MARLBOROUGH DISTRICT COUNCIL

State of the Environment Surface Water Quality Monitoring Report, 2015

Technical Report No: 15-008
October 2015

State of the Environment Surface Water Quality Monitoring Report, 2015

MDC Technical Report No: 15-008

ISSN (Online) 1179-819X
ISBN (Online) 978-1-927159-58-3

File Reference/Record No: E375-001-001-03/15195298

September 2015

Report Prepared by:
Steffi Henkel
Environmental Scientist - Water Quality
Environmental Science & Monitoring Group

Marlborough District Council
Seymour Square
PO Box 443
Blenheim 7240
Phone: 520 7400
Website: www.marlborough.govt.nz

Executive Summary

The Marlborough District Council monitors the water quality of the regions streams and rivers on a monthly basis at 34 sites. Monitoring consists of taking field measurements and the collection of samples that are analysed for a number of parameters. Field measurements and analysis results over a period of three years are combined to calculate a Water Quality Index for each site. The Index ranges from 0 to 100 with higher Indices representing better water quality.

The previous State of the Environment Surface Water Monitoring Report [6] contains in-depth trend analysis and discussions on the state of surface water quality until the end of 2013. This report updates changes to the Water Quality Indices for an additional 12 months (until the end of 2014).

As in previous years, only a small number of sites had water quality classed in the good or poor category. These were the same sites as in the previous report with the exception of the Graham River. Previously the Graham River was classes as good, now its water quality is classed as fair. This is mainly due to increased Turbidity, most likely a result of bank erosion that might have been exacerbated by the extraction of river gravel in close proximity to the sampling site.

The water quality at the majority of sites is either fair or marginal, with a roughly equal number of sites in each category. There have been several small changes, most notably a reduction of the Water Quality Indices of a number of sites in the Opawa Complex area, which includes Murphys Creek, Doctors Creek and the Taylor River. The reduction is mainly a result of occasionally lower Dissolved Oxygen Saturation and higher Turbidity, predominantly during higher flows.

Increases of the Water Quality Index could be observed for most of the sites in the upper and mid Wairau River catchment. The reasons for the improvements were quite diverse, including improved pH levels and decreased E. coli concentrations in the Branch River and decreased Turbidity in the Waihopai River.

Table of Contents

1. Introduction

1.1. Purpose

The Marlborough District Council monitors surface water quality in the streams and rivers of the region as part of its obligations under the Resource Management Act (RMA 1991). The monitored waterways cover a broad range of catchment types and developments, from pristine native bush catchments to predominantly urbanised catchments. Monitoring consists of monthly measurements of physical and chemical parameters at 34 sites. The monitoring is usually carried out as close to the bottom of each catchment as possible to allow the assessment of the cumulative effects of land use and uses of surface water resources.

The 2013 Surface Water State of the Environment Report introduced the Canadian Water Quality Index as a method of summarising water quality data into a simple single score. Unlike common statistics, the purpose of Water Quality Indices is to provide information for a non-technical audience that allows comparison between the sites. The intended outcome is the inclusion of a wider range of interested parties into the discussions around surface water quality and the effectiveness of policies and rules.

This report is an update of the 2014 Surface Water State of the Environment Report, which included detailed trend analysis. Presented are changes to the water quality in the last 12 months until the end of 2014.

2. Methodology

2.1. Chemical and Physical Water Quality

Monthly water quality samples and field measurements are taken at 34 sites across the region. Two of the sites are part of NIWA's national monitoring network and the water quality samples are collected by NIWA. NIWA kindly provides sampling data for these sites to the Marlborough District Council. At the remaining 32 sites, monitored by the Marlborough District Council, water samples are collected and then sent to an independent laboratory for analysis of a number of parameters. Water Temperature and Dissolved Oxygen Concentration are measured in the field using YSI handheld meters.

In August 2011 the laboratory service provider was changed from ELS Ltd to Hill Laboratories Ltd. A table comparing the detection limits and analysis methods used by the two laboratories for the parameters measured can be found in Appendix 6.4. The field measurements and laboratory analysis results from the three years (2012 to 2014 inclusive) were used to calculate a Water Quality Index for each site.

2.2. Water Quality Index

The Marlborough District Council uses the Canadian Water Quality Index (CCME WQI) for the reporting of surface water quality. Based on guideline values the CCME WQI combines a wide array of data and information into a single figure allowing an easy comparison of the water quality in different streams and rivers. The guidelines were chosen based on the protection of aquatic life and recreational uses of the waterbody, however, it was taken into consideration that most sampling sites are at the bottom of the catchment and a certain degree of water quality deterioration will occur naturally [10]. Justification and discussion of the guidelines currently used for the calculation of the CCME WQI can be found in the 2013 report [5].

Table 1 lists the nine parameters used for the calculation of the Water Quality Index. Also shown are the corresponding guidelines and a short comment about the importance of the individual parameters. For parameters that are also an Attribute in the new National Policy Statement for Freshwater Management [9] the relation of the Water Quality Index guideline to the Attribute Limits is mentioned.

Parameter	Guideline	Importance	National Policy Statement (NPS)
Water Temperature	21.5 °C	aquatic life supporting capacity; High Water Temperatures effect the survival of some aquatic insects and fish.	
Dissolved Oxygen Saturation	70 %	aquatic life supporting capacity; Low Dissolved Oxygen levels effect the survival of some aquatic insects and fish.	
pH	Lower: 6.7 Upper: 7.8	aquatic life supporting capacity; Deviations from natural pH can impact the growth and reproduction of fish.	
Nitrate-Nitrogen	2.4 mg/L	aquatic life supporting capacity; High Nitrate concentrations are toxic to aquatic life.	equivalent to B state limits in NPS
Ammonical-Nitrogen	winter: 0.76 mg/L summer: 0.2 mg/L	aquatic life supporting capacity; High Ammonia concentrations are toxic to aquatic life. Only some of the Ammonical Nitrogen is in the form of the toxic Ammonia. With increasing Water Temperature and pH more and more of the Ammonical Nitrogen is converted into Ammonia - hence the lower guideline for the summer months.	equivalent to B state limits in NPS
Soluble Inorganic Nitrogen	0.165 mg/L	aquatic life supporting capacity and amenity values; Soluble Inorganic Nitrogen represents the form of Nitrogen that is easily taken up by aquatic plants (i.e. algae); High concentrations can cause nuisance algae mats that effect the habitat and food availability for aquatic insects.	the Periphyton Attribute of the NPS uses the Chlorophyll-a concentration of the algae mats as a measure for nuisance algae growth
Dissolved Reactive Phosphorus	0.015 mg/L	aquatic life supporting capacity and amenity values; Dissolved Reactive Phosphorus represents the form of Phosphorus that is easily taken up by aquatic plants (i.e. algae); High concentrations can cause nuisance algae mats that effect the habitat and food availability for aquatic insects.	the Periphyton Attribute of the NPS uses the Chlorophyll-a concentration of the algae mats as a measure for nuisance algae growth
E. coli concentration	550 E.coli/100mL	Human health; E. coli are an indicator for faecal contamination and consequently the risk to human health from water borne diseases (i.e. Campylobacteriosis).	B state limit in NPS is 540 E.coli/100mL
Turbidity	5.6 NTU	recreational and amenity value; ANZEEC (2000) trigger level	

Table 1: The parameters used for the calculation of the Water Quality Index.

It has been shown that the most meaningful results are obtained when at least 30 data points are used for the calculation of the Water Quality Index [8, 12]. The Marlborough District Council undertakes monthly sampling of water quality. Therefore, to obtain a sufficient number of data points, data from three consecutive years is combined.

The actual calculation of the Index is done in three parts, which are referred to as ‘factors’ (see Figure 1).The first factor, F1 (Scope), is calculated based on the number of guidelines that are exceeded. F2 (Frequency), the second factor, is calculated from the number of samples that exceed a guideline and the third and final factor, F3 (Amplitude), is based on the magnitude by which guidelines are exceeded.

A detailed description of the calculation is given in Appendix 6.1.

$$WQI = 100 - \left(\frac{\sqrt{F1^2+F2^2+F3^2}}{1.732}\right)$$

The site is given the maximum score of 100

Every measurement that exceeds a guideline reduces the score in three parts, called 'Factors' (F1, F2 and F3). What these Factors represent is shown below.

Figure 1: The Factors of the Water Quality Index calculation.

Once calculated the Water Quality Index is a number between 0 and 100. Based on that number the water quality of a river or stream can then be categorised into one of five quality classes. The table below shows the water quality classes assigned to different values of the Index [1]. As can be seen, the higher the Water Quality Index the better the water quality.

Quality Class	*Water Quality Index*	*Description*
Excellent	95 -100	Conditions **very close to** natural or pristine level
Good	80-94	Conditions **rarely** depart from natural or desirable level
Fair	65 -79	Conditions **sometimes** depart from natural or desirable level
Marginal	45 - 64	Conditions **often** depart from natural or desirable level
Poor	0 - 44	Conditions **usually** depart from natural or desirable level

Table 2: Quality classes for the Water Quality Index and the associated meaning.

3. Results

As in the previous two annual reports, the Marlborough region has been divided into seven sub-regions (Figure 2). This reduces the number of sites that will be reported on at once, but also allows the comparison of sites with similar rainfall and flow patterns. The results for each sub-region are presented in a separate section. These sections start with a map of the sub-region and a summary table outlining some of the site and catchment characteristics. This is followed by a figure with a number of graphs. On top of this figure, the Water Quality Index for each site is shown together with the contribution of individual parameters to the reduction of the Index. Below that is a bar graph showing the parameter contributions based on the parameter specific factors, F2 and F3, only (excluding F1). This provides a better representation of the actual contribution of individual parameters to the deterioration in water quality. The lower half of the figure shows the parameter results as box and whiskers plots. These plots are a great way of showing the distribution of parameter values. Figure 3 explains how box and whiskers plots are created.

The main intention of the figures in the following sections is to show patterns, distributions and relative differences. The actual result statistics, such as the Median and Percentile values are summarized in Appendix 6.5.

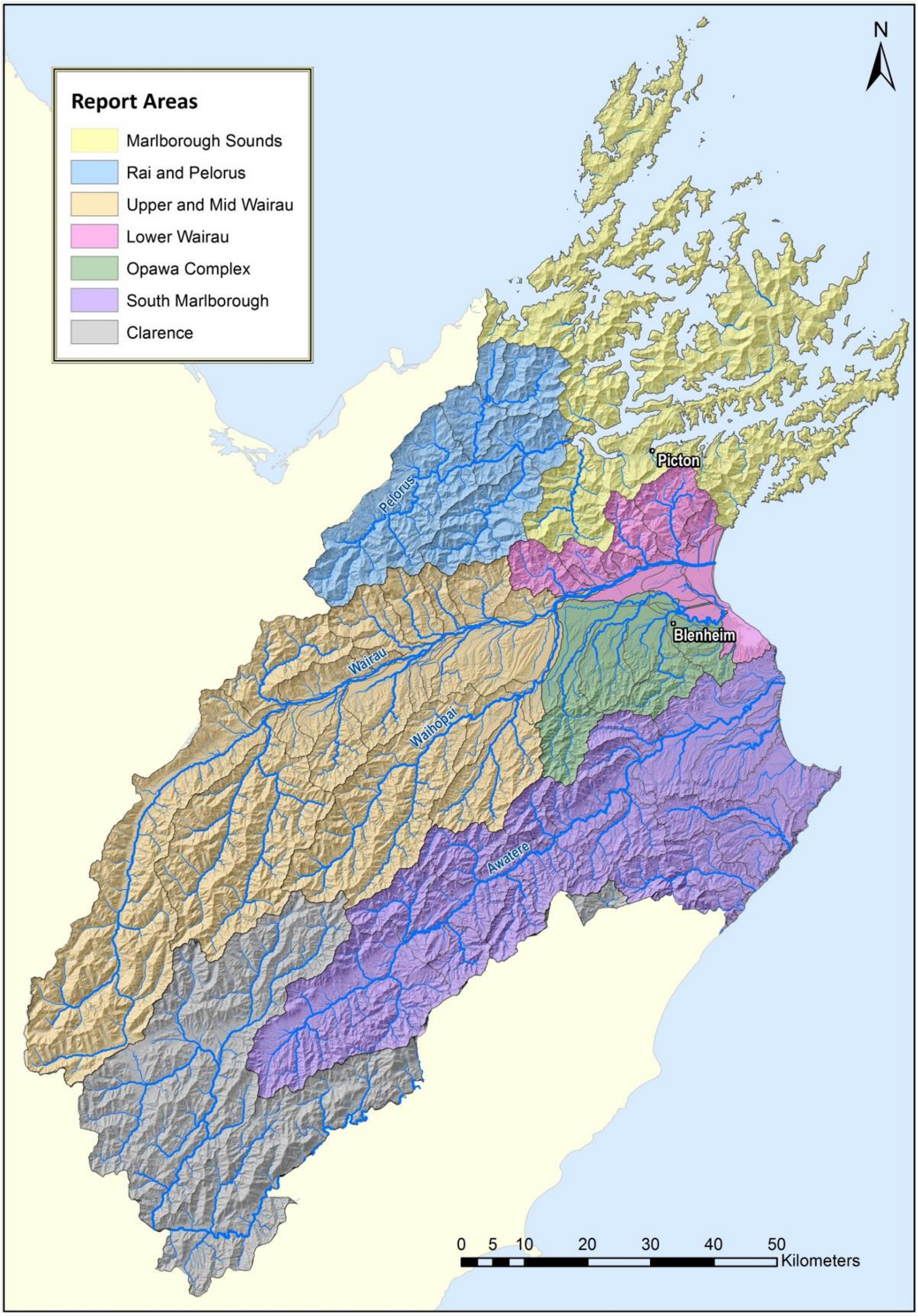


Figure 2: For purpose of this report the Marlborough regions was divided into seven areas.

The parts of the Clarence River and its tributaries that are located in the Marlborough region will not be reported on in this report as water quality in the Clarence catchment is monitored by Environment Canterbury.

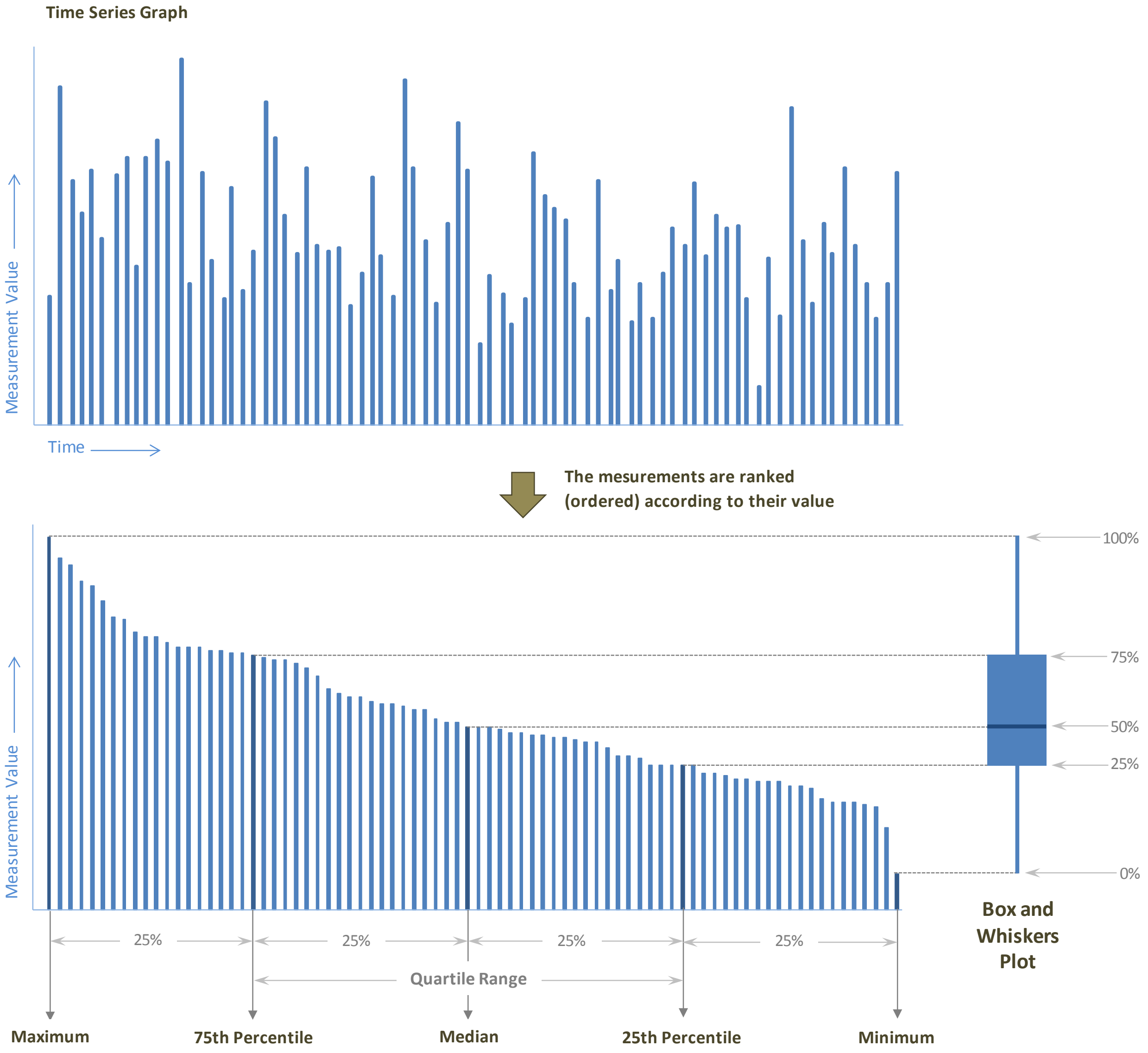
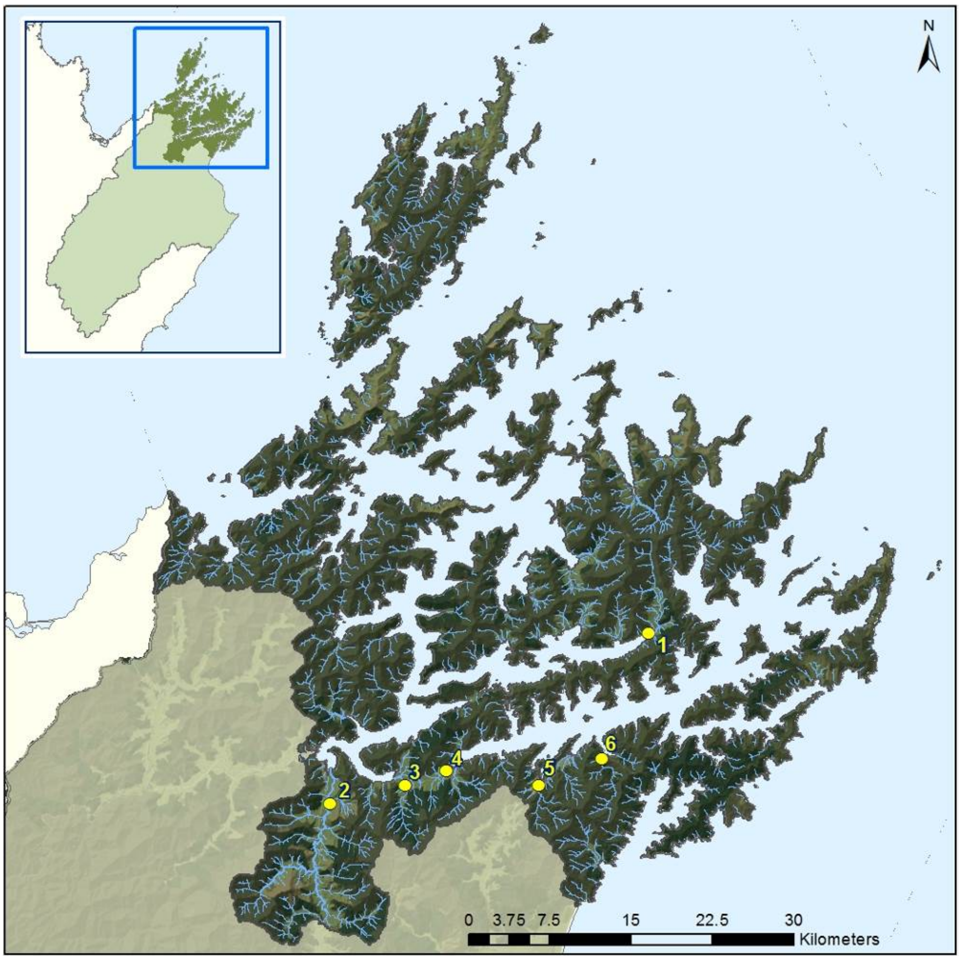


Figure 3: How Box and Whiskers Plots are created.

3.1. The Marlborough Sounds



No.	Site	Monthly Water Quality Sampling Since	Catchment Area [km²]	Landcover
1	**Kenepuru Rv**	Feb 2007	29.8	
2	**Kaituna Rv**	Feb 2007	135.6	
3	**Cullen Ck**	Jul 2009	19.5	
4	**Linkwater Stm***	Jul 2008	9.2	
5	**Waitohi Rv**	Aug 2007	15.0	
6	**Graham Rv**	Aug 2007	17.0	

* was named "Duncan Stm" in previous reports

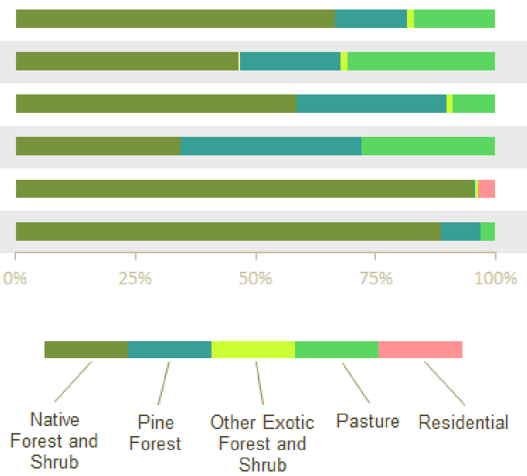


Figure 4: Sampling sites in the Marlborough Sounds.

Water Quality Indices and Parameter Contributions for the sites in the Sounds (2012-2014)

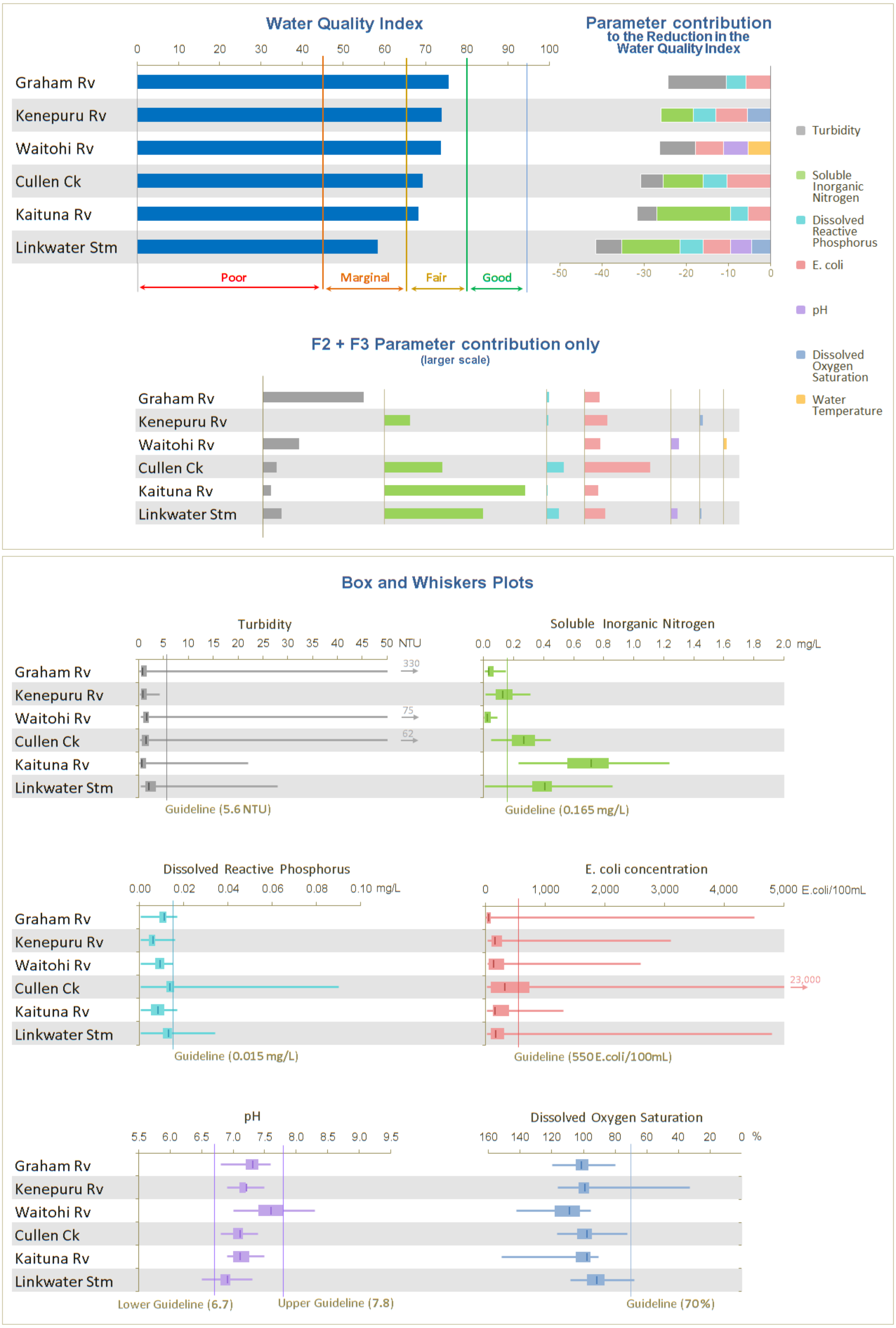


Figure 5: Water Quality Indices and Parameter contributions for the monitoring sites in the Marlborough Sounds for the period 2012-2014.

As in previous years, the Graham River has the best water quality in this group, but increased Turbidity in 2014 have resulted in a lower Water Quality Index compared to the previous report (Table 3). Field notes indicate substantial erosion of the banks in close vicinity to the sampling site might partially be attributed to the recent extraction of river gravels. The water quality of the Graham River is now classed as fair, together with most of the other monitoring sites in the Sounds.

The Waitohi River is the only waterway in this group with significant residential development in the catchment. The lower reaches of this small river are strongly influenced by the urban environment of the Picton Township. Nevertheless, the majority of the catchment remains in native vegetation. This is reflected in the very low Soluble Inorganic Nitrogen concentrations. Soluble Inorganic Nitrogen frequently exceeds guideline values in waterways with larger amounts of pastoral land use in the catchment. During rainfall and irrigation nitrogen leaches into subsurface and groundwater flows below pastures and reappears in nearby surface waters. Generally, Soluble Inorganic Nitrogen concentrations in waterways rise with increasing pastoral land use cover. As a result, in the Sounds, the highest concentrations are observed in the Kaituna River. However, the relationship between pasture cover and nitrogen leaching is often not straightforward. Other factors also influence how much nitrogen is leaching. These include the type of stock being grazed and irrigation. Pastures grazed by cattle generally leach more nitrogen than sheep pastures. An example of this is the lower Soluble Inorganic Nitrogen concentration in the Kenepuru River compared to Cullens Creek, despite the greater pasture cover in the Kenepuru catchment. Pastures in the Cullens Creek catchment are predominantly grazed by dairy cattle, while the Kenepuru catchment is predominantly grazed by sheep. Dairy cattle are also the likely source for the overall higher E. coli concentrations in Cullens Creek compared to other monitoring sites in the Sounds. Although most of the creek is fenced, potential sources of faecal contamination are a road crossing that is also used for stock movements and a cattle race located adjacent to the creek at the sampling site.

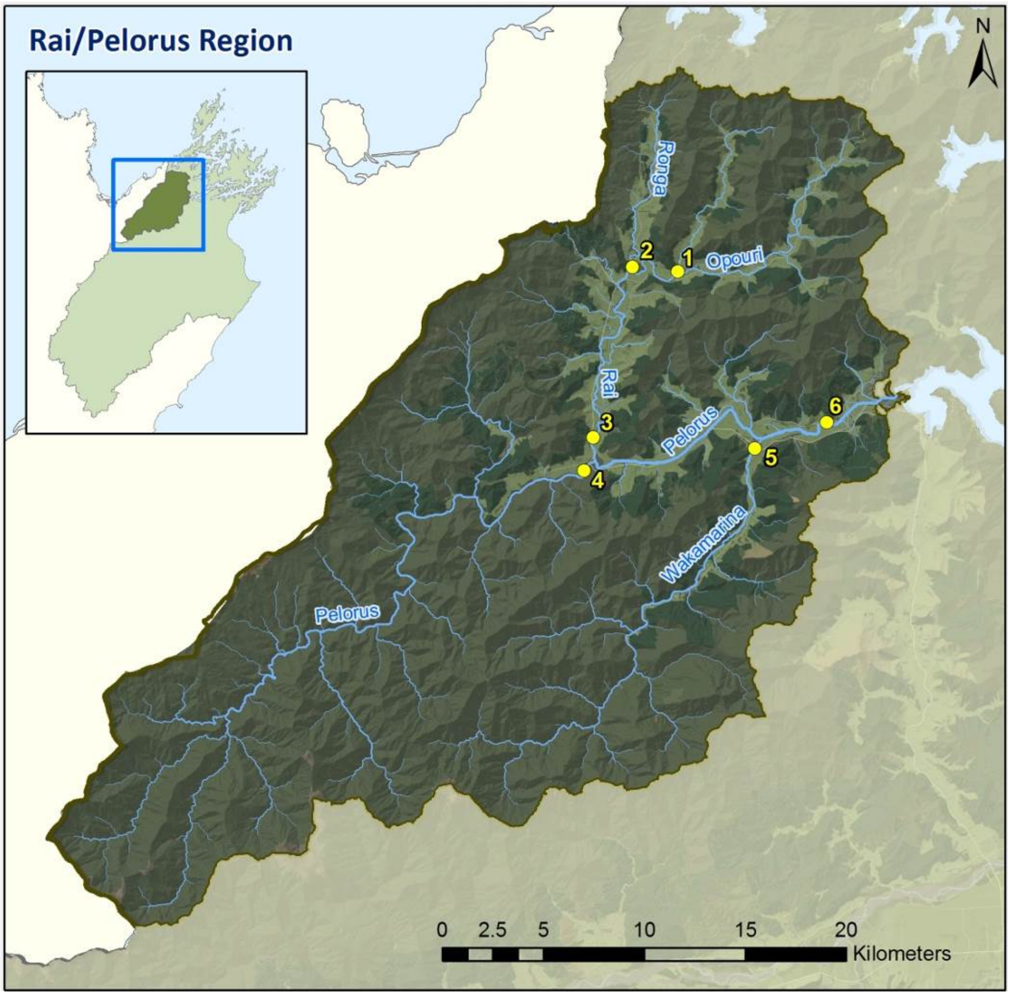
High pH values in the Waitohi River occur mainly during the warmer months and are a result of increased algae growth on the river bed. This is linked to a greater amount of sunlight reaching the bed in the urban reaches as the river banks lack taller trees and bushes that would naturally shade the waterway. Improvements of pH in the Kenepuru River resulted in a higher Water Quality Index compared to previous years. The exact causes of this improvement are unknown, but are most likely linked to better farm management.

Linkwater Stream (Duncan Stream in previous reports) is the only waterway with marginal water quality in this group. Currently, Council is conducting a catchment investigation to determine the causes of the poorer water quality in this stream. The results are expected to be reported on next year.

Site	WQI 2014 (2012-2014)	Change in WQI from last year	Comments
Graham Rv	75.6	-5.0	Significant increase in Turbidity
Kenepuru Rv	74.0	6.2	Improved pH, but slight increase in E. coli concentrations
Waitohi Rv	73.7	6.3	Decrease in Dissolved Reactive Phosphorus concentrations that are potentially an artifact of a change in laboratories in 2011
Cullens Ck	69.2	-1.7	Slight increase in E. coli concentrations
Kaituna Rv	68.3	-0.4	no significant changes
Linkwater Stm	58.4	0.3	no significant changes

Table 3: Water Quality Indices (WQI) for the period 2012-2014 and changes compared to last year for monitoring sites in the Sounds.

3.2. The Rai/Pelorus Catchment



No.	Site	Monthly Water Quality Sampling Since	Catchment Area [km²]	Landcover
1	**Opouri Rv**	Sep 2008	70.3	
2	**Ronga Rv**	Sep 2008	32.7	
3	**Rai Rv**	Feb 2007	209.9	
4	**Upper Pelorus**	Feb 2007	376.6	
5	**Wakamarina**	Feb 2007	187.7	
6	**Lower Pelorus**	Aug 2007	857.5	

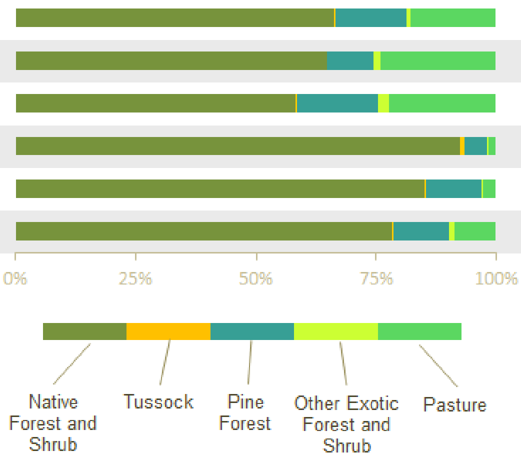


Figure 6: Sampling sites in the Rai/Pelorus catchment.

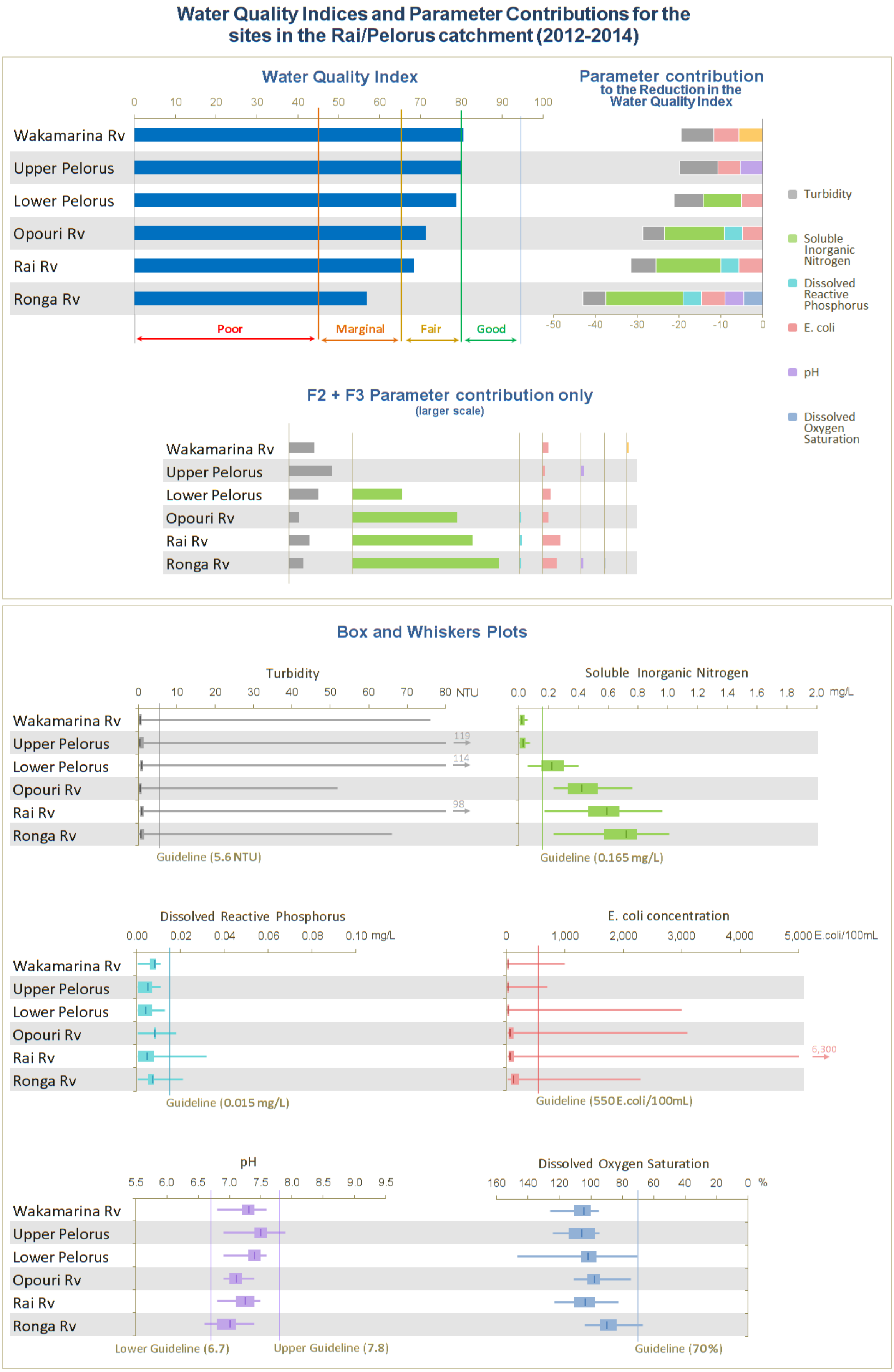


Figure 7: Water Quality Indices and parameter contributions for the monitoring sites in the Rai/Pelorus catchment for the period 2012-2014.

The Wakamarina River and upper Pelorus River both have good water quality. Guideline values for E. coli concentrations and Turbidity are usually only exceeded when these rivers are in flood. These are also the only rivers in this group with Soluble Inorganic Nitrogen concentrations consistently below the guideline level. This is a result of the limited amount of pastoral land use in the catchments. The previous report [6] showed a very good correlation between pastoral land use cover and Soluble Inorganic Nitrogen concentrations in the Rai/Pelorus area. This can be attributed to a predominance of pastures being grazed by dairy cattle. The Rai River as well as its tributaries, the Ronga and Opouri River, have Soluble Inorganic Nitrogen concentrations consistently above the guideline level for nuicance algae growth. Indeed, field notes show an abundance of filamentous algae and thick algae mats covering the river bed at the sampling sites of the Rai and Ronga rivers during low flow periods. Algae growth is substantially less at the Opouri River site, not only due to lower nitrogen concentrations, but also due to greater shading of the waterway by large trees at the sampling site. These trees reduce the amount of sunlight reaching the river bed, which slows the growth of algae.

The community of algae and fungi growing on the bed of a river is referred to as “Periphyton”. The amount of periphyton cover can be measured by removing the periphyton from a defined area of the river bed and measuring the Chlorophyll-a concentration of the sample. This is a comparatively time consuming and therefore costly method that cannot be applied to larger rivers. Council therefore does not currently measure periphyton directly, but instead assesses the potential for periphyton growth by measuring the concentrations of available plant nutrients in the water. However, the direct measurement of periphyton is a mandatory attribute in the 2014 National Policy Statement for Freshwater Management (NPS-FM). Subsequently, this method will be included in the State of the Environment sampling program in the near future, beginning with a selection of sites that potentially exceed national limits for periphyton growth, including the Rai River and Ronga River.

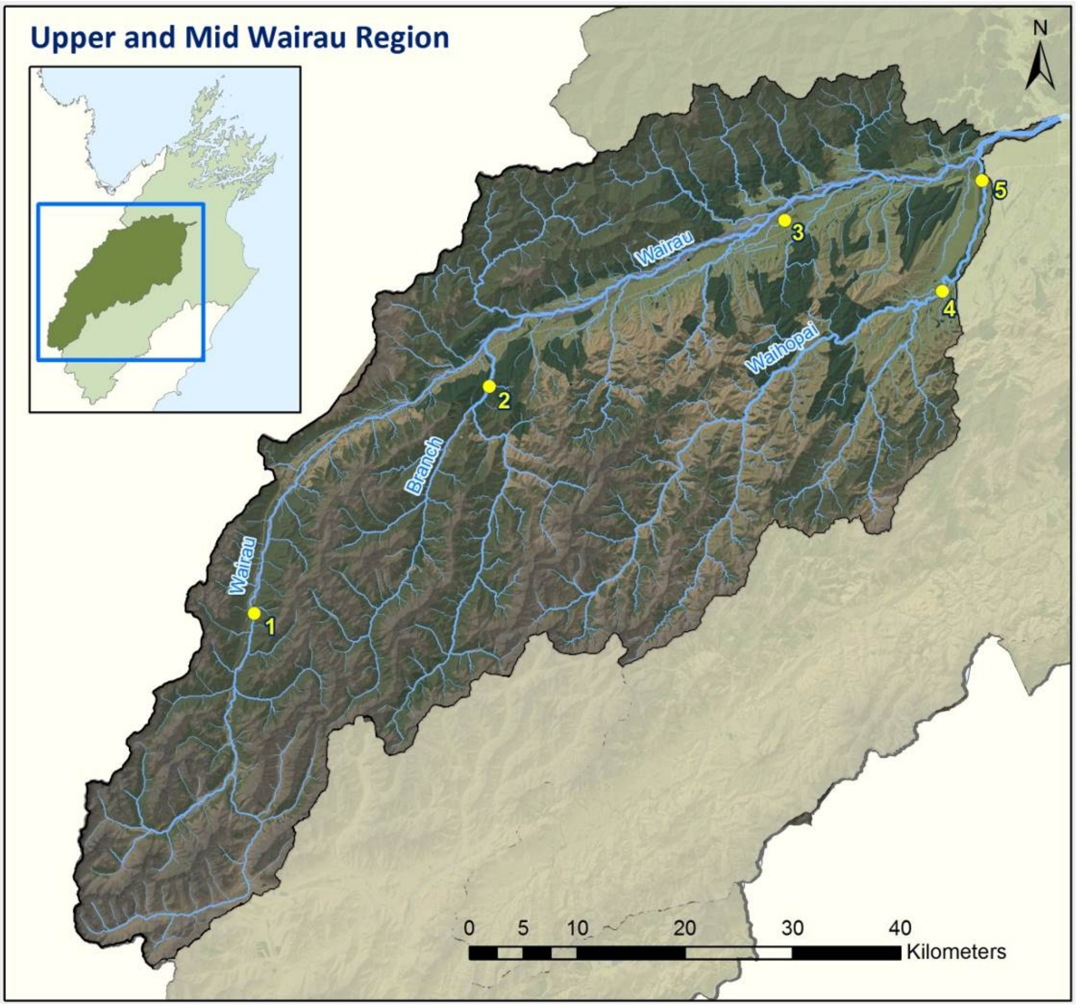
Of the sites in this group, the Ronga River has the lowest Water Quality Index with only marginal water quality. E. coli concentrations are generally elevated, but exceed guideline levels only during rainfall events. The river also has the lowest pH and Dissolved Oxygen Saturations. This is likely a result of organic matter deposited directly into the waterway, most probably as animal droppings.

Increased E. coli concentrations in the Wakamarina River and Opouri River have led to lower Water Quality Indices for these waterways compared to the previous report, but except for one sample taken during rainfall from the Opouri River, concentrations were still generally lower than those in the Ronga.River.

Site	WQI 2014 (2012-2014)	Change in WQI from last year	Comments
Wakamarina Rv	80.5	-6.6	High Water Temperature in early 2014 and increase in E. coli concentrations
Upper Pelorus	80.2	-0.4	no significant changes
Lower Pelorus	78.8	5.2	Improved pH; also decrease in Dissolved Reactive Phosphorus concentrations that are potentially an artifact of a laboratory change in 2011
Opouri Rv	71.3	-6.3	Increase in E. coli concentrations
Rai Rv	68.5	-0.7	no significant changes
Ronga Rv	56.9	-0.4	no significant changes

Table 4: Water Quality Indices (WQI) for the period 2012-2014 and changes compared to last year for monitoring sites in the Rai/Pelorus catchment.

3.3. The Upper and Mid Wairau Catchment



No.	Site	Monthly Water Quality Sampling Since	Catchment Area [km^2]	Landcover
1	**Upper Wairau**	Jan 1989 (NIWA)	517.8	
2	**Branch Rv**	Jul 2009	551.0	
3	**Mill Ck**	Sep 2008	19.8 *	*
4	**Mid Waihopai**	Jul 2007	737.8	
5	**Lower Waihopai**	Feb 2007	769.7	

* The baseflow of Mill Creek is dominated by groundwater that originates from a greater area than the surface catchment.

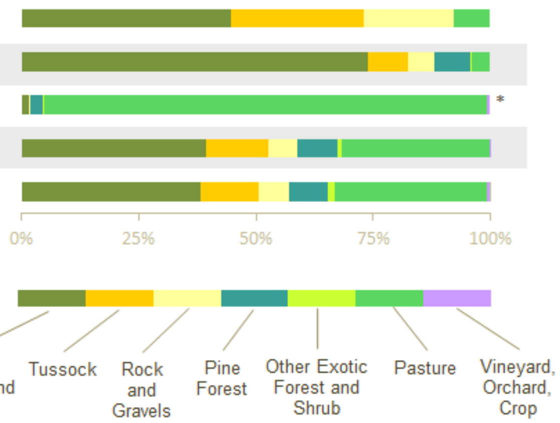


Figure 8: Sampling sites in the Upper and Mid Wairau catchment.

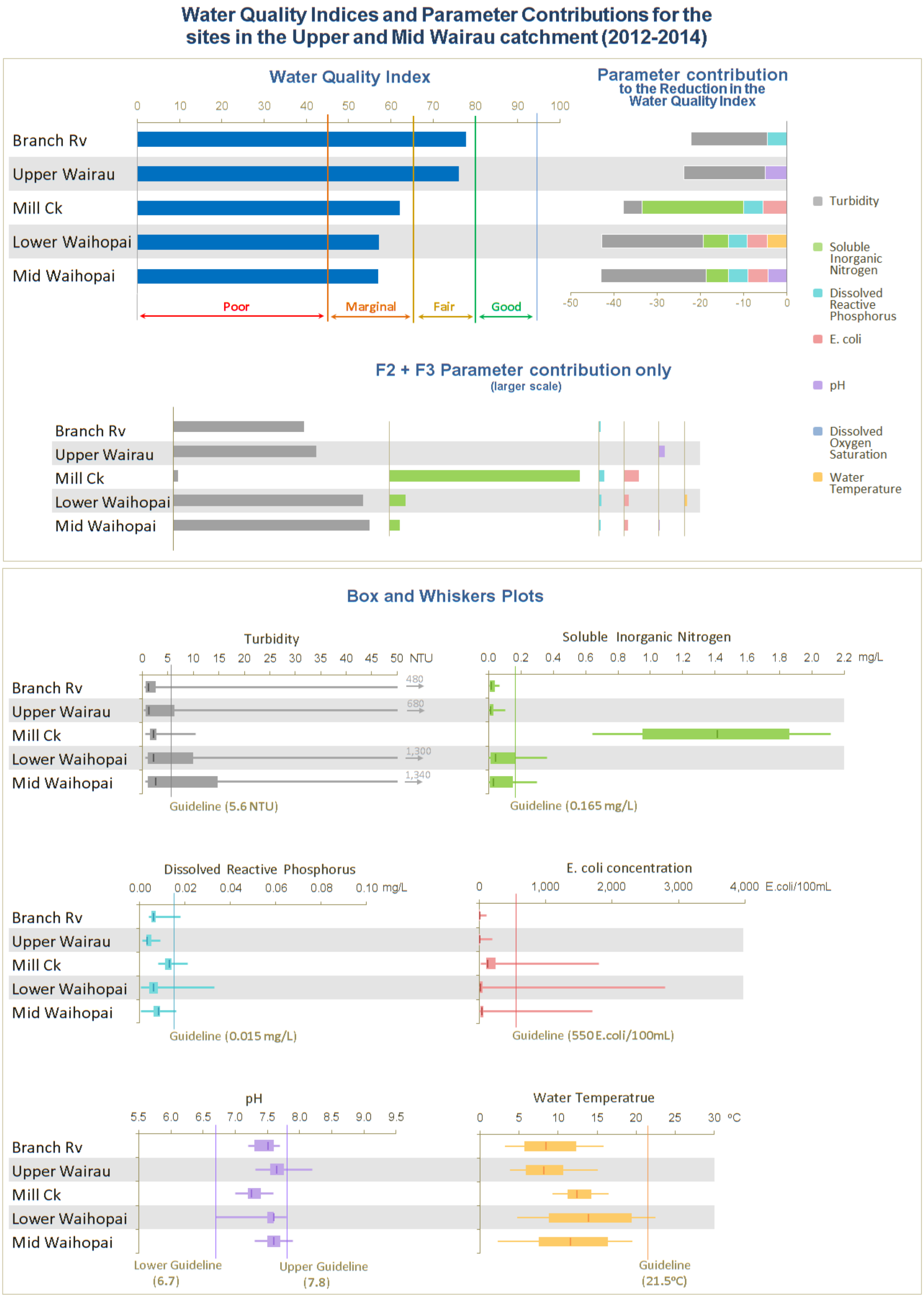


Figure 9: **Water Quality Indices and parameter contributions for the monitoring sites in the Upper and Mid Wairau catchment for the period 2012-2014.**

Turbidity is the dominating parameter affecting the water quality of most of the sites in this part of Marlborough. The exception is Mill Creek, which has naturally clear water due to the dominance of groundwater as the source of flow.

In the Waihopai River catchment localised heavy rainfall is known to cause slips, particularly in the Spray River tributary. These slips can reduce the clarity of the Waihopai river water for several weeks. Nevertheless, there has been a slight decrease of Turbidity compared to the previous year (Table 5). Additionally, pH values have been within guideline values in the Lower Waihopai in the last three years, resulting in a markedly higher Water Quality Index.

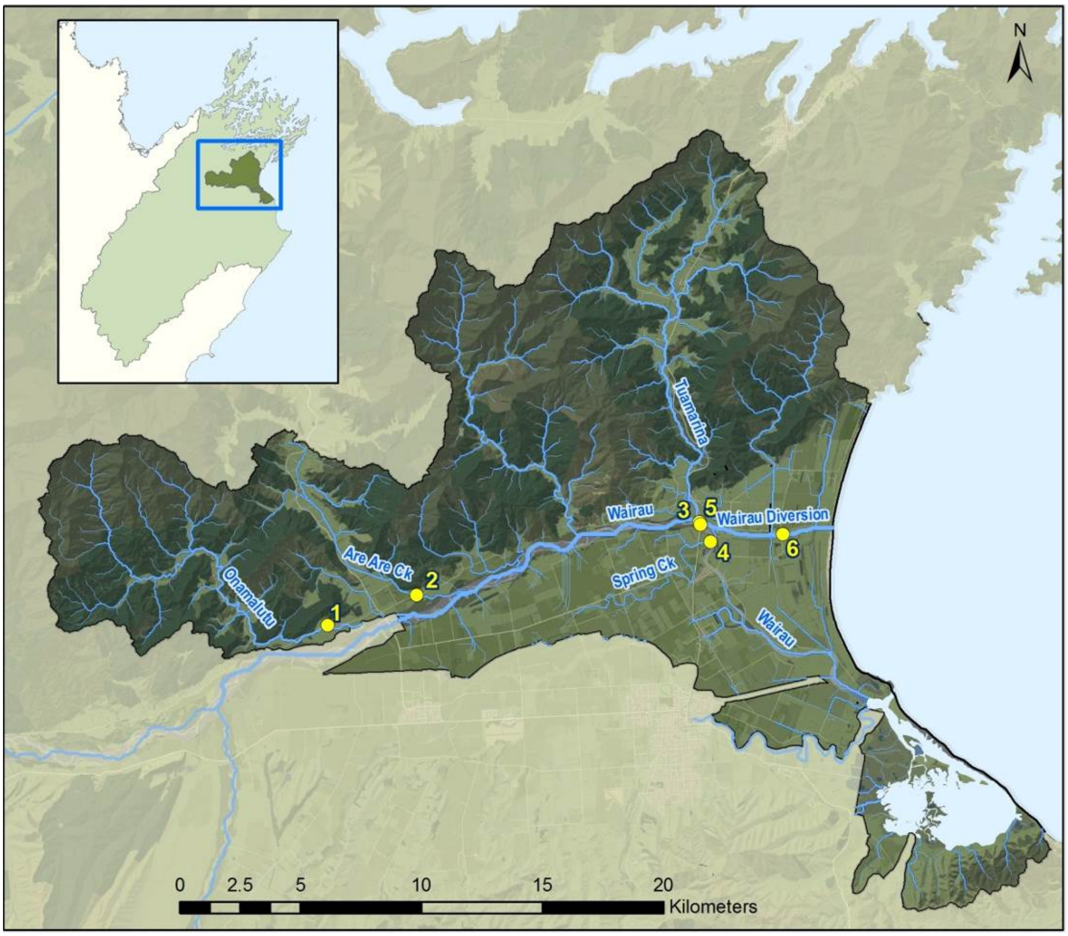
High Turbidity in the Upper Wairau River and Branch River were a result of a number of samples that were taken during comparatively high flows in 2013. This was shown in detail in the previous report [6]. As the Water Quality Index is combining measurements from the last three years, the current Index is still reflective of this. Nevertheless, lower E. coli concentrations and more stable pH values in the Branch River have resulted in an increase of the Water Quality Index.

The predominant parameter causing marginal water quality in Mill Creek is Soluble Inorganic Nitrogen with concentrations consistently well above the guideline level. Nearly all of this Nitrogen is in the form of Nitrate that originates from groundwater feeding into the stream [6]. As mentioned in Section 3.1, leaching from pastures is the main source of the Nitrogen. Nearly the entire catchment of Mill Creek has been converted to pasture, but some of the groundwater will also originate from areas further to the east. A number of pastoral farms have been converted into vineyard. Direct measurements of nitrate leachate from a vineyard in Marlborough have shown that significantly less nitrogen is lost to groundwater under vineyards compared to pastures [4]. However, at the same time, pastoral land use has been significantly intensified on other farms in the catchment. This will partially counter the potential for reduced Soluble Inorganic Nitrogen concentrations in Mill Creek. The land use changes in the catchment could provide an opportunity to investigate the impact of different land uses on the water quality of spring-fed streams in Marlborough. This knowledge could then be applied to other areas with predominantly groundwater-fed waterways, such as the Blenheim springs. Mill Creek is also one of only two waterways in Marlborough to consistently exceed the nitrate toxicity limit of the NPS-FM A-band based on the protection of freshwater ecology.

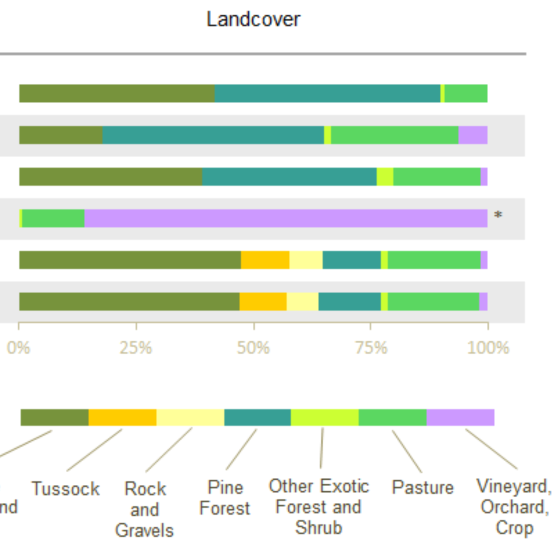
Site	WQI 2014 (2012-2014)	Change in WQI from last year	Comments
Branch Rv	77.8	8.7	Improved pH and decrease in E. coli concentrations
Upper Wairau	75.4	0.1	no significant changes
Mill Ck	62.2	5.8	Improved Dissolved Oxygen Saturation and slightly reduced Soluble Inorganic Nitrogen concentration
Lower Waihopai	57.1	8.7	Decrease in Turbidity and improved pH
Mid Waihopai	57.0	3.9	Decrease in Turbidity

Table 5: Water Quality Indices (WQI) for the period 2012-2014 and changes compared to last year for monitoring sites in the Upper and Mid Wairau catchment.

3.4. The Lower Wairau Catchment



No.	Site	Monthly Water Quality Sampling Since	Catchment Area [km^2]
1	**Onamalutu Rv**	Feb 2007	70.4
2	**Are Are Creek**	Jul 2009	31.4
3	**Tuamarina Rv**	Feb 2007	101.8
4	**Spring Ck***	Feb 2007	13.9
5	**Lower Wairau**	Jan 1989 (NIWA)	3,403.9
6	**Wairau Diversion**	Aug 2007	3,537.5



* The baseflow of Spring Creek is dominated by groundwater that originates from a greater area than the surface catchment.

Figure 10: Sampling sites in the Lower Wairau catchment.

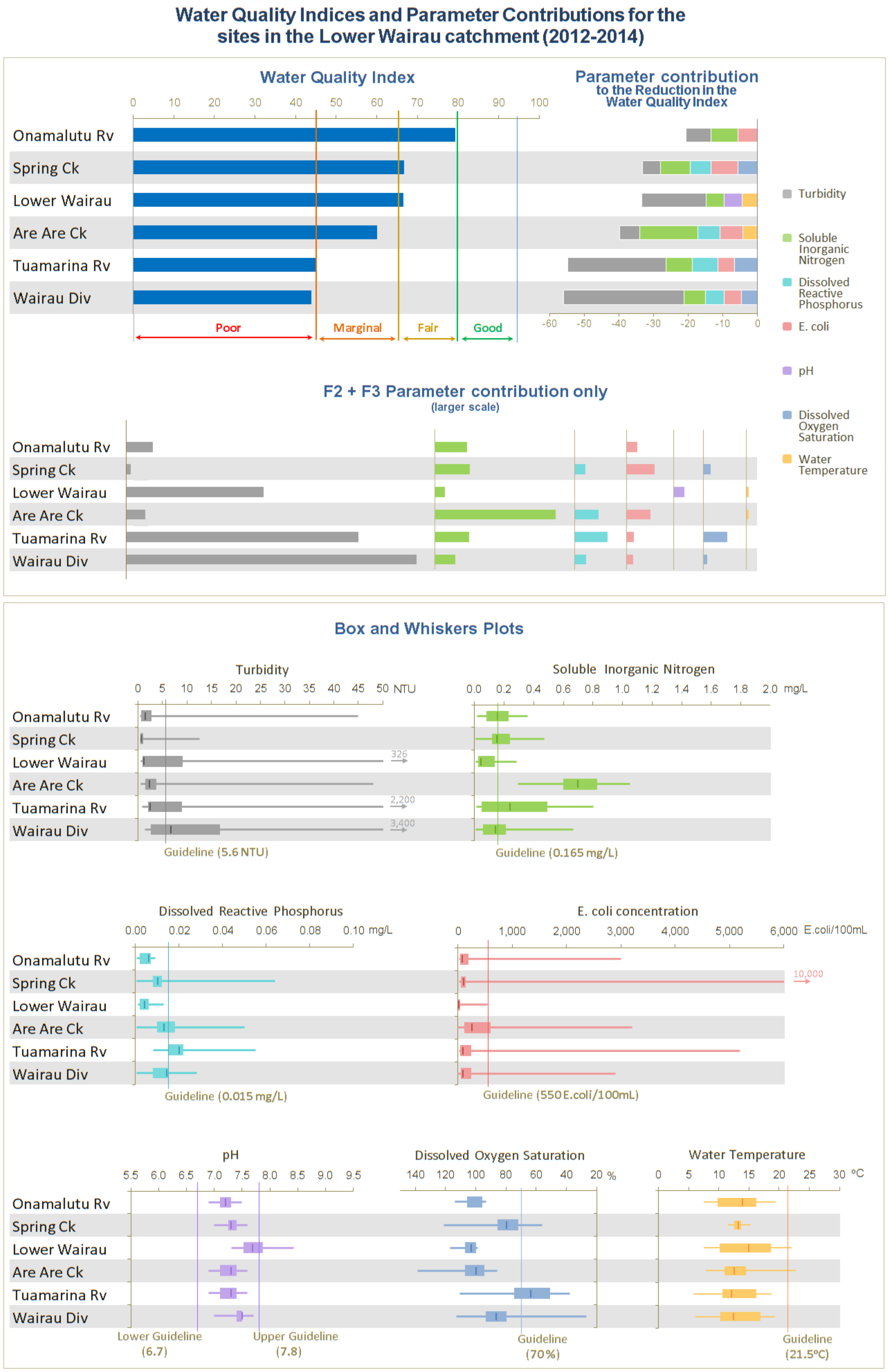


Figure 11: Water Quality Indices and parameter contributions for the monitoring sites in the Lower Wairau catchment for the period 2012-2014.

The Onamalutu River has the best water quality in this group with water quality very close to the 'good' category. Turbidity and E. coli concentrations only exceed guideline levels during flood flows, but Soluble Inorganic Nitrogen concentrations are above the guideline value half the time.

Most sites in this group exceed the guideline for Soluble Inorganic Nitrogen for some of the time, usually during the winter months when less of the nitrogen is removed from the water by aquatic plants due to lower sunshine hours and lower water temperatures reducing the growth of the plants. Are Are Creek is the only waterway with consistently elevated Soluble Inorganic Nitrogen concentrations. A catchment investigation carried out in 2013/14 showed that concentrations are above the guideline level for nearly the entire length of the stream [8]. This is predominantly a result of pastoral landuse in the lowland areas of the catchment. Are Are Creek has also the highest E. coli concentrations of this group. The catchment investigation had shown that stock access was causing high E. coli concentrations in the upper catchment, while contamination of a small tributary in the lower catchment was the main cause for high E. coli levels at the State of the Environment monitoring site. Council is working with the landowner to remove contamination sources to this small tributary which will lead to an improvement of the water quality in lower reaches of Are Are Creek.

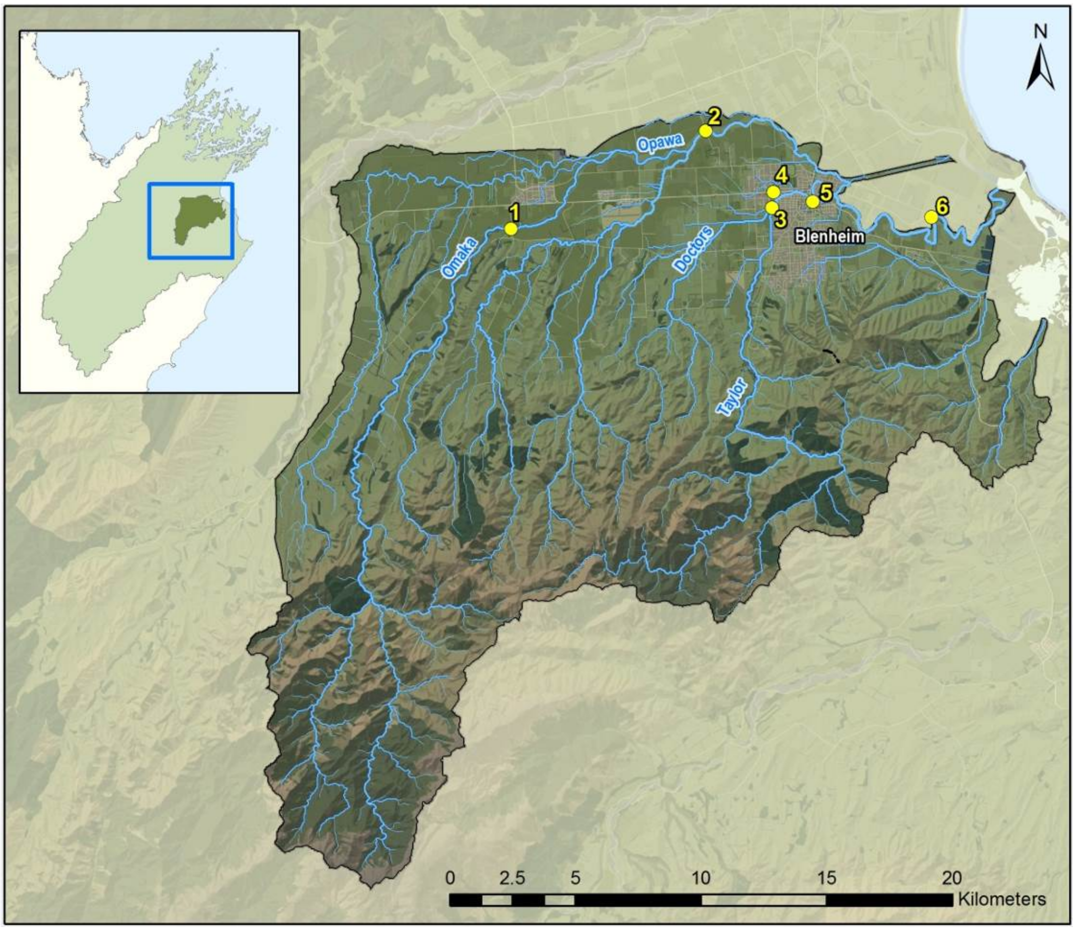
The two sites with the poorest water quality in the lower Wairau region are the Tuamarina River and the Wairau Diversion. A preliminary study into the water quality of the Tuamarina River is currently being carried out by Council. The central objective is the identification of the main areas in the catchment that contribute to the poor water quality observed at the State of the Environment monitoring site. Of particular interest is also the influence of the Para Wetland, one of the largest remaining wetlands in Marlborough. The monitoring site is located downstream of the wetland, while most of the pastoral farming is found upstream of the wetland.

In close proximity to the confluence of the Tuamarina River with the Wairau River, the Wairau River splits into the Wairau Diversion and the Lower Wairau. The location of the split leads the flow from the Tuamarina River exclusively down the Wairau Diversion. As a result, the water quality of the Wairau Diversion is strongly linked to the water quality of the Tuamarina River.

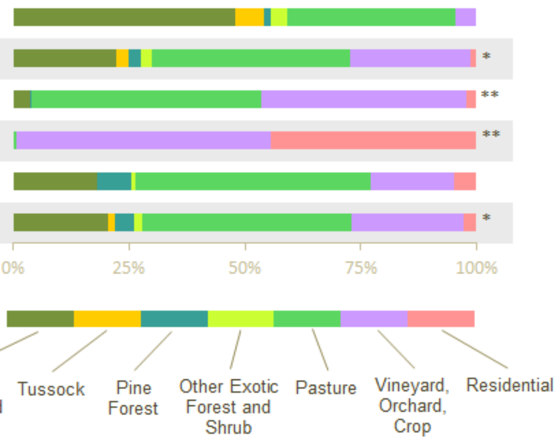
Site	WQI 2014 (2012-2014)	Change in WQI from last year	Comments
Onamalutu Rv	79.3	2.0	Slight decrease in Turbidity
Spring Ck	66.8	-0.4	no significant changes
Lower Wairau	66.5	-0.8	no significant changes
Are Are Ck	60.1	1.7	Slight decrease in Turbidity and E. coli concentrations, but also slight increase in Soluble Inorganic Nitrogen concentrations and Water Temperature
Tuamarina Rv	45.1	-1.1	Slight deterioration for a number of parameters, including Soluble Inorganic Nitrogen, Dissolved Reactive Phosphorus and E. coli concentrations
Wairau Div	44.0	0.9	no significant changes

Table 6: Water Quality Indices (WQI) for the period 2012-2014 and changes compared to last year for monitoring sites in the Lower Wairau catchment.

3.5. The Opawa Complex



No.	Site	Monthly Water Quality Sampling Since	Catchment Area [km^2]	Landcover
1	**Omaka Rv**	Feb 2007	118.5	
2	**Mid Opawa***	Feb 2007	292.9	*
3	**Doctors Ck****	Jul 2009	54.5	**
4	**Murphys Ck****	Jul 2009	2.6	**
5	**Taylor Rv**	Feb 2007	146.7	
6	**Lower Opawa***	Feb 2007	452.6	*



* water from the Wairau and Waihopai River is diverted into the Opawa River influencing the water quality particularly at base flow

** the baseflow of Doctors Ck and particularly Murphys Creek are dominated by groundwater that orignates from a greater area than the surface catchment of the creeks

Figure 12: Sampling sites in the Opawa Complex.

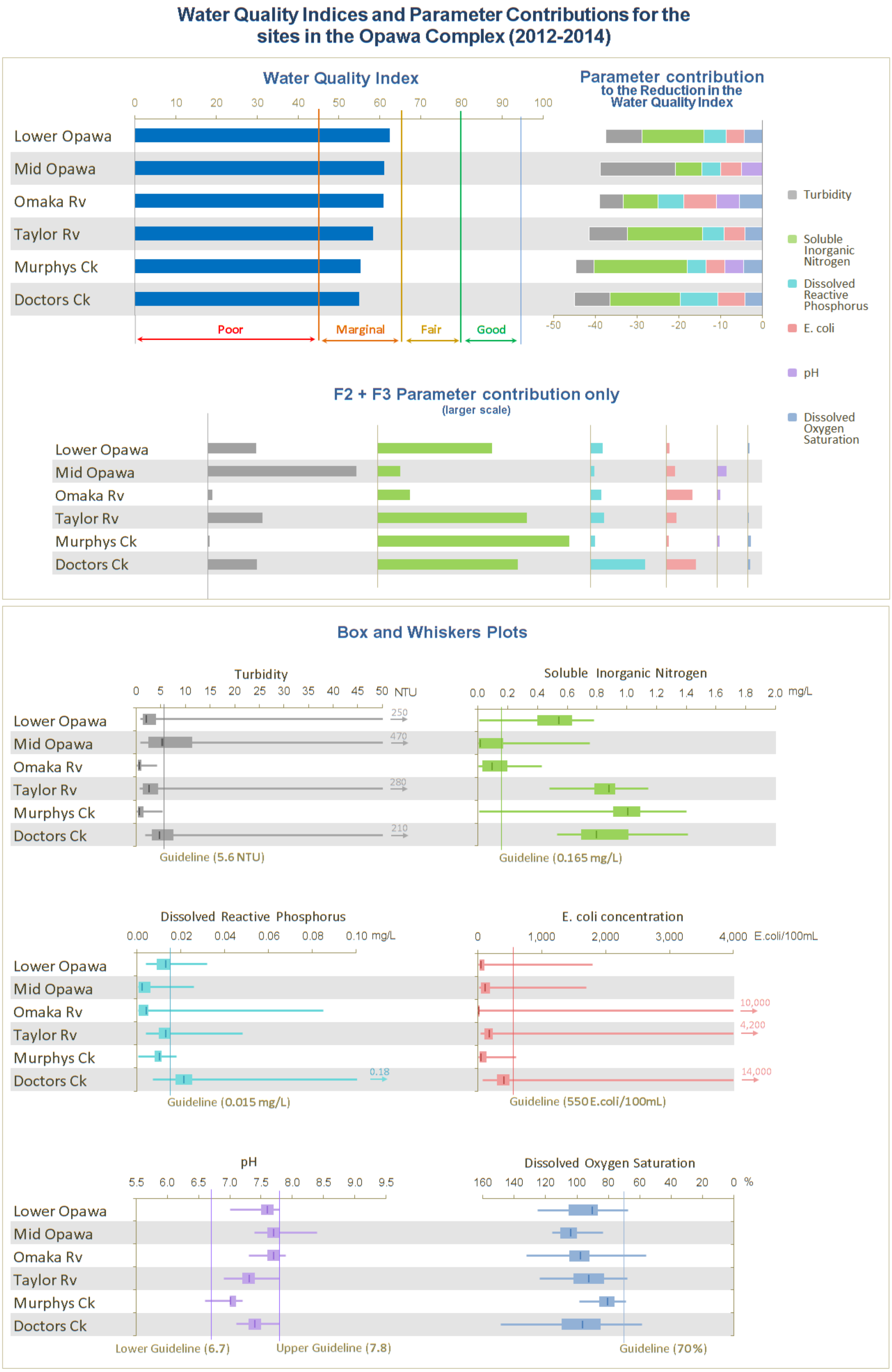


Figure 13: Water Quality Indices and parameter contributions for the monitoring sites in the Opawa Complex for the period 2012‑2014.

All sites in this group have marginal water quality. The similar Water Quality Indices for most of the sites is a result of their interconnectedness: Murphys Creek and Doctors Creek are the main tributaries of the Taylor River which in turn flows into the lower Opawa River. Additionally, upwelling groundwater contributes a varying degree to the flow of these four waterways. The strong influence of groundwater inflow is also the reason for the high Soluble Inorganic Nitrogen concentrations observed.

Doctors Creek also has Dissolved Reactive Phosphorus concentrations that are almost consistently above guideline values. An extensive catchment investigation of water quality in Doctors Creek and its tributary in 2013/2014 revealed that most of the phosphorus is a result of bank erosion, particularly where livestock have access to the waterway [7]. The investigation also found that livestock access was causing most of the elevated E. coli concentrations observed in Doctors Creek, but leakage of human sewage was an additional source in one of the smaller tributaries[1]. Using the results of the investigation Council is currently in the process of producing a catchment enhancement plan which will be the base for a collaborative approach of working with the landowners to improve water quality in Doctors Creek. Better water quality in Doctors Creek will have a follow-on effect on downstream waterways, including the Taylor River and lower Opawa River.

The Mid Opawa and Omaka River have lower Soluble Inorganic Nitrogen concentrations as these waterways are less influenced by groundwater. The Mid Opawa, however, receives water from the Waihopai River and Wairau River as part of the Southern Irrigation Scheme. Consequently, the Mid Opawa has a comparatively higher Turbidity. This is the result of the more turbid Waihopai river water contributing a significant amount of flow at the Mid Opawa monitoring site. Although the Waihopai River has been slightly less turbid in 2014, it appears that fine sediment from previous flood flows has accumulated on the bed of the Opawa River and is being moved back into the water even at slightly elevated flows.

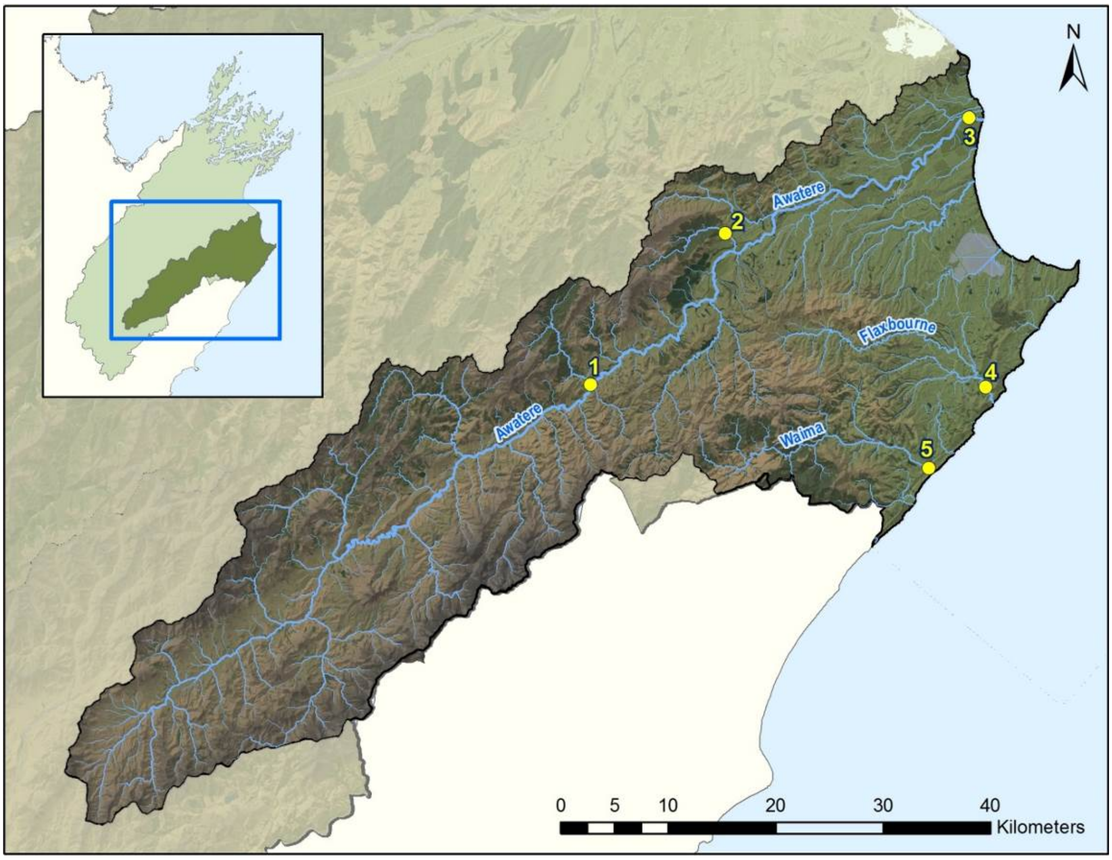
Most of the sites had low Dissolved Oxygen Saturations on some occasions in 2014. This resulted in lower Water Quality Indices for a number of sites compared to last year (Table 7). Most of the lower Dissolved Oxygen levels were observed during flood flows and are likely caused by surface run-off carrying organic material such as animal droppings into the waterways. The lower Dissolved Oxygen Saturations are a result of microbial activity. Microorganisms that break down organic material can remove a significant amount of oxygen from the water in the process.

Site	WQI 2014 (2012-2014)	Change in WQI from last year	Comments
Lower Opawa	62.5	-5.5	Increased Turbidity and low Dissolved Oxygen Saturation in the summer, but slight decrease in Soluble Inorganic Nitrogen concentrations
Mid Opawa	61.1	-3.6	Significant increased in Turbidity
Omaka Rv	60.9	0.2	no significant changes
Taylor Rv	58.4	-6.1	Lower Dissolved Oxygen Saturation, increased Turbidity and slight increase in E. coli concentrations, but also slighty lower Soluble Inorganic Nitrogen concentrations
Murphys Ck	55.3	-3.9	Slightly lower Dissolved Oxygen Saturations in summer
Doctors Ck	55.0	-6.1	Slight increase in Turbidity and E. coli concentrations; also slightly lower Dissolved Oxygen Saturation, but decrease in Soluble Inorganic Nitrogen concentrations

Table 7: Water Quality Indices (WQI) for the period 2012-2014 and changes compared to last year for monitoring sites in the Opawa Complex.

[1] Council is currently working on eliminating the sources of human sewage in this waterway.

3.6. South Marlborough



No.	Site	Monthly Water Quality Sampling Since	Catchment Area [km^2]	Landcover
1	**Mid Awatere**	Feb 2007	983.8	
2	**Black Birch Stm**	Feb 2007	29.9	
3	**Lower Awatere**	Feb 2007	1,572.7	
4	**Flaxbourne Rv**	Feb 2007	150.6	
5	**Waima Rv**	Aug 2007	158.2	

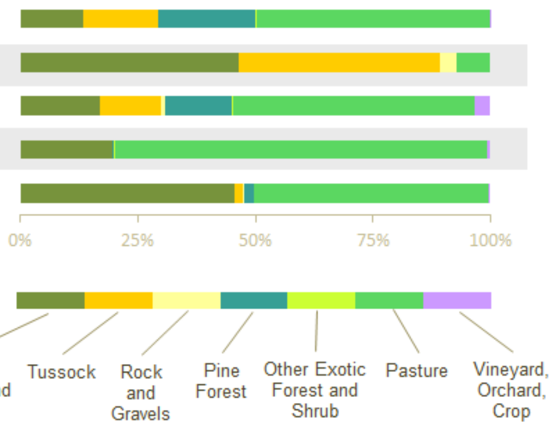
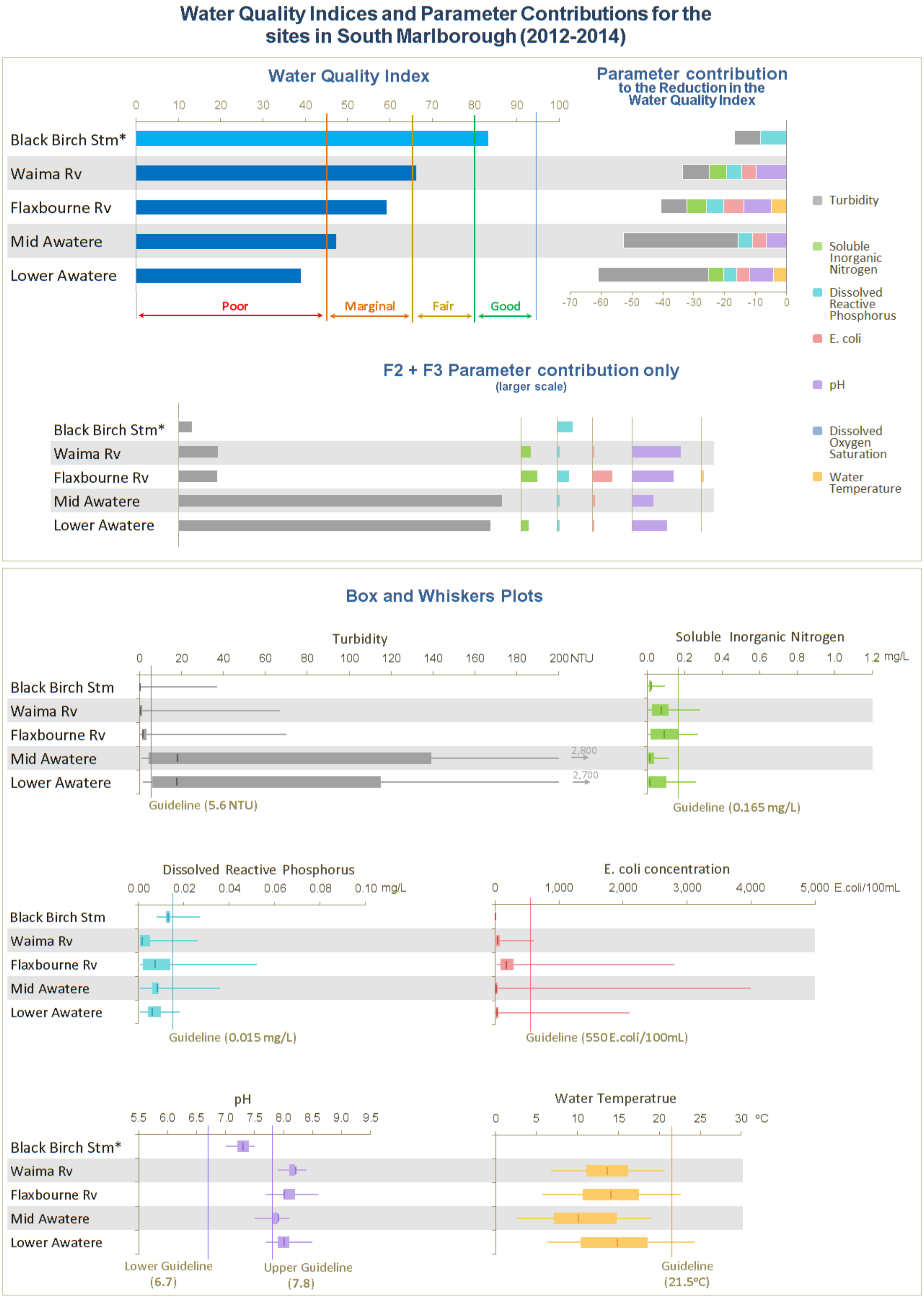


Figure 14: Sampling sites in the South Marlborough region.



* Water Quality Index for Black Birch Stm is incomplete - no Dissolved Oxygen Saturation and Water Temperature data

Figure 15: Water Quality Indices and parameter contributions for the monitoring sites in the Opawa Complex for the period 2012-2014.

Most notable in this group is the very high Turbidity of the Awatere River. This is a result of highly erodible Mudstone in the underlying geology of the catchment, which also contains limestone causing naturally elevated pH levels. Naturally high pH levels are also observed in the Waima River and Flaxbourne River further south, but these two waterways have significantly clearer water than the Awatere River. Council is planning to further study the sources of turbidity in the Awatere River to increase our understanding. This might explain occurrences such as the increased Turbidity in the Lower Awatere, but not the Mid Awatere.

Black Birch Stream has the best water quality of the sites that are monitored in South Marlborough. This can largely be attributed to the predominant native vegetation cover in the catchment of this waterway. However, the Water Quality Index for Black Birch Stream needs to be treated with caution as no Water Temperature or Dissolved Oxygen measurements are taken and there are large data gaps in the Turbidity record.

Elevated E. coli concentrations in the Flaxbourne River are a result of unrestricted livestock access to the waterway. Occasionally higher Water Temperatures in summer are due to the lack of tall vegetation on the banks of the river, which means that sunlight can reach the water unhindered. The higher Water Temperatures in the Lower Awatere River, on the other hand are a result of the large width of the river in the lower reaches, so that tall vegetation on the river banks is unable to shade the whole of the waterway.

Low Dissolved Oxygen Saturations have been observed in the Waima River in the past, but these were limited to occasions when flows were very low and water was partially flowing through the river gravels as subsurface flow only. This is likely to still occur, but has not been picked up by recent sampling due to the limited number of samples taken each year. Therefore, the significant improvement in water quality as indicated by a higher Water Quality Index should be seen in this context.

Site	WQI 2014 (2012-2014)	Change in WQI from last year	Comments
Black Birch Stm	83.3	0.0	no significant changes
Waima Rv	66.3	7.9	Decrease in Turbidity, but mainly higher Dissolved Oxygen Saturation
Flaxbourne Rv	59.3	0.1	no significant changes
Mid Awatere	47.2	-0.5	no significant changes
Lower Awatere	39.0	-5.7	Significant Increase in Turbidity

Table 8: Water Quality Indices (WQI) for the period 2012-2014 and changes compared to last year for monitoring sites in South Marlborough.

4. Summary and Discussion

Figure 16 shows the Water Quality Indices and the contribution of the different parameters to the reduction of the Index for the 34 streams and river sites monitored as part of the State of the Environment program.

As in previous years, there are only a small number of sites with either good or poor water quality. The majority of sites have water quality classed as fair or marginal with roughly equal numbers in each class.

There have been some changes to the Water Quality Index at some sites when compared to those reported in the 2014 State of the Environment report. However, these changes should be treated with caution as in most cases the differences are probably not representative of long-term changes, but rather are a result of temporal fluctuations caused by variations in weather patterns. Long-term trends are better analysed using statistical methods such as the seasonal Kendall trend test. This was done as part of the previous report and considering the limited number of new data points (only 12) it is unlikely that re-analysis would provide meaningful changes to previous results. For this reason, this report should be seen as an update on the state of the surface water quality in Marlborough and be read in conjunction with the previous report ('State of the Environment Surface Water Quality Monitoring Report, 2014' [6]).

Some of the most notable changes were reduced Water Quality Indices for most of the sites in the Opawa Complex. These were related to increases in Turbidity and lower Dissolved Oxygen levels, mainly during higher flows when surface run-off carries material from the surrounding land into the waterways. Most of the waterways in this group are closely linked via groundwater and surface water flows resulting in similar Water Quality Indices and their variation.

Increases in Turbidity also resulted in a lower Water Quality Index for the Graham River, causing a change from the good to the fair category. The higher Turbidity was a result of bank erosion, possibly exacerbated by gravel extractions near the sampling site.

On the other end of the spectrum were increased Water Quality Indices for most of the sites in the upper and mid Wairau River catchment. The causes here were less uniform and included improvement in pH levels and lower E. coli concentrations for the Branch River and lower Turbidity in the Waihopai River. The latter is likely to be a temporary phenomenon, as high Turbidity in the Waihopai River is usually caused by slips in the naturally highly erodible upper part of the catchment.

Some improvements, however, were an artefact of a change in laboratory services in 2011 which effected Dissolved Reactive Phosphorus measurements at a number of sites.

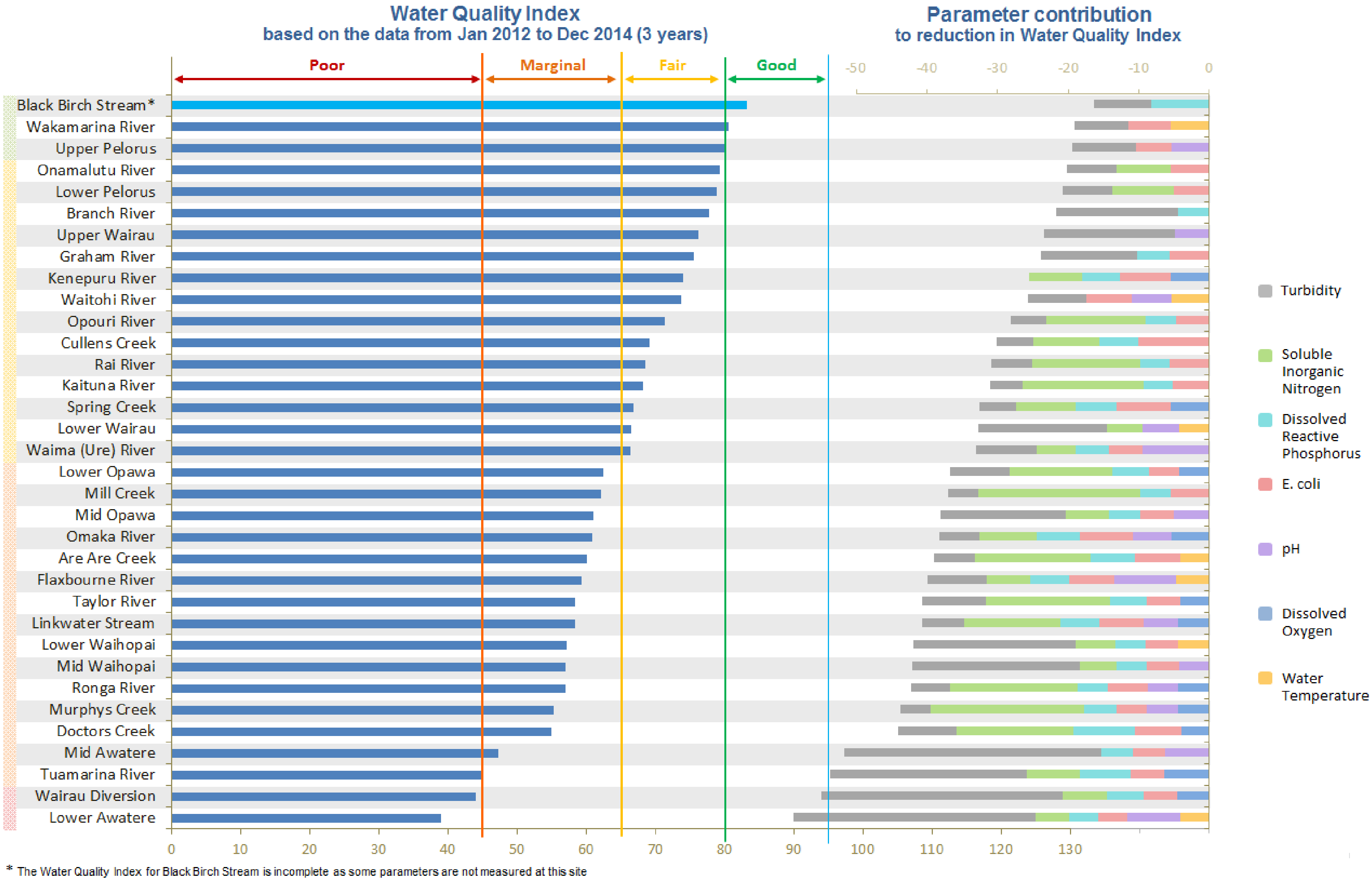


Figure 16: Water Quality Indices as well as parameter contributions to the reduction in the Water Quality Index for the three years from 2012 to 2014 for all sites monitored.

5. References

1. CCME (2001) Canadian water quality guidelines for the protection of aquatic life: DDME Water Quality Index 1.0, Technical Report. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment

2. CCME Water Quality Steering Committee (2004) CCME National Water Quality Index Workshop Proceedings. Canadian Council of Ministers of the Environment

3. Gartner Lee Ltd (2006) A sensitivity Analysis of the Canadian Water Quality Index. Canadian Council of Ministers of the Environment

4. Green S, Agnew R and Greven M (2014) Monitoring nitrate loss under vineyard soils on the Wairau Plains, Marlborough. Report prepared by Plant and Food Research for Marlborough District Council

5. MDC (2013) Investigation into High E. coli concentrations in the Taylor River during low flow. Marlborough District Council

6. MDC (2014) State of the Environment Surface Water Quality Monitoring Report 2014. Marlborough District Council Technical Report No: 14-006

7. MDC (2015a) Taylor River Catchment Characterisation – Doctors Creek. Marlborough District Council Technical Report No: 15-001

8. MDC (1015b) Water Quality in the Are Are Creek Catchment. Marlborough District Council Technical Report No: 15-004

9. New Zealand Government (2014) National Policy Statement for Freshwater Management 2014

10. Stark JD (2008) Trends in river health of the Manawatu-Wanganui region 2008 with comments on the SoE biomonitoring programme. Stark Environmental Report: 2008-07 prepared for Horizons Regional Council

6. Appendices

6.1. Water Quality Index calculation

The following section has been taken from the Canadian Water Quality Guidelines for the Protection of Aquatic Life [1].

"The index consists of three factors:

Factor 1: Scope

F1 (Scope) represents the extent of water quality guideline non-compliance over the time period of interest. It has been adopted directly from the British Columbia Index:

$$F_1 = \left(\frac{\text{Number of failed variables}}{\text{Total number of variables}} \right) \times 100$$

Where variables indicates those water quality variables with objectives which were tested during the time period for the index calculation.

Factor 2: Frequency

F2 (Frequency) represents the percentage of individual tests that do not meet objectives ("failed tests"):

$$F_2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}} \right) \times 100$$

Factor 3: Amplitude

F3 (Amplitude) represents the amount by which failed test values do not meet their objectives. F3 is calculated in three steps. The formulation of the third factor is drawn from work done under the auspices of the Alberta Agriculture, Food and Rural Development.

(i) The number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective is termed an "excursion" and is expressed as follows. When the test value must not exceed the objective:

$$excursion_i = \left(\frac{FailedTestValue_i}{Objective_j} \right) - 1$$

For the cases in which the test value must not fall below the objective:

$$excursion_i = \left(\frac{Objective_j}{FailedTestValue_i} \right) - 1$$

ii) The collective amount by which individual tests are out of compliance is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives). This variable, referred to as the normalized sum of excursions, or nse, is calculated as:

$$nse = \frac{\sum_{i=1}^{n} excursion_i}{\#\ of\ tests}$$

iii) F3 is then calculated by an asymptotic function that scales the normalized sum of the excursions from objectives (*nse*) to yield a range between 0 and 100.

$$F_3 = \left(\frac{nse}{0.01nse + 0.01} \right)$$

The CCME WQI is then calculated as:

$$CCMEWQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right)$$

The factor of 1.732 arises because each of the three individual index factors can range as high as 100. This means that the vector length can reach

$$\sqrt{100^2 + 100^2 + 100^2} = \sqrt{30000} = 173.2$$

as a maximum. Division by 1.732 brings the vector length down to 100 as a maximum.”

6.2. Site Information

Report Region	Site Name		Easting	Northing	Catchment Size [km2]		Flow
	Short Name	Long Name			Sampling Site	Water Management Unit	Station at site*
Marlborough Sounds	Kenepuru Rv	Kenepuru River at Kenepuru Head	2604300	6003929	29.8	29.8	✓
	Kaituna Rv	Kaituna River at Higgins Bridge	2574884	5988168	135.6	146.9	✓
	Cullens Ck	Cullens Creek at Road Bridge	2581811	5989883	20.5	20.7	✗
	Linkwater Stm	Duncan Stream at Outlet	2585561	5991258	9.3	10.3	✗
	Waitohi Rv	Waitohi River at State Highway One	2594144	5989933	15.0	17.9	✗
	Graham Rv	Graham River at Road Bridge	2599962	5992336	17.0	18.2	✗
Rai and Pelorus	Opouri Rv	Opouri River at Tunakino Valley Road	2562207	5999209	103.4	106.9	(✓)
	Ronga Rv	Ronga River at Upstream Rai River	2559969	5999418	32.7	32.7	(✓)
	Rai Rv	Rai River at Rai Falls	2558020	5990970	209.9	211.3	✓
	Upper Pelorus	Pelorus River at Kahikatea Flat	2557587	5989317	378.1	378.1	✓
	Wakamarina Rv	Wakamarina River at SH6	2566016	5990425	187.7	187.7	✗
	Lower Pelorus	Pelorus River at Fishermans Flat	2569576	5991721	862.4	1003.8	(✓)
Upper and Mid Wairau	Upper Wairau	Wairau River at Dip Flat	2503477	5923767	517.9	797.4	✓
	Branch Rv	Branch River at Weir Intake	2525306	5944887	550.7	563.5	✓
	Mill Ck	Mill Creek at Ormonds	2552750	5960325	19.8	21.5	✓
	Mid Waihopai	Waihopai River at Craiglochart	2567405	5953749	737.8	737.8	✓
	Lower Waihopai	Waihopai River at SH63 Bridge	2571094	5964027	769.8	769.8	✗

* (✓) = flow relationship with a nearby site has been established

Report Region	Site Name				Catchment Size [km2]		Flow
	Short Name	Long Name	Easting	Northing	Sampling Site	Water Management Unit	Station at site
Lower Wairau	Onamalutu Rv	Onamalutu River at Northbank Road	2575229	5969594	70.4	72.0	✓
	Are Are Ck	Are Are Creek at Kaituna Tuamarina Road	2578900	5970850	31.4	32.4	✓
	Tuamarina Rv	Tuamarina River at State Highway One	2590600	5973846	101.8	101.8	✗
	Lower Wairau	Wairau River at Tuamarina	2590635	5973743	4414.8	4414.8	✓
	Spring Ck	Spring Creek at Wairau River Floodgates	2591064	5973037	13.9	13.9	✗
	Wairau Diversion	Wairau Diversion at Neals Road	2594060	5973353	4537.3	4537.3	✗
Opawa Complex	Omaka Rv	Omaka River at Hawkesbury Road Bridge	2578160	5964570	119.1	119.1	✗
	Mid Opawa	Opawa River at Hammerichs Road	2585909	5968470	292.9	292.9	✓
	Murphys Ck	Murphys Creek at Nelson Street	2588597	5966040	2.6	2.6	✗
	Doctors Ck	Doctors Creek Upstream Taylor	2588550	5965400	54.5	54.5	✗
	Taylor Rv	Taylor River at Rail Bridge	2590161	5965648	86.9	86.9	✗
	Lower Opawa	Opawa River at Swamp Road	2594901	5965020	447.3	448.2	✗
South Marlborough	Mid Awatere	Awatere River at Awapiri	2570719	5929995	895.6	1041.4	✓
	Black Birch Stm	Black Birch Stream at Awatere Intake	2583282	5944040	29.9	33.5	✗
	Lower Awatere	Awatere River at River Mouth	2605963	5954796	1432.5	1432.5	✗
	Flaxbourne Rv	Flaxbourne River at Quarry	2607501	5929727	150.6	154.1	✗
	Waima Rv	Waima (Ure) River at SH1 Bridge	2602200	5922200	158.1	158.1	✗

6.3. **Land Cover**

Region	Catchment		Native Forest and Shrub	Tall Tussock	Rock and Gravels	Production Forest	Other Exotic Forest and Shrub	Pasture	Vinyard/ Orchad	Crop	Residential	Other	TOTAL
Marlborough Sounds	Kenepuru Stm	Area [km²]	19.8	0.0	0.0	4.5	0.4	5.0	0.0	0.0	0.0	0.1	29.8
		% cover	66.3	0.0	0.0	15.0	1.5	16.9	0.0	0.0	0.0	0.3	100.0
	Kaituna Rv	Area [km²]	62.7	0.0	0.3	28.3	2.1	41.7	0.1	0.3	0.0	0.1	135.6
		% cover	46.3	0.0	0.3	20.8	1.5	30.7	0.0	0.2	0.0	0.1	100.0
	Cullens Ck	Area [km²]	11.4	0.0	0.0	6.1	0.2	1.8	0.0	0.0	0.0	0.0	19.5
		% cover	58.4	0.0	0.0	31.4	1.2	9.0	0.0	0.0	0.0	0.0	100.0
	Linkwater Stm (Duncan Stm)	Area [km²]	3.2	0.0	0.0	3.5	0.0	2.6	0.0	0.0	0.0	0.0	9.2
		% cover	34.4	0.0	0.0	37.6	0.0	28.0	0.0	0.0	0.0	0.0	100.0
	Waitohi Rv	Area [km²]	14.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.6	0.0	15.0
		% cover	95.4	0.0	0.0	0.3	0.4	0.0	0.0	0.0	3.8	0.1	100.0
	Graham Rv	Area [km²]	15.1	0.0	0.0	1.4	0.0	0.5	0.0	0.0	0.0	0.0	17.0
		% cover	88.6	0.0	0.0	8.2	0.0	3.2	0.0	0.0	0.0	0.0	100.0
Rai/Pelorus	Opouri Rv	Area [km²]	46.5	0.0	0.2	10.2	0.7	12.5	0.0	0.0	0.0	0.0	70.3
		% cover	66.2	0.0	0.3	14.6	1.1	17.8	0.0	0.0	0.0	0.0	100.0
	Ronga Rv	Area [km²]	21.1	0.0	0.0	3.2	0.4	7.9	0.0	0.0	0.0	0.0	32.7
		% cover	64.6	0.0	0.0	9.9	1.3	24.1	0.0	0.0	0.0	0.0	100.0
	Rai Rv	Area [km²]	122.3	0.0	0.5	35.3	5.1	46.6	0.0	0.0	0.0	0.1	209.9
		% cover	58.2	0.0	0.2	16.8	2.4	22.2	0.0	0.0	0.0	0.0	100.0
	Upper Pelorus	Area [km²]	346.6	1.8	2.6	17.8	1.8	5.6	0.0	0.0	0.0	0.5	376.6
		% cover	92.0	0.5	0.7	4.7	0.5	1.5	0.0	0.0	0.0	0.1	100.0
	Wakamarina Rv	Area [km²]	159.0	0.4	0.5	21.4	0.8	5.2	0.0	0.0	0.0	0.4	187.7
		% cover	84.7	0.2	0.3	11.4	0.4	2.7	0.0	0.0	0.0	0.2	100.0
	Lower Pelorus	Area [km²]	667.2	2.2	3.9	98.1	8.9	74.9	0.0	0.0	0.0	2.1	857.5
		% cover	77.8	0.3	0.5	11.4	1.0	8.7	0.0	0.0	0.0	0.3	100.0

			Native Forest and Shrub	Tall Tussock	Rock and Gravels	Production Forest	Other Exotic Forest and Shrub	Pasture	Vinyard/ Orchad	Crop	Residential	Other	TOTAL
Upper and Mid Wairau	Upper Wairau	Area [km^2]	229.8	145.3	98.7	0.0	0.0	40.0	0.0	0.0	0.0	3.9	517.8
		% cover	44.4	28.1	19.1	0.0	0.0	7.7	0.0	0.0	0.0	0.8	100.0
	Branch Rv	Area [km^2]	404.6	47.2	30.7	42.2	1.4	21.2	0.0	0.0	0.0	3.6	551.0
		% cover	73.4	8.6	5.6	7.7	0.3	3.9	0.0	0.0	0.0	0.7	100.0
	Mill Ck	Area [km^2]	0.3	0.0	0.1	0.5	0.1	18.7	0.1	0.0	0.0	0.0	19.8
		% cover	1.5	0.0	0.4	2.6	0.3	94.6	0.6	0.0	0.0	0.0	100.0
	Mid Waihopai	Area [km^2]	290.5	96.6	46.9	62.4	7.4	232.7	0.1	0.0	0.0	1.2	737.8
		% cover	39.4	13.1	6.4	8.5	1.0	31.5	0.0	0.0	0.0	0.2	100.0
	Lower Waihopai	Area [km^2]	292.0	96.6	48.6	64.5	10.4	250.0	5.6	0.0	0.0	2.0	769.7
		% cover	37.9	12.6	6.3	8.4	1.3	32.5	0.7	0.0	0.0	0.3	100.0
Lower Wairau	Are Are Creek	Area [km^2]	5.5	0.0	0.0	14.8	0.4	8.6	1.8	0.2	0.1	0.0	31.4
		% cover	17.6	0.0	0.1	47.0	1.4	27.3	5.6	0.6	0.3	0.0	100.0
	Spring Ck	Area [km^2]	0.0	0.0	0.0	0.0	0.1	1.8	9.8	1.8	0.3	0.1	13.9
		% cover	0.0	0.0	0.0	0.0	0.7	12.8	70.7	12.9	2.4	0.5	100.0
	Tuamarina Rv	Area [km^2]	39.5	0.0	0.0	37.4	3.5	18.8	0.7	1.0	0.2	0.7	101.8
		% cover	38.8	0.0	0.0	36.8	3.5	18.4	0.6	1.0	0.2	0.7	100.0
	Onamalutu Rv	Area [km^2]	29.4	0.0	0.0	33.9	0.5	6.6	0.0	0.0	0.0	0.0	70.4
		% cover	41.8	0.0	0.1	48.1	0.7	9.4	0.0	0.0	0.0	0.0	100.0
	Wairau Diversion	Area [km^2]	1649.2	350.3	240.5	466.3	49.5	688.5	57.4	9.2	0.6	26.0	3537.5
		% cover	46.6	9.9	6.8	13.2	1.4	19.5	1.6	0.3	0.0	0.7	100.0
	Lower Wairau	Area [km^2]	1596.1	350.3	240.3	419.0	45.6	669.4	55.8	2.2	0.4	24.8	3403.9
		% cover	46.9	10.3	7.1	12.3	1.3	19.7	1.6	0.1	0.0	0.7	100.0

Group	Catchment		Native Forest and Shrub	Tall Tussock	Rock and Gravels	Production Forest	Other Exotic Forest and Shrub	Pasture	Vinyard/ Orchad	Crop	Residential	Other	TOTAL
Opawa Complex	Omaka Rv	Area [km^2]	56.5	7.3	0.4	1.9	3.9	43.0	5.4	0.0	0.0	0.1	118.5
		% cover	47.7	6.2	0.4	1.6	3.3	36.3	4.5	0.0	0.0	0.1	100.0
	Mid Opawa	Area [km^2]	64.4	7.3	0.7	7.8	6.8	124.1	75.0	2.7	3.4	0.6	292.9
		% cover	22.0	2.5	0.2	2.7	2.3	42.4	25.6	0.9	1.2	0.2	100.0
	Doctors Ck	Area [km^2]	2.0	0.0	0.0	0.1	0.0	26.5	23.9	0.9	1.1	0.0	54.5
		% cover	3.6	0.0	0.0	0.2	0.1	48.7	43.8	1.6	2.0	0.1	100.0
	Murphys Ck	Area [km^2]	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	1.2	0.0	2.6
		% cover	0.0	0.0	0.0	0.0	0.0	0.6	54.8	0.3	44.3	0.0	100.0
	Taylor Rv	Area [km^2]	26.3	0.0	0.2	10.6	1.2	74.0	26.2	0.9	7.1	0.2	146.7
		% cover	18.0	0.0	0.2	7.2	0.8	50.4	17.8	0.6	4.9	0.1	100.0
	Lower Opawa	Area [km^2]	90.8	7.3	1.0	18.5	8.0	201.6	108.1	3.8	12.6	1.0	452.6
		% cover	20.1	1.6	0.2	4.1	1.8	44.5	23.9	0.8	2.8	0.2	100.0
South Marlborough	Mid Awatere	Area [km^2]	132.3	155.1	0.7	202.7	2.9	488.7	0.0	0.0	0.0	1.4	983.8
		% cover	13.4	15.8	0.1	20.6	0.3	49.7	0.0	0.0	0.0	0.1	100.0
	Black Birch Stm	Area [km^2]	13.9	12.8	0.0	1.1	0.0	2.1	0.0	0.0	0.0	0.0	29.9
		% cover	46.4	43.0	0.0	3.5	0.0	7.1	0.0	0.0	0.0	0.0	100.0
	Lower Awatere	Area [km^2]	263.3	203.6	13.2	223.2	7.1	803.0	39.2	13.9	0.8	5.5	1572.7
		% cover	16.7	12.9	0.8	14.2	0.4	51.1	2.5	0.9	0.1	0.3	100.0
	Flaxbourne Rv	Area [km^2]	29.1	0.0	0.1	0.6	0.2	118.9	0.8	0.2	0.0	0.7	150.6
		% cover	19.3	0.0	0.1	0.4	0.1	78.9	0.5	0.1	0.0	0.5	100.0
	Waima Rv	Area [km^2]	71.0	2.6	0.4	3.5	0.0	77.5	0.7	0.0	0.0	2.5	158.2
		% cover	44.9	1.6	0.3	2.2	0.0	49.0	0.5	0.0	0.0	1.6	100.0

6.4. Laboratory Analysis

	Feb 2007 - Jul 2011 **Environmental Laboratories Services (ELS) Ltd**		Since Aug 2011 **Hill Laboratories Ltd.**	
Parameter	Method Description	Detection Limit	Method Description	Detection Limit
Turbidity	Analysis using a Turbidity meter. APHA 2130 B 21st ed. 2005	0.01 NTU	Analysis using a Hach 2100 Turbidity meter. APHA 2130 B 21st ed. 2005	0.05 NTU
Nitrate Nitrogen	Ion Chromatography following USEPA 300.0 (modified)	0.010 mg/L	Calculation: Nitrite/Nitrate-Nitrogen - Nitrite Nitrogen; Nitrite/Nitrate Nitrogen analysed from filtered sample as total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3- I 21st ed. 2005	0.002 mg/L
Total Ammonical Nitrogen	Flow Injection Autoanalyser following APHA 4500 NH3 H 21st ed. 2005	0.010 mg/L	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4-N + NH_3-N). APHA 4500-NH3 F (modified from manual analysis) 21st ed. 2005	0.010 mg.L
Soluble Inorganic Nitrogen	Calculation NH_4-N + NO_3-N + NO_2-N	0.010 mg/L	Calculation NH_4-N + NO_3-N + NO_2-N	0.010 mg/L
Dissolved Reactive Phosphorus	Flow Injection Autoanalyser following APHA 4500-P G 21st ed. 2005	0.005 mg/L	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st ed. 2005	0.004 mg/L
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005	0.1	pH meter. APHA 4500-H^+ B 21st ed. 2005	0.1
E. coli	APHA 9222G 21st ed. 2005	1 cfu/100mL	Membrane filtration. Count on mFC agar, incubated at 44.5°C for 22 hours, MUG Confirmation. APHA 9222 G, 22nd ed. 2012	1 cfu/100mL
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005/US EPA 200.8	0.002 mg/L	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005/US EPA 200.8	0.0011 mg/L
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005/US EPA 200.8	0.002 mg/L	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005/US EPA 200.8	0.00053 mg/L
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005/US EPA 200.8	0.005 mg/L	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005/US EPA 200.8	0.0011 mg/L
Filtration	Sample filtration through 0.45µm membrane filter		Sample filtration through 0.45µm membrane filter	

6.5. Summary Statistics

Turbidity [NTU]

Report Region	Short Site Name	Number of Samples	Minimum	25th Percentile	Median	75th Percentile	Maximum
Marlborough Sounds	Graham Rv	36	0.2	0.6	0.7	1.6	330.0
	Kenepuru Rv	36	0.3	0.5	0.8	1.7	4.3
	Waitohi Rv	36	0.4	0.9	1.6	2.1	75.0
	Cullen Ck	36	0.3	0.7	1.4	2.1	62.0
	Kaituna Rv	36	0.2	0.4	0.6	1.5	22.0
	Linkwater Stm	36	0.4	1.3	1.9	3.5	28.0
Rai and Pelorus	Wakamarina Rv	32	0.2	0.3	0.4	0.8	76.0
	Upper Pelorus	31	0.2	0.3	0.4	1.4	119.0
	Lower Pelorus	33	0.2	0.4	0.8	1.2	114.0
	Opouri Rv	33	0.2	0.3	0.4	0.9	52.0
	Rai Rv	32	0.3	0.5	0.8	1.3	98.0
	Ronga Rv	33	0.1	0.4	0.6	1.6	66.0
Upper and Mid Wairau	Branch Rv	27	0.4	0.6	1.1	2.6	480.0
	Upper Wairau	38	0.3	0.6	1.3	6.3	680.0
	Mill Ck	26	0.6	1.5	2.1	2.8	10.4
	Lower Waihopai	34	0.6	1.1	2.1	9.9	1300.0
	Mid Waihopai	34	0.6	1.0	2.6	14.7	1340.0
Lower Wairau	Onamalutu Rv	35	0.4	0.6	1.4	2.7	45.0
	Spring Ck	32	0.4	0.5	0.7	1.0	12.6
	Lower Wairau	35	0.5	0.9	1.2	9.1	326.0
	Are Are Ck	33	0.5	1.5	2.3	3.8	48.0
	Tuamarina Rv	30	0.9	2.1	2.5	9.0	2200.0
	Wairau Div	31	1.4	2.6	6.6	16.7	3400.0
Opawa Complex	Lower Opawa	31	0.9	1.3	2.0	4.0	250.0
	Mid Opawa	31	0.8	2.4	5.3	11.3	470.0
	Omaka Rv	34	0.2	0.3	0.5	1.1	4.3
	Taylor Rv	31	0.7	1.4	2.5	4.5	280.0
	Murphys Ck	30	0.2	0.4	0.6	1.5	5.4
	Doctors Ck	28	1.8	3.2	4.7	7.5	210.0
South Marlborough	Black Birch Stm	25	0.1	0.2	0.2	0.4	37.0
	Waima Rv	30	0.2	0.4	0.6	1.3	67.0
	Flaxbourne Rv	31	0.4	1.1	1.6	3.2	70.0
	Mid Awatere	33	1.0	4.3	18.1	139.0	2800.0
	Lower Awatere	34	1.5	6.0	17.6	115.0	2700.0

E. coli [cfu/100mL]

Report Region	Short Site Name	Number of Samples	Minimum	25th Percentile	Median	75th Percentile	Maximum
Marlborough Sounds	Graham Rv	36	0	18	44	90	4500
	Kenepuru Rv	36	34	98	150	270	3100
	Waitohi Rv	36	29	52	125	305	2600
	Cullen Ck	36	20	90	310	735	23000
	Kaituna Rv	36	16	115	150	395	1300
	Linkwater Stm	36	15	85	160	310	4800
Rai and Pelorus	Wakamarina Rv	32	2	13	19	36	1000
	Upper Pelorus	31	0	11	17	32	700
	Lower Pelorus	33	2	15	24	48	3000
	Opouri Rv	33	14	31	50	120	3100
	Rai Rv	32	20	38	60	130	6300
	Ronga Rv	33	23	67	110	210	2300
Upper and Mid Wairau	Branch Rv	27	0	2	3	8	110
	Upper Wairau	38	0	2	4	9	201
	Mill Ck	26	20	100	120	250	1800
	Lower Waihopai	34	0	4	12	47	2800
	Mid Waihopai	34	2	15	30	60	1700
Lower Wairau	Onamalutu Rv	35	13	33	70	190	3000
	Spring Ck	32	18	52	95	140	10000
	Lower Wairau	35	0	1	9	38	548
	Are Are Ck	33	0	110	250	600	3200
	Tuamarina Rv	30	20	40	85	240	5200
	Wairau Div	31	0	48	80	240	2900
Opawa Complex	Lower Opawa	31	15	27	47	100	1800
	Mid Opawa	31	27	50	110	190	1700
	Omaka Rv	34	0	6	13	25	10000
	Taylor Rv	31	40	100	180	240	4200
	Murphys Ck	30	12	29	48	140	600
	Doctors Ck	28	80	295	405	500	14000
South Marlborough	Black Birch Stm	34	0	0	0	2	13
	Waima Rv	30	2	17	30	69	600
	Flaxbourne Rv	31	29	80	170	290	2800
	Mid Awatere	33	1	8	15	40	4000
	Lower Awatere	34	0	12	27	50	2100

Soluble Inorganic Nitrogen [mg/L]

Report Region	Short Site Name	Number of Samples	Minimum	25th Percentile	Median	75th Percentile	Maximum
Marlborough Sounds	Graham Rv	36	0.005	0.027	0.033	0.066	0.149
	Kenepuru Rv	36	0.014	0.081	0.125	0.193	0.310
	Waitohi Rv	36	0.002	0.006	0.023	0.049	0.092
	Cullen Ck	36	0.048	0.186	0.265	0.344	0.449
	Kaituna Rv	36	0.230	0.555	0.715	0.835	1.240
	Linkwater Stm	36	0.005	0.325	0.405	0.455	0.859
Rai and Pelorus	Wakamarina Rv	32	0.003	0.007	0.019	0.038	0.061
	Upper Pelorus	31	0.002	0.005	0.025	0.044	0.074
	Lower Pelorus	33	0.057	0.149	0.220	0.300	0.400
	Opouri Rv	33	0.230	0.330	0.420	0.530	0.760
	Rai Rv	32	0.171	0.465	0.590	0.675	0.960
	Ronga Rv	33	0.230	0.570	0.720	0.790	1.010
Upper and Mid Wairau	Branch Rv	27	0.003	0.005	0.015	0.038	0.069
	Upper Wairau	38	0.002	0.005	0.011	0.029	0.102
	Mill Ck	26	0.640	0.950	1.414	1.860	2.115
	Lower Waihopai	34	0.002	0.011	0.040	0.168	0.360
	Mid Waihopai	34	0.002	0.005	0.027	0.151	0.300
Lower Wairau	Onamalutu Rv	35	0.016	0.082	0.154	0.230	0.360
	Spring Ck	32	0.005	0.116	0.146	0.239	0.470
	Lower Wairau	35	0.006	0.023	0.039	0.137	0.282
	Are Are Ck	33	0.294	0.600	0.696	0.829	1.051
	Tuamarina Rv	30	0.010	0.047	0.237	0.490	0.805
	Wairau Div	31	0.005	0.056	0.137	0.210	0.666
Opawa Complex	Lower Opawa	31	0.005	0.400	0.540	0.630	0.780
	Mid Opawa	31	0.002	0.005	0.010	0.168	0.750
	Omaka Rv	34	0.004	0.028	0.092	0.196	0.430
	Taylor Rv	31	0.482	0.780	0.880	0.920	1.144
	Murphys Ck	30	0.005	0.910	1.003	1.090	1.400
	Doctors Ck	28	0.533	0.691	0.795	1.011	1.410
South Marlborough	Black Birch Stm	35	0.000	0.010	0.018	0.020	0.095
	Waima Rv	35	0.000	0.024	0.075	0.114	0.282
	Flaxbourne Rv	31	0.005	0.016	0.089	0.165	0.582
	Mid Awatere	33	0.001	0.005	0.012	0.035	0.112
	Lower Awatere	34	0.002	0.005	0.012	0.102	0.260

Dissolved Reactive Phosphorus [mg/L]

Report Region	Short Site Name	Number of Samples	Minimum	25th Percentile	Median	75th Percentile	Maximum
Marlborough Sounds	Graham Rv	35	0.001	0.009	0.011	0.012	0.017
	Kenepuru Rv	36	0.001	0.004	0.006	0.007	0.016
	Waitohi Rv	36	0.001	0.007	0.009	0.011	0.015
	Cullen Ck	36	0.001	0.012	0.014	0.016	0.090
	Kaituna Rv	36	0.001	0.005	0.008	0.011	0.017
	Linkwater Stm	36	0.001	0.011	0.013	0.015	0.034
Rai and Pelorus	Wakamarina Rv	32	0.001	0.006	0.008	0.009	0.011
	Upper Pelorus	31	0.001	0.001	0.005	0.007	0.011
	Lower Pelorus	33	0.001	0.001	0.004	0.007	0.013
	Opouri Rv	33	0.001	0.008	0.008	0.009	0.018
	Rai Rv	32	0.001	0.001	0.005	0.008	0.032
	Ronga Rv	33	0.001	0.005	0.007	0.008	0.021
Upper and Mid Wairau	Branch Rv	27	0.004	0.005	0.006	0.007	0.018
	Upper Wairau	38	0.001	0.003	0.003	0.005	0.009
	Mill Ck	26	0.008	0.011	0.013	0.014	0.021
	Lower Waihopai	34	0.001	0.004	0.006	0.008	0.033
	Mid Waihopai	34	0.001	0.006	0.008	0.009	0.016
Lower Wairau	Onamalutu Rv	35	0.001	0.002	0.006	0.007	0.009
	Spring Ck	32	0.001	0.008	0.010	0.012	0.064
	Lower Wairau	35	0.001	0.002	0.004	0.006	0.013
	Are Are Ck	33	0.001	0.010	0.013	0.018	0.050
	Tuamarina Rv	30	0.008	0.015	0.020	0.022	0.055
	Wairau Div	31	0.001	0.008	0.014	0.015	0.028
Opawa Complex	Lower Opawa	31	0.004	0.009	0.013	0.015	0.032
	Mid Opawa	31	0.001	0.001	0.002	0.006	0.026
	Omaka Rv	34	0.001	0.001	0.004	0.005	0.085
	Taylor Rv	31	0.004	0.010	0.013	0.015	0.048
	Murphys Ck	30	0.001	0.008	0.010	0.011	0.018
	Doctors Ck	28	0.007	0.018	0.021	0.025	0.184
South Marlborough	Black Birch Stm	30	0.008	0.012	0.013	0.014	0.027
	Waima Rv	30	0.001	0.001	0.002	0.005	0.026
	Flaxbourne Rv	31	0.001	0.002	0.007	0.014	0.052
	Mid Awatere	33	0.001	0.006	0.008	0.009	0.036
	Lower Awatere	34	0.001	0.004	0.006	0.010	0.018

Nitrate Nitrogen [mg/L]

Report Region	Short Site Name	Number of Samples	Minimum	25th Percentile	Median	75th Percentile	Maximum
Marlborough Sounds	Graham Rv	36	0.005	0.025	0.033	0.066	0.112
	Kenepuru Rv	36	0.011	0.068	0.124	0.191	0.310
	Waitohi Rv	36	0.002	0.005	0.019	0.037	0.076
	Cullen Ck	36	0.047	0.182	0.265	0.340	0.450
	Kaituna Rv	36	0.002	0.525	0.700	0.830	1.290
	Linkwater Stm	36	0.005	0.325	0.400	0.455	0.860
Rai and Pelorus	Wakamarina Rv	32	0.002	0.006	0.015	0.037	0.061
	Upper Pelorus	31	0.001	0.005	0.024	0.044	0.072
	Lower Pelorus	33	0.055	0.147	0.220	0.300	0.400
	Opouri Rv	33	0.230	0.330	0.410	0.530	0.720
	Rai Rv	32	0.170	0.460	0.590	0.665	0.890
	Ronga Rv	33	0.260	0.590	0.720	0.800	1.010
Upper and Mid Wairau	Branch Rv	27	0.003	0.005	0.013	0.038	0.063
	Upper Wairau	38	0.001	0.004	0.009	0.028	0.093
	Mill Ck	26	0.640	0.950	1.435	1.860	2.100
	Lower Waihopai	34	0.002	0.010	0.036	0.167	0.360
	Mid Waihopai	34	0.001	0.005	0.027	0.144	0.290
Lower Wairau	Onamalutu Rv	35	0.001	0.071	0.153	0.230	0.360
	Spring Ck	32	0.078	0.117	0.160	0.255	0.410
	Lower Wairau	35	0.005	0.020	0.032	0.132	0.280
	Are Are Ck	33	0.260	0.590	0.670	0.830	1.010
	Tuamarina Rv	30	0.009	0.059	0.240	0.490	0.780
	Wairau Div	31	0.005	0.040	0.134	0.200	0.600
Opawa Complex	Lower Opawa	31	0.240	0.390	0.560	0.660	0.860
	Mid Opawa	31	0.002	0.005	0.049	0.186	0.830
	Omaka Rv	34	0.004	0.026	0.091	0.194	0.430
	Taylor Rv	31	0.440	0.790	0.880	0.930	1.130
	Murphys Ck	30	0.820	0.930	1.010	1.110	1.400
	Doctors Ck	28	0.520	0.690	0.800	1.000	1.400
South Marlborough	Black Birch Stm	34	0.000	0.012	0.017	0.020	0.089
	Waima Rv	30	0.003	0.014	0.069	0.113	0.260
	Flaxbourne Rv	31	0.004	0.017	0.083	0.165	0.550
	Mid Awatere	33	0.003	0.005	0.010	0.035	0.116
	Lower Awatere	34	0.002	0.005	0.011	0.101	0.260

Total Ammonical Nitrogen [mg/L]

Report Region	Short Site Name	Number of Samples	Minimum	25th Percentile	Median	75th Percentile	Maximum
Marlborough Sounds	Graham Rv	36	0.003	0.003	0.003	0.003	0.048
	Kenepuru Rv	36	0.003	0.003	0.003	0.003	0.063
	Waitohi Rv	36	0.003	0.003	0.003	0.003	0.062
	Cullen Ck	36	0.003	0.003	0.003	0.003	0.063
	Kaituna Rv	35	0.003	0.003	0.003	0.003	0.020
	Linkwater Stm	36	0.003	0.003	0.003	0.008	0.023
Rai and Pelorus	Wakamarina Rv	32	0.003	0.003	0.003	0.003	0.012
	Upper Pelorus	31	0.003	0.003	0.003	0.003	0.007
	Lower Pelorus	33	0.003	0.003	0.003	0.003	0.007
	Opouri Rv	33	0.003	0.003	0.003	0.003	0.006
	Rai Rv	32	0.003	0.003	0.003	0.003	0.027
	Ronga Rv	33	0.003	0.003	0.003	0.003	0.009
Upper and Mid Wairau	Branch Rv	27	0.003	0.003	0.003	0.003	0.023
	Upper Wairau	38	0.001	0.001	0.002	0.003	0.009
	Mill Ck	26	0.003	0.003	0.003	0.003	0.015
	Lower Waihopai	34	0.003	0.003	0.003	0.003	0.014
	Mid Waihopai	34	0.003	0.003	0.003	0.003	0.010
Lower Wairau	Onamalutu Rv	35	0.003	0.003	0.003	0.003	0.013
	Spring Ck	32	0.003	0.003	0.003	0.003	0.040
	Lower Wairau	35	0.001	0.002	0.003	0.004	0.010
	Are Are Ck	33	0.003	0.003	0.003	0.017	0.105
	Tuamarina Rv	30	0.003	0.003	0.003	0.003	0.027
	Wairau Div	31	0.003	0.003	0.005	0.020	0.146
Opawa Complex	Lower Opawa	31	0.003	0.003	0.003	0.003	0.079
	Mid Opawa	31	0.003	0.003	0.003	0.003	0.010
	Omaka Rv	34	0.003	0.003	0.003	0.003	0.117
	Taylor Rv	31	0.003	0.003	0.003	0.011	0.022
	Murphys Ck	30	0.003	0.003	0.003	0.003	0.017
	Doctors Ck	28	0.003	0.003	0.003	0.014	0.048
South Marlborough	Black Birch Stm	28	0.000	0.000	0.000	0.000	0.018
	Waima Rv	32	0.000	0.000	0.000	0.000	0.012
	Flaxbourne Rv	31	0.003	0.003	0.003	0.003	0.032
	Mid Awatere	33	0.003	0.003	0.003	0.003	0.009
	Lower Awatere	34	0.003	0.003	0.003	0.003	0.011

pH

Report Region	Short Site Name	Number of Samples	Minimum	25th Percentile	Median	75th Percentile	Maximum
Marlborough Sounds	Graham Rv	36	6.8	7.2	7.3	7.4	7.6
	Kenepuru Rv	36	6.9	7.1	7.2	7.2	7.5
	Waitohi Rv	36	7.0	7.4	7.6	7.8	8.3
	Cullen Ck	36	6.8	7.0	7.1	7.2	7.4
	Kaituna Rv	36	6.9	7.0	7.1	7.3	7.5
	Linkwater Stm	36	6.5	6.8	6.9	7.0	7.3
Rai and Pelorus	Wakamarina Rv	32	6.8	7.2	7.3	7.4	7.6
	Upper Pelorus	31	6.9	7.4	7.5	7.6	7.9
	Lower Pelorus	33	6.9	7.3	7.4	7.5	7.6
	Opouri Rv	33	6.9	7.0	7.1	7.2	7.4
	Rai Rv	32	6.8	7.1	7.3	7.4	7.5
	Ronga Rv	33	6.6	6.8	7.0	7.1	7.4
Upper and Mid Wairau	Branch Rv	27	7.2	7.3	7.5	7.6	7.7
	Upper Wairau	38	7.3	7.5	7.6	7.8	8.2
	Mill Ck	26	7.0	7.2	7.3	7.4	7.6
	Lower Waihopai	34	6.7	7.5	7.6	7.6	7.8
	Mid Waihopai	34	7.3	7.5	7.6	7.7	7.9
Lower Wairau	Onamalutu Rv	35	6.9	7.1	7.2	7.3	7.5
	Spring Ck	32	7.0	7.3	7.3	7.4	7.6
	Lower Wairau	35	7.3	7.5	7.7	7.9	8.4
	Are Are Ck	33	6.9	7.1	7.3	7.4	7.6
	Tuamarina Rv	30	6.9	7.1	7.3	7.4	7.6
	Wairau Div	31	7.0	7.4	7.5	7.5	7.7
Opawa Complex	Lower Opawa	31	7.0	7.5	7.6	7.7	7.8
	Mid Opawa	31	7.4	7.6	7.7	7.8	8.4
	Omaka Rv	34	7.3	7.6	7.7	7.8	7.9
	Taylor Rv	31	6.9	7.2	7.3	7.4	7.8
	Murphys Ck	30	6.6	7.0	7.0	7.1	7.2
	Doctors Ck	28	7.1	7.3	7.4	7.5	7.8
South Marlborough	Black Birch Stm	19	7.0	7.2	7.3	7.4	7.5
	Waima Rv	30	7.9	8.1	8.2	8.2	8.4
	Flaxbourne Rv	31	7.7	8.0	8.0	8.2	8.6
	Mid Awatere	33	7.5	7.8	7.9	7.9	8.1
	Lower Awatere	34	7.7	7.9	8.0	8.1	8.5

Dissolved Oxygen Saturation [%]

Report Region	Short Site Name	Number of Samples	Minimum	25th Percentile	Median	75th Percentile	Maximum
Marlborough Sounds	Graham Rv	34	79.9	97.1	101.4	105.0	119.8
	Kenepuru Rv	34	32.8	96.5	99.2	103.0	116.2
	Waitohi Rv	34	95.3	102.1	109.1	118.0	142.2
	Cullen Ck	34	72.1	94.8	98.2	104.0	116.7
	Kaituna Rv	34	90.5	95.6	97.9	104.7	151.5
	Linkwater Stm	33	67.7	86.8	91.7	97.7	108.3
Rai and Pelorus	Wakamarina Rv	32	94.9	100.2	104.7	110.9	125.7
	Upper Pelorus	31	94.4	97.3	105.8	114.2	124.1
	Lower Pelorus	33	70.5	96.5	101.8	106.3	146.6
	Opouri Rv	33	74.4	94.3	98.1	102.4	111.0
	Rai Rv	32	82.7	97.4	103.8	110.6	123.1
	Ronga Rv	33	67.0	83.8	90.2	94.4	103.6
Upper and Mid Wairau	Branch Rv	27	75.8	96.0	100.6	106.5	122.1
	Upper Wairau	38	99.0	100.4	100.6	100.9	102.5
	Mill Ck	26	76.0	88.2	93.7	101.9	113.1
	Lower Waihopai	34	94.5	98.2	100.2	105.8	119.0
	Mid Waihopai	34	90.5	99.0	100.7	102.2	110.4
Lower Wairau	Onamalutu Rv	35	93.1	95.6	100.1	105.5	113.6
	Spring Ck	32	56.0	71.8	79.8	85.7	120.9
	Lower Wairau	35	98.5	99.6	103.2	106.9	116.8
	Are Are Ck	33	85.9	94.2	99.9	107.0	138.4
	Tuamarina Rv	30	37.9	51.0	63.7	74.7	110.4
	Wairau Div	31	26.9	79.7	86.8	93.4	112.6
Opawa Complex	Lower Opawa	31	67.5	86.5	90.6	105.5	125.1
	Mid Opawa	31	83.3	100.2	104.3	110.8	115.7
	Omaka Rv	34	56.0	91.9	98.0	104.9	131.9
	Taylor Rv	31	67.9	82.8	92.5	102.2	123.8
	Murphys Ck	30	68.9	76.1	80.9	85.7	98.4
	Doctors Ck	28	58.5	85.1	96.8	109.6	148.7
South Marlborough	Black Birch Stm	0					
	Waima Rv	30	78.3	92.0	99.7	108.0	118.6
	Flaxbourne Rv	31	87.6	95.2	112.6	125.2	204.2
	Mid Awatere	33	81.1	96.1	100.7	103.2	112.2
	Lower Awatere	34	84.0	97.6	101.8	106.5	128.3

Water Temperature [°C]

Report Region	Short Site Name	Number of Samples	Minimum	25th Percentile	Median	75th Percentile	Maximum
Marlborough Sounds	Graham Rv	35	7.7	12.1	13.5	17.6	20.3
	Kenepuru Rv	35	8.2	9.6	11.2	13.4	15.7
	Waitohi Rv	35	7.7	10.3	12.0	16.0	22.4
	Cullen Ck	35	6.4	9.8	11.9	13.7	17.3
	Kaituna Rv	35	4.5	10.7	13.4	15.8	19.0
	Linkwater Stm	35	7.0	10.7	12.4	13.5	16.5
Rai and Pelorus	Wakamarina Rv	32	6.1	9.7	12.8	16.0	23.6
	Upper Pelorus	31	5.5	9.4	12.8	16.2	19.8
	Lower Pelorus	33	6.0	10.2	13.1	15.9	20.9
	Opouri Rv	33	9.2	11.2	12.6	13.9	17.5
	Rai Rv	32	8.2	11.0	13.7	15.1	17.9
	Ronga Rv	33	8.9	11.4	13.2	14.8	16.4
Upper and Mid Wairau	Branch Rv	27	3.2	5.7	8.4	12.3	15.8
	Upper Wairau	38	3.8	5.9	8.2	10.7	15.1
	Mill Ck	26	9.3	11.2	12.4	14.3	16.5
	Lower Waihopai	34	4.8	8.8	13.8	19.4	22.5
	Mid Waihopai	34	2.3	7.5	11.6	16.4	19.5
Lower Wairau	Onamalutu Rv	35	7.5	9.8	13.9	16.2	19.4
	Spring Ck	32	11.5	12.6	13.2	13.8	15.3
	Lower Wairau	35	7.5	10.1	14.9	18.6	22.1
	Are Are Ck	33	7.8	11.0	12.5	14.5	22.8
	Tuamarina Rv	30	5.8	10.6	12.1	16.2	18.7
	Wairau Div	31	6.1	10.3	12.4	16.9	19.3
Opawa Complex	Lower Opawa	31	8.5	12.4	14.1	17.2	20.7
	Mid Opawa	31	3.6	9.7	12.2	17.5	21.0
	Omaka Rv	34	7.1	12.2	16.3	18.9	21.3
	Taylor Rv	31	10.8	12.8	13.7	14.8	16.9
	Murphys Ck	30	13.2	13.4	13.6	14.0	14.5
	Doctors Ck	28	10.8	12.3	13.4	15.4	18.0
South Marlborough	Black Birch Stm	0					
	Waima Rv	30	6.8	11.1	13.6	16.2	20.7
	Flaxbourne Rv	31	5.7	10.6	14.0	17.5	22.6
	Mid Awatere	33	2.5	7.1	10.1	14.8	19.1
	Lower Awatere	34	6.3	10.4	14.9	18.6	24.3