BAY OF PLENTY REGIONAL COUNCIL
TOI MOANA

Recreational Waters Surveillance Report

2018/2019 Bathing Season

Bay of Plenty Regional Council
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Prepared by James Dare (Environmental Scientist)

5 Quay Street
P O Box 364
Whakatāne
NEW ZEALAND

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Reviewed by:

Name: Rochelle Carter

Position: Principal Advisor, Science

Date: 23 September 2019

Reviewed by:

Name: Paul Scholes

Position: Senior Environmental Scientist

Date: 19 September 2019

Executive summary

The Bay of Plenty Regional Council (BOPRC) undertakes annual water quality surveys of popular recreational (bathing) sites and shellfish collection areas over the warmer months (October to March). These surveys assist in identifying the risk to public health from faecal contamination in these areas. This information is then used by public health and local authorities to advise the community on the suitability of water for bathing or shellfish collection.

The objectives of this report are to present updated analyses for the 2018/19 bathing season, for the following:

- contact recreation suitability of approximately 70 river, lake, estuarine, and open coastal sites based on levels of faecal contamination;
- the state of faecal contamination at popular shellfish harvesting areas, and any associated health warnings; and
- contact recreation suitability of 13 lake and lake-fed river bathing sites based on biovolumes of planktonic cyanobacteria (free-floating blue-green algae).

Faecal contamination at river, lake, estuarine, and open coast bathing sites

Two indicator bacteria are used to assess the risk of faecal contamination in recreational waters. These are:

- Freshwaters – *Escherichia coli* (*E. coli*); and
- Marine waters – Enterococci.

A three tiered surveillance framework has been adopted to help signal when recreational waters are potentially at risk to users based on the New Zealand Microbiological Water Quality Guidelines. The system uses the colours green (safe mode), amber (alert mode) and red (action mode) to denote risk to bathers based on the latest samples. The Suitability for Recreation Grading (SFRG) is an additional method used to analyse the suitability of sites for recreation over time, using a combination of information from recreational bathing results and catchment characteristics. Data requirements for the SFRG differs from the three tiered surveillance framework as the former is an overall site assessment based on five years' of historical sampling data, and the latter is used to classify individual sample results (e.g. the most recent).

Results from the 2018/19 bathing season show a number of river, lake and estuarine sites that exhibited breaches of the amber and red thresholds during the particularly wet months of November and December 2018. Most sites returned to within the green threshold in the following drier months, however, some sites continued to exceed until the end of the season. The worst of these sites included: Kaiate at Kaiate Falls, Ngongotahā at Railway Bridge, Uretara at Henry Road Ford, Puarenga at Whakarewarewa, and Utuhina at Lake Road, which exceeded the red (action) threshold on 52%, 30%, 27%, 26% and 26% of sampling occasions, respectively.

River sites were the poorest sites for recreational bathing, with 10.3% of samples collected across all sites breaching the red (action) threshold. In comparison, 3.4% of estuarine samples, 1.1% of lake samples exceeded the red threshold, and there were no red threshold breaches for coastal sites. In general, results were worse for river and lake sites compared to the last five years' worth of data, but better for estuarine and coastal sites. Furthermore, the SFRG classed 60% of monitored river sites, 17% of lake sites, 6% of estuarine sites, and no open coastal sites, as either 'Poor' or 'Very Poor' for the 2018/19 season.

Comparison of river sites against the *E. coli* attribute in Appendix 2 of NPS-FM (2014, amended 2017) resulted in 13 sites being graded 'A', six sites 'B', 10 sites 'D', and one site 'E'. Lake sites fared better with 11 sites graded 'A' and one site graded 'B'. The NPS-FM classes grades 'A', 'B',

and ‘C’ as ‘swimmable’, which means that 63% of river sites and 100% of lake sites can be deemed swimmable.

To reduce risk of infection from microbial organisms, the message to recreational water users is to avoid swimming for at least 2-3 days after heavy of prolonged rainfall, even for sites with good water quality.

Shellfish harvesting areas

Monitoring at shellfish harvesting sites is based on the concentration of faecal coliforms found in ambient water.

The New Zealand Microbiological Water Quality Guidelines provides a dual-threshold system based on differing statistical calculations, where sites that fail both thresholds are deemed unsafe for human consumption.

For the 2018/19 bathing season, four of the 11 shellfish monitoring sites had faecal coliform concentrations that breached both thresholds. Of these, public health warnings are currently in place for: Waihi Estuary, Waiotahe Estuary, and Tauranga Harbour at Tilby Point, but not for Tauranga Harbour at Anzac Bay.

Cyanobacteria biovolumes in lakes

A three tiered warning system, similar to that used for faecal contamination at bathing sites, is also used to signal when cyanobacteria biovolumes reach volumes that pose a health risk to recreational water users.

Lake Rotoehu had a particularly persistent season for cyanobacteria blooms, and was subject to a health warning for the duration of the season. Lake Okaro had an initial bloom that lasted from October 2018 to mid-January 2019, followed by settled conditions after that. The only other lake site that breached the amber (alert) threshold was Lake Rotoiti at Okawa Bay, which bloomed from mid-May to mid-July 2019. All other monitored lake sites were below the amber threshold for the entire season for cyanobacteria.

Assessment of cyanobacteria monitoring sites against the cyanobacteria attribute in Appendix 2 of the NPS-FM showed that both Rotoehu sites breached the National Bottom Line based on data from 2016-2019. Lake Okaro was graded a ‘C’, while all other sites were graded ‘A’.

Contents

Part 1: **Introduction**

Overview

The Bay of Plenty Regional Council (BOPRC) undertakes annual water quality surveys of popular recreational (bathing) sites and shellfish beds over the warmer months (October to March). These surveys assist in identifying the risk to public health from faecal contamination at these areas. The information is then used by public health and local authorities, to advise the community on the suitability of water for bathing or shellfish consumption.

There are a number of regional plans that have objectives based on a contact recreation standard. These are:

- On-site Effluent Treatment (OSET) Regional Plan,
- Operative Regional Natural Resources Plan,
- Regional Coastal Environmental Plan,
- Regional Policy Statement.

Planktonic cyanobacteria (blue-green algae) are also monitored in lakes due to the public health risk they present. This report summarises the recreational bathing survey monitoring results for the 2018/19 season and also presents recent shellfish monitoring results.

Legislative framework and responsibilities

The National Policy Statement for Freshwater Management (NPS-FM) (MfE, 2014) has the objective to safeguard the health of people and communities. Appendix 2 of the NPS-FM sets thresholds for numeric attributes, ranked into four or five bands (A-D or E), defining water quality for “human” (and “ecosystem”) health (MfE, 2014) (see Section 2.3).

The agencies responsible for managing recreational water quality for the community are the Regional Council, district councils, district health boards and the Medical Officer of Health. There is no legislation dictating which agency is responsible for recreational bathing monitoring, but under the Health Act (1956) and the Resource Management Act (1991), local agencies and the health authority have defined responsibilities.

The Microbiological Water Quality Guidelines (MfE, 2003) provide a recommended framework of roles and responsibilities of the agencies involved in recreational water quality monitoring. Based on this framework, a protocol for monitoring and reporting has been developed for the Bay of Plenty.

Recreational water quality objectives

The objectives of the BOPRC’s recreational bathing monitoring programme are to:

- Assess the suitability of approximately 70 river, lake and marine sites in the Bay of Plenty for contact recreation over summer.
- Provide information on the suitability of shellfish for human consumption.
- Assist in safeguarding the life-supporting capacity of water, including public health.
- Provide a mechanism to determine the effectiveness of regional plans.
- Provide information for State of the Environment monitoring, regionally and nationally.

- Assist in identifying areas of poor water quality and help to identify the causes of this so remedial action can be initiated.

The recreational bathing sites that were monitored in the 2018/19 season are shown in Figure 1.1.

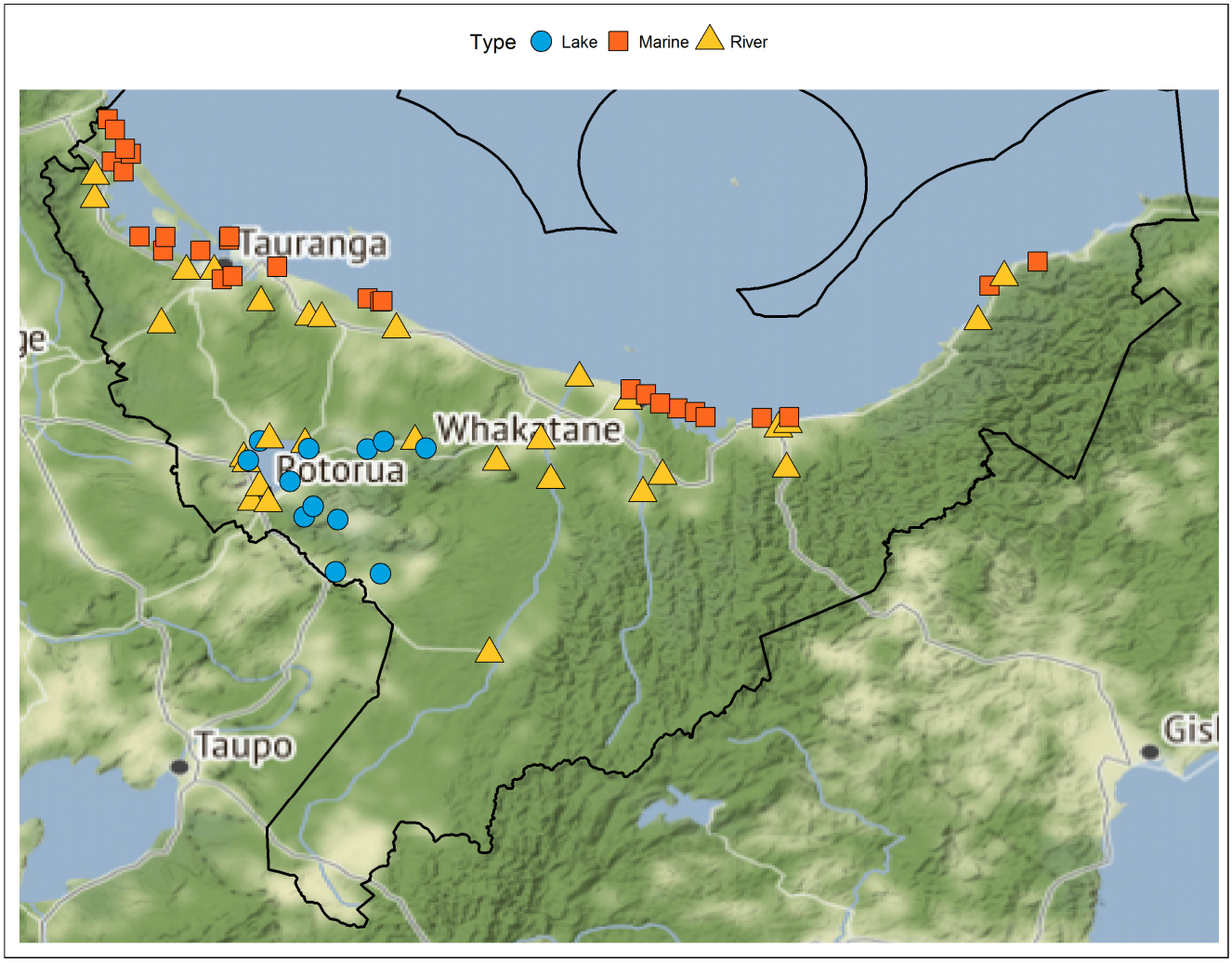


Figure 1.1 Bathing surveillance monitoring sites for the 2018/19 monitoring season, Bay of Plenty.

Part 2: **Microbiological guidelines, indicators and grading**

Introduction

If human or animal faecal matter finds its way into waters of recreational value, there is a risk that water users will be exposed to a diverse range of pathogenic (disease causing) micro-organisms. A variety of organisms are present in faecal matter such as viruses, bacteria, protozoa (single cell organisms), and helminths (nematodes). These can reach water bodies via a variety of pathways and in varying concentrations.

The impacts of pathogenic micro-organisms on human health are commonly manifested as gastro-enteritis, but other common illnesses include respiratory problems and skin rashes. Serious illness can also be attributed to infection from pathogens contained in waters, for example, hepatitis A, giardiasis, cryptosporidiosis, campylobacteriosis and salmonellosis (MfE, 2003).

As it is difficult and impractical to measure all potentially pathogenic micro-organisms in water, indicator micro-organisms are used to assess recreational water quality. Indicator micro-organisms give an indirect measure of pathogen levels. The bacteriological indicators chosen are associated with the gut of warm blooded animals and are common in faecal matter. While these indicator bacteria are not generally harmful themselves, they do indicate the presence of harmful pathogens. Bay of Plenty Regional Council uses two indicator bacteria which are commonly used in recreational waters:

- freshwaters - *Escherichia coli* (*E. coli*), and
- marine waters - Enterococci.

The use of these two indicators is stipulated in the New Zealand Microbiological Water Quality Guidelines (MfE, 2003). Research that relates illness to indicator bacterial levels has been used to develop guideline levels for these indicator bacteria which are based on the tolerable risk to healthy people. The guidelines provide a method to grade recreational waters (see Section 2.4), and trigger levels which can be used by water managers and the public to assess the potential health risk of using recreational waters. Single water sample results can be compared to guideline values to help determine if a health alert or other action should be undertaken.

Sampling and analysis

Before the start of the bathing season, a monitoring plan was designed and circulated for comment to Toi Te Ora Public Health and the city or district councils (Opotiki, Kawerau, Rotorua, Western Bay and Tauranga). The criteria for selection of sites included whether they were high-use bathing locations and whether there was known contamination risk. Other sites have been included at the request of the community. Monitoring began in late October 2018 and ran until the end of March 2019. Surface water samples were collected weekly or once every two weeks from approximately 70 sites across the Bay of Plenty region. Sampling occurred between 8:00 am and 3:30 pm and was completed by either wading or use of a sample pole. Sterile 200 ml polyethylene bottles were used to sample water at a representative location in the water column. Samples were analysed by BOPRC's IANZ accredited laboratory via the methods shown in Table 2.1 below.

Table 2.1 Methods used for analysis of water samples.

Parameter (abbreviation)	Method	Detection limit/units*
Escherichia coli (E. coli)	Membrane filtration (APHA 2005)	1 cfu/100 ml
Faecal coliform (FC)	Membrane filtration (APHA 2005)	1 cfu/100 ml
Enterococci (Ent)	Method No 1600, USEPA1985 EPA-821-R-97-004	1 cfu/100 ml

*cfu/100ml = colony forming unit/100ml

Microbiological guidelines

The microbiological guidelines provide the framework for assessing the health risk associated with faecal contamination of water. There are two tiers to the guidelines. The first tier is used to compare weekly monitoring results with the microbiological guidelines over a bathing season, providing water managers with a tool for assessing more immediate health risk to the public. The second tier is a site grading providing an analysis of the suitability for recreation over time, using a combination of information from microbiological bathing survey results and catchment characteristics.

A three-tiered management framework has been adopted to help signal when recreational waters are potentially at risk to users. The system uses the colours green (safe mode, 'surveillance'), amber (cautionary mode, 'alert') and red (unsafe mode, 'action') to denote the level of risk to users. The indicator bacteria levels and recommended management responses to these modes are listed in Table 2.2. This framework is used to assess the weekly health risk of recreational waters as individual sample results are obtained.

*Table 2.2 Surveillance, alert and action modes for fresh and marine waters used in the three tiered management framework for weekly assessment of health risk of recreational waters (*MfE*, 2003).*

Variant	Mode	Guideline	Recommended management response
Freshwater	**Green/Surveillance**	Single sample <= 260	Routine monitoring.
	Amber/Alert	Single sample > 260 and <=550	Increased monitoring, identify possible sources.
	Red/Action	Single sample > 550	Public warnings, increased monitoring, source investigation.
Marine	**Green/Surveillance**	Single sample <= 140	Routine monitoring.
	Amber/Alert	Single sample > 140	Increased monitoring, identify possible sources.
	Red/Action	Two consecutive single samples > 280	Public warnings, increased monitoring, source investigation.

Surveillance mode (green) indicates that there is an acceptable (low) risk to recreational water users. Should waters be found to be in alert mode (amber) then there is an increased risk of illness if contact is made with recreational waters. Action mode (red) indicates that waters pose an unacceptable health risk to recreational water users. In such a case, the health authority will assess the risk to public health and if necessary, issue health warnings in conjunction with local

authorities. Use of microbiological guidelines and the issuing of health warnings are dependent on the circumstances surrounding any contamination event.

Bathing surveillance grading

The microbiological guidelines outline a process to grade the suitability of marine and fresh waters for recreational use. A ‘Suitability for Recreation Grade’ (SFRG) is generated through a combination of qualitative assessment of susceptibility of recreational sites to faecal contamination and by direct weekly measurement of appropriate bacteriological indicators at the site. The alert and action levels described above provide a real time indication of the changing risk over a bathing season. In contrast, the SFRG describes the risk of faecal contamination at a given site over several bathing seasons.

The SFRG is made up of two components (Figure 2.1):

- The Sanitary Inspection Category (SIC) is composed of five ratings from very low to very high, which are dependent upon the presence and potential effect of faecal contaminant sources. It generates a measure of susceptibility of a water body to faecal contamination from potential water quality risk factors close to swimming spots, such as sewage outfalls, storm water drains, stock in waterways and run-off from land.
- Historical microbiological results (weekly indicator bacteria monitoring results) are used to generate the Microbiological Assessment Category (MAC), which provides a measurement of actual water quality over time.

These two combined give an overall SFRG (Figure 2.1), which describes the general condition of a site at any given time, based on both risk and indicator bacteria counts. The five grades in the SFRG range from ‘Very Good’ to ‘Very Poor’. These grades help determine whether ongoing monitoring is required, and provide the basis for telling people whether or not water is suitable for recreational use from a public health perspective. If there is an incompatibility between the SIC and the MAC, (this may be due to limited data) then a ‘Follow Up’ grade is given.

The SIC is developed from a ‘Catchment Assessment Checklist’ (CAC) (MfE, 2003) which explores land use, water use and characteristics, microbiological hazards, discharges, littoral drift, climatic influences, and other influences present in the catchment of the beach under analysis. Once a CAC is completed, a ‘SIC can be allocated. Catchment checklists have been surveyed by respective councils and the Regional Council in 2019 to update the SIC. The SICs have been calculated using the Bathewatch software developed by the Ministry for the Environment (MfE).

The grading system developed by MfE and the Ministry of Health (MoH) is prescriptive with a view to keeping it uncomplicated and user friendly. The only room for interpretation is within the CAC when determining microbiological hazards.

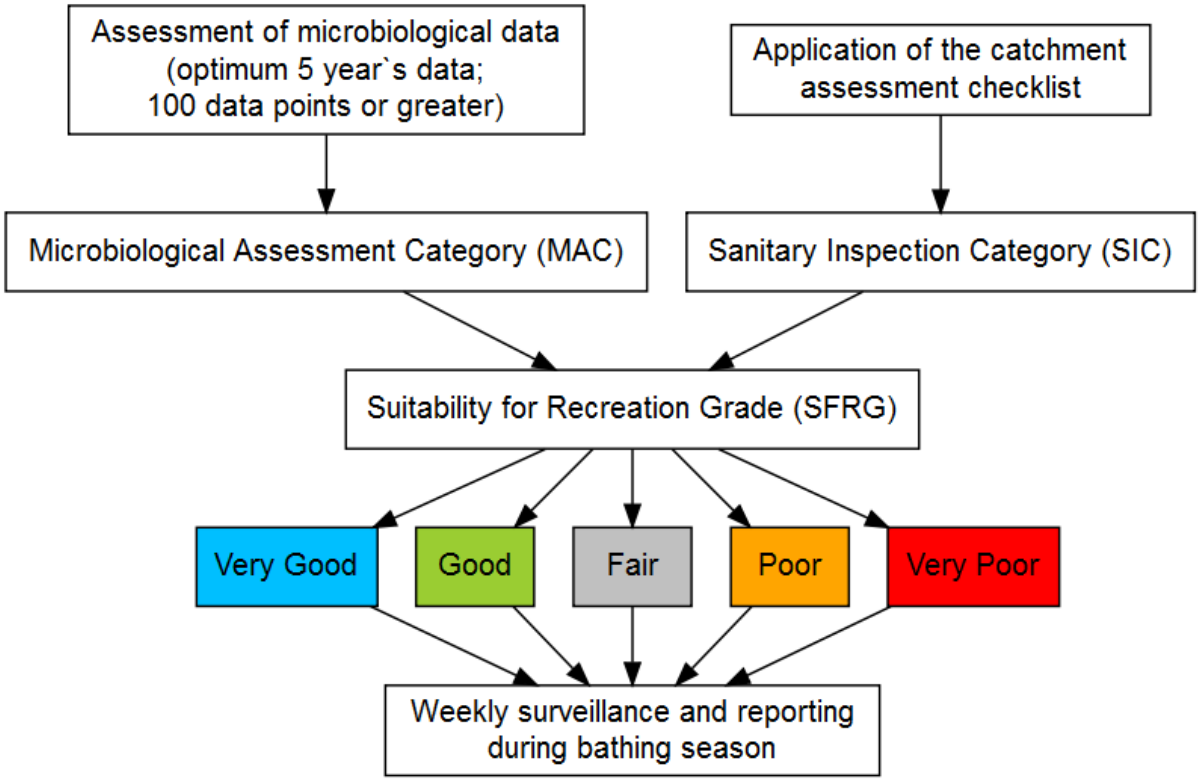


Figure 2.1 Components of the Suitability for Recreation Grade (SFGR) (From MfE*, 2003).*

The MAC is calculated as the 95th percentile of the last five years of historic faecal bacteria indicator data. Enterococci is the preferred indicator bacteria for marine waters and *Escherichia coli* (*E. coli*) is the indicator bacteria for freshwaters. Ideally, at least 20 samples collected from each site on a weekly basis during a bathing season, over a five year period to provide at least 100 sample points, are required for the MAC assessment. This has not occurred for all Bay of Plenty sites, so MAC evaluations are based on available data.

The SFRG's have been determined for recreational sites in the Bay of Plenty region since 2005. Updated SFRG's incorporating the most recent season's microbiological water quality results are summarised in Appendix 1, which are based on the last five year's data.

National Policy Statement for Freshwater (NPS-FM)

There are a series of tests involved in establishing the bands (attribute states) for rivers from Blue to Red as outlined in Appendix 2 of the NPS-FM (MfE, 2014). The table below shows the bands and the metrics that define them. At the time of publication, the Ministry for the Environment was involved in public consultation on revisions to the NPS-FM, including the way *E. coli* is graded at swimming sites. This report compares results to the operative NPS-FM (2014) and not the proposed changes under consultation.

Table 2.3 The bands and attribute states for the E. coli recreation attribute as outlined in the National Policy Statement for Freshwater (MfE, 2014).

Attribute state	Exceedances over 540 (%) (*E. coli*/100ml)	Exceedances over 260 (%) (*E. coli*/100ml)	Median (*E. coli*/100ml)	95th Percentile (*E. coli*/100ml)	Narrative
What it means?	How often the river exceeds the acceptable threshold for swimming.	How often the river goes over the point where additional monitoring is needed at primary contact sites.	The mid-point (i.e. half the time *E. coli* is lower than this, half the time it is higher).	*E. coli* only rarely goes past this point (only 5% of the time).	Risk of *Campylobacter* infection (based on *E. coli* indicator).
A (Blue)	<5%	<20%	<=130	<=540	For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk). The predicted average infection risk is 1%
B (Green)	5-10%	20-30%	<=130	<=1000	For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk). The predicted average infection risk is 2%
C (Yellow)	10-20%	20-34%	<=130	<=1200	For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk). The predicted average infection risk is 3%
D (Orange)	20-30%	>34%	>130	>1200	For at least half the time, the estimated risk is =50 in 1,000 (>5% risk). The predicted average infection risk is >3%
E (Red)	>30%	>50%	>260	>1200	For at least half the time, the estimated risk is =50 in 1,000 (>5% risk). The predicted average infection risk is >7%

The NPS-FM states that the attribute state should be determined by using a minimum of 60 samples over a maximum of 5 years, collected on a regular basis regardless of weather and flow conditions. However, where a sample has been missed due to adverse weather or error, attribute state may be determined using samples over a longer timeframe (MfE, 2014).

Appendix 2 of the NPS-FM states that the *E. coli* attribute state (A-E) must be determined by satisfying all numeric attribute states outlined in the *E. coli* attribute table. More often than not, numeric attribute states line up to provide a consistent *E. coli* attribute state. However, in some

instances, numeric attributes can cross multiple *E. coli* attribute state bands, which violates the requirement stated above. This report deals with this problem by employing the following logical steps:

1 If all numeric attributes line up to satisfy the requirements of a single attribute state band, then that attribute state band is adopted.

2 If numeric attributes cross multiple attribute state bands, the band corresponding to the worst numeric attribute is adopted. In the case of the numeric attribute 'median concentration', attribute bands A-C (<=130 cfu) are equal so an 'average' attribute band of 'B' is attributed. For the numeric attribute '95th percentile', bands D and E are equal (>1200 cfu) and a 'D' attribute band is attributed.

Data preening

Many of the monitored bathing sites are also regional State of the Environment (SOE) monitoring sites or involved in catchment specific investigations. The objectives of these programmes differ from that of the bathing programme, often in drastic ways. For example a catchment investigation objective may be to understand *E. coli* concentrations at different stages of the hydrograph, so a flood peak may be intensively sampled. Despite these data being collected at the same site and measuring the same parameter, these additional samples can affect analysis and be misleading to the person interpreting the results. For this reason, the current study is limited to samples that were collected as part of the bathing monitoring, shellfish, or cyanobacteria monitoring programmes only.

Part 3: **Recreational bathing surveillance and grading results 2018/19**

Overview

Lake sites were the best performing freshwater category of bathing sites for the 2018/19 season based on the SFRG grading system, with nine sites (75%) obtaining a ‘very good’ or ‘good’ grade, and only two sites (17%) being graded as ‘poor’ or worse. This result is worse than the last published grading result for the 2016/17 season, where 91.7% of lake sites were graded as ‘good’ or ‘very good’.

In contrast, river sites, had 56.7% of sites obtaining an SFRG of ‘poor’ or ‘very poor’, an increase from 33.3% in 2016/17, and 30% of sites achieving ‘good’ or ‘very good’.

The majority (53.3%) of estuarine sites achieved ‘good’ or ‘very good’ status, although this is a significant drop from 85.7% in 2016/17. The main difference between the two seasons appears to be a shift from a number of sites achieving ‘good’ status in 2016/17 to ‘fair’ in 2018/19, while sites that were graded ‘fair’ in 2016/17 further degraded to ‘poor’ in 2018/19’.

Open coastal sites were the best performing category of all freshwater, marine, and estuarine sites, with all sites being graded as either ‘good’ or ‘very good’. This was an improvement from 2016/17 where the percentage of ‘very good’ sites increased from around 8% to 61.5%.

Detailed results of the monitoring are presented in tabular form in Appendix 1a–1d. These tables give information on the 95th percentile value, MAC score, SIC score, SFRG, as well as NPS-FM attribute banding (where applicable). The SFRG’s are presented in Figures 3.1 and 3.2.

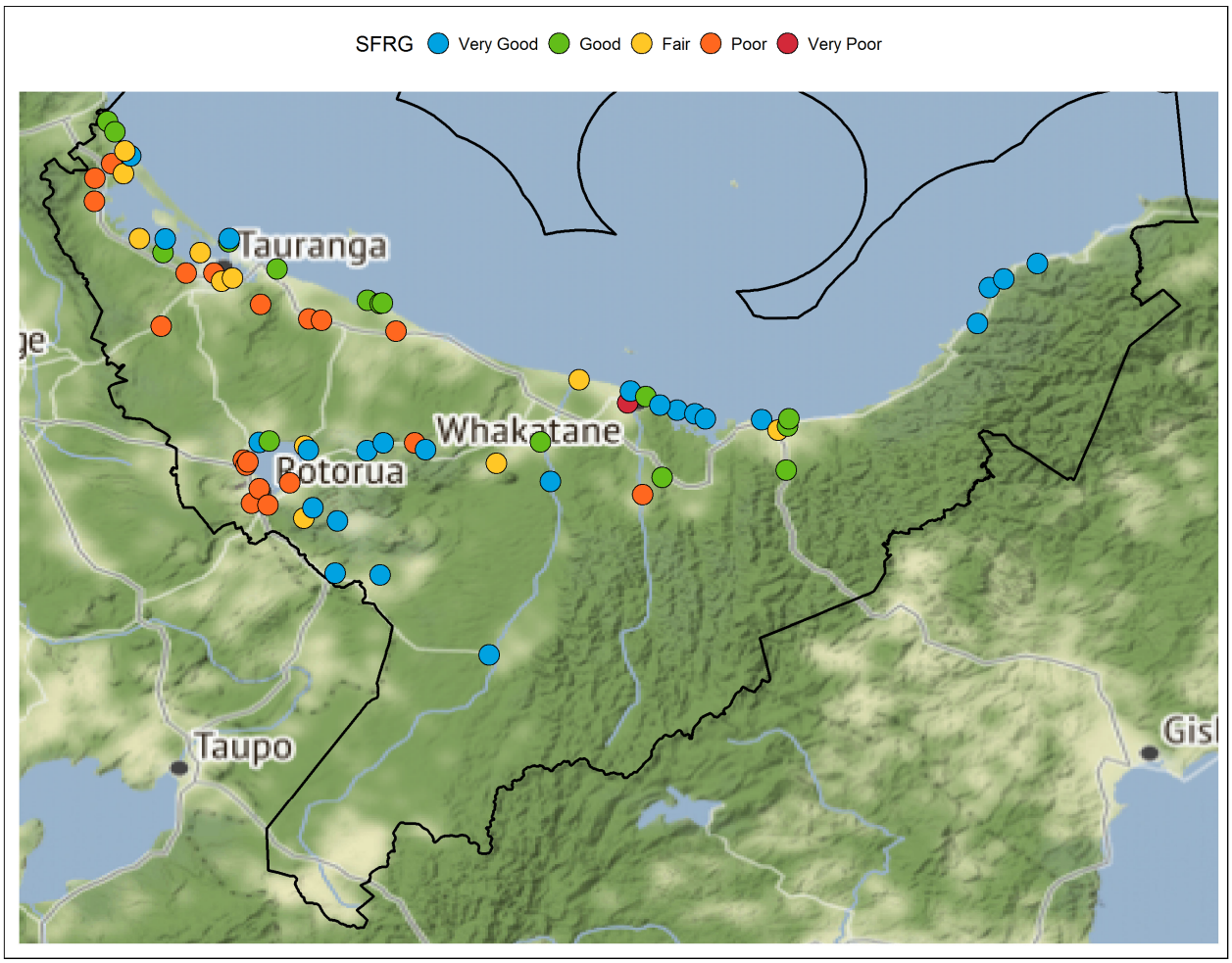


Figure 3.1 *Suitability for Recreation Grades for Bay of Plenty contact recreation monitoring sites, 2018/19.*

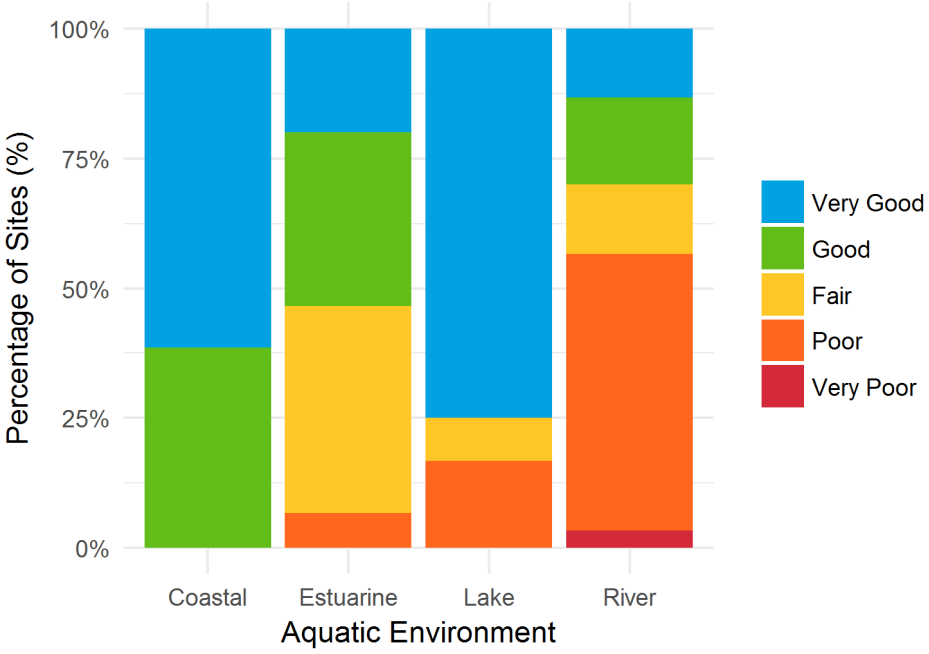


Figure 3.2 *Comparison of the 2018/19 results for the SFRG across aquatic environments.*

The status of monitored contact recreation sites against the red/action mode in the New Zealand Microbiological Guidelines, are presented in Table 3.1. This shows that open coastal sites had the highest quality overall, where 100% of samples were less than the red (action) threshold. This is an improvement relative to the last five years' worth of data, implying a 'better than normal' year for red-threshold exceedances at these sites. Lake sites also performed better than normal, increasing from 98.2% of samples less than the red (action) threshold over the past five years, to 98.9% of samples in 2018/19. Estuarine and river sites both decreased relative to the five year value, where the former reduced from 96.8% to 96.6%, and the latter from 90.6% to 89.7%. This suggests that more red-threshold breaches occurred during the 2018/19 season than in a 'typical' season over the last five years, for these sites.

*Table 3.1 Percentage of weekly samples from monitored bathing sites with indicator bacteria levels less than the Red/Action Mode, as defined by the New Zealand Microbiological Water Quality Guidelines (*MfE*, 2003).*

		Rivers	Lakes	Estuarine	Coastal
Samples less than the Red/Action Mode	**2018/19**	89.7	98.9	96.6	100.0
	Last 5 Years	90.6	98.2	96.8	98.9

River and stream sites

Figure 3.3 shows the range of *E. coli* results recorded at each site for the 2018/2019 season. Twenty three of the 30 sites (77%) had instances where the amber (alert) threshold was breached. Furthermore, 18 sites (60%) exceeded the red (action) threshold at some time during the season.

Kaiate at Kaiate Falls Road was the worst performing site over the 2018/19 season, where 52% of samples exceeded the red (action) threshold, and a further 43% of samples exceeded the amber (alert) threshold, equating to 95% of samples exceeding the amber (alert) status defined in the Microbiological Guidelines. This is a significant increase from 2016/17 where 15% of samples collected from Kaiate at Kaiate Falls Road exceeded the red (action) threshold, although less than the 2015/16 season where 60% of samples were in excess. A comprehensive catchment survey is underway in this catchment, with the objective of isolating areas of disproportionate contribution to faecal source contamination. The local community is involved with this work, and discussions of future mitigation scenarios are taking place.

Over 50% of samples collected from Ngongotahā at Railway Bridge, Uretara at Henry Road Ford, Utuhina at Lake Road, and Puarenga at Whakarewarewa exceeded either the amber (alert) or red (action) thresholds during the most recent bathing season. These sites have previously been noted as 'problem' sites, with reasons for exceedances primarily being attributed to rainfall events (Scholes, 2018). However, elevated results during the 2018/19 season are not limited to periods of high rainfall, implying that other factors are involved. The Integrated Catchment Management (ICM) team at BOPRC has highlighted many of these catchments to be part of their 'priority catchment' investigations, which aims to better understand the spatial and temporal variation of contamination (including faecal contamination), with the intention of being able to apply mitigations to improve the overall condition of the catchment and preserve community values. Catchment investigations within the Uretara and Ngongotahā catchments have already begun, with a number of others commencing in the 2019/20 financial year.

Eighteen of the 30 monitored bathing sites (60%) had 95th percentile values in excess of the red (action) threshold, using data collected over the last five bathing seasons (2014-2019) (Figure 3.4). This has increased from 37% reported in the 2016/17 bathing report (Scholes, 2018; based on 2012-2017 data), which either implies that some sites are becoming more susceptible to overland flow caused by rainfall events, or that contamination events caused by rainfall are larger or more frequent in recent years. Regardless, although 95th percentile values are useful to identify which

catchments should be prioritised for investigation, people are unlikely to be actively swimming when contamination events of this magnitude occur due to elevated flows.

Median values over the same time period are also plotted in Figure 3.4, and give a measure of the average risk to water users. There were three sites that had a median value that exceeded the amber (alert) threshold for the 2018/19 season. These were: Uretara at Henry Road Ford (270 cfu/100ml), Ngongotahā at Railway Bridge (340 cfu/100ml), and Kaiate at Kaiate Falls Road (510 cfu/100mL). All other sites had median values below the orange (alert) threshold, suggesting that more often than not, the majority of river sites were safe to swim at during the 2018/19 bathing season.

Bathing sites monitored during the 2018/19 season were also assessed against the *E. coli* attribute in Appendix 2 of the NPS-FM (Table 3.2), which requires at least 60 data points collected within the last five years (i.e. between 2014 and 2019). Analysis revealed that 43.3% of sites were classed within the 'A' attribute band, 20% were within the 'B', 33.3% were within the 'D', and 3.3% within the 'E' band. The *E. coli* attribute table also defines whether a site is swimmable or not depending on attribute band results, where bands 'A' to 'C' are classed as swimmable and 'D' to 'E' are classed as un-swimmable. Results for this analysis imply that 63% of monitored bathing sites could be classed as swimmable, and 37% as un-swimmable.

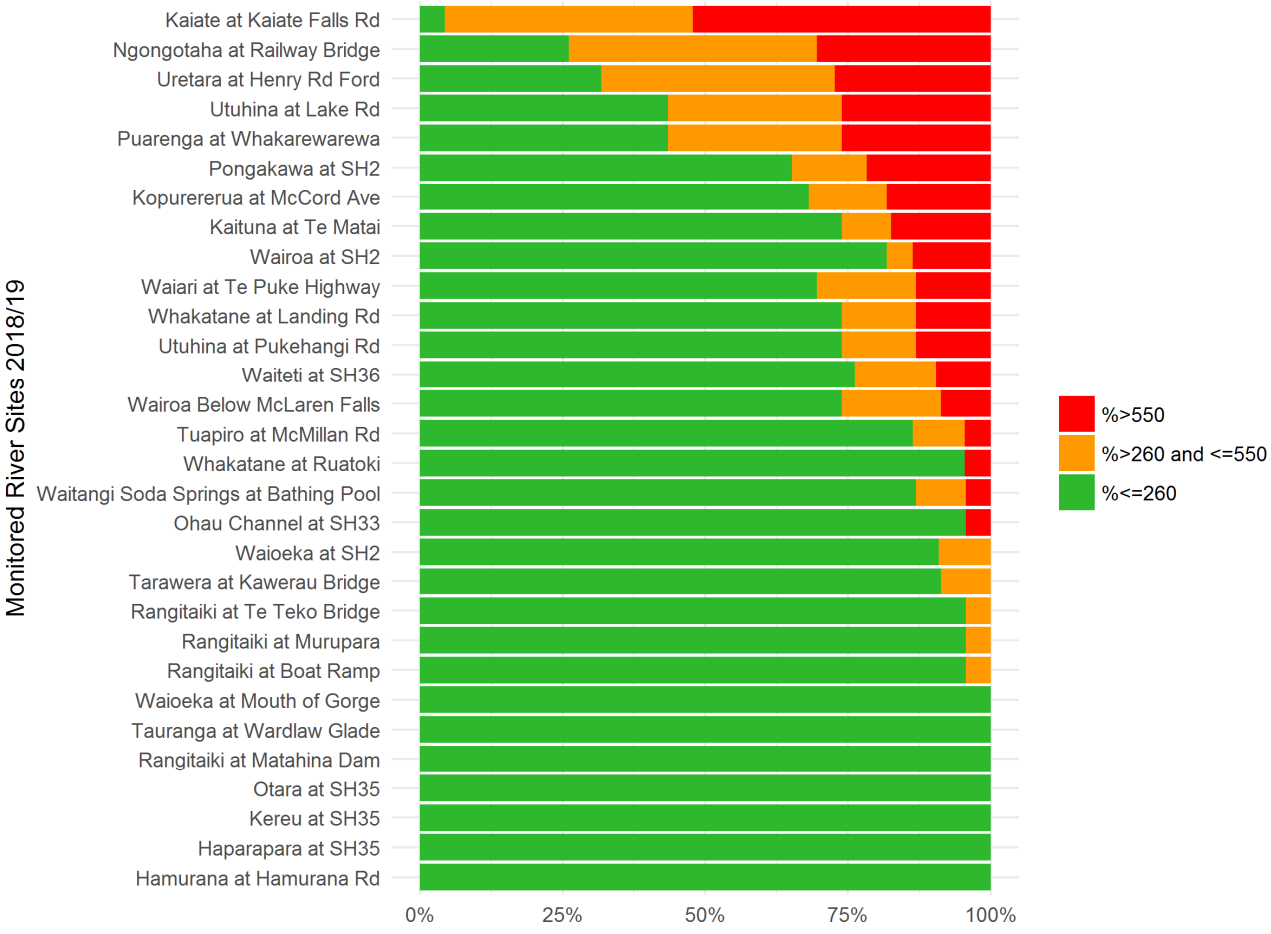


Figure 3.3 *Percentage of samples from river and stream sites with E. coli concentrations (cfu/100ml) in each of the modes in the Microbial Water Quality Guidelines (*MfE*, 2003), 2018/19 bathing season.*

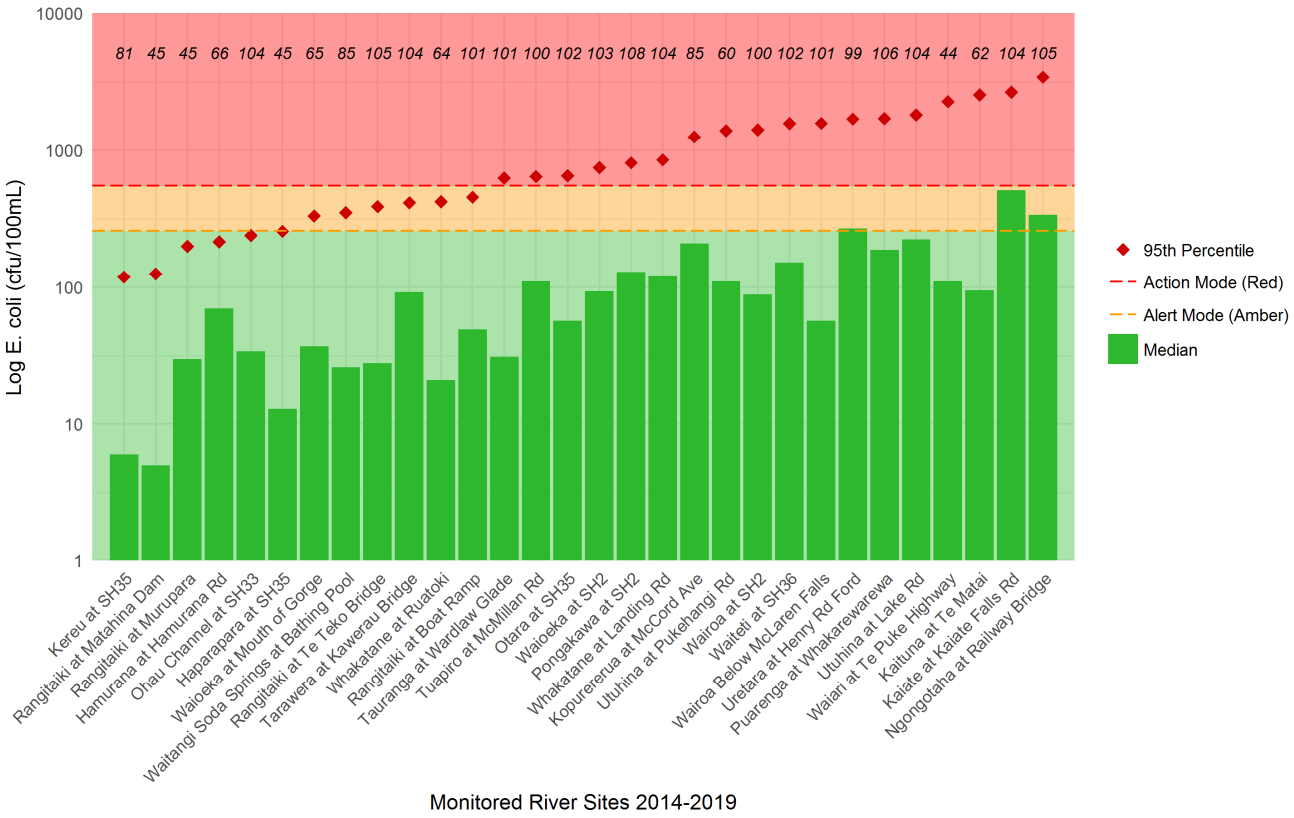


Figure 3.4 *95th Percentile and median E. coli concentrations at river and stream sites over the past five years. The black numbers represent the number of samples available for the analysis period.*

Table 3.2 *The percentage of river sites falling within each band specified in Appendix 2 of the NPS-FM, over the past five year period (2014-2019).*

Attribute State Band	A	B	C	D	E
Average infection risk	1%	2%	3%	>3%	>7%
% sites	43.3	20.0	0.0	33.3	3.3
n	13	6	0	10	1

Lake sites

Figure 3.5 shows a summary of results from lake bathing sites over the 2018/19 season. Of the 12 lake sites monitored on a weekly basis, six sites (50%) had at least one sample that exceeded the amber (alert) threshold, with two sites (17%) breaching the red (action) threshold. Lake Rotorua at Ngongotahā was the worst performing lake bathing site, with two samples breaching the red (action) threshold (including one sample on the 3 December that reached 17600 cfu/100mL), and a further two samples that breached the amber (alert) threshold. This is an improvement from the 2016/17 season where four samples breached the red (action) threshold, although no additional samples breached the amber (alert) threshold. The 3 December sample was collected after approximately 100 mm of rainfall had been recorded in the upper catchment, over the previous two days. This implies that the Lake Rotorua at Ngongotahā bathing site is significantly influenced by the Ngongotahā Stream, which had a particularly bad year with regard to faecal contamination levels. This river is currently undergoing a catchment investigation to try and identify spatial and temporal hotspots that can be mitigated using appropriate land management interventions, which should help improve the quality of the lake site.

Lake Rotorua at Holdens Bay, situated on the opposite side of the Lake from Ngongotahā, was the only other site to experience a red (action) exceedance. This site is close to the outflow of the Waingaehe Stream which has a significant agricultural component, however, further investigation is needed to draw a causal link between inflow conditions and elevated results at the bathing site. Lake Tikitapu at Beach exceeded the amber/alert threshold on four occasions, with the most contaminated sample returning 450 cfu/100mL. It is unknown why this may have occurred given the low intensity of land use in the vicinity of the bathing site, although avian sources are a strong possibility.

Two of the 12 monitored lake sites had 95th percentile values in excess of the red (action) threshold, based on analysis of a five year dataset (Figure 3.6). One of these sites, Lake Rotorua at Ngongotahā, showed similar results in Scholes (2018) (based on 2012-2017 data), implying that rainfall event related contamination has been, and continues to be, a problem for this site. Lake Rotorua at Hamurana also had a 95th percentile value that exceeded the red threshold. This site has worsened significantly since reported by Scholes (2018), who calculated the 95th percentile to be approximately 120cfu/100mL. All sites in the current analysis had median values that were less than 50cfu/100mL, implying that all lake bathing sites are swimmable most of the time. However, as previously discussed, some sites are subject to short lived contamination events, most likely linked to rainfall.

All lake bathing sites were deemed swimmable under the *E. coli* attribute table in the NPS-FM (Table 3.3), with 11 sites (92%) achieving an 'A' band status, and one site (8%) being graded a 'B'.

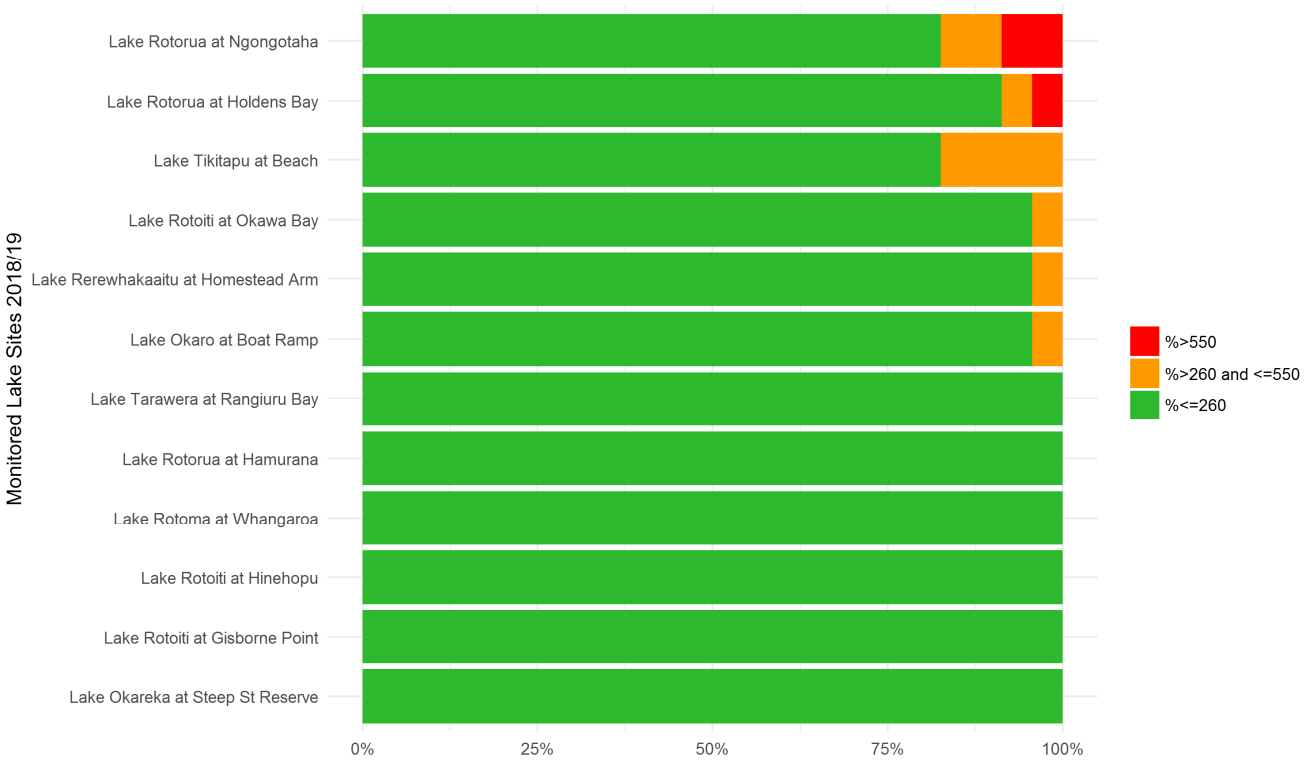


Figure 3.5 *Percentage of samples from lake sites with E. coli concentrations (cfu/100ml) in each of the modes in the Microbial Water Quality Guidelines (*MfE*, 2003), 2018/19 bathing season.*

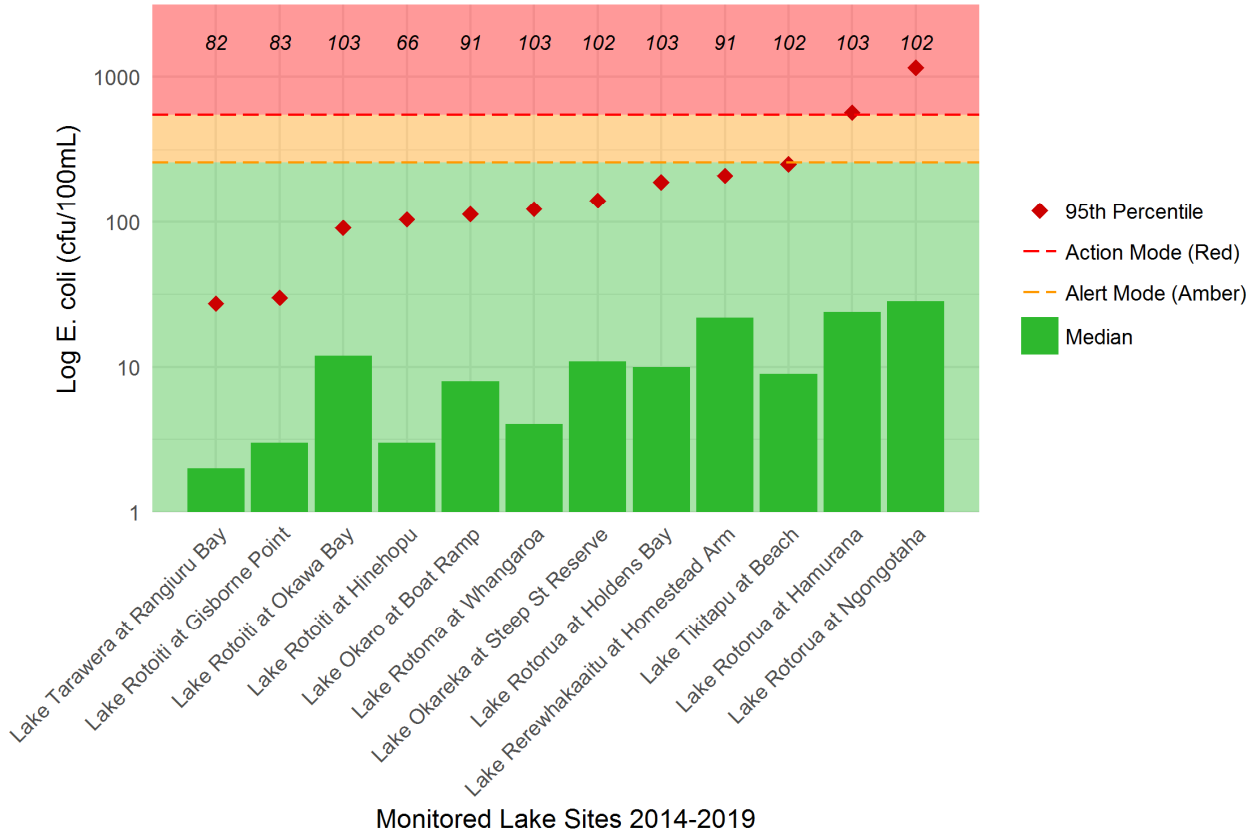


Figure 3.6 *95th Percentile and median E. coli concentrations for lake sites over the past five years. The black numbers represent the number of samples available for the analysis period.*

Table 3.3 *The percentage of lake sites falling within each band specified in Appendix 2 of the NPS-FM for E. coli, based on 2018-2019 data.*

Attribute State Band	A	B	C	D	E
Average infection risk	1%	2%	3%	>3%	>7%
% sites	91.7	8.3	0.0	0.0	0.0
n	11	1	0	0	0

Marine sites

Open coastal

Only two of the 13 monitored open coastal sites (15%) had samples that exceeded the amber (alert) threshold over the 2018/19 bathing season. These were: Waihi Beach at 3 Mile Creek, and Hikuwai Beach at end of Snell Road (Figure 3.7). All sites had median values over the past five seasons that were less than or equal to 5cfu/100mL, which suggests that coastal sites experience extremely low levels of contamination. Two sites, Waihi Beach at 3 Mile Creek and Te Kaha at Maraetai Bay, had 95th percentile values in excess of the amber (alert) threshold, which suggests that these sites experience short lived, mild contamination events. However, these events are not significant enough to warrant further investigative action at this stage.

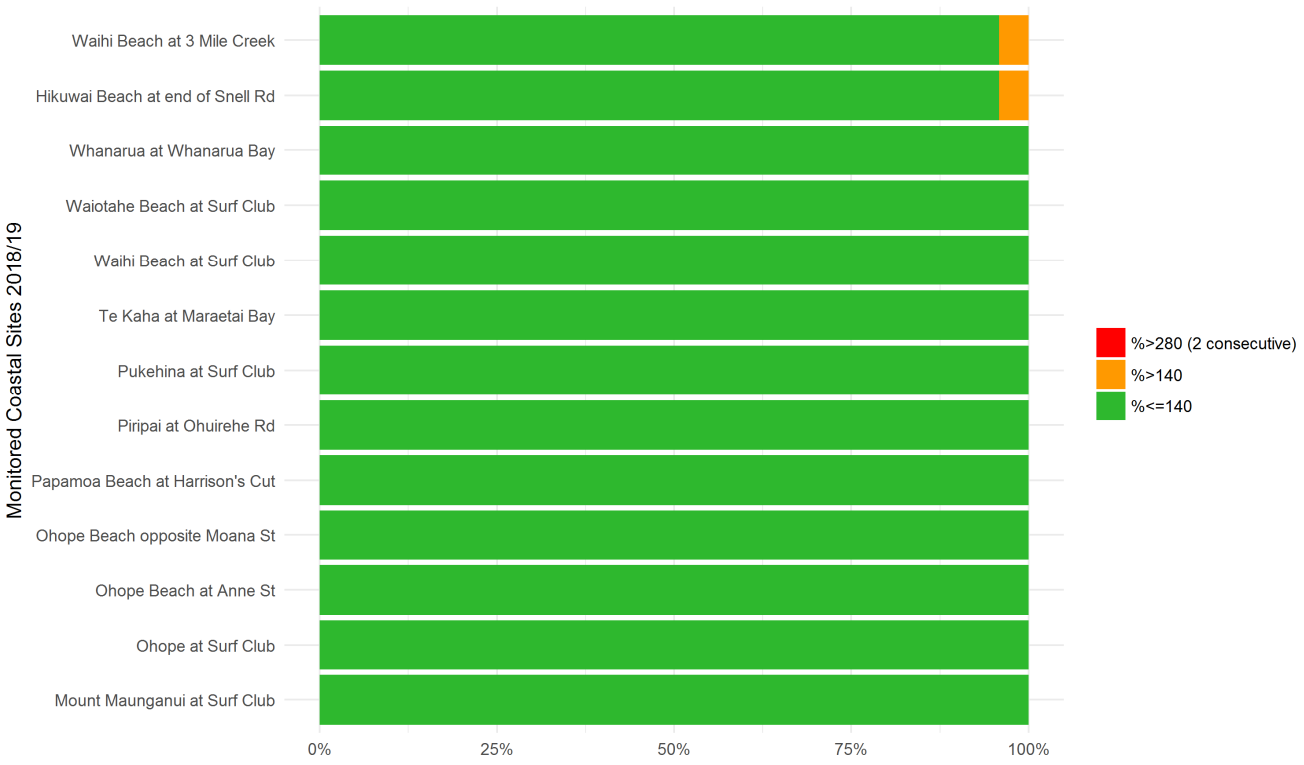


Figure 3.7 *Percentage of samples from open coastal marine sites with Enterococci concentrations (cfu/100ml) in each of the modes in the Microbial Water Quality Guidelines (*MfE*, 2003), 2018/19 bathing season.*

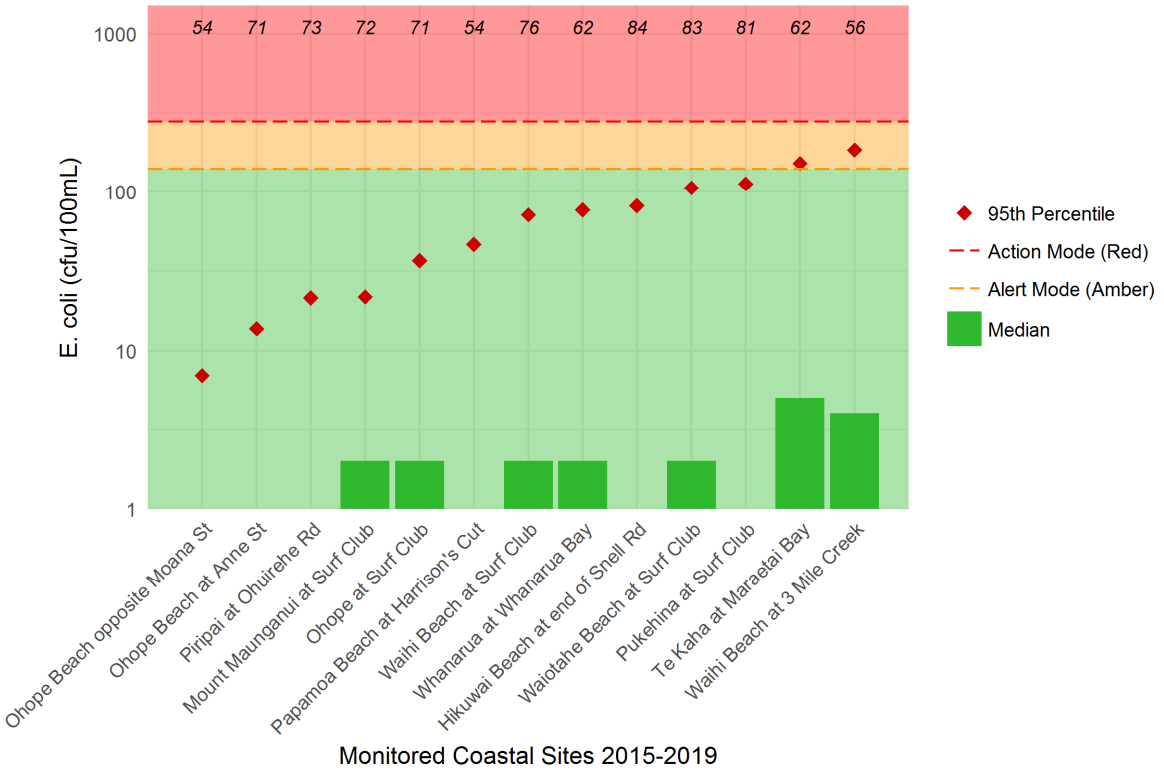


Figure 3.8 *95th Percentile and median Enterococci concentrations for open coastal sites over the past five years. The black numbers represent the number of samples available for the analysis period.*

Estuarine

Twelve of the 15 estuarine bathing sites (80%) had samples that breached the amber (alert) threshold at some stage during the 2018/19 season (Figure 3.9). Two sites (13%), Tauranga Harbour at Pahoia Beach Road and Tauranga Harbour at Tilby Point, exceeded the red (action) threshold, which means that two consecutive samples collected within 24 hours of each other (i.e. the original sample and follow up sample), exceeded 280cfu/100mL. Tauranga Harbour at Pahoia Beach Road had two red (action) occurrences, while Tauranga Harbour at Tilby Point had one. Neither of these sites exceeded the red (action) threshold in 2016/17, with all samples collected at Tilby Point during that season having Enterococci values less than the amber (alert) threshold (140 cfu/100mL).

Five of the 15 monitored sites (33%) had 95th percentile values that exceeded the red (action) threshold value of 280 cfu/100mL, based on five seasons of bathing data (Figure 3.10). This is an increase from the 2016/17 season analysis where only two sites had 95th percentile values exceeding the red (action) threshold. In addition to Tauranga Harbour at Ongare Point and Tauranga Harbour at Pahoia Beach Road, which both exceeded in 2016/17, Waihi Estuary at Main Channel, Tauranga Harbour at Tanners Point Beach, and Tauranga Harbour at Waimapu Bridge also exceeded. Of these, all 95th percentile values were less than 500cfu/100mL, with the exception of Tauranga Harbour at Ongare Point, which had a 95th percentile value of 1001cfu/100mL. This elevated 95th percentile value is caused by three elevated results recorded between January and March 2016. All samples collected after that date have been less than 500cfu/100mL. This suggests that there may have been a localised contamination event that has since been fixed, yet legacy of this event is still affecting analysis over the five year dataset.

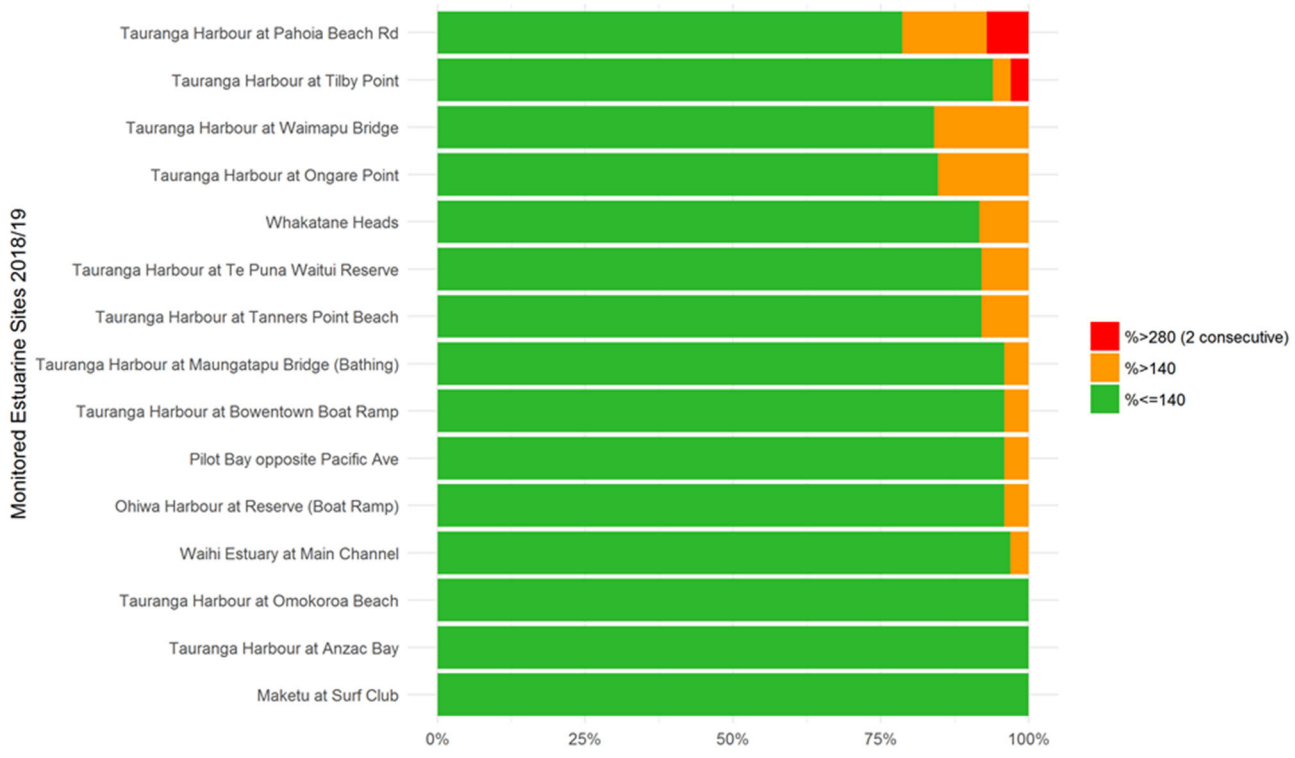


Figure 3.9 *Percentage of samples from estuarine sites with Enterococci concentrations (cfu/100ml) in each of the modes in the Microbial Water Quality Guidelines (MfE/MoH 2003), 2018/19 bathing season.*

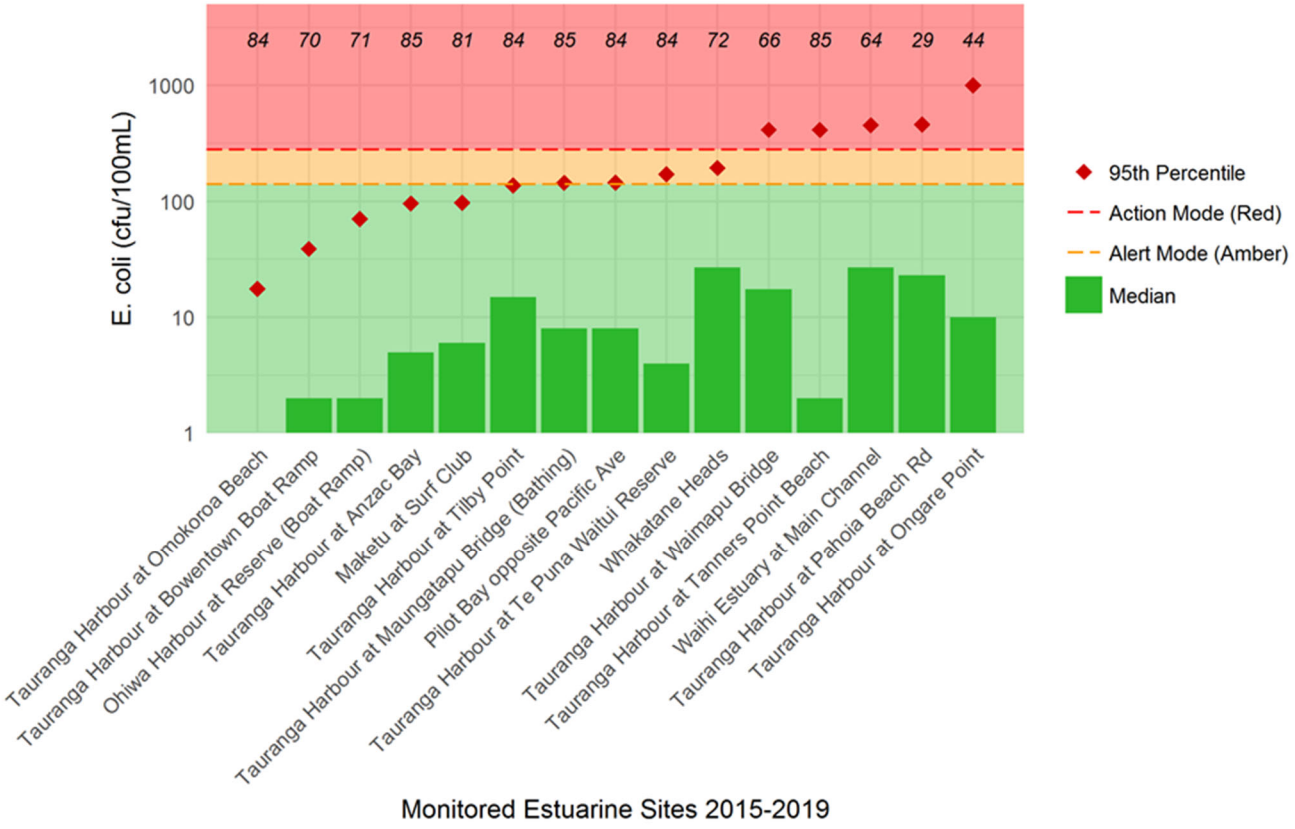


Figure 3.10 95th Percentile and median Enterococci concentrations for estuarine sites over the past five years. The black numbers represent the number of samples available for the analysis period.

Part 4: **Shellfish and recreational gathering waters**

Guidelines, sampling and analysis

Ten of the 28 open coastal and estuarine bathing surveillance sites, in addition to Waiotahe Estuary, are regarded by communities as desirable shellfish gathering locations. Accordingly, water samples from these sites are additionally analysed for Faecal coliforms (FC), which are suitable microbiological indicators for sanitary safety with regards to public shellfish consumption. Faecal coliforms have a stronger correlation with health risks associated with eating shellfish than Enterococci (MfE, 2003), making them a useful indicator. The FC values specified in the microbiological guidelines indicate the likely presence of pathogenic bacteria, protozoa and viruses.

Water quality guidelines for safe shellfish consumption are as follows:

- The median FC content should not exceed a Most Probable Number (MPN) of 14/100 ml, and
- No more than 10% of samples should exceed a MPN of 43/100 ml.

Compliance with these guidelines does not ensure that shellfish in the waters will be safe for consumption as they do not account for biotoxins. However, they do provide a useful management tool to assess the risk to human health from faecal contamination. The sampling and analysis for FC is described in Section 2.2.

Results

Results for shellfish water sampled over the 2018/19 season are shown in Figures 4.1 and 4.2. Four of the 11 monitored sites (36%) breached the median threshold of 14 MPN FC/100mL. Of these, two sites, Waiotahe Estuary and Tauranga Harbour at Tilby Point, breached the median limit in 2016/17, suggesting ongoing problems with faecal contamination, while Waihi Estuary at Main Channel and Tauranga Harbour at Anzac Bay were below the median limit during that season. All four of these sites also breached the 10% exceedance of 43 FC MPN/100mL, which breaches the overall safe-for-consumption guidelines.

Toi Te Ora has active health warnings in place for Waiotahe Estuary, Tauranga Harbour at Tilby Point, and Waihi Estuary, which advise against consuming shellfish from these sites. However, no current warning is in place for Tauranga Harbour at Anzac Bay. Waiotahe Estuary is also subject to a comprehensive catchment investigation that is using faecal source tracking to attempt to identify the source animal, as well as spatial and temporal signature associated with estuarine contamination. The Integrated Catchment Management (ICM) Team is looking to establish similar catchment investigations in the Pongakawa catchment, upstream of Waihi Estuary, which should help identify and mitigate sources within that catchment.

In addition to the four aforementioned sites, five other sites breached the 10% percentage threshold for exceedances of 43 MPN/100mL, making nine sites in total (81%). These additional sites are: Maketū at Surf Club, Waihi Beach at 3 Mile Creek, Tauranga Harbour at Te Puna Waitui Reserve, Ohiwa Harbour at Reserve (Boat Ramp), and Tauranga Harbour at Bowentown Boatramp. The 10% threshold provides an indication of event-based contamination, which is likely to originate from overland flow pathways in nearby catchments. These results suggest that the 2018/19 season was subject to a number of rainfall events that mobilized catchment-derived contamination.

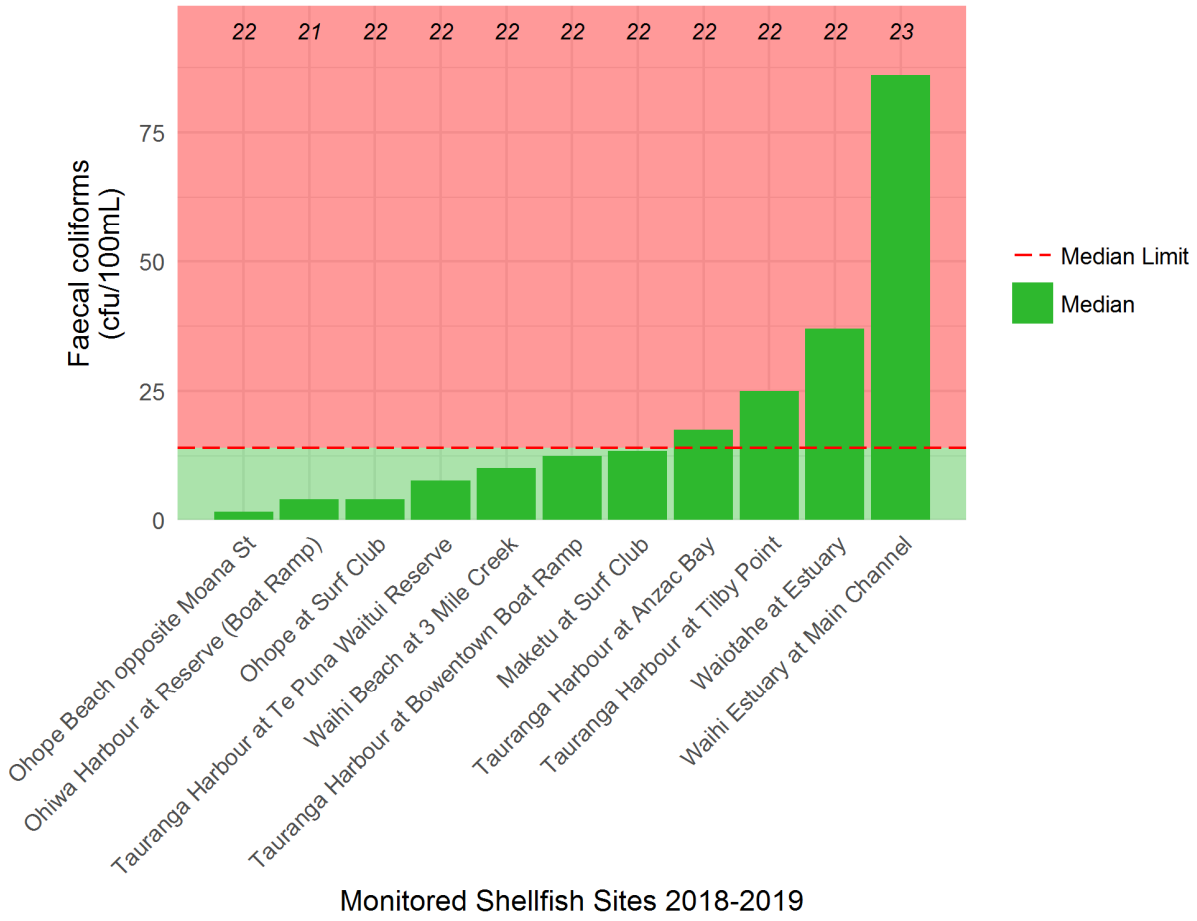


Figure 4.1 *Median faecal coliform concentrations at shellfish gathering locations for the 2018/19 season and guideline median limit for safe shellfish consumption. The black numbers represent the number of samples available for the analysis period.*

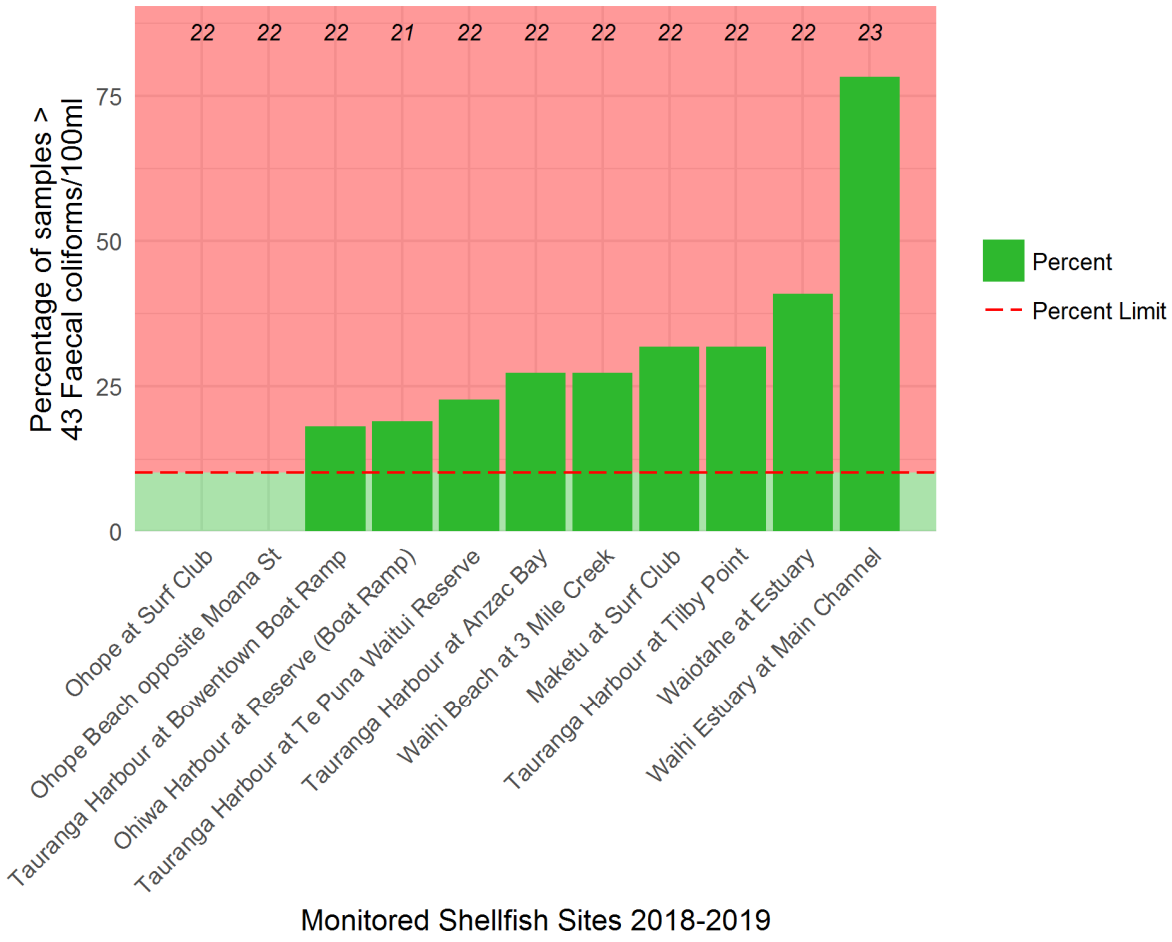


*Figure 4.2 Percentage of sample at shellfish gathering locations in the 2018/19 season exceeding the limit of 43 cfu/100ml stipulated by the Microbiological Water Quality Guidelines (*MfE*, 2003). The black numbers represent the number of samples available for the analysis period.*

Part 5: **Lake algae monitoring programme**

Introduction

Blue-green algae are widespread throughout New Zealand. Lakes and rivers in the Bay of Plenty are affected by free living algal blooms at times (leading to soupy looking water or surface scums) or blooms of attached 'benthic' algae (often in the form of mats covering the river bed). These blooms may or may not be toxic.

The presence of toxin producing blue-green algae species (cyanobacteria) and the occurrence of blooms within the Rotorua Lakes is a natural phenomenon. Blooms can also occur in the 'cleaner' (oligotrophic/lower nutrient) lakes (including Lakes Tarawera and Okataina). Although, a number of the lakes have a history of cyanobacteria blooms that are significantly influenced by artificially elevated nutrient enrichment. The intensity of cyanobacteria blooms can be increased by anthropogenic inputs of nutrients from human activities when the environmental conditions are favourable (i.e. calm weather, high temperatures, low amount of mixing between the epilimnion (surface) and hypolimnion (bottom) layers of the lake, limited out flow, shallow conditions).

The BOPRC cyanobacteria monitoring programme was set up in 1997 after blooms exceeded levels safe for drinking and recreation in four of the Rotorua lakes (Lakes Okaro, Rotoiti, Rotorua, and Rotoehu). Blooms have occurred in these lakes on an almost annual basis since 1997. In addition, at least two other lakes and the Kaituna River are intermittently affected by blooms. The monitoring programme has now been tailored to anticipate and pre-empt periods of heightened bloom activity. In the periods with anticipated bloom activity, the frequency of monitoring increases to enable timely health warnings. However, during the anticipated bloom time periods swimming may still be safe, provided bloom activity remains at low levels.

The cyanobacteria monitoring programme targets areas where the public is likely to have the greatest exposure to cyano-toxins (either through immersion, consumption or inhalation of water affected by cyano-toxins or irritants). The Medical Officer of Health (MO) relies on cell counts provided by BOPRC along with the results of toxicity tests, to determine whether cyanobacteria blooms pose a public health risk. The cell count generates the information to determine whether a site's sample has exceeded a given cyanobacteria biovolume threshold indicating that a health warning is required. The biovolume thresholds are based on the potential health risk of that amount of cyanobacteria and the warnings indicate it is no longer safe to use the lake water for swimming, drinking, and watersports.

A number of blue-green algae are known to produce cyano-toxins. These include the cyclic peptides (microcystin and nodularin), alkaloids (cylindrospermopsin, anatoxins and saxitoxins) and lipopolysaccharides (LPS) (Wood, 2004). Microcystin and its various analogues are the most prevalent cyano-toxin in the Rotorua lakes and therefore also potentially the most harmful.

Monitoring methods

There are 13 sites in the Rotorua lakes region that were sampled on a weekly basis. This may vary depending on health status of the lakes (e.g. if blooms are present).

- Lake Rotoehu - Kennedy Bay, Otautu Bay.
- Lake Rotoiti - Hinehopu, Okawa Bay, Te Weta Bay, Okere Arm, Otaramarae.
- Kaituna River - Trout Pool at Okere Falls.
- Lake Rotorua - Ohau Channel, Hamurana, Ngongotahā, Holdens Bay.

- Lake Okaro - Boat ramp.

Sampling involves taking five integrated samples from different locations around the sampling site (around 1 m apart) and subsampling an 80 ml to 100 ml aliquot from a pooled sample. The sample is fixed with lugols iodine. Visual observations at the site (such as time, water clarity, wind direction) are also recorded.

Samples are analysed using the Axiovert 100 microscope using whole plate or random colony counts depending on cyanobacteria colonies present. Cell counts are entered to a database and converted to biovolume for reporting purposes.

Guidelines and reporting framework

Results are reported weekly on the BOPRC website as well as The Land and Water Aotearoa (LAWA) website. If alert level is reached, a range of actions follow, potentially culminating in health warnings if blooms reach the biovolumes listed in Table 5.1. The alert level framework used by BOPRC follows that given in the interim 'New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters' (MfE, 2009). Once an alert level (amber/red) is detected the Medical Officer of Health (MoH) of Toi Te Ora Public Health is informed immediately. The MoH will update their website, undertake any media warnings and instruct the relevant territorial authority to post warning signs.

Table 5.1 Alert - level framework for planktonic cyanobacteria (when using biovolume not cell/ml).

Alert Level	Actions
Surveillance (green mode): The biovolume equivalent for the combined total of all cyanobacteria material does not exceed 0.5 mm3/L.	Undertake weekly or fortnightly visual inspection and sampling of water bodies where cyanobacteria are known to proliferate between spring and autumn.
Alert (amber mode): 0.5 to < 10 mm3/L total biovolume of all cyanobacterial material.	Increase sampling frequency to at least weekly.
	Notify the public health unit.
	Multiple sites should be inspected and sampled.
Action (red mode): 10 mm3/L total biovolume of all cyanobacterial material or greater.	Continue monitoring as for alert (amber mode).
	If potentially toxic taxa are present consider testing samples for cyanotoxins.
	Notify the public of a potential risk to health.

The volume of cyanobacteria present in a given lake or freshwater body is one of the attributes within Appendix 2 of the NPS-FM. The attribute bands scale lake cyanobacteria levels through a ranking system of A to D, where B band is not applicable (Table 5.2). These bands are based either on biovolume or cell count of cyanobacteria, using the 80th percentile of a site over a three year period to compare with the bands numerical thresholds. The results for this can be found in the following sections.

Table 5.2 Cyanobacteria attribute state from NPS-FM (2014).

Value	Attribute state (Cyanobacteria Biovolume (mm3/L))			
	A	**B**	**C**	**D**
Numeric state 80th percentile*.	<= 0.5 mm3/L bio-volume, or 500 cells/mL.	N/A	> 0.5 and less than or equal to 1.8 mm3/L toxic cyanobacteria biovolume, or > 0.5 and >= 10 mm3/L total cyanobacteria.	>1.8 mm3/L toxic cyanobacteria biovolume, OR 10 mm3/L total cyanobacteria.
Human health for secondary contact (annual median).	Risk exposure from cyanobacteria is no different to that in natural conditions (from any contact with fresh water).		Low risk of health effects from exposure to cyanobacteria (from any contact with fresh water).	Potential health risks (e.g. respiratory, irritation and allergy symptoms) exist from exposure to cyanobacteria (from any contact with fresh water).

*80th percentile must be calculated using a minimum of 12 samples collected over three years.

Results

Lake Okaro

Lake Okaro is monitored at one site, located at the boat ramp on Okaro road. Results for the 2018/19 cyanobacteria season show a number of exceedances of the amber (alert) and red (action) thresholds early in the bathing season (Figure 5.1), which prompted Toi Te Ora to issue a public health warning. The first sample of the season in late November was dominated by a bloom of *Anabaena cf. spiroides* which remained until late December when *Anabaena cf. circinalis* began to dominate. Cyanobacteria biovolumes returned below the amber threshold after the 23 January and remained settled until the end of the season. Health warnings for this site were lifted on the 5 February 2019.

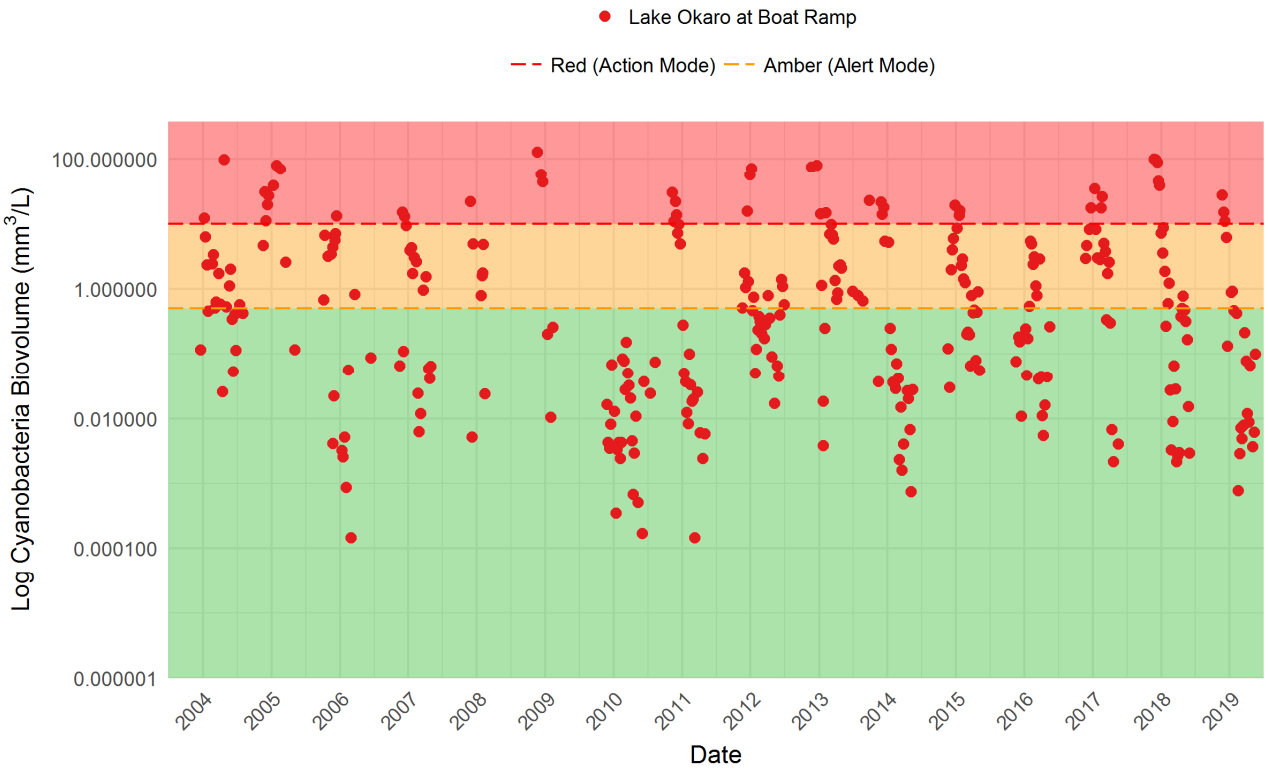


Figure 5.1 Total cyanobacteria biovolume sampled at Lake Okaro boat ramp, 2003 to 2019.

Lake Rotoehu

Cyanobacteria is monitored at two sites on Lake Rotoehu; Lake Rotoehu at Kennedy Bay and Lake Rotoehu at Otautu Bay Boat Ramp. The 2018/19 cyanobacteria season was the worst on record (Figure 5.2), with a health warning being issued at the beginning of the season and persisting until the end. *Anabaena cf. circinalis* dominated the species composition at Lake Rotoehu until mid-February 2019, at which stage *Microcystis cf. wesenbergii* became dominant and persisted for the rest of the season. Samples were collected for cyanotoxin analysis in May 2019, with results showing microcystin and nodularin toxins were below detectable limits at both monitoring sites.

Lake Rotoehu continued to bloom at the end of the traditional monitoring season, which prompted additional sampling to monitor biovolumes through the off-season (data not shown in Figure 5.2). As of August 2019, levels had not dropped low enough to remove the public health warning.

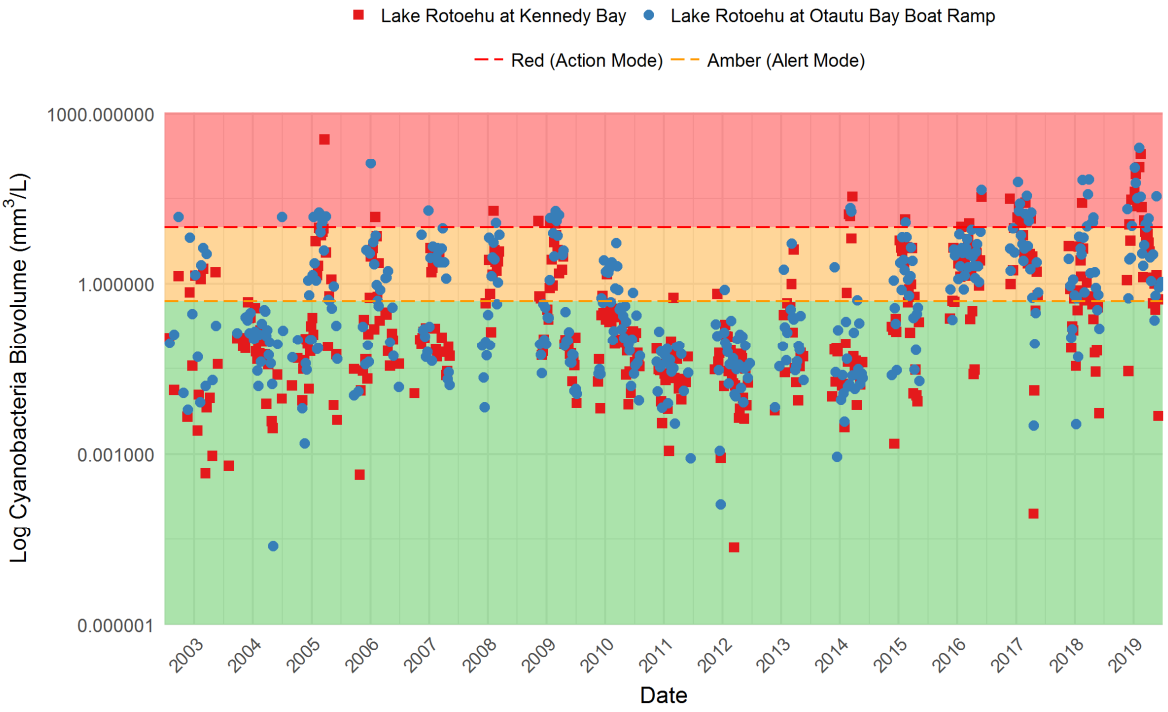


Figure 5.2 *Total cyanobacteria biovolume sampled at Otautu Bay and Kennedy Bay of Lake Rotoehu, 2003 to 2019.*

Lake Rotorua

The four monitored Lake Rotorua sites had a comparatively mild 2018/19 cyanobacteria season, with no single sample breaching the amber/alert threshold at any site (Figure 5.3). This rates as the best cyanobacteria season for this lake since sampling began in 1997.

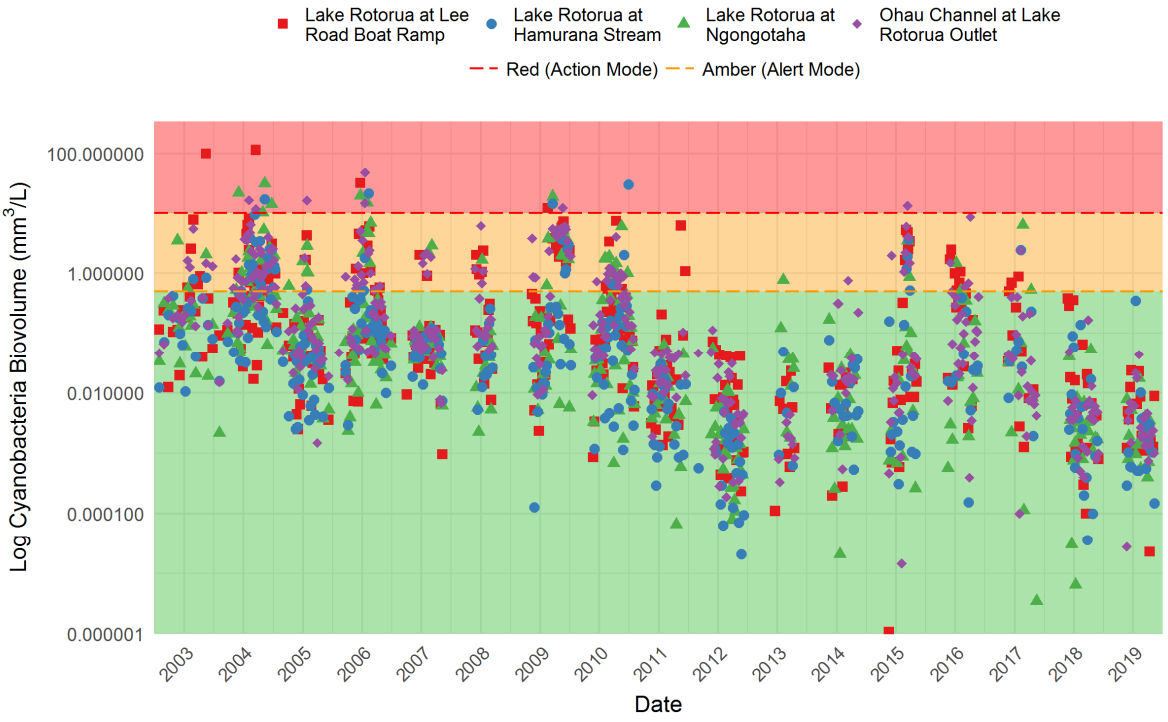


Figure 5.3 *Total cyanobacteria biovolume sampled at Holdens Bay, Ngonogotaha, Hamurana, and Ohau Channel, Lake Rotorua, 2003 to 2019.*

Lake Rotoiti

All of the samples collected at four of the five monitored sites on Lake Rotoiti were lower than the amber (alert) threshold in the New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters (MfE, 2009) (Figure 5.4). The exception was Lake Rotoiti at Okawa Bay, which had consistently higher biovolumes than other sites for the majority of the season, as well as a short-lived bloom of *Anabaena cf. planctonica* and *Aphanizomenon sp.* in early May 2019. A public health warning was issued at this time, and removed in July 2019.

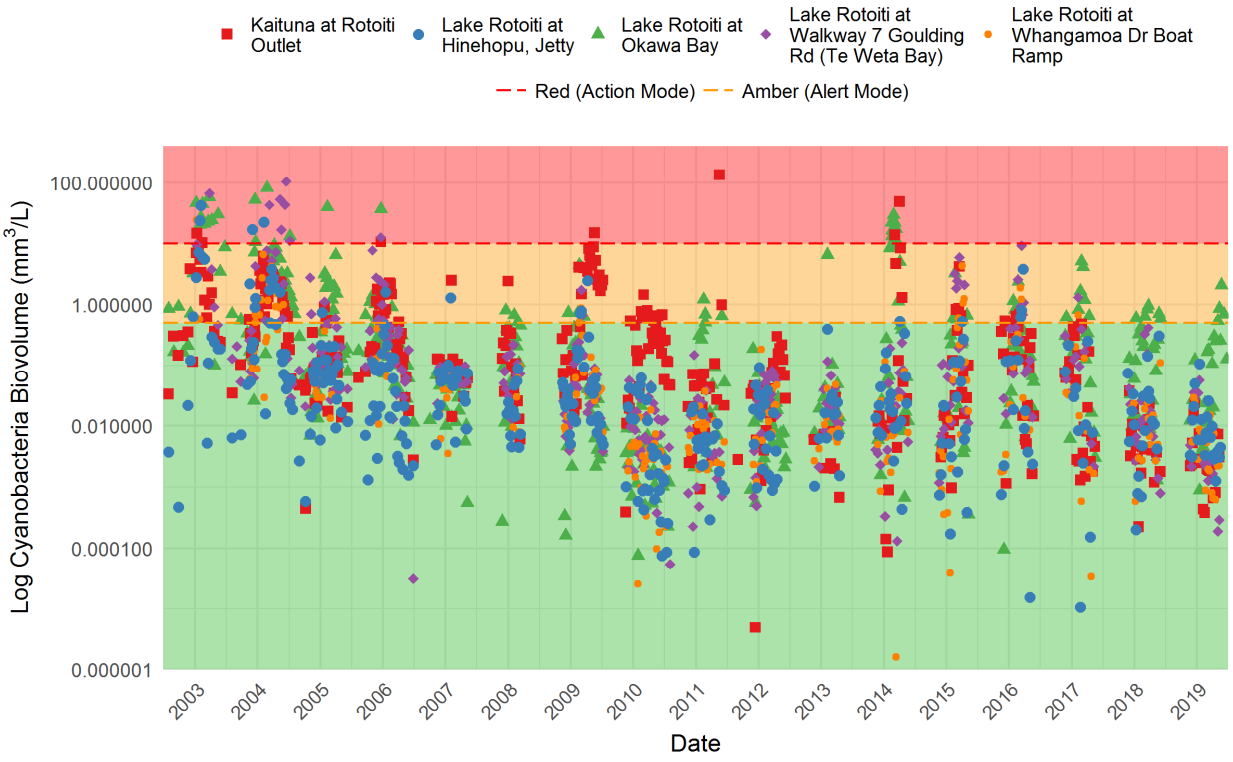


Figure 5.4 *Total cyanobacteria biovolume sampled at Hinehopu, Okawa Bay, Okere Arm, and Te Weta Bay, Lake Rotoiti, 2003 to 2019.*

Comparison with Appendix 2 of the NPS-FM

Table 5.3 shows how data from each of the 13 routinely monitored cyanobacteria sites, collected over the past three cyanobacteria seasons, compared to the total cyanobacteria (planktonic) attribute in Appendix 2 of the NPS-FM. Results show that 10 of the 13 monitored sites (77%) achieved an 'A' grade. One site (8%), Lake Okaro at Boat ramp, was attributed a 'B', while the two Rotoehu sites (15%), Lake Rotoehu at Otautu Bay and Lake Rotoehu at Kennedy Bay, breached the national bottom line ('D' band).

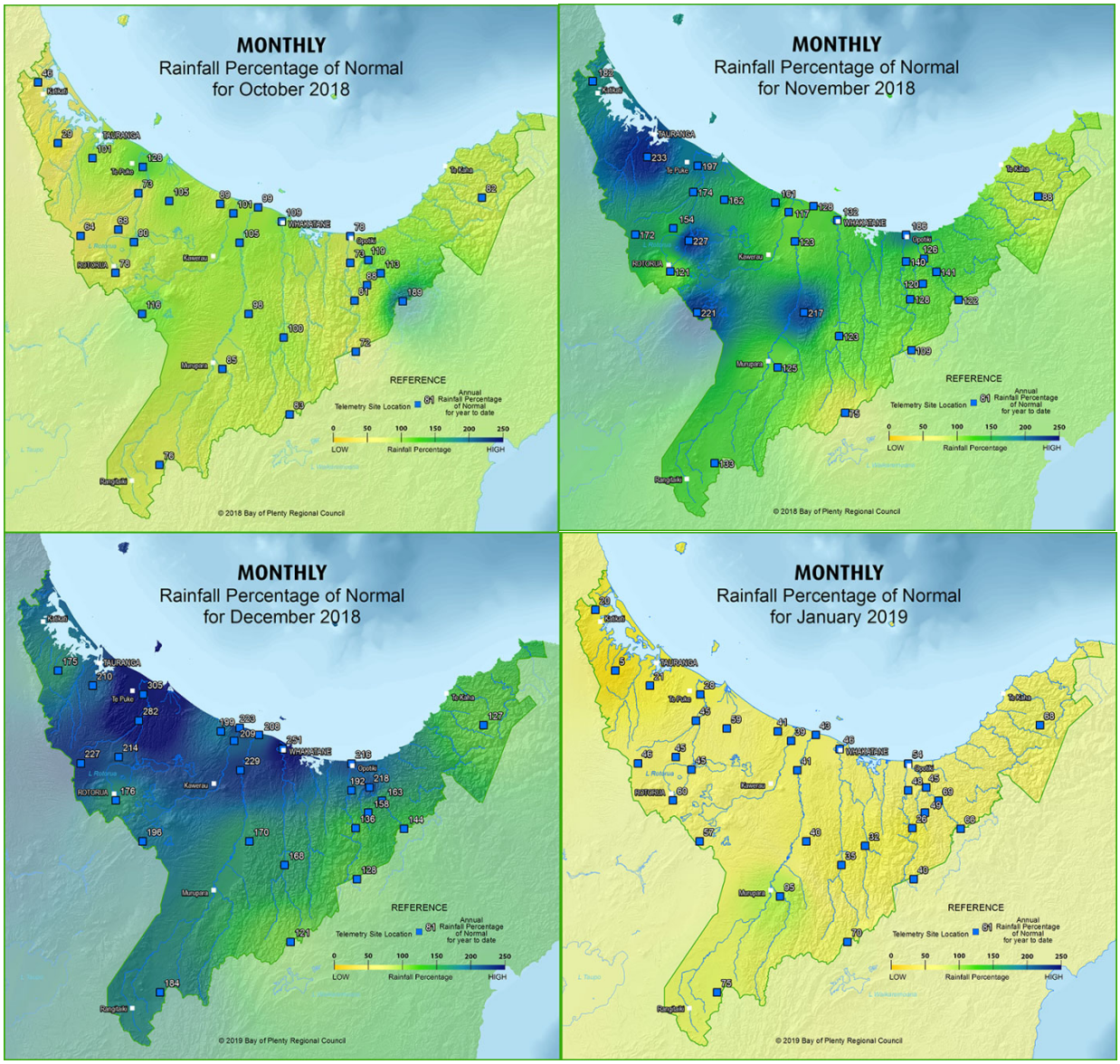
Overall, Lake Rotoehu, Lake Okaro, and Okawa Bay continue to persist as hotspots for cyanobacteria blooms.

Table 5.3 NOF banding result for Total Cyanobacteria (planktonic) biovolumes in Rotorua Te Arawa lakes, 2016 to 2019.

Lake	Site Name	n	80th Percentile	Attribute State Band
Lake Okaro	Lake Okaro at Boat Ramp	73	7.83	C
Lake Rotoehu	Lake Rotoehu at Kennedy Bay	73	14.46	D
	Lake Rotoehu at Otautu Bay Boat Ramp	75	17.09	D
Lake Rotoiti	Lake Rotoiti at Whangamoa Dr Boat Ramp	51	0.02	A
	Lake Rotoiti at Hinehopu, Jetty	52	0.03	A
	Kaituna at Rotoiti Outlet	67	0.04	A
	Lake Rotoiti at Walkway 7 Goulding Rd (Te Weta Bay)	54	0.11	A
	Lake Rotoiti at Okawa Bay	70	0.46	A
Lake Rotorua	Lake Rotorua at Ngongotahā	53	0.02	A
	Lake Rotorua at Hamurana Stream	53	0.03	A
	Lake Rotorua at Lee Road Boat Ramp	56	0.03	A
	Ohau Channel at Lake Rotorua Outlet	72	0.04	A
None	Kaituna at Trout Pool Rd	66	0.07	A

Part 6: **Rainfall and faecal contamination**

Figure 6.1 shows spatial rainfall accumulation for each month over the 2018/19 bathing season, relative to 'normal' monthly rainfall, i.e. the mean rainfall for that month across all years. This shows that November and December 2018 were much wetter than normal, while other months were drier.



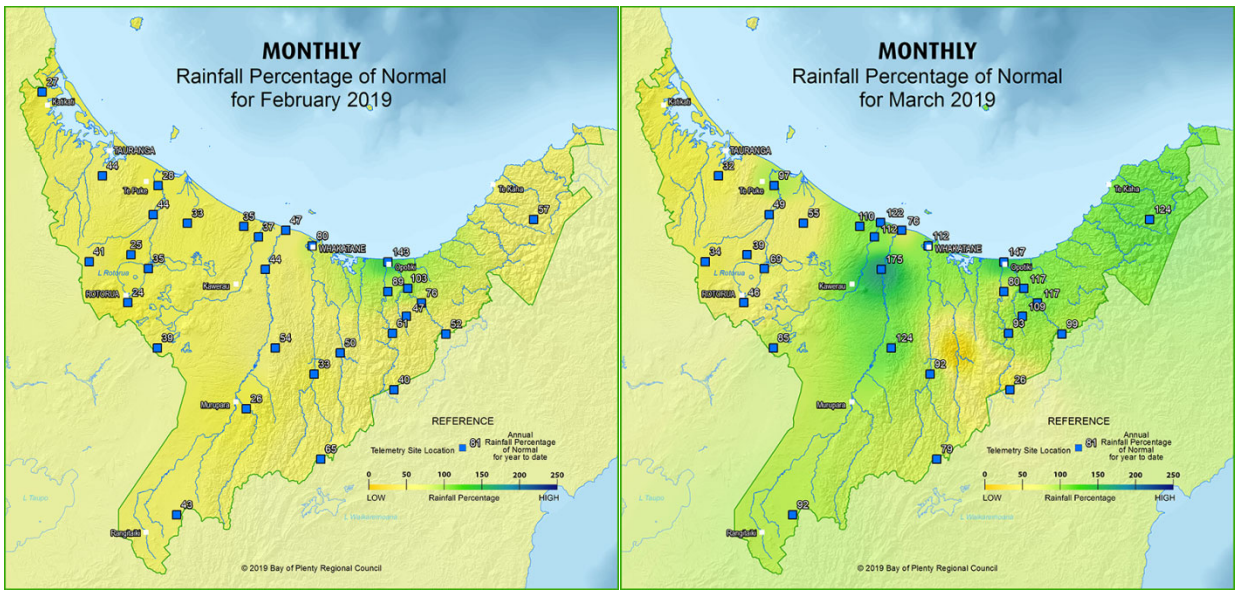


Figure 6.1 Spatial distribution of rainfall relative to mean rainfall, for each month during the 2018/19 bathing season.

Figure 6.2 shows the percentage of samples in green, amber (alert), and red (action) categories, for each month, across each of the 30 river monitoring sites. Comparing this figure with the rainfall distribution figure above, allows sites to be split in to three broad categories based on the site-specific response to rainfall over the 2018/19 season. The first group of sites did not breach the amber (alert) threshold at any time during the entire bathing season, and included a number of east coast sites (e.g. Kereu at State Highway 35), spring fed sites (e.g. Hamurana at Hamurana), sites mitigated by hydro-dams (e.g. Rangitāiki at Matahina Dam), and sites downstream of large areas of native or exotic forest (e.g. Waioeka at Mouth of Gorge).

The second group of sites had exceedances of the amber and red thresholds over most of the summer months, regardless of the amount of rainfall. These sites are typically recognized as ‘problem sites’ and, in most cases, there are either catchment investigations planned or underway to investigate the abnormal faecal contamination signature. These sites include: Kaiate at Kaiate Falls Road, Kopurererua at McCord Avenue, Ngongotahā at Railway Bridge, Puarenga at Whakarewarewa, Uretara at Henry Road Ford, Utuhina at Lake Road, and (to a lesser extent) Utuhina at Pukehangi.

The remaining sites typically had an increased percentage of amber or red threshold breaches during months with above normal rainfall, but returned (predominantly) to the green band during drier periods. These sites express a signature similar to most agricultural catchments in New Zealand, although terrain may exacerbate the issue in some steep catchments (e.g. western Lake Rotorua catchments, or north-western Tauranga Harbour catchments).

Estuarine sites showed a similar relationship with high rainfall months, where all red threshold exceedances occurred in late October and early November. The two exceeding sites were both located in Tauranga Harbour which experienced significant rainfall accumulation over that time. Two Lake Rotorua sites (Lake Rotorua at Holdens Bay; Lake Rotorua at Ngongotahā) also experienced red threshold exceedances during November and December.

It should be noted that this analysis is intended as a general regional overview, and there has been no attempt to directly link faecal contamination at each site to location specific rainfall accumulation.

Figure 6.2 Percentage of samples belonging to Green, Amber (alert), and Red (action) bands, per month, for each of the 30 river bathing water quality monitoring sites.

Part 7: **Summary discussion**

Bathing water quality

The particularly wet months of November and December 2018 resulted in a number of bathing sites exceeding the swimmability thresholds set in the Microbiological Water Quality Guidelines (MfE, 2003). River sites were the worst affected, however, some lake and estuarine sites also experienced red threshold breaches over this period. Most sites returned to acceptable levels in the drier months that followed, although there were a number of river sites that continued to exceed amber and red thresholds, implying that faecal contamination at these sites is controlled by other factors, in addition to rainfall.

When river data from the 2018/19 bathing season was assessed against the SFRG in the Microbiological Water Quality guidelines (MfE, 2003): six sites were classed as either 'Very Good' or 'Good' (20%), six were classed as 'Fair' (20%), and 18 were either 'Poor' or 'Very Poor' (60%). Lake sites were less affected, with 10 of 12 sites (83%) classed as 'Very Good', and two sites (17%) classed as 'Poor'. Furthermore, 10 of 15 estuarine sites (67%) were classed 'Very Good' or 'Good', four were classed 'Fair' (27%), and one site was classed 'Poor' (6%). All open sites were either classed 'Very Good' or 'Good' (100%).

The SFRG grading system is a combination of the Sanitary Inspection Category (SIC; a catchment analysis of potential contamination sources at each site), and the bathing results from the most recent monitoring season. The majority of river sites that were graded 'Poor' or 'Very Poor' over the 2018/19 season had been attributed a SIC category of 'Moderate'. This specific SIC category is intended for sites that have direct discharge of urban stormwater run-off (not contaminated by sewage), or low intensity agriculture, marinas or boat moorings. This SIC class limits each site to a SFRG of 'Good'- 'Poor', i.e. they are ineligible to be graded 'Very Good' or 'Very Poor'. The results above show that many of these 'Moderate' sites had a 95th percentile value in excess of 550cfu/100ml, which may indicate that some of the less developed agricultural catchments, or urban catchments with stormwater inputs, experienced greater-than-expected contamination problems during high rainfall events.

According to the *E. coli* attribute in Appendix 2 of the NPS-FM (MfE, 2014), 19 of the 30 monitored river sites (63%) were deemed suitable for primary contact (swimmable). However, it should be noted that four of the 30 river sites had less than the required 60 data points collected over a maximum of five years, and technically should not have been analysed using this method. With this in mind, of the 26 sites with more than 60 samples, 16 were deemed swimmable (62%). Furthermore, all 12 lake sites were deemed swimmable, with only Lake Rotorua at Ngongotahā achieving less than an 'A' band grade (grade = 'B').

Shellfish

Monitoring of shellfish waters revealed that four sites were in breach of the dual threshold guidelines for the 2018/19 season. These were: Tauranga Harbour at Anzac Bay, Tauranga Harbour at Tilby Point, Waihi Estuary at Main Channel, and Waiotahe at Estuary. A catchment investigation is currently taking place in the Waiotahe catchment, and the Waihi Estuary will form part of the upcoming priority catchment work. However, there has been no detailed research into the drivers behind exceedances at either Tilby Point or Anzac Bay, nor is there a permanent health warning issues for Anzac Bay. It is recommended that these gaps be investigated in the near future.

Cyanobacteria

Lake Rotoehu had a particularly poor 2018/19 cyanobacteria season, where biovolumes at both monitoring sites were the worst on record. Consequently, a public health warning was issued in October 2018 and is still active as of August 2019.

There were a number of key factors that seemed to combine to cause perfect conditions for cyanobacteria proliferation in Lake Rotoehu over the 2018/19 season. Firstly, lake levels were the highest they had been since the mid 1970's, which impacted the ability for the lake to wind-mix following periods of stratification. This, in combination with a calm 2019 summer period, resulted in prolonged periods of stratification and greater nutrient release from enriched bottom sediments.

Elevated lake levels also impacted the flow coming from the Waitangi Springs inflow, which is where alum is dosed into the lake in an attempt to sequester natural sources of dissolved reactive phosphorus (DRP). Reduced flows meant that alum dosing was impractical, and a decision was made to halt alum dosing prior to the start of the 2018/19 season. This decision was also influenced by research presented to the Lake Rotoehu Technical Advisory Group by Eager (2017), who suggested that alum dosing at Waitangi Springs is potentially less effective than in the Utuhina or Puarenga Streams of Lake Rotorua, due to natural sources of colloidal iron, and pH fluctuations from large beds of invasive hornwort (Ceratophyllum demersum).

Bay of Plenty Regional Council has recently applied for consent to install an alum diffuser in the middle of the lake to avoid complications from the Waitangi Springs inflow, and to address nutrient release from bottom sediments in the main basin. This consent will also include approval to 'shock dose' the dendritic arms with alum, on an as-needed basis. This management strategy should help lock inorganic phosphorus in bottom sediments, and prevent any release that occurs when the lake stratifies.

Aside from Lake Rotoehu, only Lakes Okaro and Rotoiti had sample biovolumes that exceeded the amber (alert) or red (action) thresholds in the NZ Guidelines for Cyanobacteria in Recreational Fresh Waters (MfE, 2009). Lake Okaro had an early bloom that lasted until January 2019, and Okawa Bay in Lake Rotoiti experienced a late, short lived bloom of A. cf. planctonica and Aphanizomenon sp. Specific drivers behind these blooms are less defined than for Lake Rotoehu, however, periods of calm weather and subsequent stratification is likely to be a major factor.

Overall, the two Lake Rotoehu sites were the only sites to breach the National Bottom Line for the Cyanobacteria attribute in Appendix 2 of the NPS-FM ('D' band). Lake Okaro was graded 'C', and all other cyanobacteria monitoring sites were graded 'A'. This result implies that the vast majority of monitored cyanobacteria sites posed no risk to human health over the past three cyanobacteria seasons. Lakes Okaro and Rotoehu sites are the exception, and it is important that public health warnings are communicated effectively to ensure potential bathers are aware of the health risks.

Part 8: **References**

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Appendix 1a: Suitability for recreation grading - grades for river and stream sites

District	Site name	Site ID	n	Mean	Median	95th Percentile	MAC	SIC	SFRG	% of Samples < Action/Red Mode	NOF Band
Kawerau	Tarawera at Kawerau Bridge	IK555889	83	180.7	120.0	445.0	C	Very Low	Fair	96.4	A
Opotiki	Haparapara at SH35	RN123610	45	38.6	13.0	220.0	B	Very Low	Very Good	100.0	A**
	Kereu at SH35	RO629568	81	138.3	6.0	110.0	A	Very Low	Very Good	96.3	A
	Otara at SH35	NL683503	102	303.5	57.0	486.5	D	Moderate	Poor	95.1	A
	Waioeka at Mouth of Gorge	NK608503	65	122.3	37.0	296.0	C	Moderate	Fair	96.9	A
	Waioeka at SH2	NL517414	103	346.5	93.0	737.0	D	Moderate	Poor	90.3	B
Rotorua	Hamurana at Hamurana Road	EL613536	66	97.6	70.0	210.0	B	Low	Good	98.5	A
	Ngongotahā at Railway Bridge	EL192023	105	875.2	340.0	2896.0	D	Low	Poor	72.4	D
	Ohau Channel at SH33	FL230406	104	87.6	34.0	199.5	B	Low	Good	98.1	A
	Puarenga at Whakarewarewa	EK537123	106	432.6	188.3	1550.0	D	Moderate	Poor	87.7	D
	Utuhina at Lake Road	EK405487	104	422.1	225.0	1710.0	D	Moderate	Poor	82.7	D
	Utuhina at Pukehangi Road	EK260170	60	306.7	110.0	860.0	D	Moderate	Poor	91.7	B
	Waitangi Soda Springs at Bathing Pool	HL149406	85	86.2	26.0	330.0	C	Moderate	Fair	97.6	A
	Waiteti at SH36	EL143137	102	595.8	152.5	1495.0	D	Moderate	Poor	88.2	D
TCC	Kopurererua at McCord Ave	DP768284	85	582.1	210.0	1166.0	D	Moderate	Poor	88.2	D

District	Site name	Site ID	n	Mean	Median	95th Percentile	MAC	SIC	SFRG	% of Samples < Action/Red Mode	NOF Band
	Wairoa at SH2	DP281304	100	386.8	88.3	1357.5	D	Moderate	Poor	90.0	D
WBOP	Kaiate at Kaiate Falls Road	EO564565	104	1156.3	510.0	2485.0	D	Moderate	Poor	57.7	E
	Kaituna at Te Matai	FO620177	62	364.8	95.0	2145.5	D	Moderate	Poor	90.3	D
	Pongakawa at SH2	GN922883	108	274.1	130.0	803.0	D	Moderate	Poor	91.7	B
	Tuapiro at McMillan Road	BR748451	100	222.3	110.0	622.5	D	Moderate	Poor	93.0	B
	Uretara at Henry Road Ford	BQ723939	99	607.7	270.0	1620.0	D	Moderate	Poor	79.8	D
	Waiari at Te Puke Highway	FO397216	44	429.0	110.0	2095.0	D	Low	Poor	88.6	D**
	Wairoa Below McLaren Falls	CO809137	101	593.6	57.0	1500.0	D	Moderate	Poor	89.1	D
Whakatāne	Rangitāiki at Boat Ramp	KM083686	101	115.7	49.0	450.0	C	Moderate	Fair	99.0	A
	Rangitāiki at Matahina Dam	JK491452	45	22.1	5.0	98.4	A	Very Low	Very Good	100.0	A**
	Rangitāiki at Murupara	IG265664	45	47.4	30.0	182.0	B	Very Low	Very Good	100.0	A**
	Rangitāiki at Te Teko Bridge	JL348334	105	70.9	28.0	386.0	C	Low	Fair	98.1	A
	Tauranga at Wardlaw Glade	LK445461	101	208.1	31.0	610.0	D	Moderate	Poor	94.1	B
	Whakatāne at Landing Road	KM909138	104	286.7	120.0	815.5	D	High	Very Poor	90.4	B
	Whakatāne at Ruatoki	LK082095	64	228.8	21.0	276.5	C	Moderate	Fair	95.3	A

*less than 60 samples but greater than 50
**less than 50 samples

Appendix 1b: Suitability for recreation grading - grades for lake sites

Lake	Site name	Site ID	n	Mean	Median	95th Percentile	MAC	SIC	SFRG	% of Samples < Action/Red Mode	NOF Band
Okareka	Lake Okareka at Steep Street Reserve	FK325034	102	40.8	11.0	123.8	B	Very Low	Very Good	100.0	A
Okaro	Lake Okaro at Boat Ramp	FI660574	91	33.7	8.0	104.5	A	Very Low	Very Good	98.9	A
Rerewhakaaitu	Lake Rerewhakaaitu at Homestead Arm	GI442508	91	56.9	22.0	210.0	B	Very Low	Very Good	98.9	A
Rotoiti	Lake Rotoiti at Gisborne Point	GL314263	83	9.2	3.0	27.6	A	Very Low	Very Good	100.0	A
	Lake Rotoiti at Hinehopu	GL606421	66	17.0	3.0	96.7	A	Very Low	Very Good	100.0	A
	Lake Rotoiti at Okawa Bay	FL289316	103	23.4	12.0	86.0	A	Very Low	Very Good	100.0	A
Rotoma	Lake Rotoma at Whangaroa	HL337241	103	22.8	4.0	118.3	A	Very Low	Very Good	99.0	A
Rotorua	Lake Rotorua at Hamurana	EL438512	103	131.7	24.0	500.0	D	Very Low	Poor	95.1	A
	Lake Rotorua at Holdens Bay	EK935598	103	50.3	10.0	179.0	B	Moderate	Good	98.1	A
	Lake Rotorua at Ngongotahā	EL224087	102	432.6	28.5	988.0	D	Moderate	Poor	90.2	B
Tarawera	Lake Tarawera at Rangiuru Bay	FJ737728	82	7.2	2.0	26.5	A	Very Low	Very Good	100.0	A
Tikitapu	Lake Tikitapu at Beach	FJ157807	102	37.2	9.0	219.5	B	Very Low	Very Good	100.0	A

*less than 60 samples but greater than 50
**less than 50 samples

Appendix 1c: Suitability for recreation grading - grades for open coastal sites

District	Site name	Site ID	n	Mean	Median	95th Percentile	MAC	SIC	SFRG	% of Samples < 280 n/100ml
Opotiki	Hikuwai Beach at end of Snell Road	NL713661	84	46.9	1.0	72.3	B	Moderate	Good	98.8
	Te Kaha at Maraetai Bay	RO364396	62	186.9	5.0	126.1	B	Very Low	Very Good	98.4
	Waiotahe Beach at Surf Club	NL243661	83	140.5	2.0	103.4	B	Low	Good	97.6
	Whanarua at Whanarua Bay	SO235884	62	174.4	2.0	76.0	B	Very Low	Very Good	98.4
TCC	Mount Maunganui at Surf Club	EQ065035	72	6.1	2.0	21.5	A	Very Low	Very Good	100.0
	Papamoa Beach at Harrison's Cut	EP886340	54	11.7	1.0	38.9	B	Low	Good	100.0
WBOP	Pukehina at Surf Club	GO701513	81	31.5	1.0	74.0	B	Moderate	Good	97.5
	Waihi Beach at 3 Mile Creek	CS131458	56	29.1	4.0	113.0	B	Moderate	Good	98.2
	Waihi Beach at Surf Club	CS010698	76	21.4	2.0	62.2	B	Low	Good	97.4
Whakatāne	Ohope at Surf Club	LM474063	71	7.7	2.0	36.0	A	Very Low	Very Good	100.0
	Ohope Beach at Anne Street	ML081849	71	2.4	0.0	12.0	A	Very Low	Very Good	100.0
	Ohope Beach opposite Moana Street	LL770939	54	2.6	1.0	7.0	A	Very Low	Very Good	100.0
	Piripai at Ohuirehe Road	KM969398	73	4.4	1.0	17.0	A	Very Low	Very Good	100.0

Appendix 1d: Suitability for recreation grading - grades for estuarine sites

Estuary	Site name	Site ID	n	Mean	Median	95th Percentile	MAC	SIC	SFRG	% of Samples < 280 n/100ml
Maketū	Maketū at Surf Club	GO441583	81	44.4	6.0	91.0	B	Moderate	Good	97.5
Ohiwa	Ohiwa Harbour at Reserve (Boat Ramp)	ML251726	71	13.2	2.0	65.5	B	Very Low	Very Good	100.0
Tauranga	Pilot Bay opposite Pacific Avenue	EP057968	84	38.3	8.0	119.3	B	Moderate	Good	96.4
	Tauranga Harbour at Anzac Bay	CR395919	85	19.7	5.0	91.0	B	Very Low	Very Good	100.0
	Tauranga Harbour at Bowentown Boat Ramp	CS292034	70	21.8	2.0	38.1	A	Low	Very Good	98.6
	Tauranga Harbour at Maungatapu Bridge (Bathing)	EP095164	85	33.1	8.0	135.2	B	Low	Good	97.6
	Tauranga Harbour at Omokoroa Beach	CQ940066	84	8.5	1.0	16.7	A	Very Low	Very Good	98.8
	Tauranga Harbour at Ongare Point	CR253528	44	106.6	10.0	925.9	D	Low	Poor	90.9
	Tauranga Harbour at Pahoia Beach Road	CQ490084	29	90.6	23.0	394.0	C	Low	Fair	89.7
	Tauranga Harbour at Tanners Point Beach	CR054756	85	46.7	2.0	356.8	C	Low	Fair	94.1
	Tauranga Harbour at Te Puna Waitui Reserve	CP895761	84	28.1	4.0	149.7	B	Low	Good	97.6
	Tauranga Harbour at Tilby Point	DP547739	84	43.5	15.0	135.4	B	Low	Good	96.4

Estuary	Site name	Site ID	n	Mean	Median	95th Percentile	MAC	SIC	SFRG	% of Samples < 280 n/100ml
	Tauranga Harbour at Waimapu Bridge	DP896097	66	70.5	17.5	387.5	C	Moderate	Fair	92.4
Waihi	Waihi Estuary at Main Channel	GO661503	64	160.4	27.0	214.6	C	Moderate	Fair	95.3
Whakatāne	Whakatāne Heads	LM237268	72	58.0	27.0	172.5	B	Moderate	Good	98.6

Appendix 2: List of sites

Type	Site ID	Name	Easting	Northing
Coastal	NL713661	Hikuwai Beach at end of Snell Road	1977138	5786616
	EQ065035	Mount Maunganui at Surf Club	1880652	5830352
	LM474063	Ohope at Surf Club	1954743	5790635
	ML081849	Ohope Beach at Anne Street	1960813	5788495
	LL770939	Ohope Beach opposite Moana Street	1957708	5789391
	EP886340	Papamoa Beach at Harrison's Cut	1888867	5823406
	KM969398	Piripai at Ohuirehe Road	1949691	5793985
	GO701513	Pukehina at Surf Club	1907018	5815139
	RO364396	Te Kaha at Maraetai Bay	2013648	5813967
	CS131458	Waihi Beach at 3 Mile Creek	1861312	5854588
	CS010698	Waihi Beach at Surf Club	1860109	5856987
	NL243661	Waiotahe Beach at Surf Club	1972431	5786610
	SO235884	Whanarua at Whanarua Bay	2022352	5818841
Cyanobacteria	FL356693	Kaituna at Rotoiti Outlet	1893562	5786935
	FL344809	Kaituna at Trout Pool Road	1893447	5788095
	FI660574	Lake Okaro at Boat Ramp	1896600	5755748
	HL129560	Lake Rotoehu at Kennedy Bay	1911292	5785607
	HL143688	Lake Rotoehu at Otautu Bay Boat Ramp	1911431	5786889
	GL604463	Lake Rotoiti at Hinehopu, Jetty	1906043	5784631
	FL289316	Lake Rotoiti at Okawa Bay	1892891	5783164
	FL416536	Lake Rotoiti at Walkway 7 Goulding Road (Te Weta Bay)	1894160	5785365
	FL779744	Lake Rotoiti at Whangamoa Dr Boat Ramp	1895773	5787441
	EL606530	Lake Rotorua at Hamurana Stream	1886066	5785303
	EK984647	Lake Rotorua at Lee Road Boat Ramp	1889850	5776471
	EL224087	Lake Rotorua at Ngongotaha	1882247	5780874

Type	Site ID	Name	Easting	Northing
	FL168384	Ohau Channel at Lake Rotorua Outlet	1891686	5783849
Estuarine	GO441583	Maketū at Surf Club	1904414	5815835
	ML251726	Ohiwa Harbour at Reserve (Boat Ramp)	1962517	5787266
	EP057968	Pilot Bay opposite Pacific Avenue	1880567	5829686
	CR395919	Tauranga Harbour at Anzac Bay	1863958	5849190
	CS292034	Tauranga Harbour at Bowentown Boat Ramp	1862924	5850349
	EP095164	Tauranga Harbour at Maungatapu Bridge (Bathing)	1880957	5821645
	CQ940066	Tauranga Harbour at Omokoroa Beach	1869400	5830662
	CR253528	Tauranga Harbour at Ongare Point	1862533	5845284
	CQ490084	Tauranga Harbour at Pahoia Beach Road	1864908	5830841
	CR054756	Tauranga Harbour at Tanners Point Beach	1860542	5847565
	CP895761	Tauranga Harbour at Te Puna Waitui Reserve	1868959	5827615
	DP547739	Tauranga Harbour at Tilby Point	1875472	5827396
	DP896097	Tauranga Harbour at Waimapu Bridge	1878968	5820974
	GO661503	Waihi Estuary at Main Channel	1906617	5815039
	LM237268	Whakatāne Heads	1952377	5792687
Lake	FK325034	Lake Okareka at Steep Street Reserve	1893250	5770341
	FI660574	Lake Okaro at Boat Ramp	1896600	5755748
	GI442508	Lake Rerewhakaaitu at Homestead Arm	1904423	5755088
	GL314263	Lake Rotoiti at Gisborne Point	1903140	5782634
	GL606421	Lake Rotoiti at Hinehopu	1906063	5784210
	FL289316	Lake Rotoiti at Okawa Bay	1892891	5783164
	HL337241	Lake Rotoma at Whangaroa	1913370	5782419
	EL438512	Lake Rotorua at Hamurana	1884387	5785126
	EK935598	Lake Rotorua at Holdens Bay	1889359	5775980
	EL224087	Lake Rotorua at Ngongotahā	1882247	5780874

Type	Site ID	Name	Easting	Northing
	FJ737728	Lake Tarawera at Rangiuru Bay	1897377	5767284
	FJ157807	Lake Tikitapu at Beach	1891571	5768077
	EL613536	Hamurana at Hamurana Road	1886132	5785363
	RN123610	Haparapara at SH35	2011231	5806108
	EO564565	Kaiate at Kaiate Falls Road	1885648	5815655
	RO629568	Kereu at SH35	2016299	5815685
	DP768284	Kopurererua at McCord Avenue	1877686	5822847
	EL192023	Ngongotahā at Railway Bridge	1881925	5780238
	FL230406	Ohau Channel at SH33	1892304	5784064
	NL683503	Otara at SH35	1976838	5785034
	GN922883	Pongakawa at SH2	1909225	5808837
	EK537123	Puarenga at Whakarewarewa	1885377	5771236
	KM083686	Rangitāiki at Boat Ramp	1940875	5796975
	JK491452	Rangitāiki at Matahina Dam	1934919	5774526
River	IG265664	Rangitāiki at Murupara	1922660	5736647
	JL348334	Rangitāiki at Te Teko Bridge	1933489	5783348
	IK564876	Tarawera at Boyce Park	1925589	5778832
	IK555889	Tarawera at Kawerau Bridge	1925555	5778893
	LK445461	Tauranga at Wardlaw Glade	1954452	5774619
	BR748451	Tuapiro at McMillan Road	1857482	5844516
	BQ723939	Uretara at Henry Road Ford	1857235	5839394
	EK405487	Utuhina at Lake Road	1884052	5774873
	EK260170	Utuhina at Pukehangi Road	1882598	5771708
	FO397216	Waiari at Te Puke Highway	1893975	5812165
	NK608503	Waioeka at Mouth of Gorge	1976081	5775032
	NL517414	Waioeka at SH2	1975174	5784146
	DP281304	Wairoa at SH2	1872819	5823049

Type	Site ID	Name	Easting	Northing
	CO809137	Wairoa Below McLaren Falls	1868096	5811374
	HL149406	Waitangi Soda Springs at Bathing Pool	1911491	5784063
	EL143137	Waiteti at SH36	1881436	5781370
	KM909138	Whakatāne at Landing Road	1949094	5791381
	LK082095	Whakatāne at Ruatoki	1950830	5770958
Shellfish	ML922670	Waiotahe at Estuary	1969229	5786705