MARLBOROUGH DISTRICT COUNCIL

Recreational Water Quality Report 2013-2014

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Executive Summary

Twenty one popular beaches and river sites were sampled weekly from the beginning of November 2013 until the end of March 2014. Samples were analysed for concentrations of faecal indicator bacteria in order to assess the risk to the health of recreational users in regard to water borne diseases.

Except for the Taylor River at Riverside, unsafe faecal bacteria concentrations were generally associated with rainfall or flood events. Four coastal sites had bacteria concentrations below the guideline values during the whole of the season, while another four coastal beaches and six of the river sites had at least one sample with faecal bacteria levels considered unsafe for contact recreation.

Trend analysis showed significant improvements in microbial water quality at a number of sites, particularly the Rai River at Rai Falls. Nevertheless, Suitability for Contact Recreation Grades (SFR Grades) for these sites were not revised as a review had been carried out for all sites in the program last year. If water quality remains at a better state in coming seasons some of the sites could be given a better SFR Grade.

Figure 1: Kayakers at Whites Bay – one of the sites that did not exceed any of the microbial guideline values.

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1. Introduction

Marlborough has a number of beautiful beaches and rivers that are popular with visitors and local residents during the warmer months of the year. Swimming, boating, surfing and fishing are only a few of the many water based recreational activities that take place in the region. The Resource Management Act (RMA 1991) and Health Act require Councils to monitor popular beaches and river locations and assess the risk to human health from faecal contamination. Accidental ingestion of water during recreational activities can result in illness when faecal bacteria concentrations in the water are high. Weekly samples are taken from the beginning of November until the end of March and analysed for faecal indicator bacteria. Results are assessed according to national guidelines published by the Ministry for the Environment [MfE, 2003].

This report presents the results for the samples taken during the summer season of 2013/2014 and investigates long term trends in the microbial water quality where possible. It is important to note that the recreational water quality program is exclusively focused on health based risks associated with faecal contamination and results are not reflective of the general water quality of a site.

2. The Microbiological Water Quality Guidelines

In 2003 the Ministry for the Environment and the Ministry of Health published a Guideline document providing a framework for the monitoring of the microbiological water quality of recreational areas (MfE, 2003). The document provides general recommendations in regard to the management of recreational water quality and guideline values allowing the assessment of results from individual samples. The guidelines also provide a method to evaluate the overall bacterial risk at a site, not just at the time a sample is taken. The Suitability for Contact Recreation Grade (SFR Grade) takes into account the risks of faecal contamination from the surrounding areas and the sampling results over a five year period.

2.1. Guideline values for individual samples

Measuring the concentrations of all microorganisms that can be hazardous for the health of water users (pathogens) is both difficult and expensive. A more cost effective approach to assessing the number of pathogens present is the use of indicator bacteria. These are comparatively easily measured and are generally present when water is contaminated with harmful organisms like Salmonella, Campylobacter, Giardia or Cryptosporidium. Scientific research has shown that high concentrations of indicator bacteria are a sign that there is an increased health risk associated with the use of a water body for contact recreation and the water is potentially contaminated with human sewage or animal faeces.

Two different indicator bacteria are used depending on the type of sample being analysed. Freshwater samples are analysed for the concentration of E. coli while Enterococci are the preferred indicator bacterium for coastal samples. The MfE Guideline document provides two guideline values for each of the indicator bacteria. Based on these guidelines sample results are categorised into three “Modes” which then allow a decision to be made on whether the water can be considered safe for contact recreation. Table 1 outlines these “Modes” and their meaning as well as the actions that need to be taken as a result. In this report the lower limit for the Alert Mode is referred to as Alert Guideline, 260 E. coli/100mL and 140 Enterococci/100mL, while the upper limit for the Alert Mode (lower limit of the Action Mode) is referred to as the Action Guideline, 550 E. coli/100mL and 280 Enterococci/100mL.

Mode	Freshwater E. coli/100mL	Coastal Enterococci/100mL	Meaning	Required Action
Green Mode	<260	<140	Safe for contact recreation	Conitue routine monitoring
	260	140	Alert Guideline	
Alert Mode	260 - 550	140 - 280	Increased risk for health	Investigate possible causes and increase sampling frequency if no cause can be found, otherwise continue routine sampling
	550	280	Action Guideline	
Action Mode	>550	>280	Unsafe for conctact recreation	Increase sampling frequency and warn the public that the beach is considered unsafe (Warning signs at site)[1]

Table 1: Modes and the corresponding Guidelines as outlined by the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (2003).[1]

The process followed when samples are in the Alert or Action Mode is described in Chapter 3.

2.2. Suitability for Contact Recreation Grades

Suitability for Contact Recreation Grades (SFR Grades) provide an overall measure for the microbial water quality of a beach or river site. The Grades are based on a 'reasonable risk' approach in regard to the possibility of contracting a water borne disease associated with faecal contamination when pursuing recreational activities in and around the water.

The SFR Grade is the combination of a catchment assessment (Sanitary Inspection Category, SIC) and an assessment of the Microbiological Water Quality (Microbiological Assessment Category, MAC).

The catchment assessment is primarily focused on potential sources of faecal contamination. Sanitary Inspection Categories (SIC) based on this assessment range from Very Low, Low, Moderate, High to Very High (Risk). Sites surrounded by bush and forest are given a SIC of Very Low. Low intensity agriculture in the catchment results in a SIC of Low. Categories of High and Very High are given to sites which are likely to directly receive treated or untreated sewage or run-off from high-intensity agriculture.

The Microbiological Assessment Category (MAC) is derived from the Enterococci or E. coli concentrations in routine samples taken from a site over five consecutive summers. MACs range from "A" to "D" (Table 2) and are based on the 95th percentile (95%ile) calculated with the Hazen method.

The Sanitary Inspection Category (SIC) and the Microbiological Assessment Category (MAC) for a site are then combined into the Suitability for Contact Recreation Grade (SFR Grade).The SFR Grades range from Very Good, Good, Fair, Poor to Very Poor. Table 3 outlines the definitions for the individual Grades.

[1] For coastal samples the Action Mode is usually only applied after concentrations in two consecutive samples exceed 280 Enterococci/100mL; however if high numbers of people are expected to visit the beach (i.e. Holiday period), a precautionary approach is taken and warning signs are erected after only one Exceedance.

MAC (Microbiological Assessment Category)	Coastal Enterococci/100mL*	Freshwater E. coli/100mL*
A	<41	<131
B	41 - 200	131 - 260
C	201 - 500	261 - 550
D	>500	>550

Table 2: Microbiological Assessment Categories (MAC).
*** upper 95%ile of routine sampling over 5 consecutive summers.**

SFR Grade	Meaning
Very Good	Considered satisfactory for swimming at all times.
Good	Satisfactory for swimming most of the time with exceptions following rainfall.
Fair	Generally satisfactory for swimming. Caution should be taken during periods of high rainfall and swimming avoided if water is discoloured.
Poor	Swimming should be avoided, particularly by the very young, the very old and those with compromised immunity.
Very Poor	Generally swimming is not recommended.

Table 3: Suitability for Contact Recreation Grades and their meaning.

SFR Grades are not indicative of the general water quality at a site as their assignment is purely based on the health risk posed by potential faecal bacteria contamination and does not take into consideration other water quality parameters.

3. Recreational Water Quality Monitoring

The recreational water quality of twelve coastal beaches and nine river sites was monitored from the beginning of November 2012 until the end of March 2013. Samples were taken weekly, usually at the beginning of each week independent of weather conditions and tides. Hill Laboratories in Blenheim was contracted to measure the E. coli or Enterococci concentrations in the samples. Bacteria levels were determined as MPN counts using Enterolert for Enterococci and Colilert for E. coli after 24 hour incubation at 41□C and 35□C respectively.

As soon as analysis results were received from the laboratory the Marlborough District Council website (www.marlborough.govt.nz) was updated in order to provide the public with up-to-date information. If bacteria concentrations were above the Alert or Action Guideline (Table 1) possible causes were considered and the District Health Board was informed. A joint decision was then made on how to proceed. Warning signs were usually erected at the site if bacteria levels were above the Action guideline and the site was sampled more frequently until bacteria concentrations were at a low enough level for the water to be considered safe again. A flowchart outlining the process is shown in Appendix 4.

4. Trend Analysis

The change in faecal bacteria concentrations over a period of 10 seasons was analysed (seasons 2004/05 to 2013/14). Only results from routine sampling were used and detection limits were adjusted[2].

The Seasonal Kendall Trend Test was used to find statistically significant changes in faecal indicator bacteria concentrations. The data was divided into five 'seasons', one for each month, to account for the generally drier conditions towards the end of the summer (potentially resulting in a reduced dilution of faecal contaminations). Because exceedances at rivers sites are mostly associated with flood events, the E. coli concentrations measured in rivers were flow adjusted using a LOWESS fit of 30%.

Although the Seasonal Kendall Trend Test provides a statistical method of assessing changes over time, it only recognises consistently downward or upward trends. This means changes in trend during the time period analysed are not picked up, resulting in no trends being found at all (i.e. when an increasing trend turned into a decreasing trend and vice versa). In order to see possible trend changes, the Microbial Assessment Category values (5-year 95%iles) were plotted over time (see Figure 2).

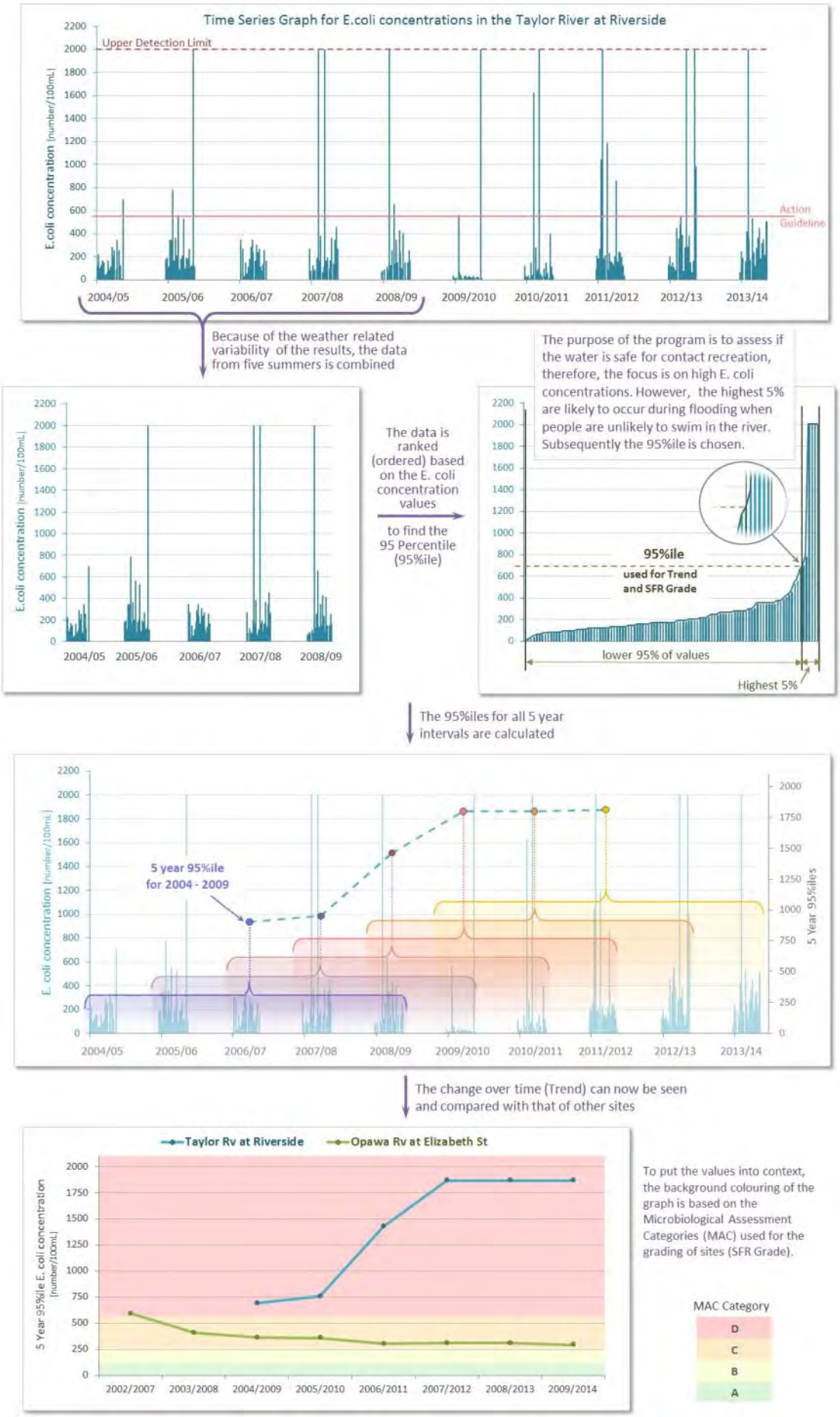
5. Results

The following chapters present the results for this summer as well as changes of faecal bacteria concentrations over time (trends). Where appropriate, sites are grouped into sets of three or two in order to keep the document at a manageable size. For each group the concentration of faecal indicator bacteria in the samples taken from the sites during the summer of 2013/14 is shown together with rainfall and flow data recorded at nearby sites. This allows the results to be viewed with regard to rainfall and flood events. A map shows the location of the sampling sites as well as the rainfall and/or flow recorder. For sites with longer monitoring records, a graph showing the 5-year-95%ile (MAC) values illustrate the changes of microbial water quality over time. Where the Kendall trend analysis indicated statistically significant trends, these are also shown in small graphs beside the MAC graphs. It is important to note that the E. coli concentrations in the Kendall trend graphs are flow adjusted.

Summary tables showing the numerical results for all samples taken this season can be found in the Appendices, along with the results from the Kendall trend analysis. Additionally, Appendix 2 contains graphs showing the compliance history and box and whiskers plots for sites that have been monitored for more than five years.

▶ **Figure 2: Creation of 5-Year-95%ile Graphs.**

[2] Changing detection limits required the adjustment of all data to the lowest higher detection limit of 2000 units/100mL and the highest lower detection limit of 10 units/100mL.


Time Series Graph for E.coli concentrations in the Taylor River at Riverside
Upper Detection Limit
E.coli concentration (number/100mL)
Action Guideline
2004/05
2005/06
2006/07
2007/08
2008/09
2009/2010
2010/2011
2011/2012
2012/13
2013/14
Because of the weather related variability of the results, the data from five summers is combined
The purpose of the program is to assess if the water is safe for contact recreation, therefore, the focus is on high E. coli concentrations. However, the highest 5% are likely to occur during flooding when people are unlikely to swim in the river. Subsequently the 95%ile is chosen.
The data is ranked (ordered) based on the E. coli concentration values
to find the 95 Percentile (95%ile)
95%ile
used for Trend and SFR Grade
lower 95% of values
Highest 5%
The 95%iles for all 5 year intervals are calculated
5 year 95%ile for 2004 - 2009
E. coli concentration (number/100mL)
5 Year 95%iles
The change over time (Trend) can now be seen and compared with that of other sites
Taylor Rv at Riverside
Opawa Rv at Elizabeth St
5 Year 95%ile E. coli concentration (number/100mL)
2002/2007
2003/2008
2004/2009
2005/2010
2006/2011
2007/2012
2008/2013
2009/2014
To put the values into context, the background colouring of the graph is based on the Microbiological Assessment Categories (MAC) used for the grading of sites (SFR Grade).
MAC Category
D
C
B
A

5.1. Moetapu Bay

Site

Moetapu Bay was recently added to the program as a result of a beach usage survey carried out in 2011 [MDC, 2012b]. It is the only site located in the Pelorus Sound and water quality is impacted by the Pelorus River when the river is in flood. A substantial number of homes and batches are located in the catchment of the wider bay; however, samples are taken at a DoC campground with only a limited amount of residential development in the immediate vicinity.

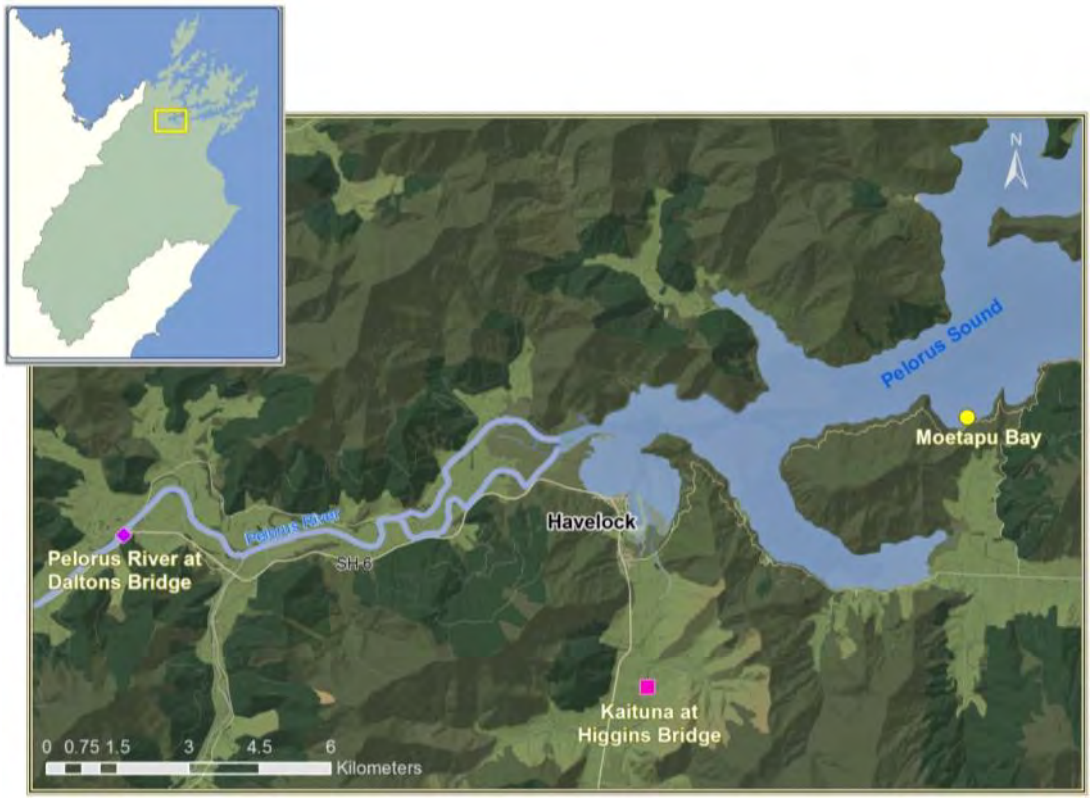


Figure 3: Map of the Moetapu Bay sampling sites and rainfall and flow recorders.

Results

None of the samples taken from Moetapu Bay this summer indicated unsafe concentrations of faecal bacteria at the site. The highest Enterococci concentrations were observed mid-March, during the largest flood of the Pelorus River this season.

Field observations have shown that nearby Double Bay Reserve has a significantly larger number of visitors than the DoC campground where samples are currently taken (Figure 5). Double Bay also has a greater number of homes and batches in the immediate catchment. The greater usage and potentially larger impact of residential development on water quality at the Double Bay Reserve compared to the current sampling site, suggest that a review of the location of the sampling site is advisable. Shifting the site, however, will mean that a SFR Grade for Moetapu Bay cannot be established in the near future. The SFR Grade is important as it provides a measure for the general suitability of the site for contact recreation, since actual sampling of sites is limited to once a week. A possible option is to sample both sites for a limited number of seasons. If water quality is similar at both locations, a SFR Grade can be established using the date from the current site and monitoring continued at Double Bay only. If Enterococci concentrations are significantly different, monitoring should be focused on the site with generally higher faecal contamination.

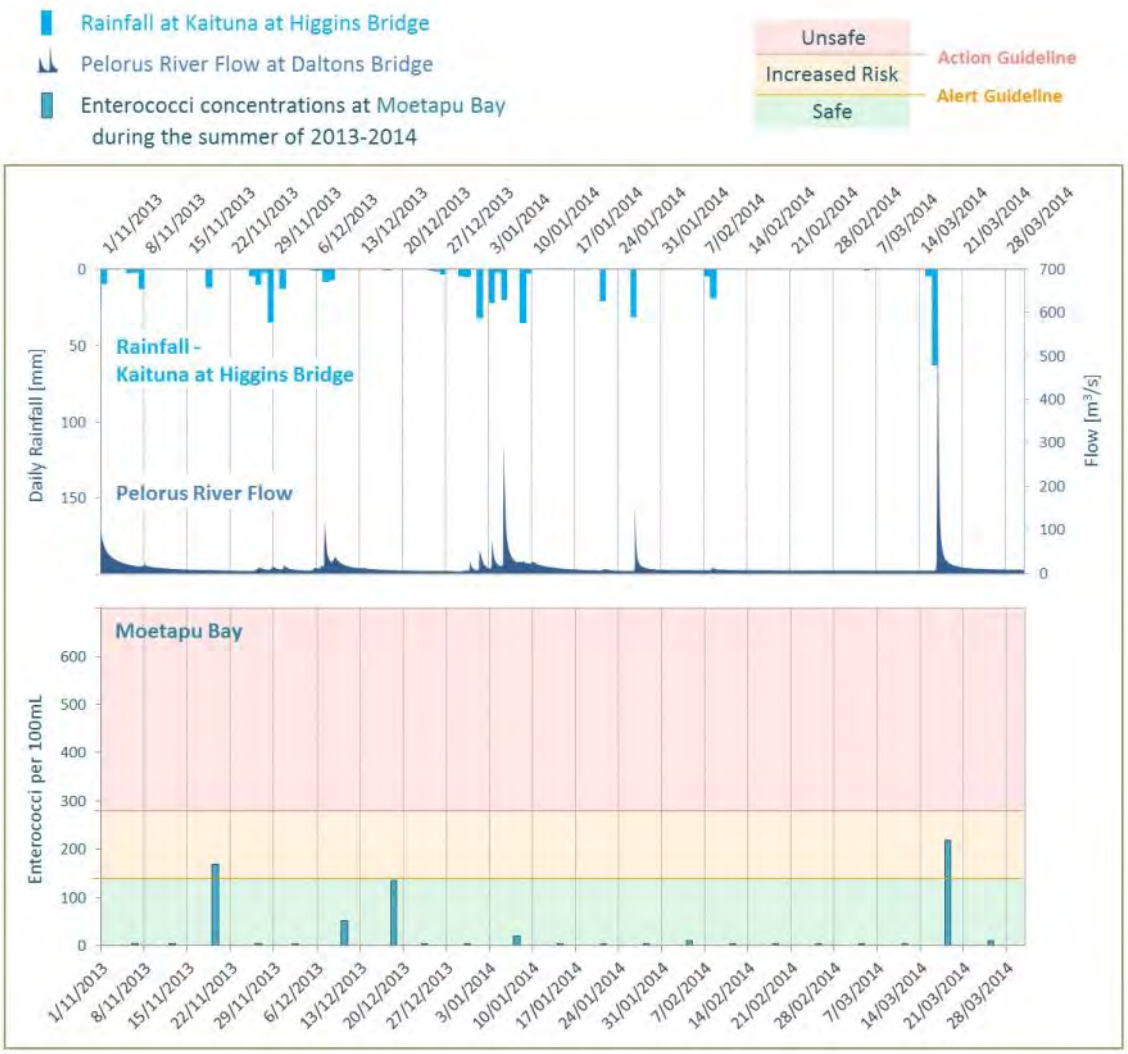


Figure 4: Results for Moetapu Bay for the summer season of 2013/2014.

Figure 5: Double Bay Reserve and current Moetapu Bay sampling site.

5.2. Anakiwa and Mistletoe Bay

Sites

Anakiwa is located in the innermost part of the Queen Charlotte Sound. The microbiological water quality is influenced by the surrounding residential development, but most likely also by Duncan Stream and Ada Creek. Both streams drain farm land including a dairy farm and flow into the Sound less than 2 km from the Anakiwa sampling site. Monthly monitoring of Duncan Stream has shown that water quality is marginal and E. coli concentrations are frequently high [MDC, 2013c].

In contrast, Mistletoe Bay has few possible sources of faecal contamination. The enclosed Bay is surrounded by bush-clad hills with the Mistletoe Bay Trust facility and a few houses the only residential developments in the catchment.

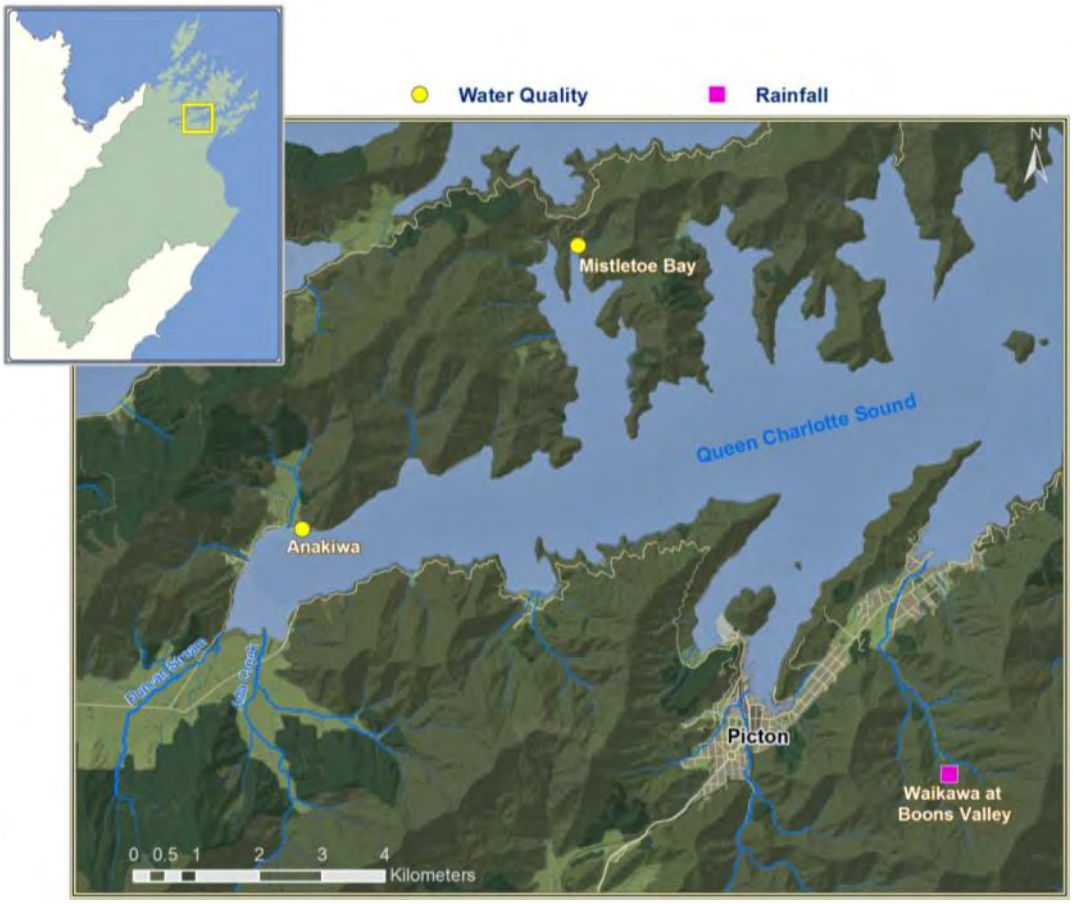


Figure 6: Map of the sampling sites and rainfall recorder.

Results

Despite the greater number of potential sources of faecal contamination in Anakiwa Bay a rainfall event mid-December resulted in very high Enterococci concentrations in Mistletoe Bay while the concentration in Anakiwa did not reach unsafe levels. A second sample containing unsafe faecal bacteria concentrations was taken from Mistletoe Bay during dry conditions. Anecdotal evidence points to boat(s) moored in the bay at the time. Unfortunately illegal dumping of sewage from boats is very difficult to verify unless it is witnessed by coincidence. The occasionally high Enterococci concentrations observed at Mistletoe Bay during rainfall, however, should be investigated with targeted sampling during rainfall events to determine the source of the contamination using faecal source tracking methods.

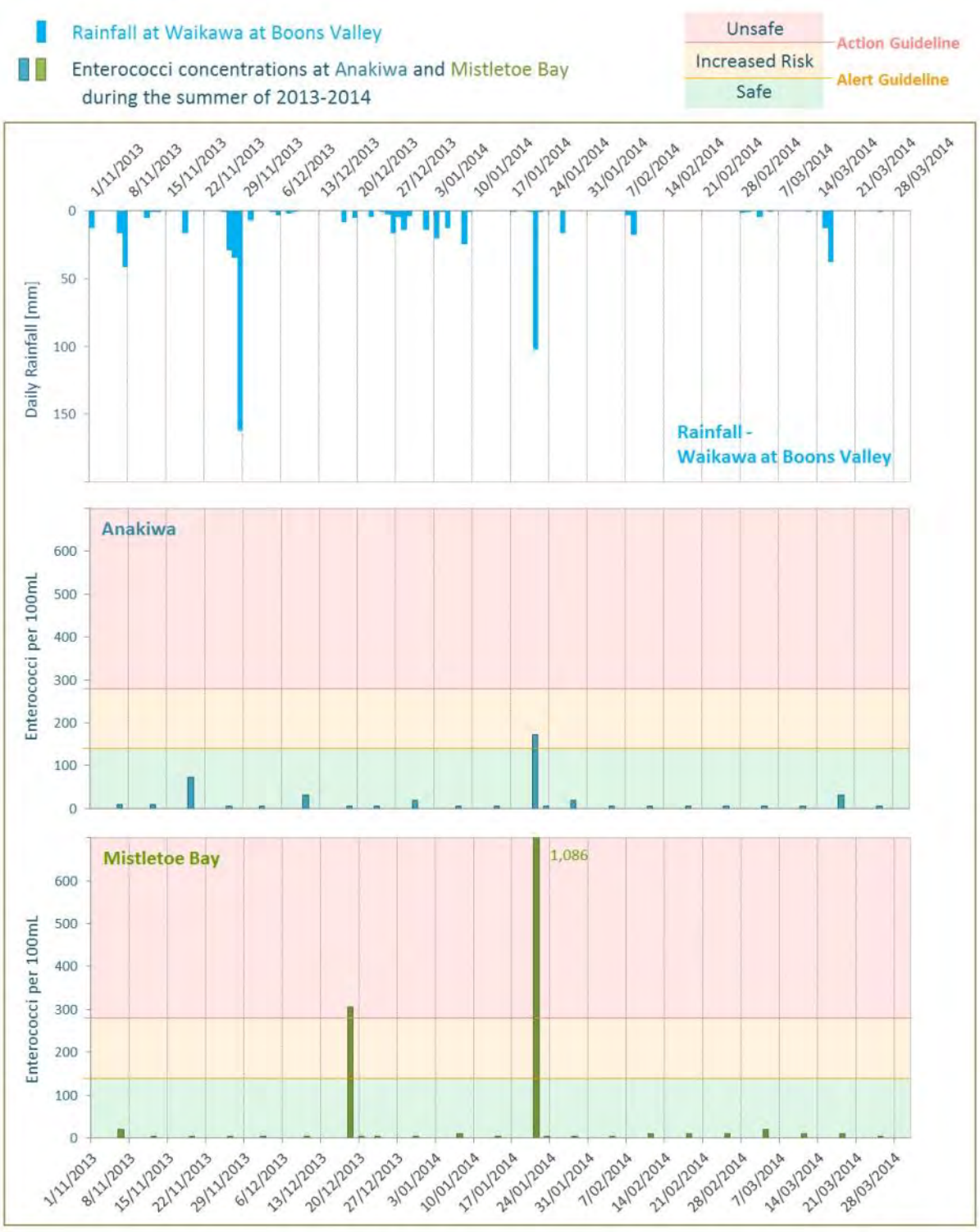


Figure 7: Results for Anakiwa and Mistletoe Bay for the summer season of 2013/2014.

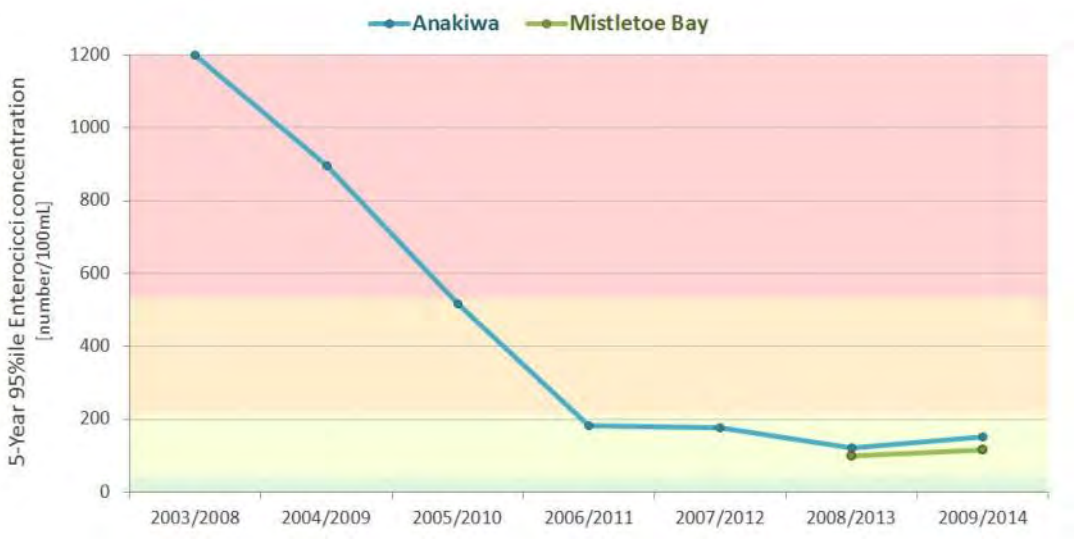


Figure 8: 5-Year-95%iles for Anakiwa and Mistletoe Bay.

There has been a significant reduction in the level of faecal contamination at Anakiwa since 2008 and water quality continued to be good in recent years. The requirement for the fencing of water ways on dairy farms may lead to further reductions in faecal contamination as a result of potential water quality improvement in Duncan Stream and Ada Creek.

Despite the two exceedances of the Alert Guideline at Mistletoe Bay this summer, microbiological water quality remains slightly better than at Anakiwa, resulting in the better SFR Grade of 'Very Good' for Mistletoe Bay compared to a SFR Grade of 'Good' for Anakiwa.

Figure 9: Mistletoe Bay.

5.3. Momorangi, Ngakuta and Governors Bay

Sites

Momorangi Bay, Ngakuta Bay and Governors Bay are neighbouring bays in the Queen Charlotte Sound. Ngakuta Bay is the largest and most enclosed bay in this group with the greatest amount of residential development. There are nearly 100 houses and holiday homes in the catchment compared to less than 20 in Momorangi Bay and none in Governors Bay. Momorangi Bay, however, has a very popular campground which attracts more visitors during the summer months than the other two bays combined.

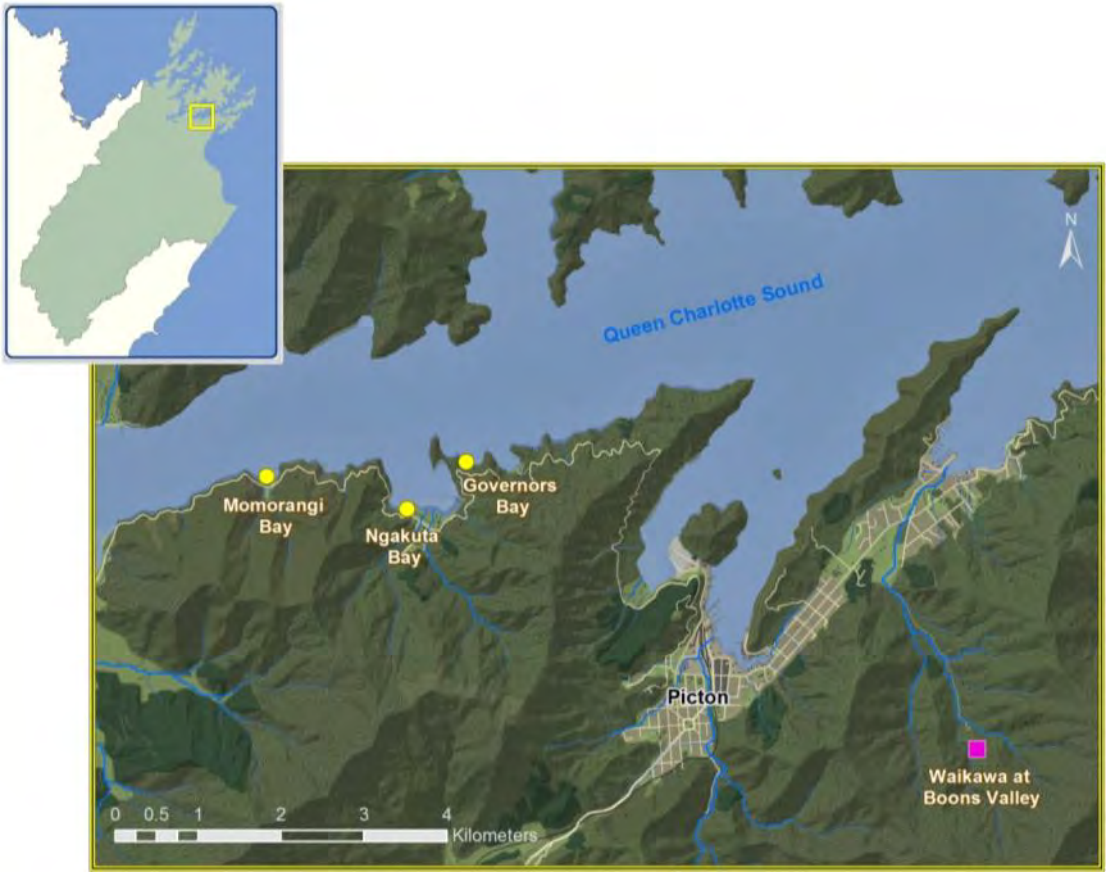


Figure 10: Map of the sampling sites and rainfall recorder.

Results

The only sample with unsafe Enterococci concentration in this group was taken from Momorangi Bay during heavy rainfall. Surprisingly, the same rainfall event did not cause elevated faecal bacteria levels at Ngakuta Bay or Governors Bay. The slightly elevated Enterococci concentration in a sample taken from Governors Bay at the end of the summer season is unusual. However, there may have been a discharge from a boat or a localised rain shower on the day the sample was taken, as a small amount of rainfall was recorded at Waikawa.

▶ **Figure 11: Results for Momorangi, Ngakuta and Governors Bay for the summer season of 2013/2014.**


Rainfall at Waikawa at Boons Valley
Enterococci concentrations at Momorangi Bay, Ngakuta Bay and Governors Bay during the summer of 2013-2014
Unsafe
Increased Risk
Safe
Action Guideline
Alert Guideline
1/11/2013
8/11/2013
15/11/2013
22/11/2013
29/11/2013
6/12/2013
13/12/2013
20/12/2013
27/12/2013
3/01/2014
10/01/2014
17/01/2014
24/01/2014
31/01/2014
7/02/2014
14/02/2014
21/02/2014
28/02/2014
7/03/2014
14/03/2014
21/03/2014
28/03/2014
Daily Rainfall [mm]
0
50
100
150
Rainfall - Waikawa at Boons Valley
Momorangi Bay
1,178
Enterococci per 100mL
0
100
200
300
400
500
600
Ngakuta Bay
Governors Bay

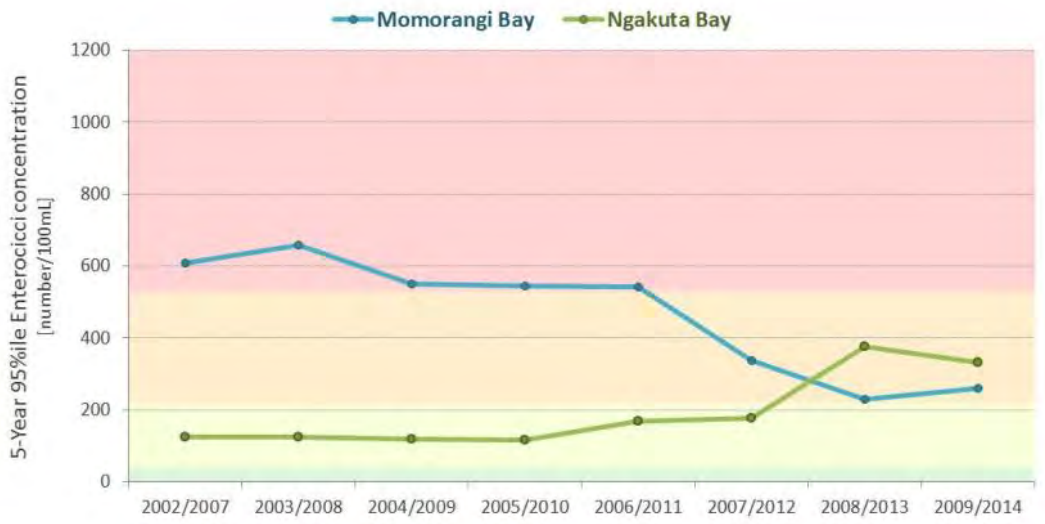


Figure 12: 5-Year-95%iles for Momorangi and Ngakuta Bay.

Generally, Enterococci concentrations in Momorangi Bay have been on a downward trend over the years. Momorangi Bay is also the only coastal site which showed a significant trend in the Kendall Trend Analysis. Microbial Source Tracking carried out in 2011 showed that faecal contamination was neither of human nor ruminant origin and it was concluded that wildfowl might be a major source of faecal bacteria [MDC, 2012a]. Large numbers of ducks could be seen in the Bay in the past and the Department of Conservation has erected signs discouraging the feeding of ducks which, together with the upgrade of the sewage system, are likely contributors to the improvement in microbiological water quality.

In contrast, microbial water quality in Ngakuta Bay was good in the early years of the program, but has since shown some degradation resulting in a change of the SFR Grade last year from 'Very Good' to 'Fair'. According to residents, cattle were grazed on a small farm in the catchment until recently, but have been replaced with horses. Microbial Source Tracking planned for this season was not carried out as Enterococci concentrations remained low the whole summer. There has been a slight reversal in the trend and the coming years will show if change in microbial water quality was only temporary. Should Enterococci concentrations again reach unsafe levels next season, Microbial Source Tracking should still be carried out on samples from the Bay as well as the streams draining the surrounding catchment.

Figure 13: Ngakuta Bay.

5.4. Picton Foreshore and Waikawa Bay

Sites

The water quality of Picton Foreshore and Waikawa Bay are both influenced by the urban environment that surrounds these sites. The substantially greater amount of residential development of the Picton Township is reflected in the poorer water quality at the Foreshore.

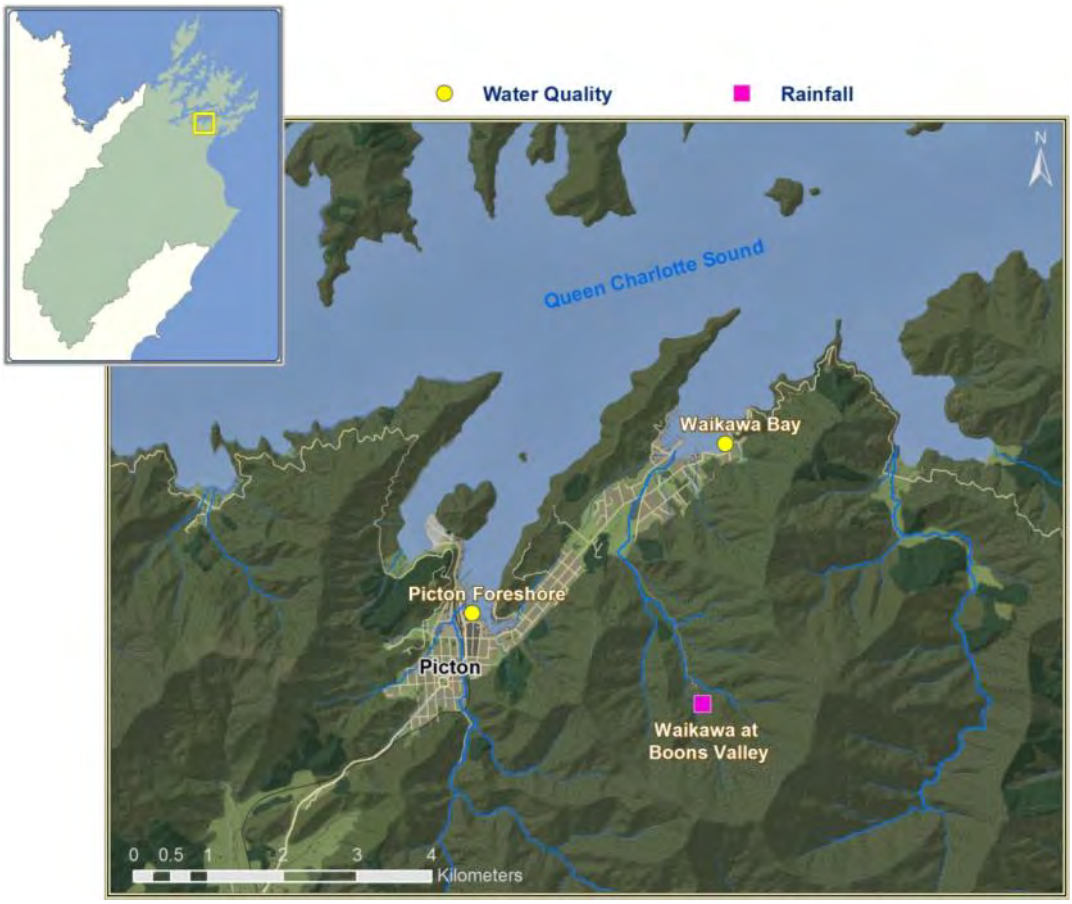


Figure 14: Map of the sampling sites and rainfall recorder.

Results

Four samples taken from the Picton Foreshore this summer had Enterococci concentrations in exceedance of the guidelines. All of these samples were taken shortly after rainfall. Unlike previous season, this summer Enterococci concentrations stayed below guideline values during dry periods. The only sample with unsafe faecal bacteria levels from Waikawa Bay was taken during heavy rainfall.

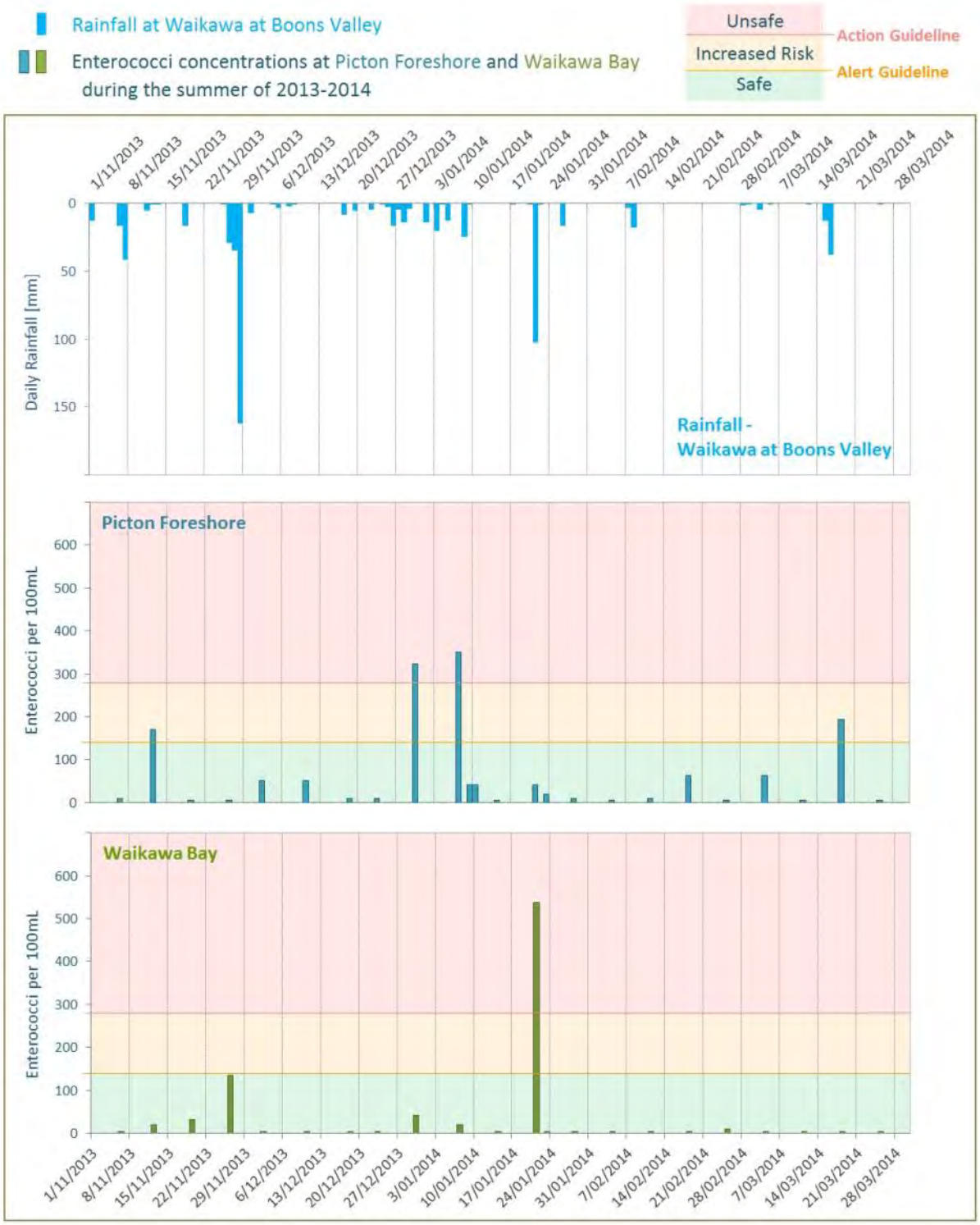


Figure 15: Results for Momorangi, Ngakuta and Governors Bay for the summer season of 2013/2014.

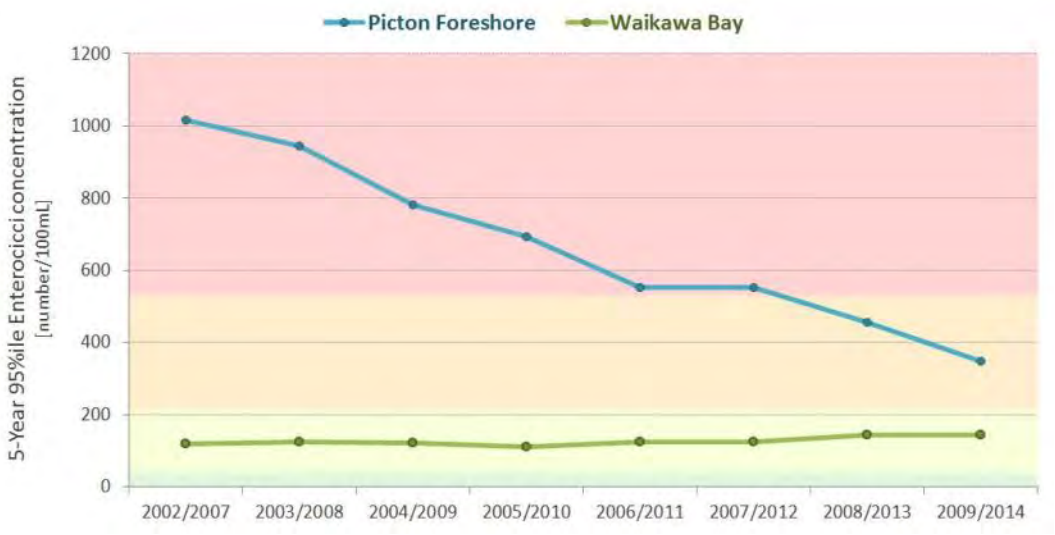


Figure 16: 5-Year-95%iles for Picton Foreshore and Waikawa Bay.

The 5-year 95%ile values show a continued downward trend for Enterococci concentrations at the Picton Foreshore[3]. This is the result of great efforts by the Assets and Services Department of the Council in tracking down and repairing damaged sewers and cross-connections between sewer and stormwater pipes. The planned Picton sewer upgrade will also result in a significant reduction of overflows during heavy rainfall events leading to further improvements of the water quality at the Picton Foreshore. A review of the SFR Grades carried out last season resulted in a better grade for this site.

Microbial water quality at Waikawa Bay has not changed significantly over the years and the site continuous to have a SFR Grade of 'Good'.

[3] The improvement shown by the 5-year-95%ile (MAC) values might seem odd when viewed in the light of the exceedance history shown in Appendix 2. However, the calculation of the MAC value combines 5 years of data and removes the highest 5% of the values (see Figure 2) as it is assumed that people will not swim during large flood events. Therefore, although there have been as many exceedances in recent years as there were several years ago, the actual Enterococci concentrations measured during most of these events have reduced substantially.

Figure 17: Picton Foreshore.

Figure 18: Waikawa Bay.

5.5. Whites Bay and Robin Hood Bay

Sites

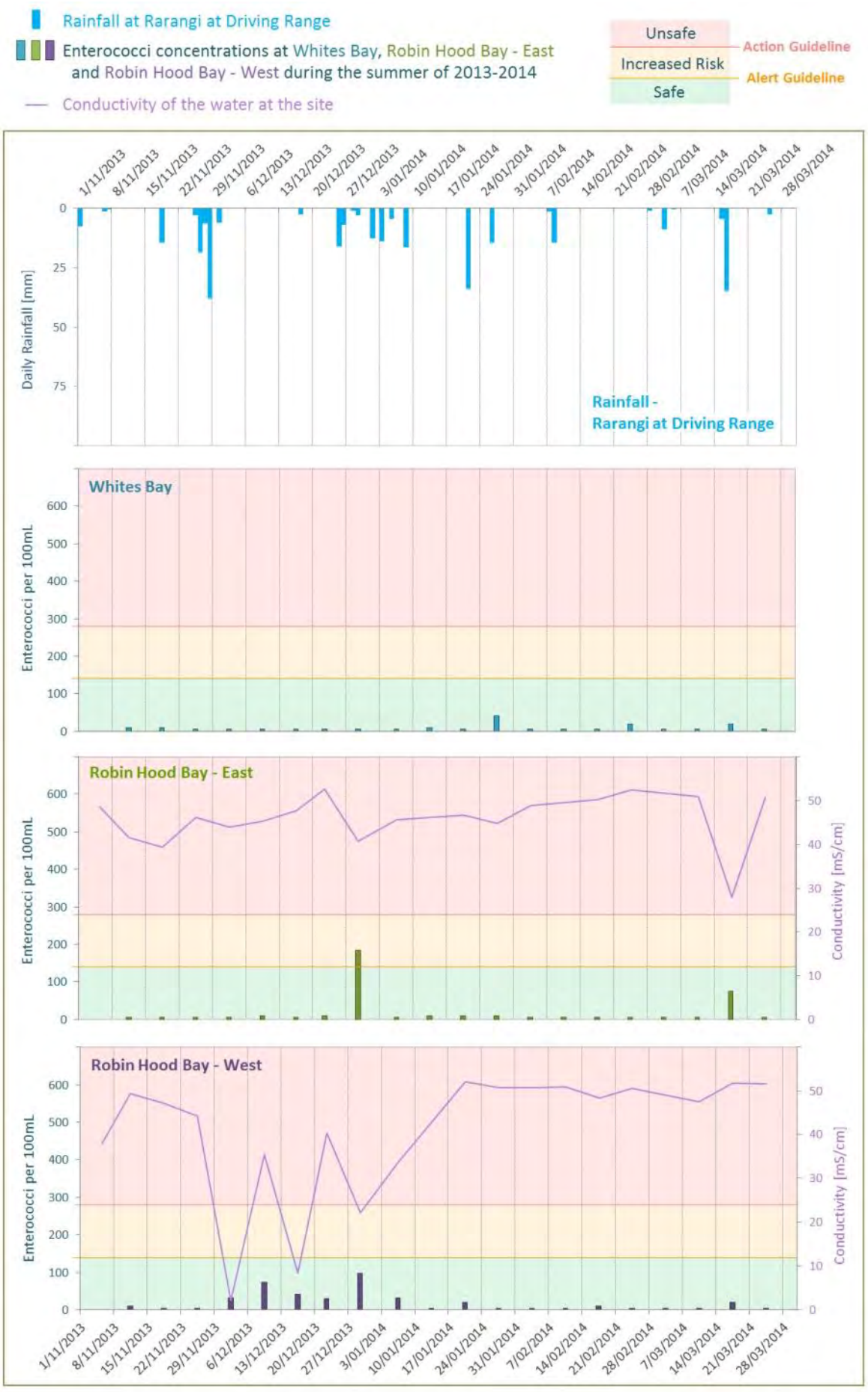
Whites Bay and Robin Hood Bay are located on the East Coast of the region. Whites Bay is one of the most popular beaches in Marlborough. A DoC campground is the only development in the bay and consequently water quality is generally very good. Robin Hood Bay, located only a few kilometres north of Whites Bay also offers a campground, but has agricultural land use in the catchment, which potentially affects the water quality in the bay. Robin Hood Bay is sampled at two sites, a surf beach on the Southwest side of the Bay and a swimming beach on the Northeast side that is also used for launching boats.

Figure 19: Map of the sampling sites and rainfall recorder.

Results

None of the samples taken from Whites Bay and Robin Hood Bay this season had unsafe concentrations of faecal bacteria. Concentrations were particularly low at Whites Bay, while one sample taken from Robin Hood Bay East exceeded the Alert Guideline.

▶ Figure 20: Results for Whites Bay and the two Robin Hood Bay sites for the summer season of 2013/2014.


Rainfall at Rarangi at Driving Range
Enterococci concentrations at Whites Bay, Robin Hood Bay - East and Robin Hood Bay - West during the summer of 2013-2014
Conductivity of the water at the site
Unsafe
Action Guideline
Increased Risk
Alert Guideline
Safe
1/11/2013
8/11/2013
15/11/2013
22/11/2013
29/11/2013
6/12/2013
13/12/2013
20/12/2013
27/12/2013
3/01/2014
10/01/2014
17/01/2014
24/01/2014
31/01/2014
7/02/2014
14/02/2014
21/02/2014
28/02/2014
7/03/2014
14/03/2014
21/03/2014
28/03/2014
Daily Rainfall [mm]
0
25
50
75
Rainfall - Rarangi at Driving Range
Whites Bay
Enterococci per 100mL
600
500
400
300
200
100
0
Robin Hood Bay - East
Conductivity [mS/cm]
50
40
30
20
10
Robin Hood Bay - West

A large flood event in late November caused significant damage to the road and also resulted in the shift of the mouth of Stace Creek toward the western beach. Stace Creek is the largest stream in the catchment draining approx. 80 km^2 of pasture. Its increased effect on the water quality of the western sampling site is evident from lower conductivity values measured at the site for some time after the flood event. During this time Enterococci concentrations were elevated, but did not exceed any of the guidelines and when samples were taken during a rainfall event in late-December the Enterococci concentration was higher at Robin Hood Bay – East, resulting in the only guideline exceedance for this group. There are no ducks and only occasionally a small number of seagulls seen at this sampling site. A small stream flowing through the eastern beach into the sea is therefore a likely source for the faecal contamination and should be further investigated. Microbial Source tracking will provide information about possible sources.

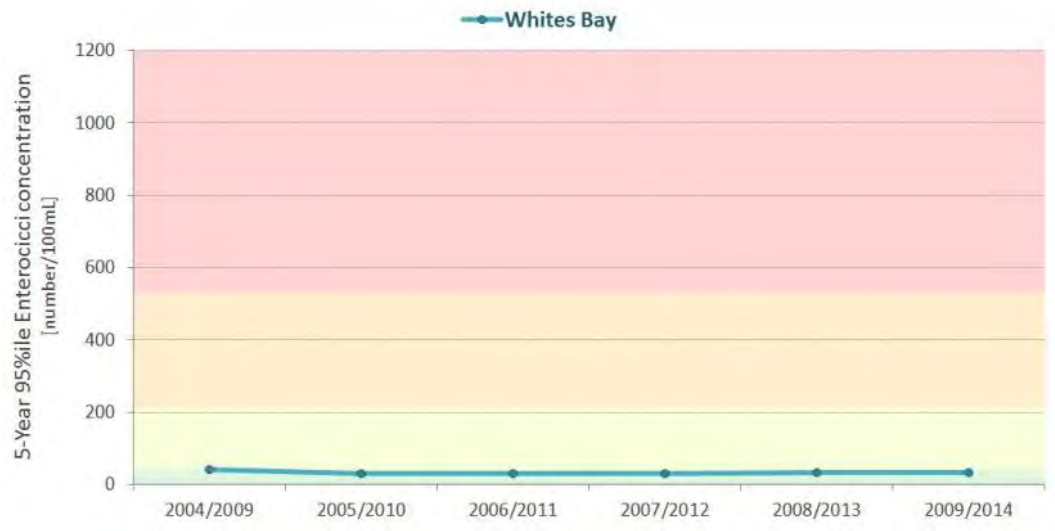


Figure 21: 5-Year-95%iles for Whites Bay.

There has been very little change of Enterococci concentrations at Whites Bay and the site continues to have very good water quality.

Figure 22: Whites Bay.

5.6. Marfells Beach

Site

Marfells Beach is the most Southern sampling site, located on the lower East Coast of the region. There are no large rivers or streams flowing into the sea close to the site, which means that the surrounding low intensity pastoral farming has little effect on the water quality. A popular DoC campground is located next to the beach and there are usually more than 100 seagulls on the beach. After storms large amounts of seaweed can be found along the shore. There is some evidence that Enterococci bacteria can potentially replicate in decaying seaweed [Anderson, 2000]. Nevertheless, Marfells Beach has the best water quality of all sites sampled as part of the Recreational Water Quality Program.

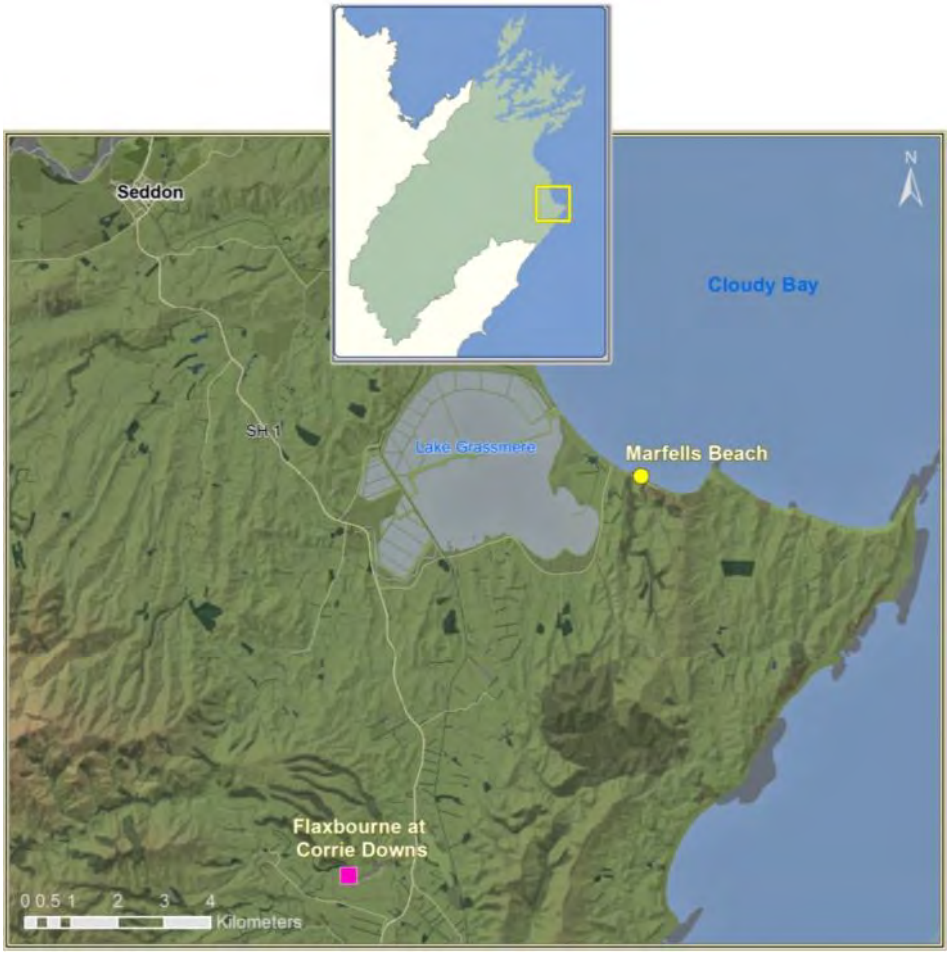
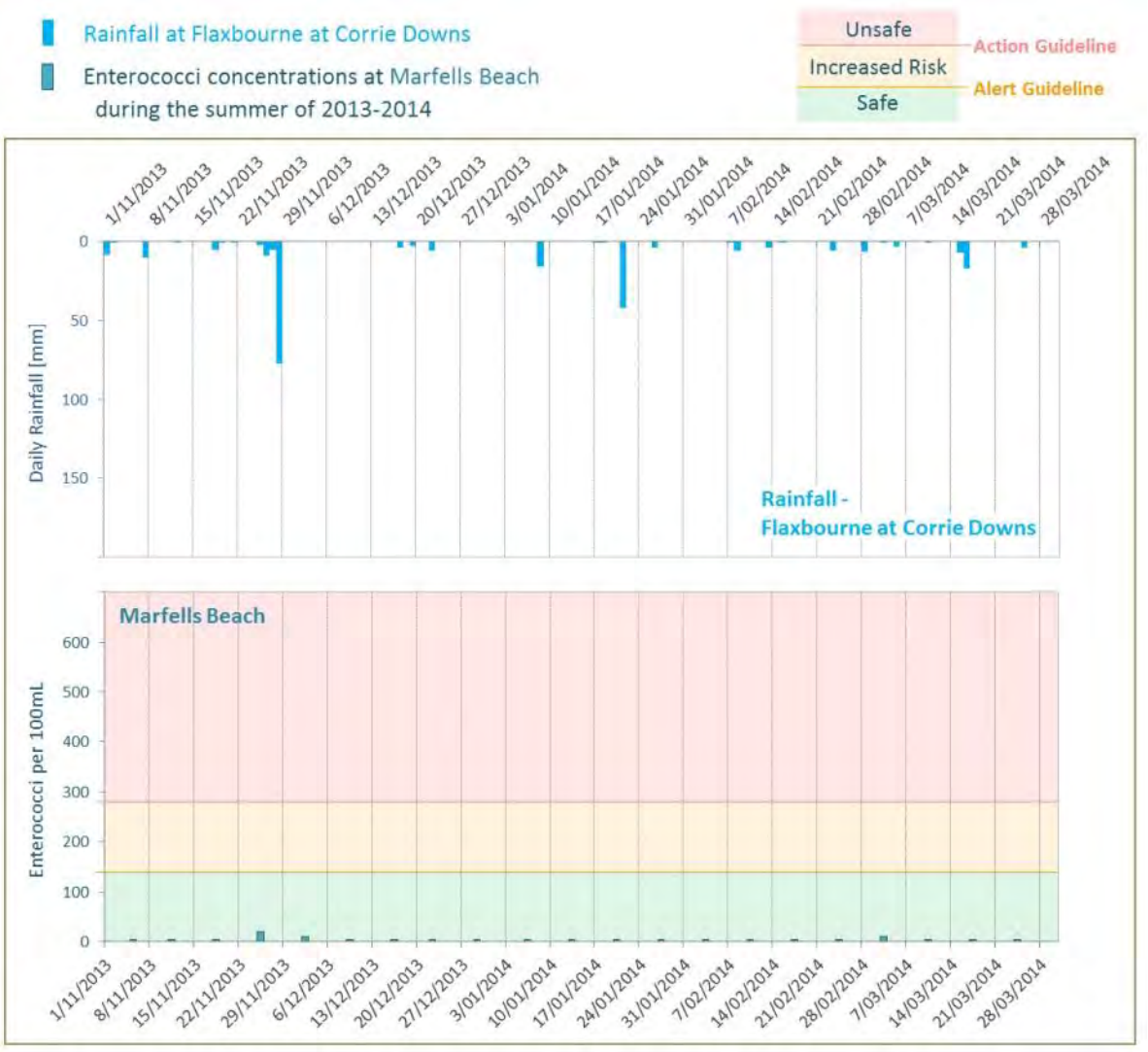


Figure 23: Map of the sampling sites and rainfall recorder.

Results

Since 2009 there have been no exceedances of any of the guidelines at this site and all samples taken this summer had very low Enterococci concentrations. The continuously very good water quality at Marfells Beach means that the site could temporarily be removed from the program to investigate the water quality of other popular beaches. However, a new beach usage survey would have to be carried out to find alternative sites before a decision can be made. Also, due to the popularity of the beach, monitoring should not be stopped altogether and instead a less frequent monitoring schedule put in place.



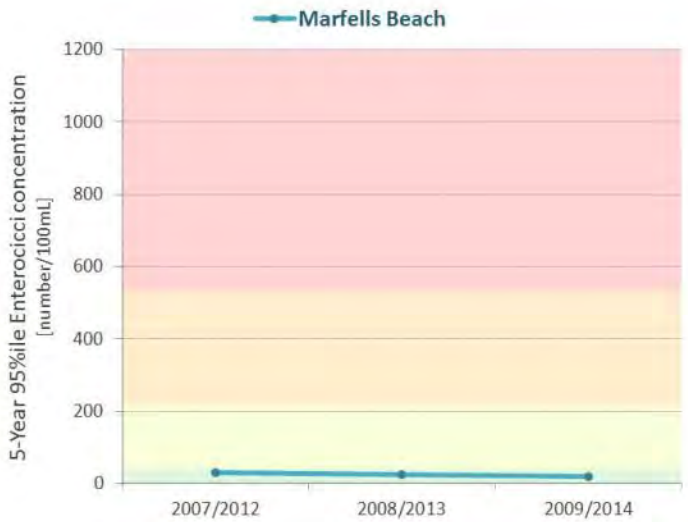


Figure 24: Results for the summer season of 2013/2014 and 5-Year-95%iles for Marfells Beach.

5.7. Rai River and Pelorus River

Sites

The Pelorus River has two popular swimming sites that are sampled as part of the Recreational Water Quality program, Pelorus Bridge and Totara Flat. The Rai River, which is sampled at the Rai Falls, flows into the Pelorus River approximately 300m upstream of Totara Flat. Consequently, water quality in the Pelorus River at Totara Flat is strongly influenced by the Rai River.

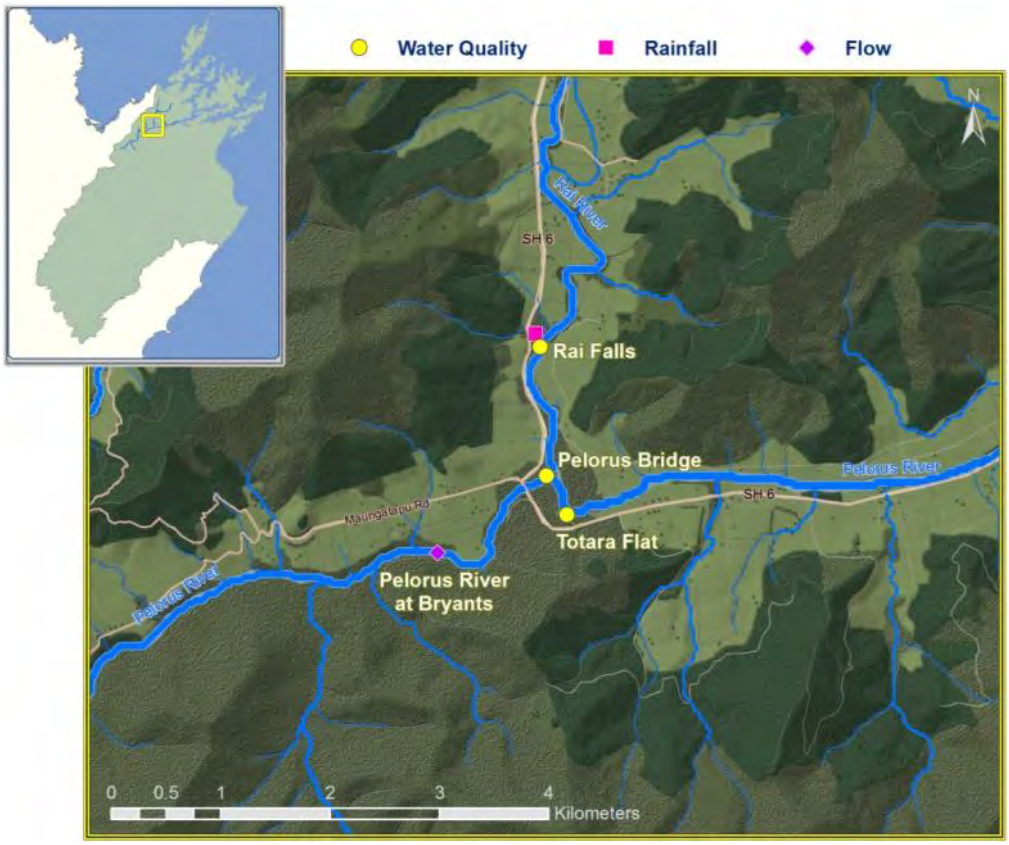


Figure 25: Map of the sampling sites as well as rainfall and flow recorders.

Results

Only one sample, taken during a rainfall event from the Rai River at Rai Falls, had unsafe E. coli concentrations during this summer season. On the same occasion faecal concentrations at the two Pelorus River sites were also elevated, but did not reach unsafe levels. Microbial source tracking of E. coli in samples taken from the Rai River at Rai Falls in 2011 showed that up to 100% of faecal contamination originates from ruminant sources. The presence of bovine markers indicated that cows might be the main source of that contamination [Cornelisen et al., 2012]. The Rai River catchment is one of the largest dairy catchments in the region, but a small amount of dairying and other pastoral land use can also be found in the Pelorus catchment.

▶ Figure 26: Results for the Rai River at Rai Falls and the two Pelorus River sites for the summer season of 2013/2014.


Rainfall at Rai Falls
Pelorus River Flow at Bryants
E. coli concentrations at Rai Falls, Pelorus Bridge and Totara Flat during the summer of 2013-2014
Unsafe
Increased Risk
Safe
Action Guideline
Alert Guideline
Rainfall - Rai Falls
Pelorus River Flow
Daily Rainfall [mm]
Flow [m³/s]
Rai Falls
Pelorus Bridge
Totara Flat
E.coli per 100mL
1/11/2013
8/11/2013
15/11/2013
22/11/2013
29/11/2013
6/12/2013
13/12/2013
20/12/2013
27/12/2013
3/01/2014
10/01/2014
17/01/2014
24/01/2014
31/01/2014
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14/02/2014
21/02/2014
28/02/2014
7/03/2014
14/03/2014
21/03/2014
28/03/2014

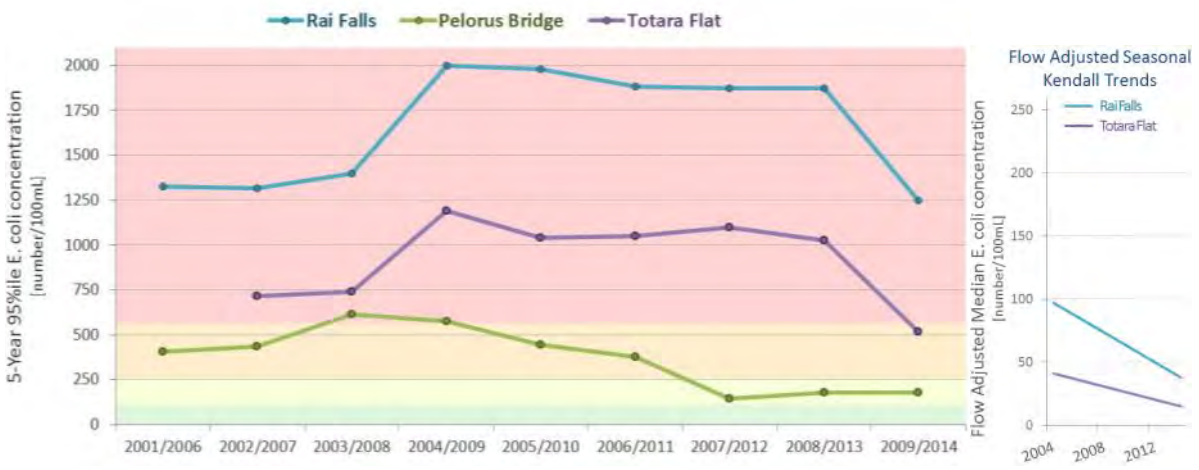


Figure 27: 5-Year-95%iles and flow adjusted Kendall Trends for the Rai River at Rai Falls and the two Pelorus River sites.

The Marlborough District Council and Landcare Trust have been working with the landowners to improve management practices in the catchment. The result has been a significant reduction in E. coli concentrations in the Rai River. This can be seen in the 5-Year-95%iles and is also confirmed to be a statistically significant change by the Seasonal Kendal Trend Test. The water improvement gained national recognition with the presentation of the NZ River Award in 2013.

As mentioned, water quality of the Pelorus River at Totara Flat is strongly influenced by the water quality of the Rai River. Therefore the improvements in the Rai River are reflected at Totara Flat. This summer was the first season during which none of the samples taken from the site had unsafe E. coli concentrations[4]. The reduction in faecal contamination can be seen from the 5-year 95%ile (MAC) values, but is also confirmed by the seasonal Kendall trend test. The MAC value indicates that the SFR Grade for this site could potentially be changed from 'Poor' to 'Fair'. However, it is advisable to await the results for another season in order to establish whether the change is permanent.

The Pelorus River at Pelorus Bridge continuous to have the best water quality of this group and has a SFR Grade of 'Good'.

[4] Only seasons with at least 18 samples were included in the analysis

Figure 28: Pelorus River at Pelorus Bridge.

5.8. Waihopai River

Site

The Waihopai River swimming hole at the Craiglochart #2 Bridge is popular with local residents. Often there will be nobody at the site when samples are taken, but it is know that school groups and families are using the site frequently, especially in the weekends. Over a quarter of the catchment area has been converted to pasture, but grazing is mostly of low intensity.

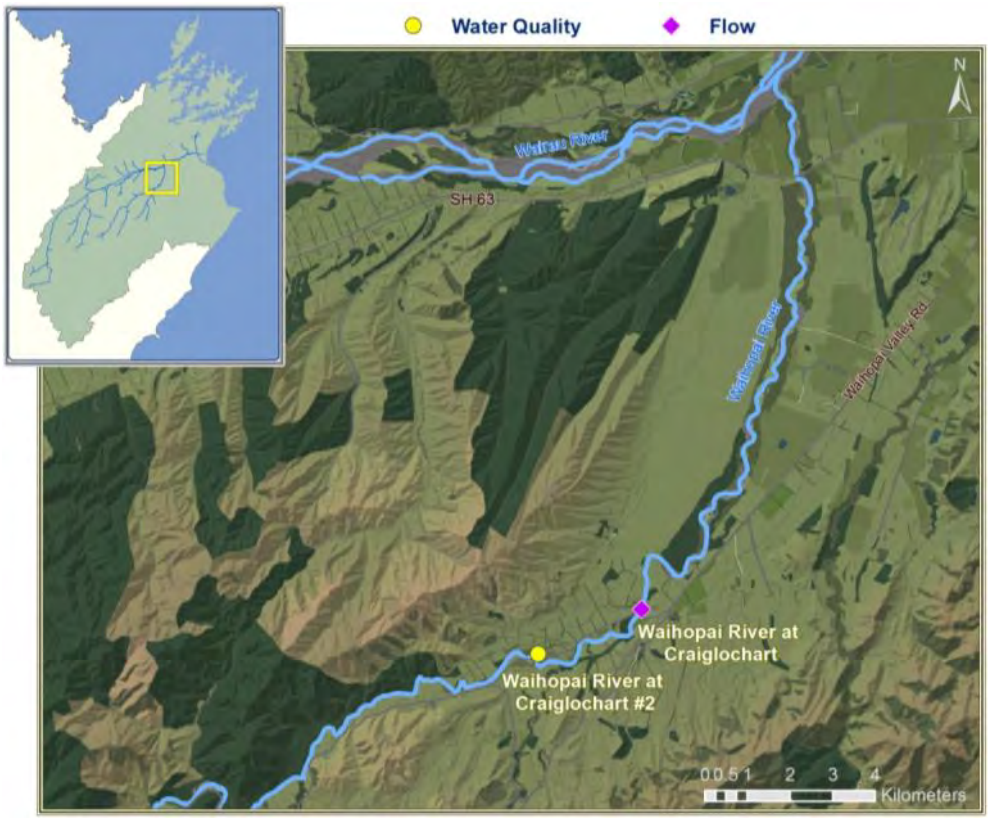
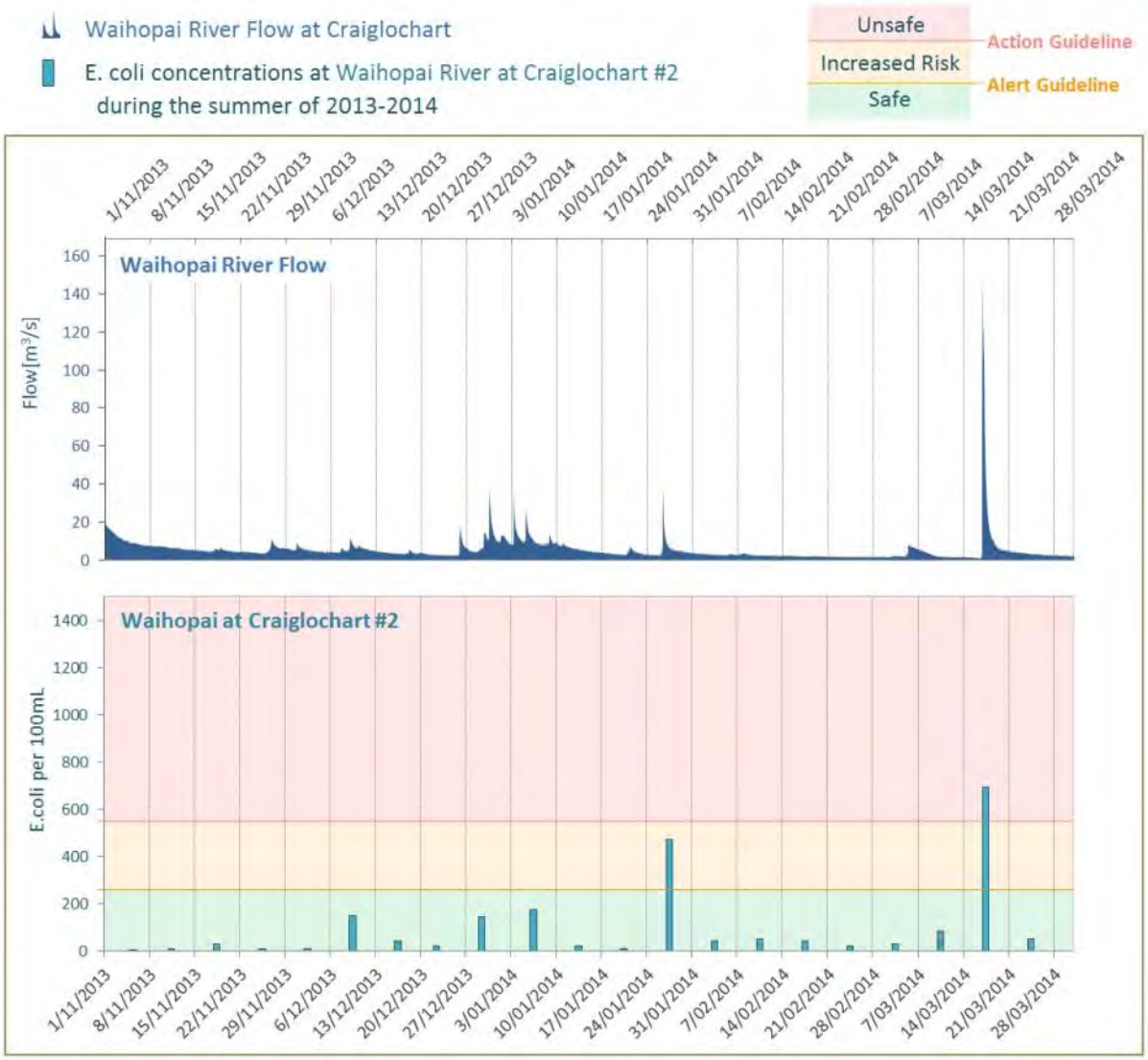


Figure 29: Map of the sampling site and flow recorder.

Results

The only sample with unsafe E. coli concentration this season was taken shortly after the largest flood event of the summer in mid-March. An earlier, smaller flood resulted in E. coli levels above the Alert Guideline. On both occasions, the water was turbid therefore providing an indication for visitors that water quality was potentially unsuitable for contact recreation.

There has been a continuous improvement in microbial water quality at this site resulting in a change of the SFR Grade from 'Poor' to 'Fair' last year. There appears to be a slight increase in E. coli concentrations recently. If this trend continues in coming seasons the causes need to be investigated.



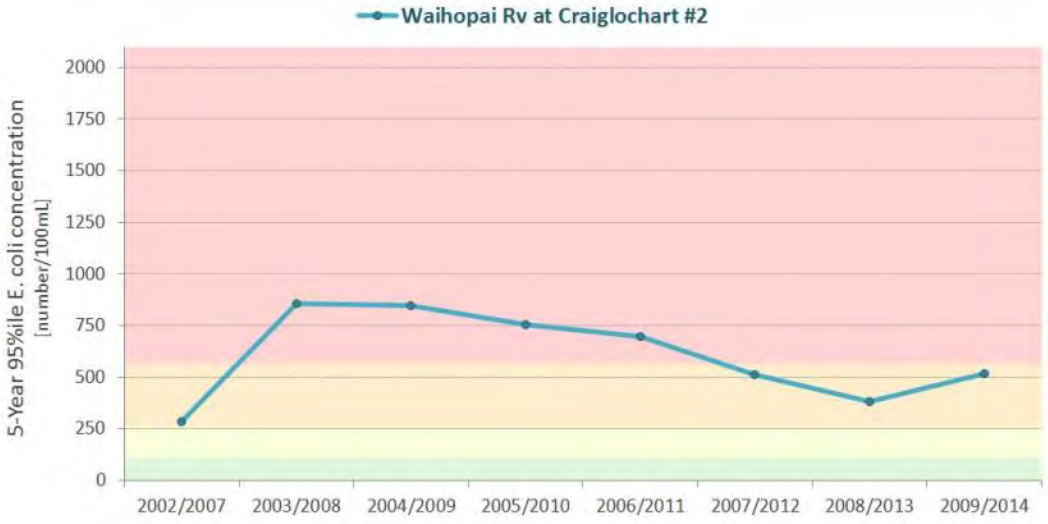


Figure 30: Results for the summer season of 2013/2014 and 5-Year-95%iles for the Waihopai River at Craighlochart #2.

5.9. Wairau River

Sites

There are three sites along the Wairau River that are sampled as part of the Recreational Bathing Water Quality program. The two sites located furthest downstream, Ferry Bridge and Blenheim Rowing Club, have been part of the program for some time, while the site at the State Highway Six Bridge was added recently as a result of a beach usage survey carried out in 2011 [MDC, 2012a].

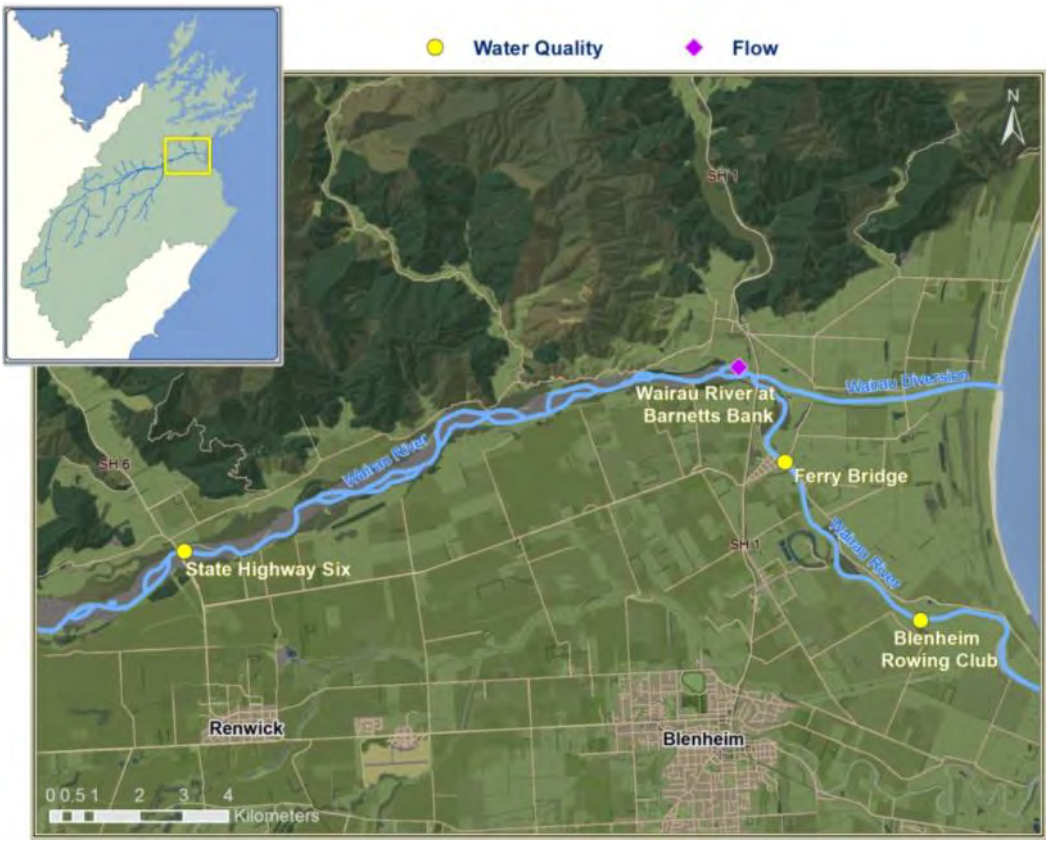
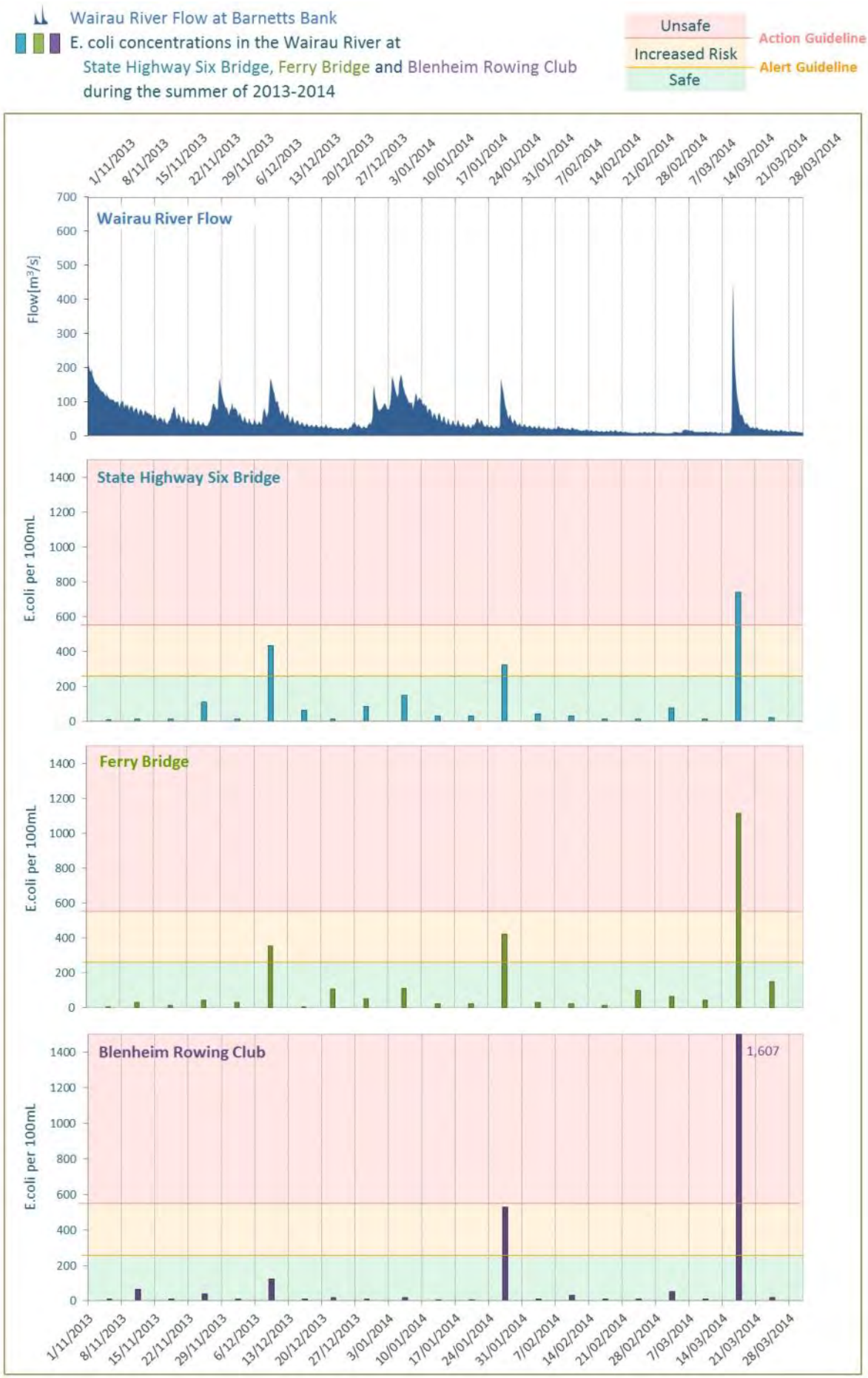


Figure 31: Map of the sampling sites and flow recorder.

Results

As all sites are located along the same river the pattern of E. coli concentrations is very similar. Unsafe concentrations were measured only at the largest flood event in mid-March during which faecal contamination appears to have increased the further downstream a sample was taken. During dry conditions, however, the water quality is usually slightly better at the site closest to the river mouth, the Blenheim Rowing Club.

▶Figure 32: Results for the Wairau River sampling sites for the summer season of 2013/2014.


Wairau River Flow at Barnetts Bank
E. coli concentrations in the Wairau River at
State Highway Six Bridge, Ferry Bridge and Blenheim Rowing Club
during the summer of 2013-2014
Unsafe
Increased Risk
Safe
Action Guideline
Alert Guideline
1/11/2013
8/11/2013
15/11/2013
22/11/2013
29/11/2013
6/12/2013
13/12/2013
20/12/2013
27/12/2013
3/01/2014
10/01/2014
17/01/2014
24/01/2014
31/01/2014
7/02/2014
14/02/2014
21/02/2014
28/02/2014
7/03/2014
14/03/2014
21/03/2014
28/03/2014
Wairau River Flow
Flow[m³/s]
State Highway Six Bridge
E.coli per 100mL
Ferry Bridge
E.coli per 100mL
Blenheim Rowing Club
1,607
E.coli per 100mL

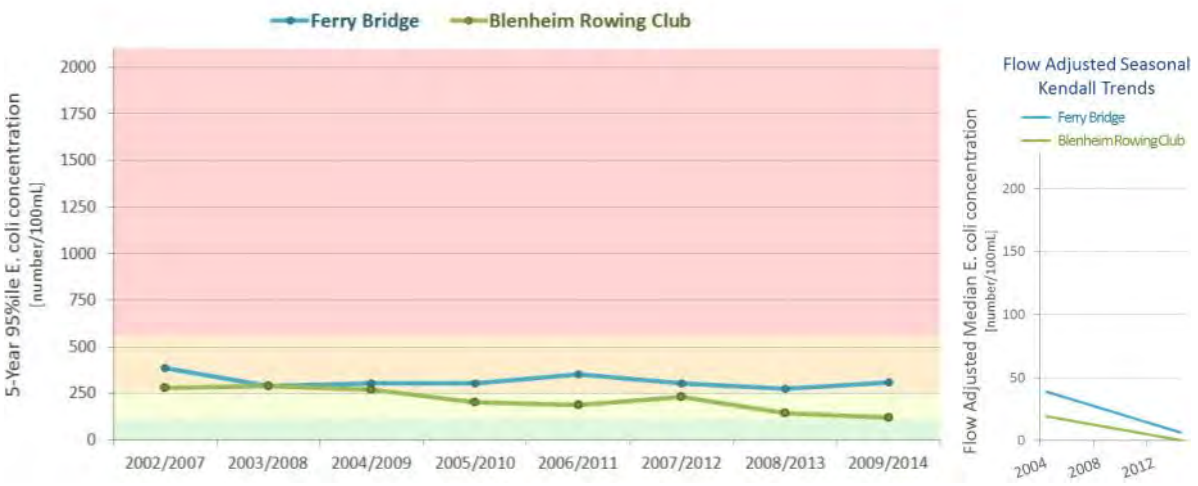


Figure 33: 5-Year-95%iles and flow adjusted Kendall Trend for the Wairau River at Ferry Bridge and Blenheim Rowing Club.

E. coli concentrations at Blenheim Rowing Club have been decreasing since monitoring began in 2002 and continue to do so. Consequently, a review of the SFR Grades last year resulted in a Grade change from ‘Fair’ to ‘Good’. The water quality improvement was also confirmed by the Seasonal Kendall Trend Test analysis. The trend analysis also showed a statistically significant reduction of E. coli concentrations at the Ferry Bridge site. Nevertheless, faecal bacteria levels remain higher than at the Blenheim Rowing Club, resulting in the lower SFR Grade of ‘Fair’.

Figure 34: Wairau River at Blenheim Rowing Club.

5.10. Taylor River and Opawa River

Sites

The Taylor River at Riverside and Opawa River at Elizabeth St Bridge are recreational river sites that are located in Blenheim and are heavily influenced by their urban environment. Although both rivers also flow through rural areas, the agricultural land use in the catchment appears to have limited impact on the microbial water quality at the sampling site.

Figure 35: Map of the sampling sites and rainfall recorder.

Results

The Taylor River continues to contain elevated E. coli concentrations at the Riverside sampling site with numbers sporadically reaching levels unsafe for contact recreation. The highest concentrations were again measured during low flow conditions. Nevertheless, flow is not a very good predictor of E. coli levels, which indicates that other factors are of greater importance.

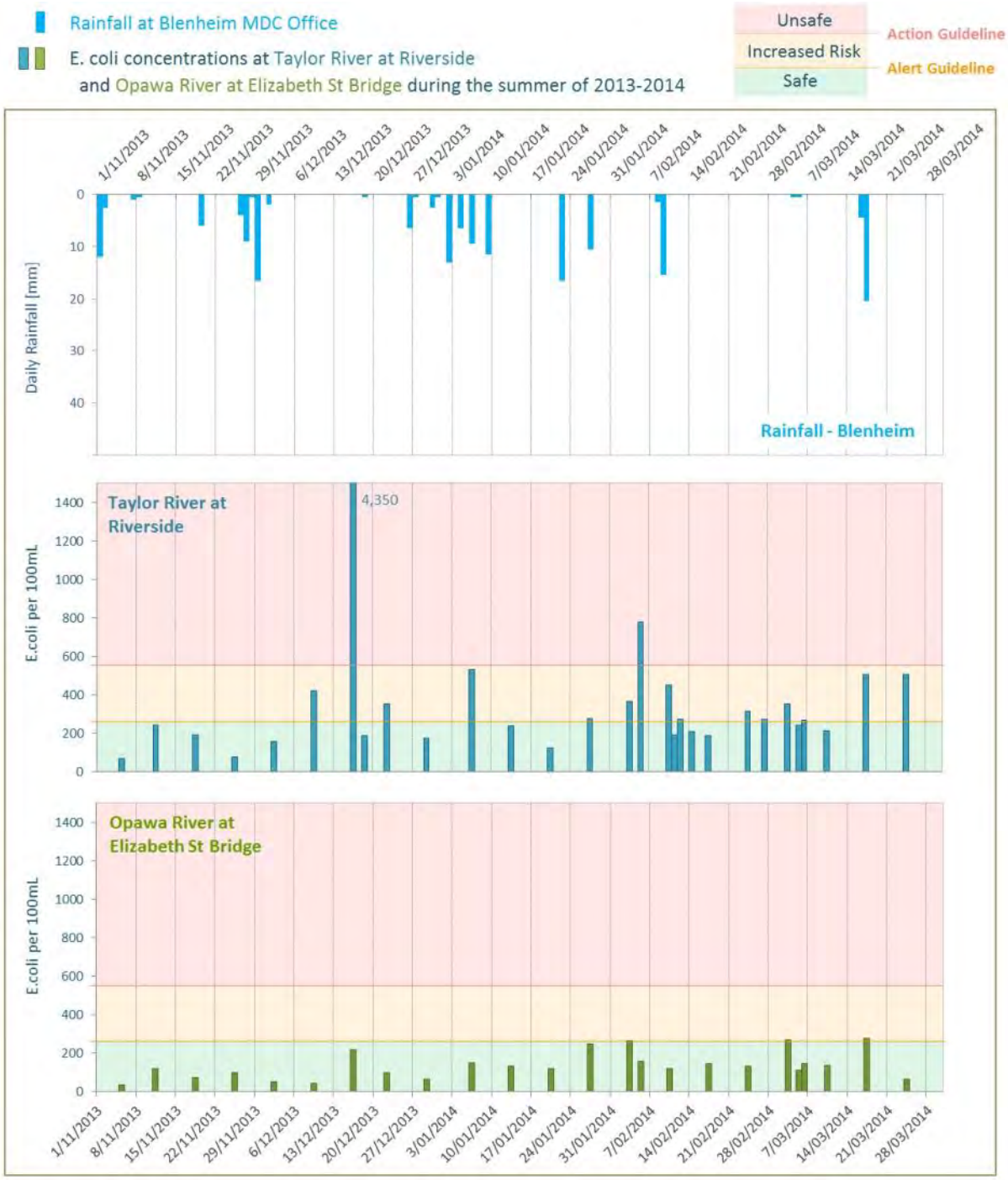


Figure 36: Results for the Taylor River at Riverside and Opawa River at Elizabeth St for the summer season of 2013/2014.

The Marlborough District council is currently conducting a water quality survey of the storm water entering the Taylor River with the aim to locate and remedy sources of human faecal contamination. Another part of this wider study of the catchment focuses on Doctors Creek, which is the main rural influence on the water quality of the Taylor River. Management of the water quality in Doctors Creek will most certainly have a positive effect on the water quality of the Taylor River, however, a study carried out last summer showed that at the site sampled as part of the Recreational Water Quality Program, rural inputs only have minor effects on the microbiological water quality [MDC, 2013b]. The study found that at low flow conditions inflows from other tributaries, like Murphys Creek, and

subsurface flow have a diluting effect, significantly reducing E. coli concentrations with distance from the confluence of Doctors Creek. The study also found that dogs and wildfowl were the main contributors to faecal contamination in the Taylor River at Riverside. This might explain the unpredictability of the faecal bacteria concentrations observed at this site. The unpredictability of faecal contamination potentially increases the risk to human health as no general rule of thumb can be given as to when the water is safe for swimming and other contact recreation. As E. coli concentrations continue to be at a relatively high level (see Figure 37) it appears that there is a potential conflict between the use of the Taylor River for swimming on one hand and as a dog exercise and duck feeding area on the other. A decision as to which of the uses are of greater importance may have to be made by the residents of Blenheim.

The Opawa River at Elizabeth St also has elevated E. coli concentrations most of the time. Nevertheless, the concentrations are usually lower and very rarely exceed the Action Guideline. For the third consecutive year, none of the samples taken from the Opawa River at this site had unsafe levels of faecal bacteria, although several samples had concentrations slightly above the Alert Guideline. The microbial water quality has not changed significantly in recent years and the site retains a SFR Grade of 'Fair'.

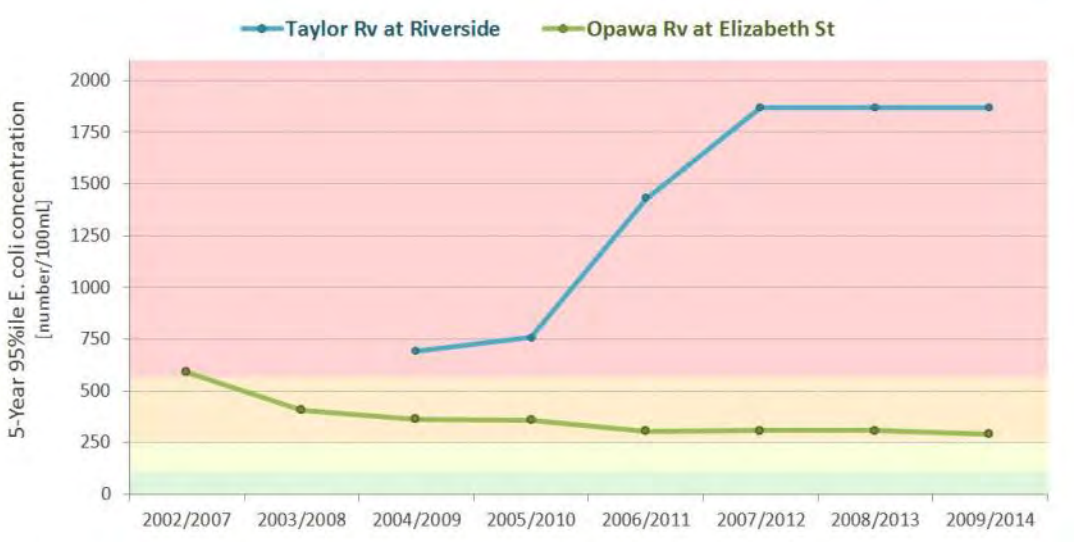


Figure 37: 5-Year-95%iles for Taylor River at Riverside and Opawa River at Elizabeth St.

Figure 38: Taylor River approx. 500m upstream of the Riverside sampling site.

6. Result Summary

With the exception of the Taylor River at Riverside, unsafe concentrations of faecal bacteria were linked to rainfall or flood events.

Four coastal sites had faecal bacteria concentrations below the guideline values during the whole season. Another four coastal sites had one or two exceedances of the Alert Guideline, but faecal contamination did not reach levels considered unsafe for contact recreation. The remaining four coastal beaches had at least one sample with Enterococci concentrations above the Action Guideline (see Figure 39).

As was the case in previous seasons, Picton Foreshore had the worst microbial water quality while Marfells Beach had the lowest Enterococci concentrations [MDC, 2013a]. This is reflected in the SFR Grades for these sites; 'Poor' for Picton Foreshore and 'Very Good' for Marfells Beach.

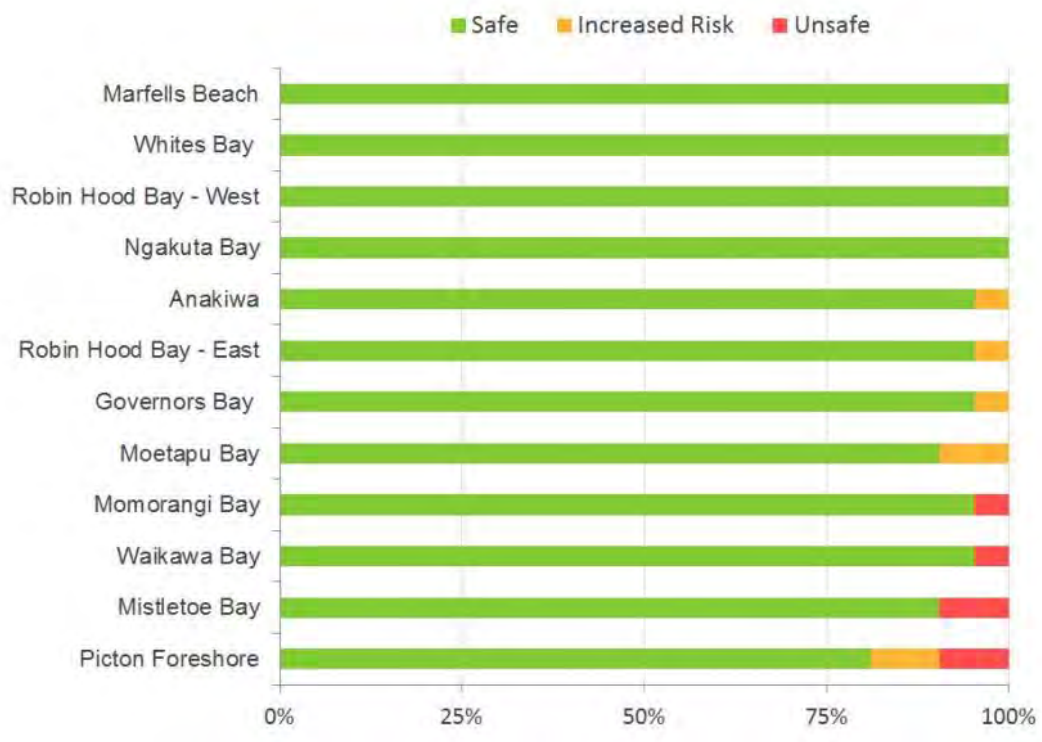


Figure 39: Compliance of coastal beaches with the Recreational Water Quality Guidelines.

Of the River sites, the Taylor River at Riverside again had the worst water quality with less than 50% of the samples below the guideline values. However, only one sample taken from this site exceeded the Action Guideline. Apart from the two Pelorus River sites and the Opawa River at Elizabeth St, all other sites had also one sample with E. coli concentrations in excess of the level considered safe for contact recreation (see Figure 40).

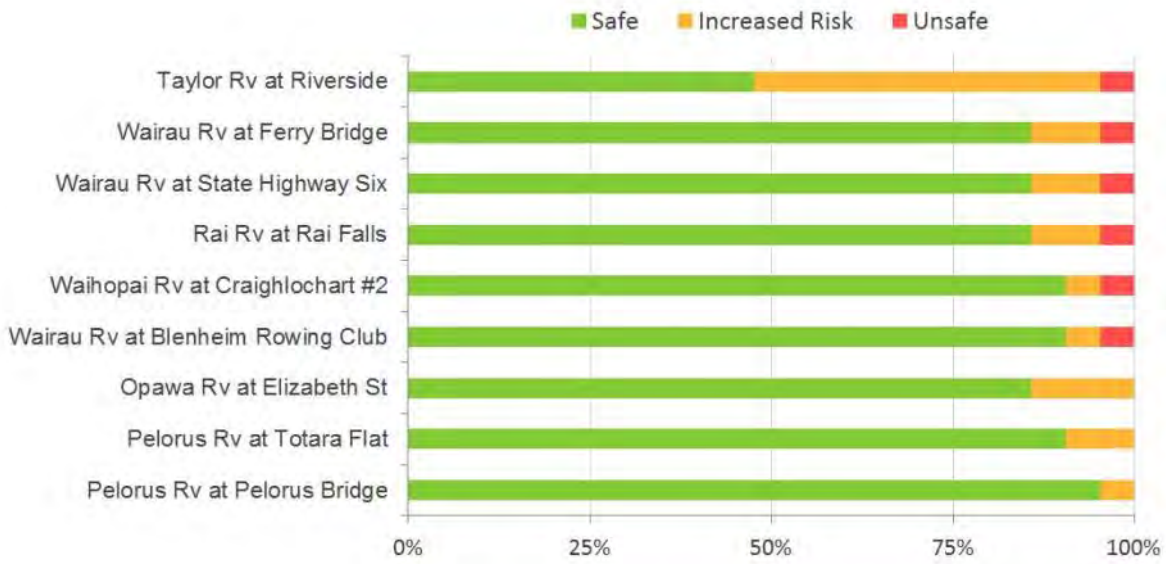


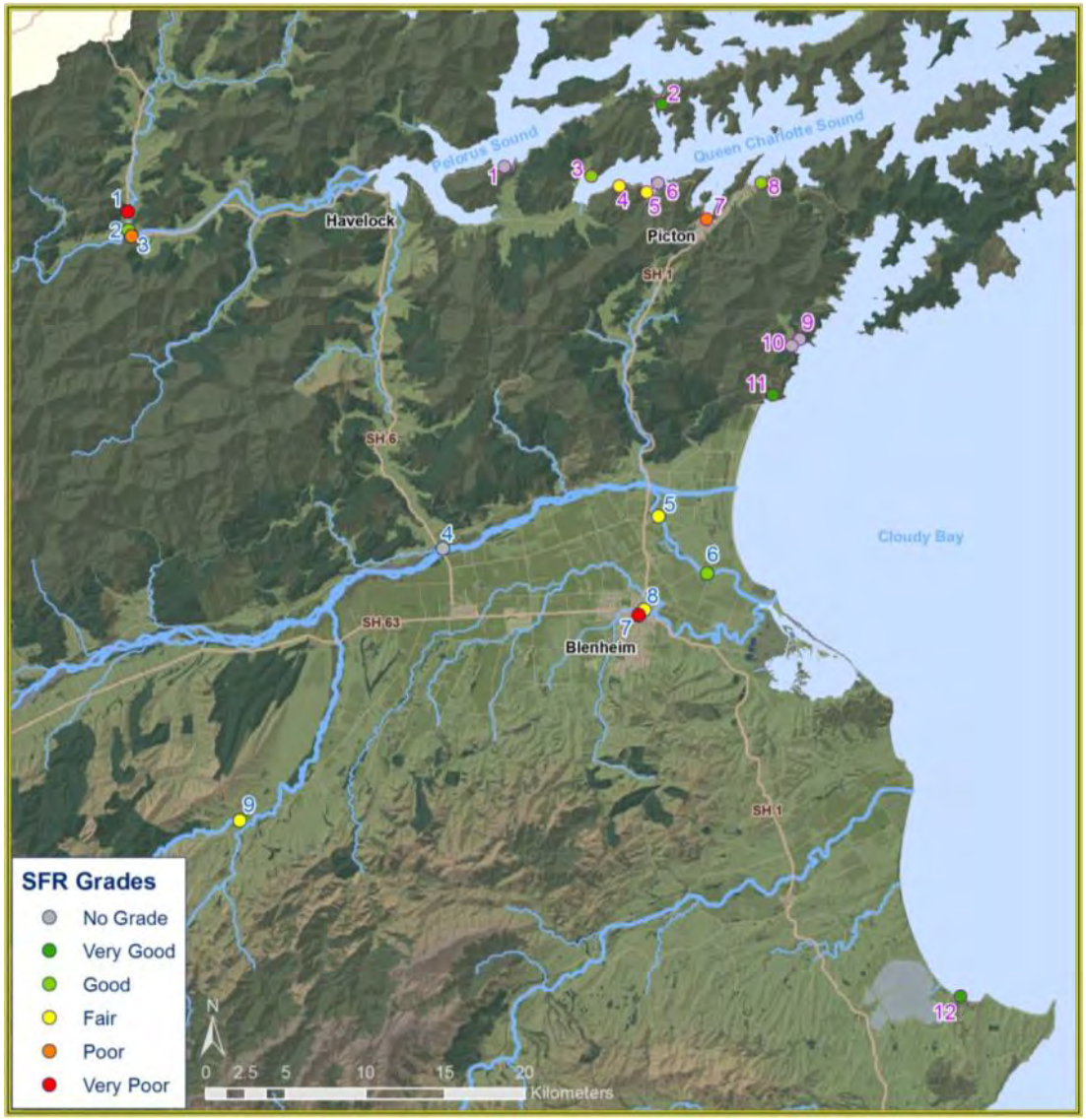
Figure 40: Compliance of River sites with the Recreational Water Quality Guidelines.

At most of the sites faecal bacteria concentrations were lower than last season, which is most likely the result of generally less rainfall and lower river flows in the 48 – 72 hours before the samples were taken. For example, during last year's summer period two large floods occurred in the Waihopai/Wairau catchment with Wairau River flows in excess of 1,000m^3/s at Barnetts bank, while the flow in the Wairau River during this seasons largest flood did not reach 500m^3/s.

Trend Analysis using the seasonal Kendall Trend Test showed that reduction in faecal bacteria concentrations were statistically significant for Momorangi Bay, the two lower Wairau River sites, the Pelorus River at Totara Flat and the Rai River at Rai Falls. The Rai River had the greatest median annual reduction in E. coli concentrations followed by the Wairau River at Ferry Bridge and Pelorus River at Totara Flat.

Suitability for Contact Recreation Grades (SFR Grades), were reviewed last year, resulting in a number of changes. Calculation of the 5-Year-95%ile values, which are used for establishing SFR Grades, showed substantial improvements at some of the river sites, particularly the Rai River and Pelorus River at Totara Flat. If the following season(s) show that these changes are permanent, the SFR Grade for these sites should be revised as part of a future report. Figure 41 shows the location of all sampling sites as well as their current SFR Grade.

▶ Figure 41: Suitability for Contact Recreation Grades for the sites sampled during the summer of 2013/2014.



Type	No.	Site	Easting	Northing	SIC (Sanitary Inspection Category)	MAC (Microbiological Assessment Category)	SFR Grade (Suitability for Contact Recreation Grade)
Coastal Sites	1	Moetapu Bay	1671600	5432100	new site (insufficiant data)		
	2	Mistletoe Bay	1681470	5436007	Very Low	B	Very Good
	3	Anakiwa	1677073	5431495	Moderate	B	Good
	4	Momorangi Bay	1678817	5430879	Moderate	C	Fair
	5	Ngakuta Bay	1680514	5430489	Moderate	C	Fair
	6	Governors Bay	1681310	5431030	new site (insufficiant data)		
	7	Picton Foreshore	1684298	5428815	High	C	Poor
	8	Waikawa Bay	1687695	5431090	Low	B	Good
	9	Robin Hood Bay East	1690115	5421285	new site (insufficiant data)		
	10	Robin Hood Bay West	1689595	5420930	new site (insufficiant data)		
	11	Whites Bay	1688425	5417793	Very Low	A	Very Good
	12	Marfells Beach	1700194	5380089	Very Low	A	Very Good
River Sites	1	Rai Rv at Rai Falls	1648018	5429266	High	D	Very Poor
	2	Pelorus Rv at Pelorus Bridge	1648077	5428091	Low	B	Good
	3	Pelorus Rv at Totara Flat	1648262	5427731	Moderate	D	Poor
	4	Wairau Rv at State Highway Six	1667780	5408150	new site (insufficiant data)		
	5	Wairau Rv at Ferry Bridge	1681274	5410163	Moderate	C	Fair
	6	Wairau Rv at Blenheim Rowing Clu	1684319	5406605	Moderate	B	Good
	7	Taylor River at Riverside	1680023	5403987	High	D	Very Poor
	8	Opawa River at Elizabeth St Bridge	1680393	5404310	Moderate	C	Fair
	9	Waihopai River at Craiglochart #2	1655029	5391098	Moderate	C	Fair

7. References

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8. Appendices

Appendix 1: Results for the 2013/2014 summer season

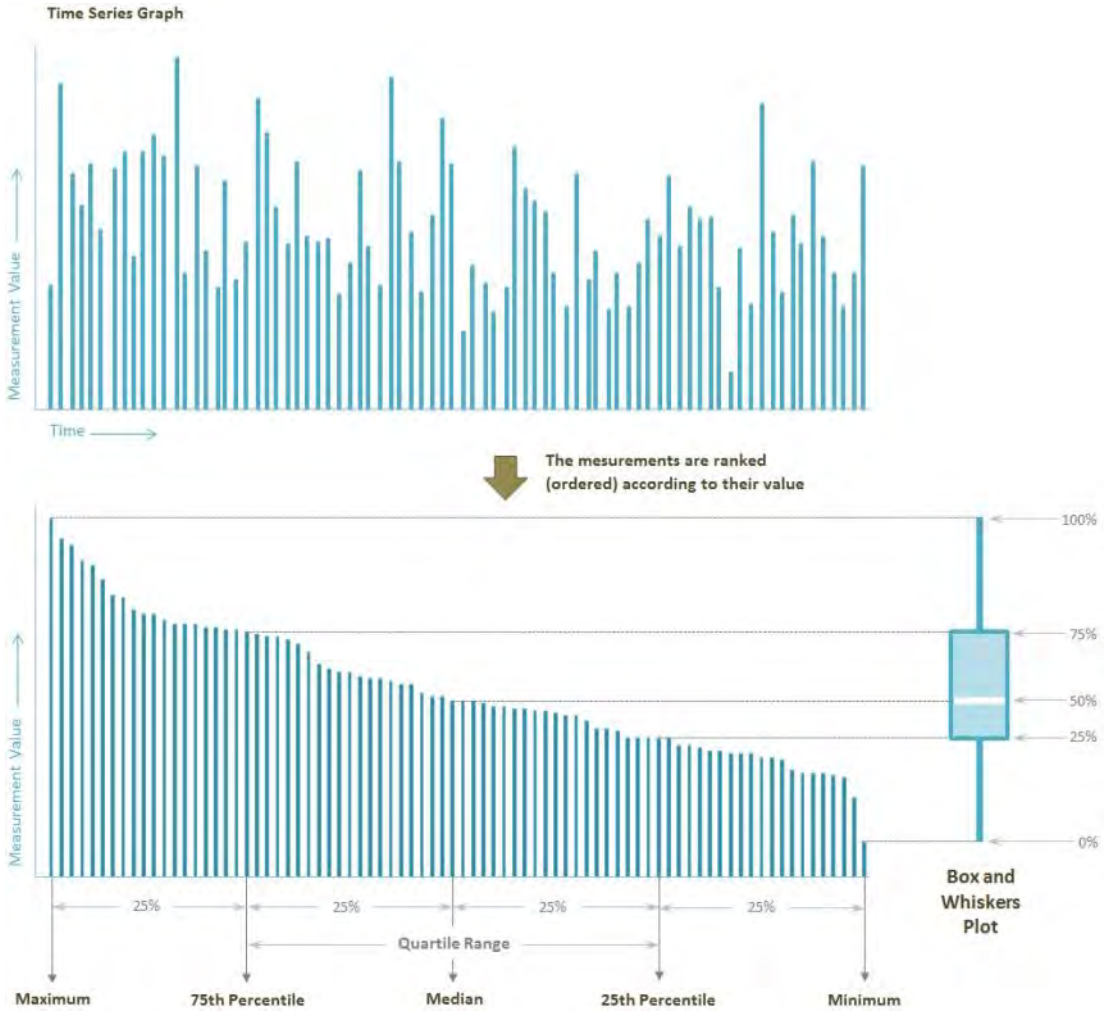
Results are Enterococci concentrations for coastal sites and E. coli concentrations for river sites, both in MPN/100mL

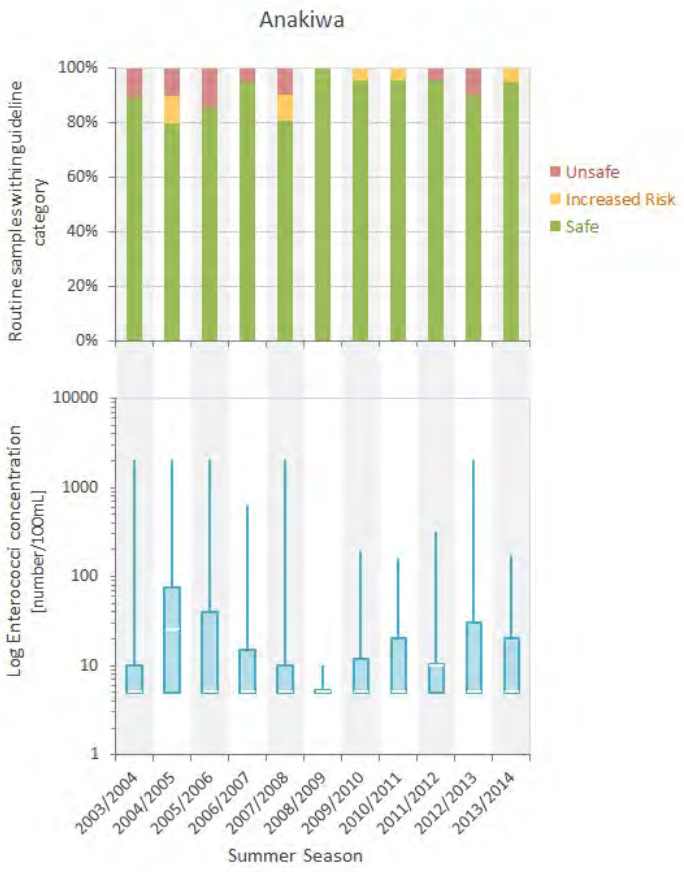
Site Type	Week	Sample Date	Anakiwa	Mistletoe Bay	Moetapu Bay	Momorangi Bay	Ngakuta Bay	Governors Bay	Picton Foreshore	Waikawa Bay	Whites Bay	Robin Hood Bay East	Robin Hood Bay West	Marfells Beach
Coastal	1	05/06 Nov 2013	10	20	<10	10	<10	20	10	<10	<10	<10	10	<10
	2	11/12 Nov 2013	10	<10	<10	<10	<10	<10	171	20	10	<10	10	<10
	3	18/19 Nov 2013	74	<10	169	10	<10	10	<10	31	10	<10	<10	<10
	4	25/26 Nov 2013	20	<10	<10	20	10	<10	<10	135	<10	<10	<10	20
	5	02 Dec 2013	<10	<10	<10	10	<10	<10	52	<10	<10	<10	31	10
	6	09/10 Dec 2013	31	<10	52	41	10	<10	52	<10	<10	10	74	<10
	7	16/18 Dec 2013	<10	305	135	20	20	10	10	<10	<10	<10	41	<10
	Follow-up	18/20 Dec 2013		<10										
	8	22/23 Dec 2013	<10	<10	<10	<10	<10	<10	10	<10	<10	10	30	<10
	9	29/30 Dec 2013	20	<10	<10	85	30	20	323	41	<10	185	97	<10
	10	06/07 Jan 2014	<10	10	20	10	41	<10	350	20	<10	<10	31	<10
	Follow-up	09 Jan 2014							41					
	Follow-up	10 Jan 2014							41					
	11	13/14 Jan 2014	<10	<10	<10	<10	<10	<10	<10	<10	10	10	<10	<10
	12	20/21 Jan 2014	173	1086	<10	1178	<10	10	41	537	<10	10	20	<10
	Follow-up	23 Jan 2014	<10	<10		<10			20	<10				
	13	27/28 Jan 2014	20	<10	<10	10	10	<10	10	<10	41	10	<10	<10
	14	03/04 Feb 2014	<10	<10	10	<10	63	<10	<10	<10	<10	<10	<10	<10
	15	10/11 Feb 2014	<10	10	<10	10	<10	<10	10	<10	<10	<10	<10	<10
	16	17/18 Feb 2014	<10	10	<10	20	<10	<10	63	<10	<10	<10	10	<10
	17	24/25 Feb 2014	<10	10	<10	<10	<10	<10	<10	10	20	<10	<10	<10
	18	03/04 Mar 2014	<10	20	<10	<10	<10	10	63	<10	<10	<10	<10	10
	19	10/11 Mar 2014	<10	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	20	17/18 Mar 2014	31	10	218	10	20	52	195	<10	20	75	20	<10
	21	24/25 Mar 2014	<10	<10	10	<10	10	189	<10	<10	<10	<10	<10	<10

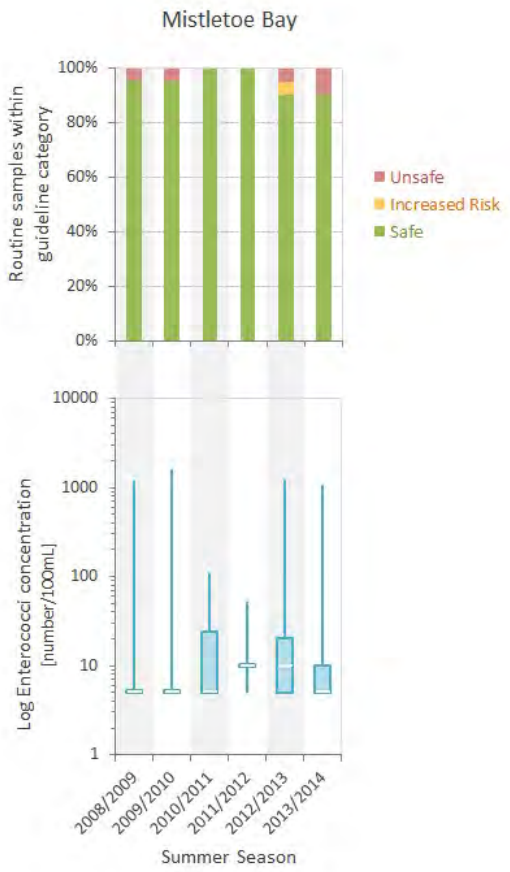
Site Type	Week	Sample Date	Rai Falls	Pelorus Rv at Pelorus Bridge	Pelorus Rv at Totara Flat	Waihopai Rv at Craiglochart #2	Wairau Rv at State Highway Six	Wairau Rv at Ferry Bridge	Wairau Rv at Blenheim Rowing Club	Taylor Rv at Riverside	Opawa Rv at Elizabeth St
River	1	05/06 Nov 2013	30	41	20	6	8	5	11	68	34
	2	11/12 Nov 2013	31	<10	10	10	10	31	63	243	121
	3	18/19 Nov 2013	130	28	46	31	10	10	10	189	74
	4	25/26 Nov 2013	813	448	426	10	109	41	41	75	97
	Follow-up	28 Nov 2013	256								
	5	02 Dec 2013	98	31	62	10	10	30	10	158	52
	6	09/10 Dec 2013	134	20	158	148	435	350	122	420	41
	7	16/18 Dec 2013	20	<10	10	41	63	<10	10	4350	216
	Follow-up	18/20 Dec 2013								187	
	8	22/23 Dec 2013	10	10	20	20	10	107	20	350	97
	9	29/30 Dec 2013	189	86	85	146	86	52	10	175	63
	10	06/07 Jan 2014	288	75	98	175	146	109	20	530	148
	11	13/14 Jan 2014	41	31	31	20	30	20	<10	238	134
	12	20/21 Jan 2014	145	134	201	10	31	20	<10	121	121
	13	27/28 Jan 2014	41	31	52	471	323	420	529	275	246
	14	03/04 Feb 2014	41	<10	31	41	41	31	10	364	262
	Follow-up	05 Feb 2014								776	158
	15	10/11 Feb 2014	63	10	10	51	31	20	31	448	120
	Follow-up	11 Feb 2014								189	
	Follow-up	12 Feb 2014								272	
	Follow-up	14 Feb 2014								209	
	16	17/18 Feb 2014	31	10	<10	41	10	10	10	185	145
	17	24/25 Feb 2014	10	<10	<10	20	10	98	10	315	132
	Follow-up	27 Feb 2014								272	
	18	03/04 Mar 2014	20	<10	<10	31	75	63	52	350	269
	Follow-up	05 Mar 2014								243	109
	Follow-up	06 Mar 2014								269	146
	19	10/11 Mar 2014	10	10	<10	86	10	41	10	213	135
	20	17/18 Mar 2014	480	85	309	691	738	1112	1607	504	275
	21	24/25 Mar 2014	86	31	31	52	20	148	20	504	63

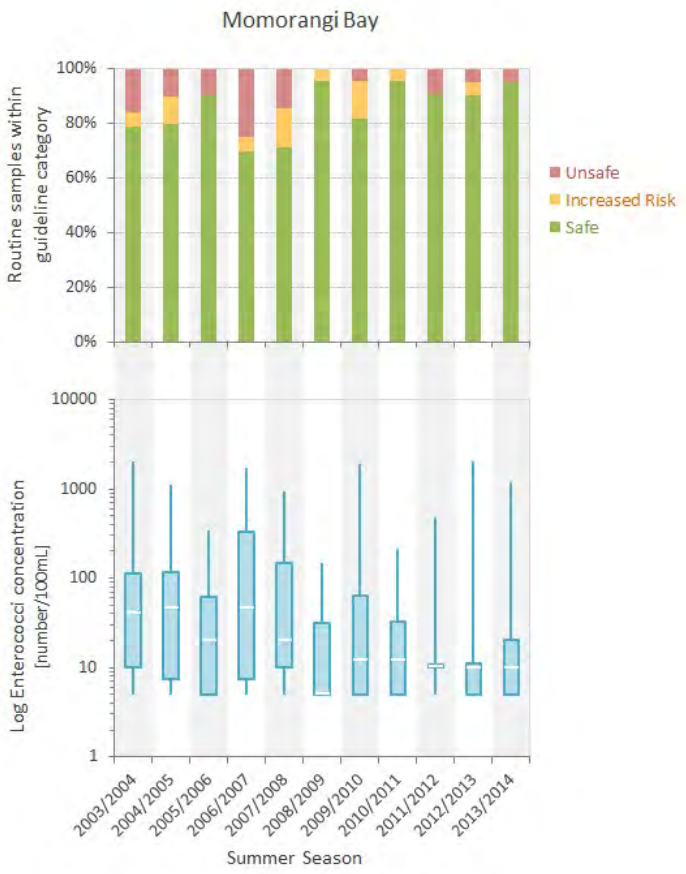
Appendix 2: Levels of compliance and Box and Whiskers plots

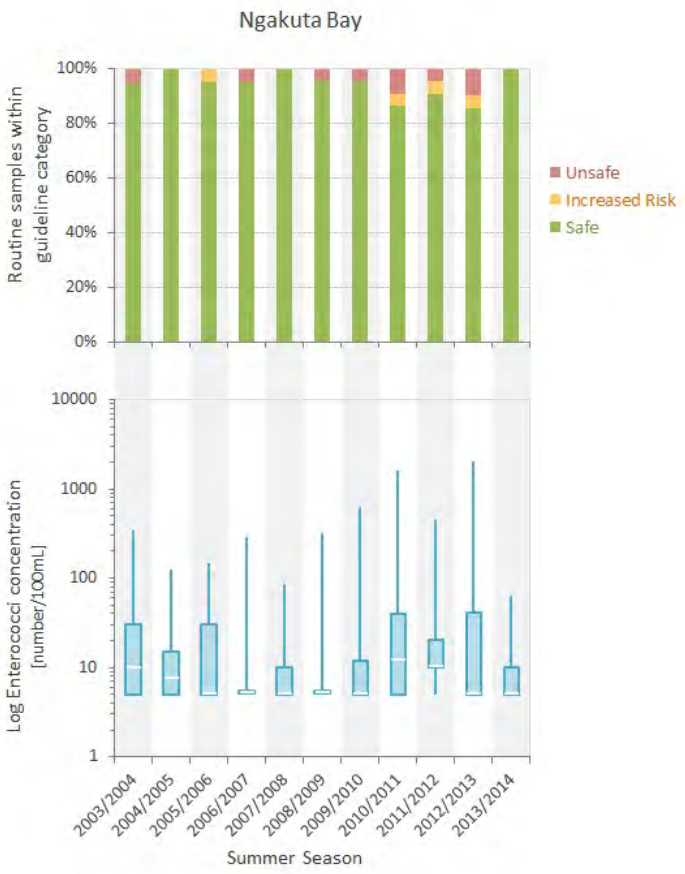
The Plots were created from the results of the routine sampling only. The first figure shows how Box and Whiskers Plots are created. Note that concentrations in the Box and Whiskers Plots for the actual sample results are on a logarithmic scale and only sites with a minimum of 3 years of record are shown.

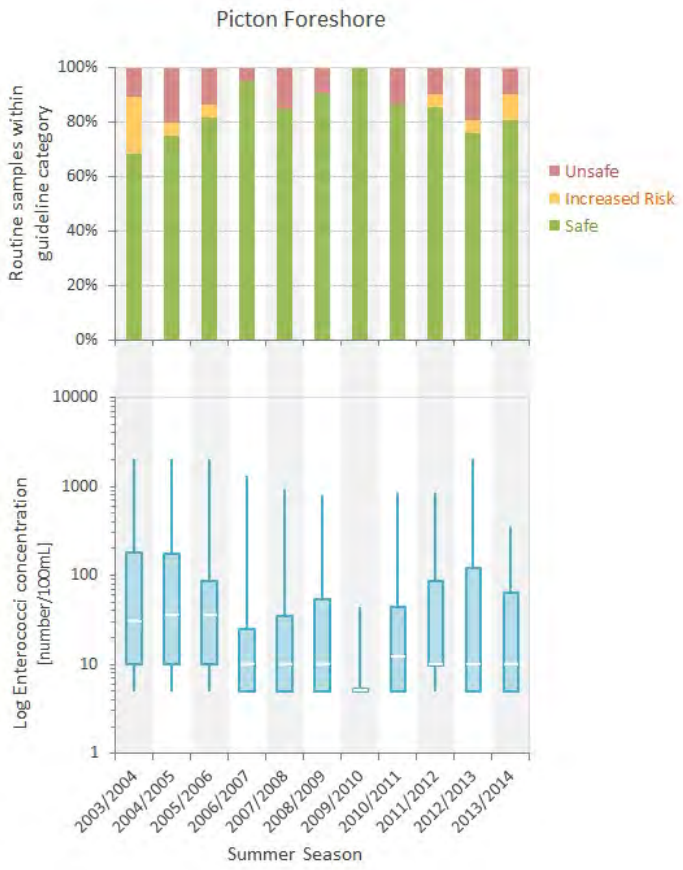


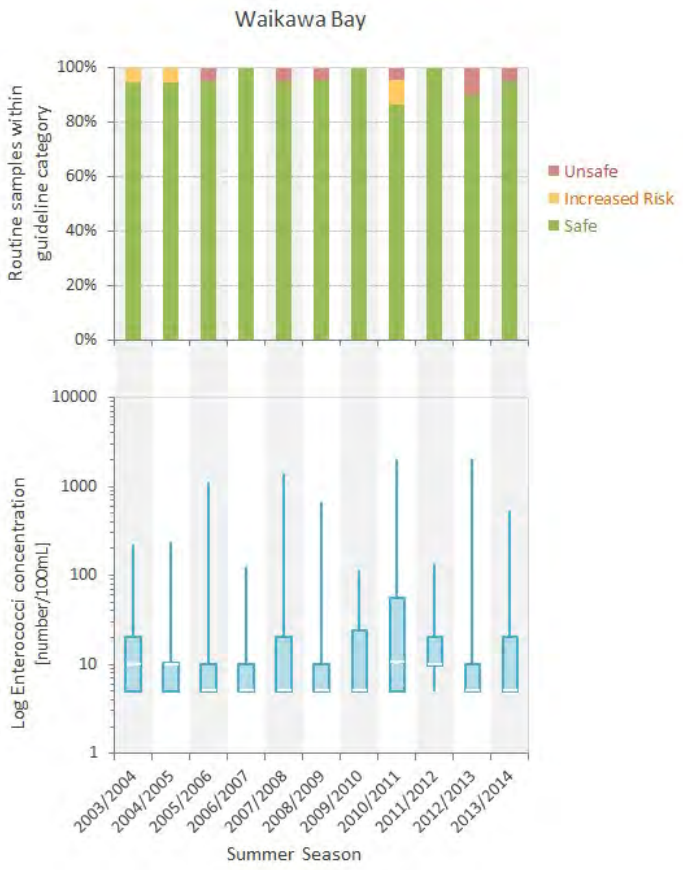

Anakiwa
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season

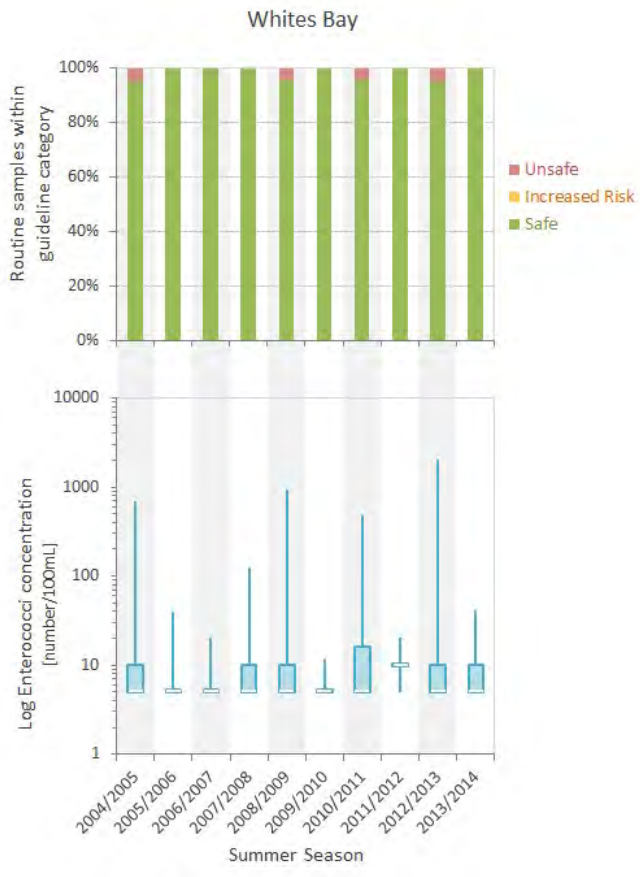

Mistletoe Bay
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season

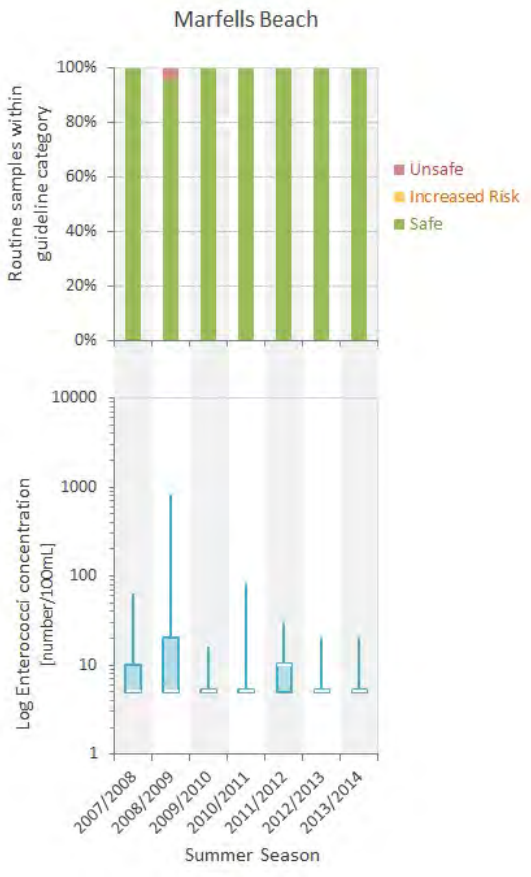

Momorangi Bay
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season

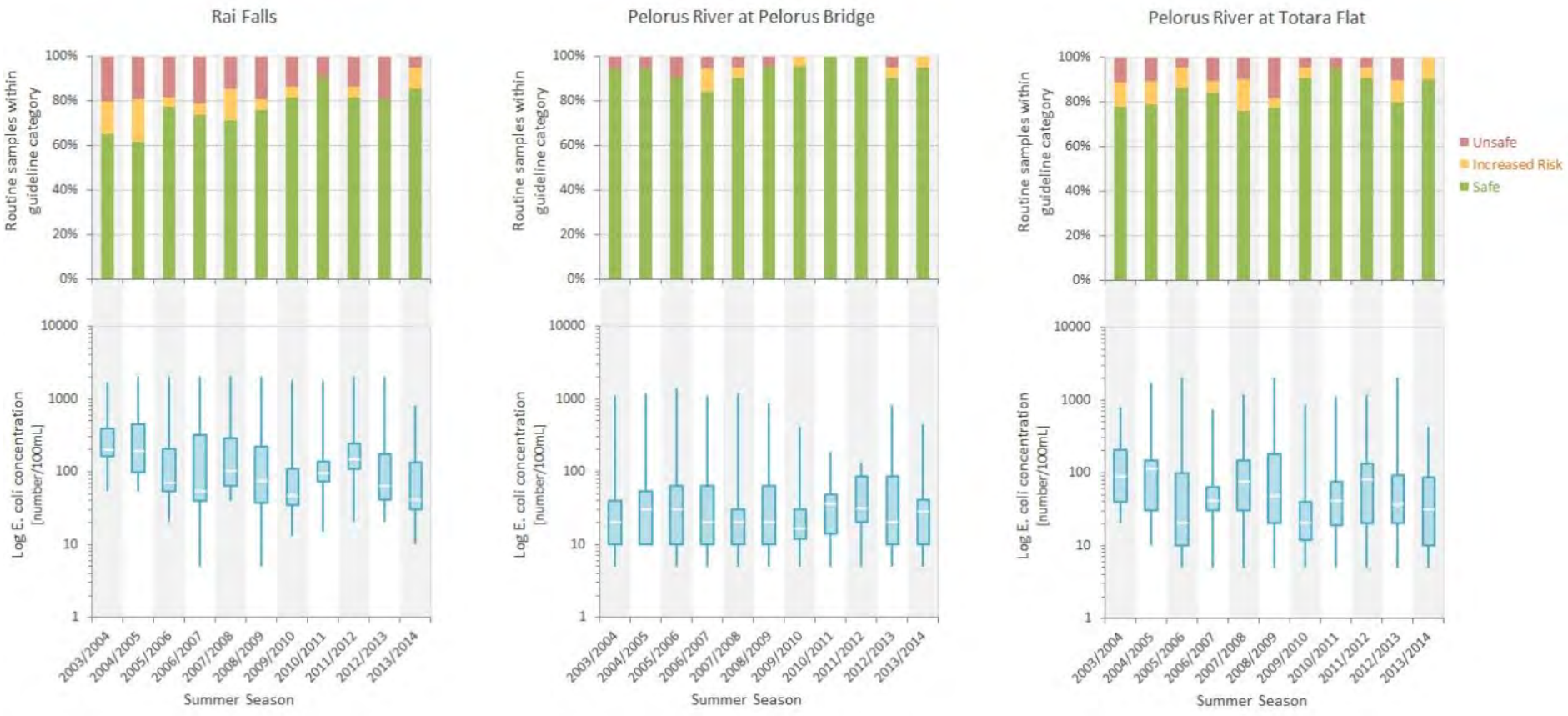

Ngakuta Bay
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season

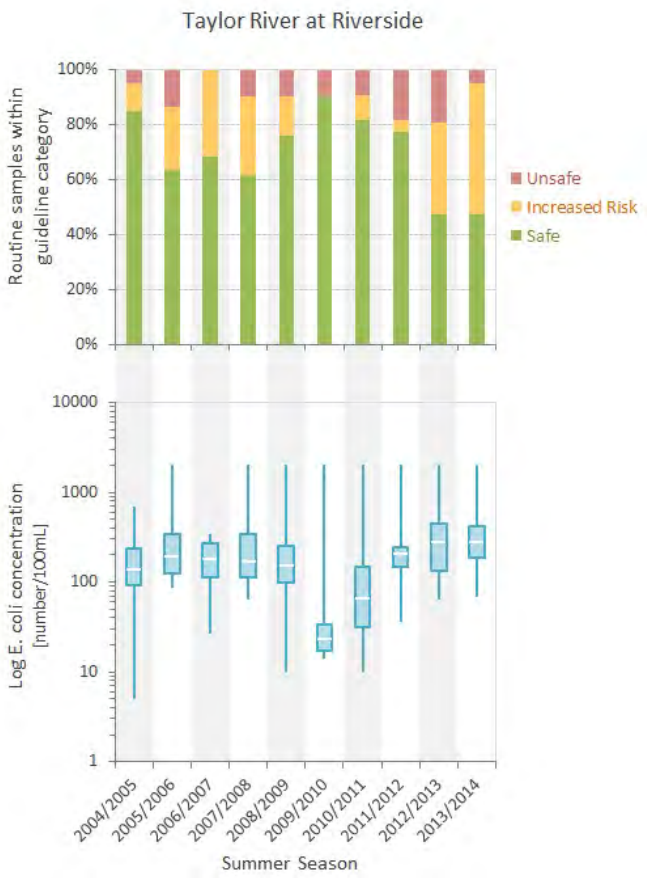

Picton Foreshore
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season

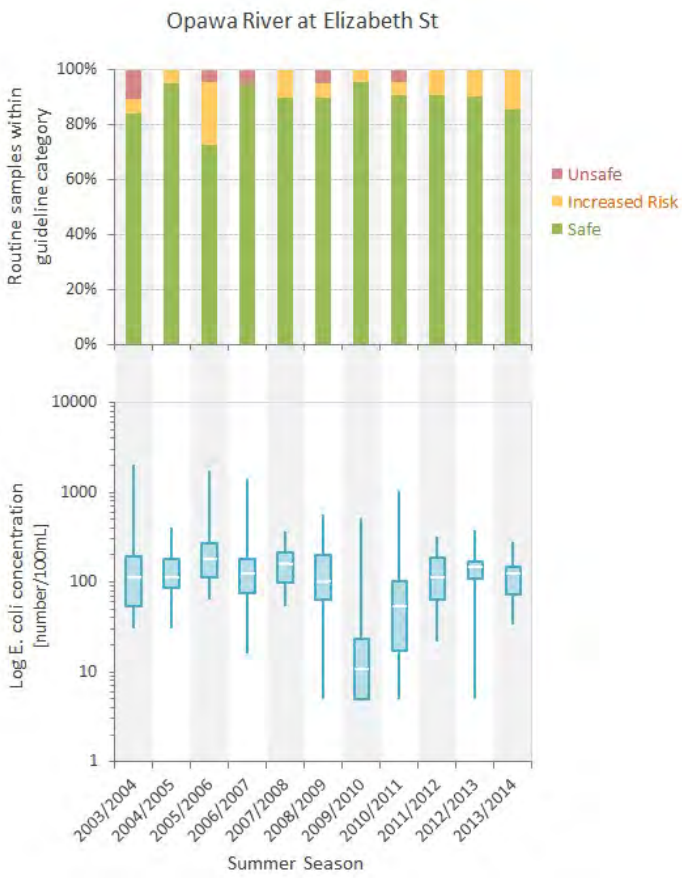

Waikawa Bay
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season

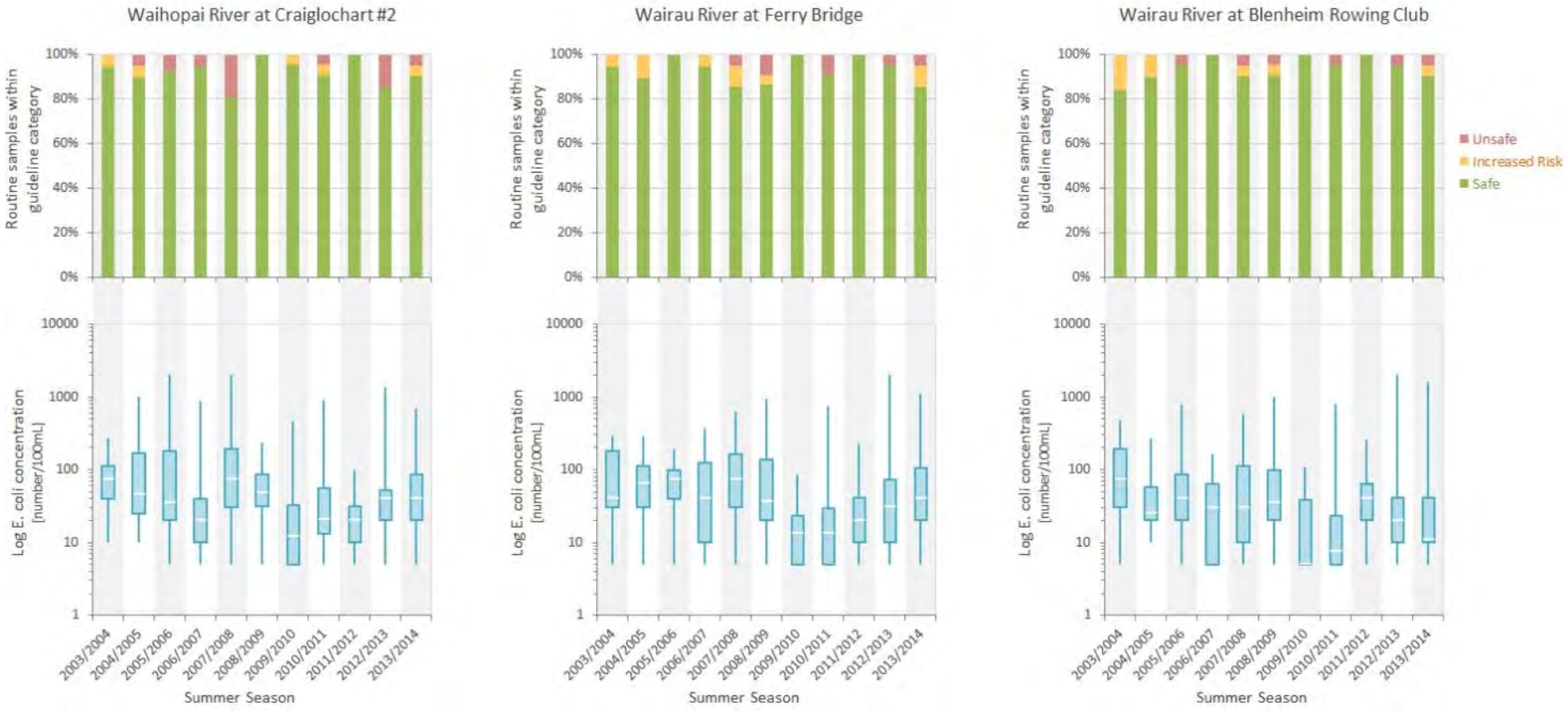

Whites Bay
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season


Marfells Beach
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log Enterococci concentration [number/100mL]
10000
1000
100
10
1
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season


Rai Falls
Pelorus River at Pelorus Bridge
Pelorus River at Totara Flat
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log E. coli concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season


Taylor River at Riverside
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log E. coli concentration [number/100mL]
10000
1000
100
10
1
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season


Opawa River at Elizabeth St
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Unsafe
Increased Risk
Safe
Log E. coli concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season


Waihopai River at Craiglochart #2
Wairau River at Ferry Bridge
Wairau River at Blenheim Rowing Club
Routine samples within guideline category
100%
80%
60%
40%
20%
0%
Log E. coli concentration [number/100mL]
10000
1000
100
10
1
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
Summer Season
Unsafe
Increased Risk
Safe

Appendix 3: Seasonal Kendall Trend Analysis Results

Site	Number of observations	Period	Median	Kendall statistic	Z	P	Median annual change	Flow Site
Anakiwa	212	10 seasons	5	-176	-0.9	0.37	0	N/A
Ngakuta Bay	212	10 seasons	5	166	0.83	0.41	0	N/A
Momorangi Bay	**212**	**10 seasons**	**10**	**-664**	**-3.21**	**0**	**-0.5**	**N/A**
Picton Foreshore	211	10 seasons	10	-337	-1.64	0.1	0	N/A
Waikawa Bay	211	10 seasons	5	68	0.34	0.74	0	N/A
Whites Bay	207	10 seasons	5	112	0.58	0.56	0	N/A
Pelorus River at Pelorus Bridge	211	10 seasons	25.97	-338	-1.61	0.11	-1.25	Pelorus River at Bryants
Rai River at Rai Falls	**212**	**10 seasons**	**67.6**	**-744**	**-3.53**	**0**	**-6.6**	**Rai River at Rai Falls**
Pelorus River at Totara Flat	**209**	**10 seasons**	**27.95**	**-537**	**-2.6**	**0.01**	**-2.9**	**Rai River at Rai Falls + Pelorus River at Bryants**
Taylor River at Riverside	209	10 seasons	159.42	269	1.3	0.19	5.18	Taylor River at Borough Weir
Opawa River at Elizabeth St	205	10 seasons	101.25	-74	-0.37	0.71	-0.89	Opawa River at Blicks Lane
Wairau River at Ferry Bridge	**210**	**10 seasons**	**22.83**	**-616**	**-3.1**	**0**	**-3.6**	**Wairau River at Barnetts Bank**
Wairau River at Blenheim Rowing Club	**211**	**10 seasons**	**9.9**	**-690**	**-3.31**	**0**	**-2.15**	**Wairau River at Barnetts Bank**

Appendix 4: Management procedure for exceedances of bathing water guidelines