/m3)		0.132	0.120	0.127	0.137	0.131
Amonia Nitrogen (g/m3)		0.010	0.010	0.010	0.010	0.010
Dissolved Calcium (g/m3)		5.20	5.25	5.25	5.17	5.25
Total Phosphorus (g/m3)		0.013	0.014	0.013	0.012	0.012
Dissolved Reactive Phosphorus (g/m3)		0.012	0.011	0.012	0.012	0.009
Total Nitrogen (g/m3)		0.17	0.18	0.17	0.18	0.19
Ph	17.02.17	7.3	7.3	7.2	7.30	7.3
Conductivity (ms/m)		10.60	10.80	11.00	10.70	10.70
Inorganic Nitrogen (g/m^3)		0.19	0.21	0.25	0.190	0.11
Nitrite Nitrate Nitrogen (g/m3)		0.188	0.207	0.254	0.191	0.113
Amonia Nitrogen (g/m3)		0.010	0.010	0.010	0.01	0.010
Dissolved Calcium (g/m3)		4.85	5.00	5.10	4.420	4.85
Total Phosphorus (g/m3)		0.021	0.018	0.020	0.020	0.019
Dissolved Reactive Phosphorus (g/m3)		0.016	0.016	0.015	0.02	0.006
Total Nitrogen (g/m3)		0.28	0.26	0.27	0.3	0.27
Ph	3.3.17	7.5	7.7	7.6	7.7	7.6
Conductivity (ms/m)		11.30	11.30	11.50	11.40	11.30
Inorganic Nitrogen (g/m^3)		0.17	0.09	0.11	0.12	0.11
Nitrite Nitrate Nitrogen (g/m3)		0.167	0.091	0.111	0.110	0.111
Amonia Nitrogen (g/m3)		0.010	0.01	0.010	0.010	0.010
Dissolved Calcium (g/m3)		5.13	5.240	5.15	5.17	5.17
Total Phosphorus (g/m3)		0.017	0.012	0.011	0.011	0.011
Dissolved Reactive Phosphorus (g/m3)		0.008	0.009	0.008	0.008	0.009

Parameters	Date	R1	R2	R3	C1	C2
Total Nitrogen (g/m3)		0.17	0.120	0.12	0.16	0.15

Appendix 3. Chlorophyll a data

Date	Site	Sample	Chlorophyll *a* (mg per m^2)
2 December 2016	R1	Pooled x10	29.0
	R2	Pooled x10	5.0
	R3	Pooled x10	3.4
	C1	Pooled x10	2.1
	C2	Pooled x10	3.8
16 December 2016	R1	Pooled x10	25.7
	R2	Pooled x10	77.6
	R3	Pooled x10	46.0
	C1	Pooled x10	30.1
	C2	Pooled x10	34.2
29 December 2016	R1	Pooled x10	28.7
	R2	Pooled x10	47.0
	R3	Pooled x10	41.9
	C1	Pooled x10	15.4
	C2	Pooled x10	39.5
14 January 2017	R1	Pooled x10	31.2
	R2	Pooled x10	37.4
	R3	Pooled x10	44.5
	C1	Pooled x10	20.9
	C2	Pooled x10	19.9
17 February 2017	R1	Pooled x10	1.9
	R2	Pooled x10	5.7
	R3	Pooled x10	6.0
	C1	Pooled x10	1.8
	C2	Pooled x10	4.2
3 March 2017	R1	Pooled x10	45.1
	R2	Pooled x10	152.4
	R3	Pooled x10	116.0
	C1	Pooled x10	43.0
	C2	Pooled x10	38.1

Appendix 4 – Fish survey data

Fish Monitoring - 17 February 2017

Waikanae river flow at survey = 4.1 cumecs at the GWRC Waikanae WTP monitoring site

R3	**Pass**					
17.2.17	1	2	3	Total		
length	7	8	9	24		
width of sample	3	3	3	3		
Area fished	21	24	27	72		
Torrent fish	1	4	1			
Long fin eel	0	0	0			
elva	0	1	0			
red fin bully	1	1	4			
			Fish total	13		
			Fish density	0.18		
Size distribution	Torrent fish	Elva	Redfin bully			
mm	50		30			
	70	100	30			
	30					
	30					
	40					
	40		30			
			30			
			40			
			30			

R1	**Pass**					
17.2.17	1	2	3	Total		
length	18	20	19	57		
width of sample	3	3	3	3		
Area fished	54	60	57	171		
Torrent fish		2	1			
Long fin eel	5	7	10			
elva	1	3				
red fin bully	0	0	0			
			Fish total	29		
			Fish density	0.169590643		

Size distribution	Torrent fish	long fin eel	Elva			
		140	60			
		100				
		120				
		110				
		110				
	70	150	80			
	120	110	80			
		130	90			
		160				
		150				
		120				
		110				
	70	100				
		120				
		140				
		110				
		100				
		100				
		140				
		180				
		100				
		200				
C1	**Pass**					
17.2.17	1	2	3	4	Total	
length	14	12	10	10	30	
width of sample	3	3	3	3	3	
Area fished	42	36	30	30	138	
Torrent fish	0	0	0	0		
Long fin eel	5	4	0	0		
elva	1	0	0	0		
red fin bully	1	1	0	0		
Banded kokopu	1	0	0	0		
		Fish total			13	
		Fish density			0.094203	

Size distribution	long fin eel	banded kokopu	Elva	Redfin bully		
	100	20	80	70		
	120					
	180					
	100					
	110					
	110			60		
	90					
	120					
	140					
C2	**Pass**					
17.2.17	1	2	3	4	Total	
length	8	8	10	12	38	
width of sample	3	3	3	3	3	
Area fished	24	24	30	36	114	
Torrent fish	0	2	0	0		
Long fin eel	0	4	0	2		
elva	0	0	0	0		
red fin bully	0	2	0	0		
Banded kokopu	1	0	0	0		
			Fish total		11	
			Fish density		0.096491	
Size distribution	Torrent fish	long fin eel	banded kokopu	Redfin bully		
			30			
	90	100		30		
	70	130		70		
		120				
		180				

Fish Monitoring – 9 March 2017

Waikanae river flow at survey = 1.9 cumecs at the GWRC Waikanae WTP monitorng site

R3	**Pass**					
9.3.17	1	2	3	4	Total	
length	11	13	12	7	43	

width of sample	3	3	3	3	3	
Area fished	33	39	36	21	129	
Torrent fish	5	6	2	0		
Long fin eel	3	3	0	2		
elva	1	1	2	0		
red fin bully	6	2	1	8		
Brown trout	1	0	0	0		
			Fish total		43	
			Fish density		0.333333	
Size distribution	Torrent fish	long fin eel	short fin eel	Elva	Redfin bully	Brown trout
mm	60	200		90	15	150
	20	180			10	
	20	140			15	
	30				20	
	60				50	
					30	
	60	110		80	40	
	50	140			60	
	70	160				
	60					
	20					
	70					
	60			70	20	
	70			100		
		140			20	
		150			40	
					20	
					50	
					20	
					10	
					20	
					40	

R1	**Pass**					
9.3.17	1	2	3	4	Total	
length	15	19	18	17	69	
width of sample	3	3	3	3	3	
Area fished	45	57	54	51	207	
Torrent fish	2	1	0	0		
Long fin eel	5	4	3	0		

elva	1	1	2	0		
red fin bully	2	1	0	2		
			Fish total		14	
			Fish density		0.067633	
Size distribution	Torrent fish	long fin eel	short fin eel	Elva	Redfin bully	
	80	150		70	30	
	60	210			20	
		140				
		130				
		200				
	80	220		70	30	
		250				
		230				
		180				
		230		80		
		300		90		
		180				
					30	
					30	

C1	**Pass**					
9.3.17	1	2	3	Total		
length	9	10	11	30		
width of sample	3	3	3	3		
Area fished	27	30	33	90		
Torrent fish	0	0	2			
Long fin eel	3	3	3			
elva	0	0	4			
red fin bully	0	0	1			
		Fish total		16		
		Fish density		0.177777778		
Size distribution	Torrent fish	long fin eel	short fin eel	Elva	Redfin bully	

		250				
		160				
		160				
		90				
		150				
		100				
	70	150		90	30	
	80	140		120		
		160		100		
				110		

C2	**Pass**					
9.3.17	1	2	3	4	Total	
length	14	15	15	16	60	
width of sample	3	3	3	3	3	
Area fished	42	45	45	48	180	
Torrent fish	0	0	0	0		
Long fin eel	1	2	3	6		
elva	0	1	1	0		
red fin bully	1	0	1	0		
Bluegill bully	1	1	0	0		
Shortfin eel	2	0	0	1		
			Fish total		21	
			Fish density		0.116667	

Size distribution	Torrent fish	long fin eel	short fin eel	Elva	Redfin bully	Bluefin bully
		150	180		50	60
			170			
		170		110		70
		160				
		160		90	70	
		180				
		120				
		100	110			
		260				
		150				
		140				
		120				
		180				