Bathing and shellfish surveillance monitoring report 2010/2011

Prepared by Paul Scholes and Matt Bloxham, Environmental Scientists

Bay of Plenty Regional Council
Environmental Publication 2011/13
October 2011

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ISSN: 1175-9372 (Print)
ISSN: 1179-9471 (Online)

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Bay of Plenty
REGIONAL COUNCIL

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Cover Photo: Mclaren Falls

Acknowledgements

Thanks to Joel Henton, Brooke Thomas, document specialists and the laboratory crew who have made this report possible.

Executive summary

Bay of Plenty Regional Council undertakes annual quality surveys of popular recreational (bathing) waters and shellfish beds over the warmer months (October to March). The surveys assist in identifying the risk to public health from faecal contamination within 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. The breadth of the programme has recently been increased to include monitoring of benthic cyanobacteria (*Phormidium*) in rivers and streams.

The main objective of this report is to report on the bathing suitability of approximately 80 river, lake and marine sites in the Bay of Plenty over the 2010/2011 bathing season. 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), orange (cautionary mode) and red (unsafe mode) to denote the risk to users. Two indicator bacteria are used in this assessment for recreational waters, these are:

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

In 2010-2011 lake sites consistently showed a very low level of contamination with only three sites exceeding the orange alert level. River and stream sites exceeded this level on more occasions and one site, the Waimapu River, was on average above the orange alert level. For many sites the microbiological guidelines were exceeded after rainfall events indicating that there is an elevated risk to health when swimming within 48-hours of rainfall.

Open coastal sites showed excellent water quality with respect to faecal contamination with only four sites registering a value above the orange alert guideline. Estuarine sites also displayed low level faecal contamination for most of the summer. No estuarine sites triggered the red alert mode of the microbiological guidelines.

Suitability for Recreation Grading of marine sites for the last five seasons has shown one site in the ‘very poor’ grade and three in the ‘poor’ grade. Five marine sites are graded as ‘fair’ reflecting their days out of compliance ranging from four to nine percent of the time. Seven sites did not reach the Ten Year Plan key performance indicator (KPI) of 95% compliance, although the average percentage of days in compliance was 97%.

The Ten Year Plan KPI of 95% compliance for lake sites was met. No lakes sites are graded ‘poor’ or ‘very poor’ and only one site is ‘fair’ reinforcing the generally good microbiological water quality of the lakes. Two new sites at Lake Rerewhakaaitu do not yet have enough data to be graded.

River sites have the highest number of ‘very poor’ (three) and ‘poor’ (twelve) grades. Over the 2010/2011 season only one site was lower than the Ten Year Plan KPI of 85% (the lower Waimapu River). The average percentage of days in compliance for river sites over the past five years was 93%.

Shellfish at five open coastal and estuarine sites were found to have indicator bacteria levels above safe consumption guidelines. No viruses were detected in four samples analysed, but F-specific RNA phage indicative of human faecal contamination was found at Waihi Estuary and the Waioeka Estuary.

Phormidium, a benthic mat-forming cyanobacteria that can proliferate during periods of sustained low flows, has generally only been found at low levels in rivers in the Bay of Plenty. The algae, which forms expansive black/brown leathery mats across large expanses of river substrate, was also found to be growing in western Bay of Plenty streams in 2010/2011 at levels near to the interim recreational threshold. Sites in the east of the region had low levels of coverage compared to previous years.

The current surveillance programme for faecal contamination of water is working well in providing guidance to health authorities on the status of bathing sites. However, the programme does not meet the sampling frequency recommended by Ministry for the Environment/Ministry of Health (MfE/MoH) for all sites (20 per season, 100 over five years). To assist in addressing this, surveillance monitoring of lake and open coastal sites will now be reduced from annually to every three years as these have consistently shown low levels of faecal contamination. This will allow resources to be focused on the poorer quality river and estuarine sites (including source tracking) and allow the sampling frequency to be increased.

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Part 1: Introduction

1.1 Overview

Bay of Plenty Regional Council undertakes annual quality surveys of popular recreational (bathing) waters and shellfish beds over the warmer months (October to March). The surveys assist in identifying the risk to public health from faecal contamination within 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. The breadth of the programme has recently been increased to include monitoring of benthic cyanobacteria (*Phormidium*) in rivers and streams.

The Ten Year Plan 2009-2019 has a KPI for performance of the regions recreational bathing sites. This is based on the 'Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas' (MfE/MoH 2003), hereafter referred to as the 'microbiological guidelines'. For marine and lake sites the target is 95% while for rivers the target is 85%. There are also a number of regional plans that have objectives based on a contact recreation standard, these are:

- On-site Effluent Treatment (OSET) Regional Plan
- Regional Water and Land Plan
- Regional Coastal Environmental Plan
- Regional Policy Statement

This report summarises the annual bathing survey monitoring results for the 2010/2011 season and also presents recent shellfish and *Phormidium* monitoring results.

1.2 Legislative framework and responsibilities

The agencies with responsibilities related to recreational water quality are regional councils, 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 guidelines (MfE/MoH 2003) provide a recommended framework for 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.

1.3 Recreational water quality objectives

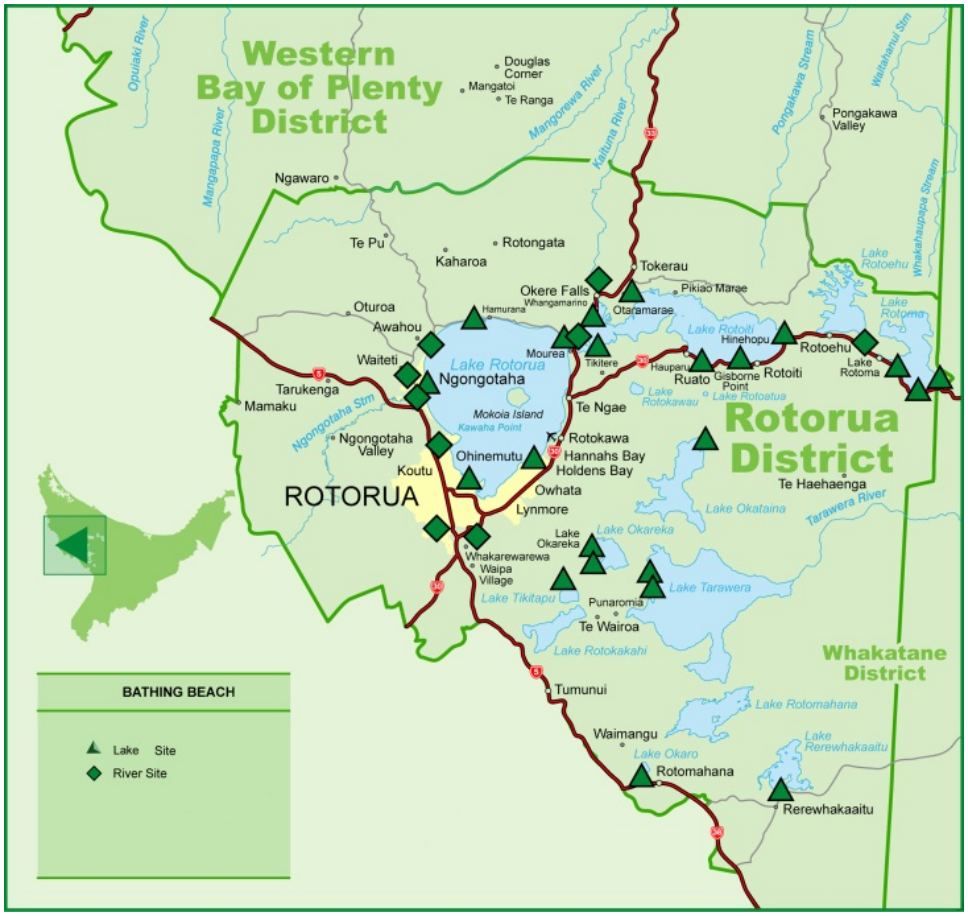
The objectives of the Bay of Plenty Regional Council's recreational water quality monitoring programme are to:

- Assess the suitability of approximately 80 river, lake and marine sites in the Bay of Plenty for contact recreation.
- Assess the suitability of shellfish for human consumption.
- Assist in safeguarding the life-supporting capacity of the water, including public health.
- Provide a mechanism to determine the effectiveness of regional plans.
- Provide information for State of the Environment monitoring.

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

The bathing surveillance monitoring sites are shown in the maps that follow (Figure 1).


Bay of Plenty
WHAKATANE
Whakatane District
Kawerau District
Opotiki District
Opotiki
Ohiwa Harbour
Hauone
Pikowai
Kohioawa Beach
Matata
Awakaponga
Thornton
Coastlands
Kohi Point
Otarawairere Bay
Paroa
Piripai
Ohope
Otakiri
Edgecumbe
Poroporo
White Pine Bush
Manawahe
Awakeri
Awakeri Springs
Te Teko
Onepu
Lake Pupuwharau
Kawerau
Te Mahoe
Lake Matahina
Matahina
Taneatua
Wainui
Cheddar Valley
Kutarere
Kererutahi
Ohiwa
Waiotahi Beach
Waiotahi
Hospital Hill
Paerata Ridge
Woodlands
Apanui
Waioeka
Kukumoa
Tablelands
Te Rere Pa
Otara
Waiotahi Valley
Waioeka Pa
Opouriao
Ruatoki North
Waimana
Nukuhou North
Matahapa
Matahanea
Waikirikiri
Raroa
Tanatana
Okiore
Oponae
Matahi
Tahora
Paraoanui
Tauwhare
Hopeone
Horomanga
Kopuriki
Lake Aniwhenua
BATHING BEACH
Marine Site
River Site
Lake Site


Western Bay of Plenty District
Rotorua District
Whakatane District
ROTORUA
Douglas Corner
Mangatoi
Te Ranga
Ngawaro
Te Pu
Rotongata
Kaharoa
Tokerau
Okere Falls
Whangamarino
Hamurana
Otaramarae
Pikiao Marae
Oturoa
Awahou
Waiteti
Lake Rotorua
Ngongotaha
Mourea
Tikitere
Hinehopu
Rotoehu
Lake Rotoehu
Lake Rotoma
Haupapa
Ruato
Gisborne Point
Rotoiti
Lake Rotoiti
Lake Rotoehu
Tarukenga
Mamaku
Mokoia Island
Kawaha Point
Te Ngae
Lake Rotokawau
Lake Rotoatua
Ngongotaha Valley
Rotokawa
Ohinemutu
Hannahs Bay
Holdens Bay
Koutu
Owhata
Lynmore
Te Haehaenga
Lake Okataina
Tarawera River
Lake Okareka
Whakarewarewa
Waipa Village
Lake Tikitapu
Lake Tarawera
Punaromia
Te Wairoa
Lake Rotokakahi
Tumunui
Lake Rotomahana
Waimangu
Lake Okaro
Rotomahana
Lake Rerewhakaaitu
Rerewhakaaitu
BATHING BEACH
Lake Site
River Site

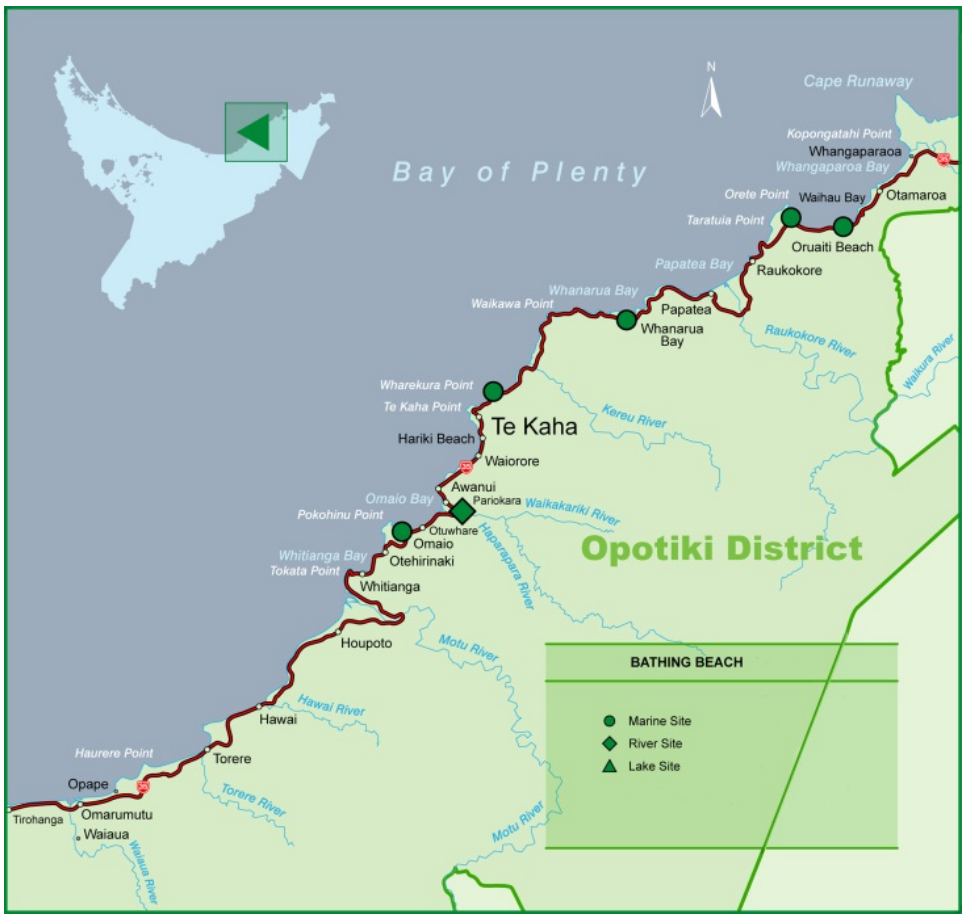


Figure 1 Bathing surveillance sites

Part 2: Methods

2.1 Sampling and analysis

Sampling and analyses where performed in accordance with established internal procedures. Most analyses were performed by the regional council laboratory or the Tauranga City Council laboratory.

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, USEPA 1986 EPA-821-R-97-004	1 cfu/100 ml

Sampling occurred between 8.00 am and 6.00 pm and was undertaken by either wading or by use of a sample pole. Sterile 500 ml polyethylene bottles were used to sample water at a representative location in the water column. Water quality analyses were completed using the methods in Table 2.1. All samples were stored and returned within the time period stipulated by the methods.

Shellfish were collected by hand and placed in plastic bags with immediate cool storage in a chilly bin. The samples were then transported to the laboratory within six hours.

Shellfish were analysed for *Escherichia coli*, enterococci and faecal coliforms. The most probable number (MPN) method was used for faecal coliform and enterococci analysis (APHA 2005), and *E.coli* analysis (APHA 1985).

Viral and F-RNA bacteriophage analyses were undertaken by the Institute of Environmental Science and Research (ESR) using two step real-time polymerase chain digestion (RT-PCR) assays. F-RNA bacteriophage were identified and genotyped using a semi-quantitative multiplex real-time assay (RT-PCR).

Part 3: Microbiological guidelines and indicators

3.1 Introduction

If human or animal faecal matter finds its way into recreational waters 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 recreational waters via a variety of pathways and in variable concentrations.

The impacts of pathogenic micro-organisms on human health are most commonly manifest 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/MoH, 2003).

Indicator micro-organisms are used to assess recreational water quality as it is difficult and impractical to measure all potentially pathogenic micro-organisms. 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. Two indicator bacteria 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 microbiological guidelines (MfE/MoH 2003). Studies relating illness to indicator bacterial levels have been used to develop guideline levels for which a tolerable risk to healthy people is established. The microbiological guidelines provide trigger levels which can be used by water managers and the public to assess the potential risk of using recreational waters. Single sample results can be compared to guideline values to help determine if a health alert or other action should be implemented.

Comparison of survey results with the microbiological guidelines over the bathing season provides water managers with a tool for water quality assessment to be used in conjunction with beach grades. Beach grading provides an analysis of the suitability of recreation over time using combined information on 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), orange (cautionary mode) and red (unsafe mode) to denote the risk to users. The indicator bacteria levels and management responses to these different modes are listed in Table 3.1.

Table 3.1 Surveillance, alert and action levels for fresh and marine waters (MfE/MoH, 2003).

Mode	Guideline - Freshwaters (*E.coli* count in colony forming units per 100 mL)	Recommended Management Response
Green/Surveillance	Single sample ≤ 260	Routine monitoring
Orange/Alert	Single sample > 260 and ≤ 550	Increased monitoring, identify possible sources
Red/Action	Single sample > 550	Public warnings, increased monitoring, source investigation

Mode	Guideline - Marine (Enterococci count in colony forming units per 100 mL)	Recommended Management Response
Green/Surveillance	Single sample ≤ 140	Routine monitoring
Orange/Alert	Single sample > 140 and ≤ 280	Increased monitoring, identify possible sources
Red/Action	Two consecutive single samples > 280	Public warnings, increased monitoring, source investigation

Surveillance mode indicates there is an acceptable risk to recreational water users. Should waters be found to be in *Alert mode* then there is an increased risk of illness if contact is made with recreational waters. *Action mode* indicates 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 the microbiological guidelines and issuing of health warnings will be dependent on the circumstances surrounding any contamination event.

3.2 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 from the combination of a qualitative assessment of the susceptibility of a recreational site to faecal contamination and direct measurements of the appropriate bacteriological indicator at the site. The SFRG describes the general risk of faecal contamination at a site at any given time.

SFRGs have been determined for recreational sites in the Bay of Plenty region since 2005. Updated SFRGs reflecting the 2010/2011 microbiological water quality results are summarised in Appendix 1 for the last five years.

3.3 Additional risk to recreational users

The Bay of Plenty Regional Council monitors waterways with a high probability of toxic planktonic algal blooms. This includes several of the Rotorua Lakes and the Kaituna River. The results of the monitoring are reported in the annual Lakes Water Quality Report. When monitoring indicates high risk to water users a health warning or health advisory is issued for the affected area. Media releases, websites and recorded telephone messages also provide information on the lake status for the public.

Monitoring for the mat-forming cyanobacteria *Phormidium* also occurs in a number of eastern Bay of Plenty rivers including the Rangitāiki, Whakatāne, Otara and Waimana.

Other sites are now also monitored in the western Bay of Plenty. The beds of these rivers can support substantial mats of this toxin producing algae at times of low flow. The mats may contain neurotoxins that are highly toxic to humans and animals. New Zealand studies have shown that at times of high biomass, *Phormidium* can also produce high levels of free toxins in the water (Heath, 2009).

The microbiological guidelines are not inclusive of the health risks posed by toxic algal blooms however interim guidelines are available (MfE/MoH 2009).

Part 4: 2010/2011 bathing surveillance season

4.1 Recreational surveillance monitoring

Before the start of the bathing season a monitoring plan was designed and circulated for comment to Toi Te Ora Public Health and the district councils. The criteria for selection of sites included whether they were high-use bathing locations and whether there was known contamination risk.

Monitoring began on 26 October 2010 and ran until 16 March 2011. Approximately 80 sites around the region were monitored with sites sampled weekly or once every two weeks.

The results of analysis are generally available after 24-hours after which they were posted onto the Bay of Plenty Regional Council website[1]. Media releases also help keep the public informed of the situation with regards to bathing water quality.

If orange or red modes are flagged these results are directly communicated to Toi Te Ora Public Health and the relevant district council. Follow-up sampling then occurs within a 24-hour period. Should a water quality problem be found to be recurring Toi Te Ora Public Health have the responsibility to decide if a public health warning needs to be issued. If a warning is required Toi Te Ora Public Health will initiate media releases and inform the district council of the need for warning signs and any further monitoring required.

4.2 Results

Monitoring results are presented here graphically as box-whisker plots. These plots show the range of results for the season as well as the median, 25th and 75th percentiles, outliers and extreme values.

4.2.1 River and stream sites

River and stream sites were monitored on a weekly or two-weekly basis.

Figure 4.1 shows the range of *E.coli* results recorded at each site ranked in order of median levels. Only one site, Waimapu River at Greerton, had a median *E.coli* concentration above the orange alert level. Of the 28 sites monitored 22 had individual instances of alert levels occurring and 16 of these had results over 550 *E.coli* cfu/100 ml (red alert level).

Kaiate Stream was the second most contaminated of the river sites. Although it had a lower median *E.coli* level than the Pongakawa River and Ngongotaha Stream, Kaiate Falls had consistently high levels particularly at the start of the season. A warning sign was installed at this site over much of the bathing season recommending that contact recreation be avoided.

Multiple results above the red alert mode guideline occurred predominantly as a result of several large storm events that occurred over the summer.

[1] http://www.boprc.govt.nz/Environment/Swimming-Water-Quality.aspx

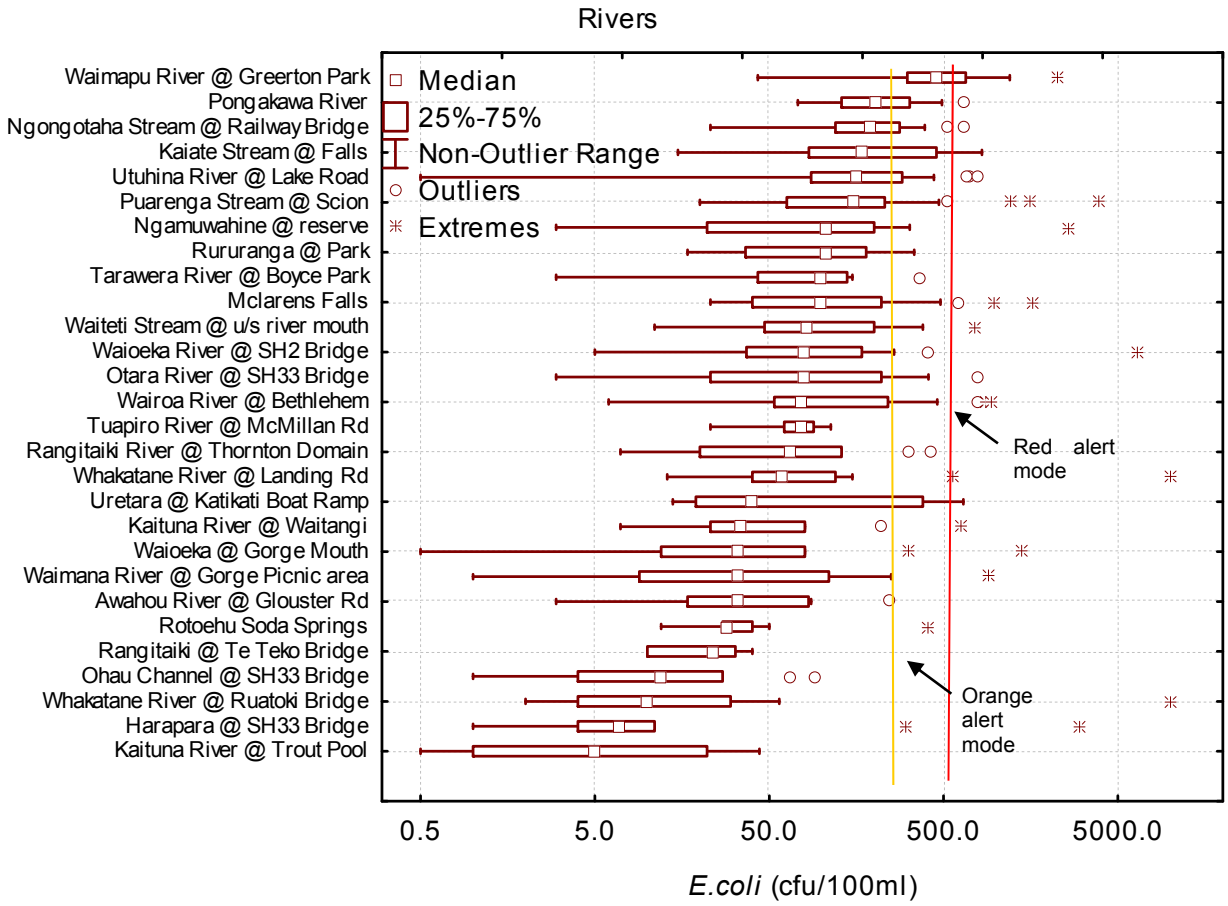


Figure 4.1 Box-whisker plots of E.coli concentrations, river sites 2010/2011 bathing season

4.2.2 Lake sites

Sampling occurred at 20 lake sites once every two weeks.

Figure 4.2 shows the range of *E.coli* results at each site ranked in order of median levels. Three Lake Rotorua sites had samples above the orange alert level on one occasion; Hamurana, Holdens Bay and Ohinemutu. No sites exceeded the red alert mode.

Lake Rotorua at Hamurana had the highest median and 75th percentile *E.coli* concentrations of the lake sites. Strong wind and the shallow embayment around Hamurana, causing sediments to be frequently disturbed, will have contributed to the comparatively elevated *E.coli* levels at this site. Median *E.coli* concentrations were below 15 cfu/100 ml indicating that all of the lake sites on average have a very low level of faecal contamination.

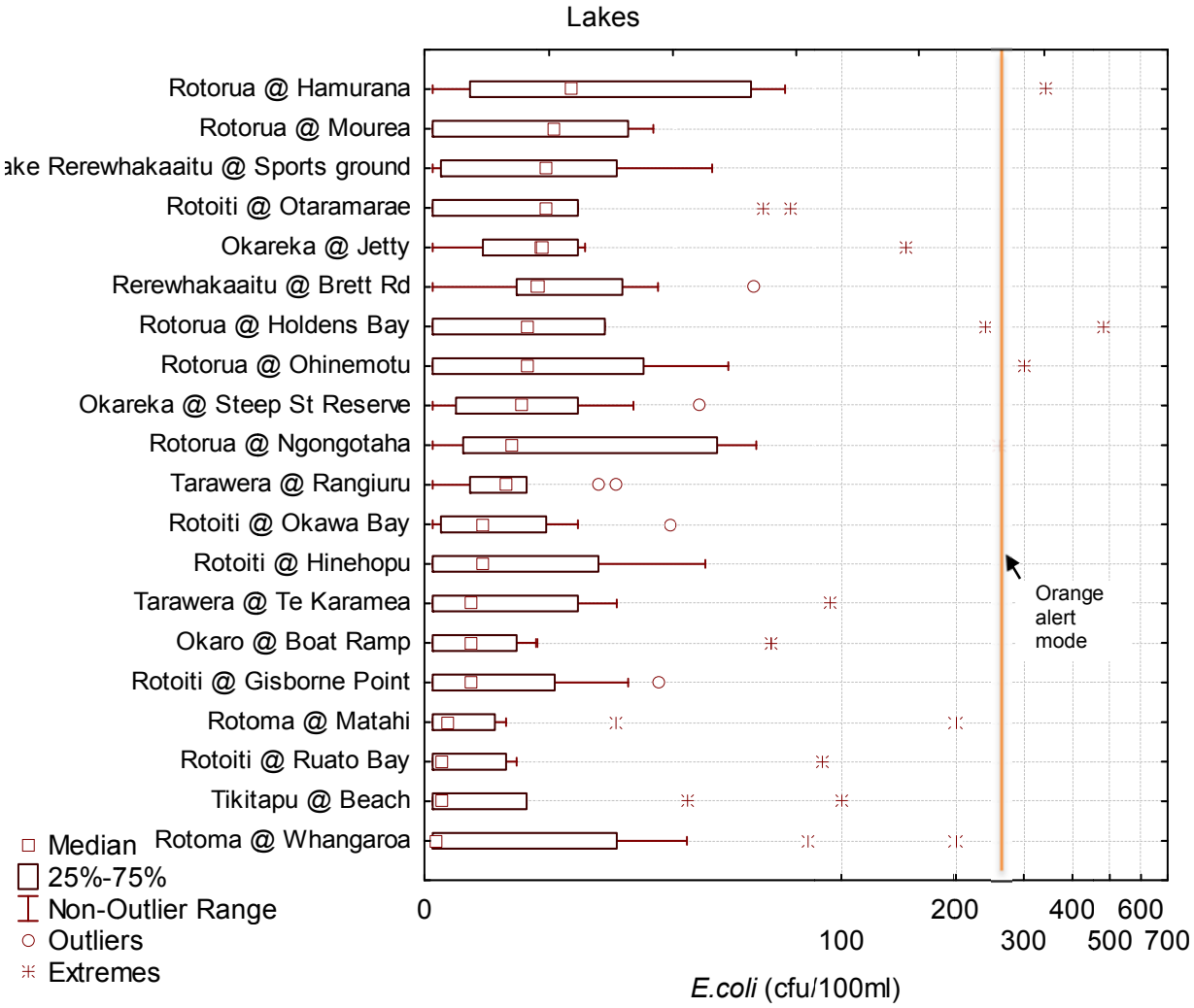


Figure 4.2 Box-whisker plots of E.coli concentrations, lake sites 2010/2011 bathing season

4.2.3 Marine sites

Of the 16 open coastal marine sites four were monitored weekly and the others every second week. Figures 4.3 (coastal marine) and 4.4 (estuarine) show the range of enterococci results at each site ranked in order of median levels.

No sites reached the red alert mode (two consecutive samples greater than 280 Enterococci/100ml). Individual samples from four open coastal sites reached the orange alert level; Waihī Beach at surf club, Waiotahi Beach at surf club, Ohope Beach at Surf ‘n Sand and Omanu Beach. Two of these sites are adjacent to treated wastewater effluent discharges and may have experienced elevated results due to strong storm surges. The median enterococci concentrations for coastal marine sites were all below 15 cfu/100 ml.

Overall the open coastal waters had very low levels of contamination as indicated by the enterococci indicator bacteria.

Eight of the 18 estuarine sites reached the orange alert level during the season (Figure 4.4). No sites triggered the red alert mode although seven sites reached the red alert level (two consecutive samples above the red alert level are required to trigger the red alert mode). Median and 75th percentile enterococci concentrations were generally well below the orange alert level.

No health alerts were required at marine sites over the 2010/2011 season.

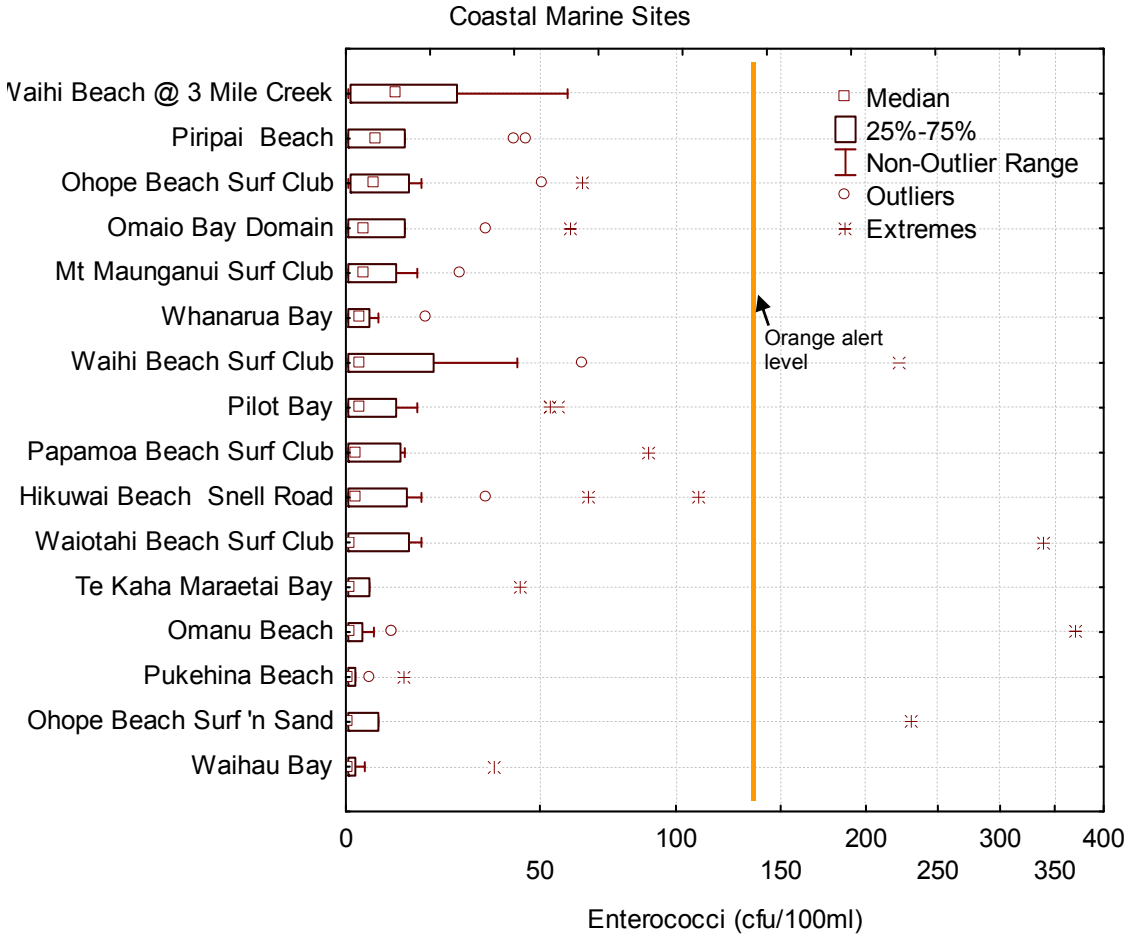


Figure 4.3 Box-whisker plots of enterococci concentrations, coastal marine sites 2010/2011 bathing season

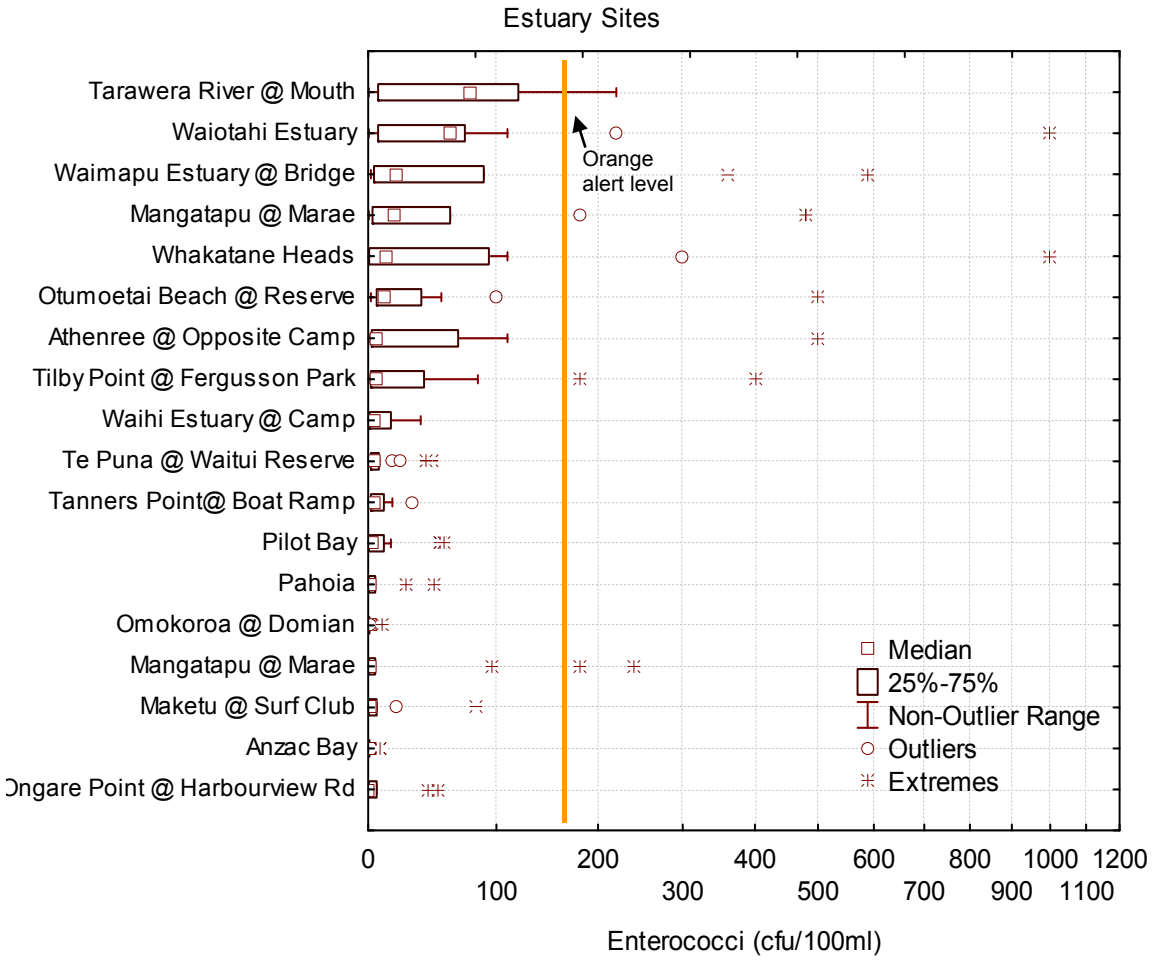


Figure 4.4 Box-whisker plots of enterococci concentrations, estuarine sites 2010/2011 bathing season

Part 5: River algae monitoring programme

5.1 Introduction

Rivers and lakes are monitored over summer-autumn for blue-green algae (cyanobacteria).

Blue-green algae are widespread throughout New Zealand. In the Bay of Plenty lakes and rivers are at times affected by both free living (seen as discoloured, soupy looking water or surface scums) and attached 'benthic' forms (seen as dark olive green or light brown mats covering the river bed) of potentially toxic blue-green algae.

Phormidium is a benthic mat-forming cyanobacteria that can proliferate during periods of sustained river low flows, and form expansive black/brown leathery mats across large areas of river bed (Wood and Heath, 2010). *Phormidium* produces a potent neurotoxin and has been linked worldwide with dog and stock deaths (Heath, 2009). While ingestion of the mats is the most direct route of exposure, there is one account in international literature of dog deaths occurring after they drank from a bloom affected river.

Stable substrate provides attachment points for these cyanobacteria and other algae and for this reason blooms are most often associated with cobbled river beds. However, investigation following the death in 2007 of a dog near the Rangitāiki River revealed that *Phormidium* can also form continuous mats over pumice beds after long low-flow events. This is significant for a number of lowland rivers in the Bay of Plenty.

When extensive mats of blue-green algae are found a warning may be issued by the health authority. This will advise the public not to drink or use affected water and to keep away from the areas affected.

When a warning is issued the district council places signs at major public access points. Updated information on warnings is also posted on Bay of Plenty Regional Council and Toi Te Ora Public Health websites and on recorded telephone messages.

5.2 Monitoring method

Benthic cyanobacteria are monitored at sites along the Rangitāiki, Whakatāne, Waimana and Otara rivers. Monitoring involves estimating the percentage cover of cyanobacteria at five points along four transects. Transects begin downstream and progress upstream to avoid disturbance to areas not yet surveyed. A transect is made across the river, if shallow, or to a maximum depth of 0.6 metres, for larger, deeper rivers. A mean percentage cover is generated for each site using cover estimates at all 20 points.

The sites monitored include river entry points of known recreational value. River reaches that contain optimum habitat for *Phormidium*, and that are shown perennially to harbour large mats, are also monitored as these provide a comparative measure of mat development (even if they receive little recreational use).

5.3 Phormidium - monitoring framework

An early warning system is operated on the Whakatāne and Rangitāiki Rivers based on telemetered flow recorders[2]. The status level for the Whakatāne River is also used to represent the situation in the Waimana River. As each alert level is reached, a range of actions follow, potentially culminating in health warnings if and when mat cover reaches or exceeds 50% cover (Table 5.1). The alert level framework generally follows that given in the interim 'New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters' (MfE/MoH 2009).

A network of river users also informs the council when *Phormidium* is present at levels that may require field measurements.

Alert level	Trigger	Action
Phormidium Surveillance (green mode)	Up to 20% coverage of potentially toxigenic cyanobacteria attached to substrate	Undertake fortnightly surveys between spring and autumn at representative locations in the water body where known mat proliferations occur and where there is recreational use.
Phormidium Yellow Alert	No flush in last 14 days	Continue to monitor the situation.
Phormidium Orange Alert	Flow <10 percentile	Begin field assessments. If coverage of potentially toxigenic cyanobacteria 20−50%, notify the public health unit and Increase sampling to weekly.
Phormidium Red Alert	Phormidium mat covering ≥50% of the bed	Immediately notify the public health unit. Health warning instated. If municipal water takes are at risk SPATT may be established to monitor for free toxins

Table 5.1 Alert level framework in place for Phormidium

5.4 Results

5.4.1 Waimana River

The Waimana River is monitored at two sites including Wardlaw Reserve and Kirkbride Road. A third monitoring station at Lowe Road, which is situated upstream of Waimana township, has been discontinued after years of low *Phormidium* cover.

As with the 2009/2010 summer season *Phormidium* coverage was low in 2010/2011 (1-2%) and no health warnings were issued. After very low cover in spring *Phormidium* was effectively absent at both sites over summer and autumn (Figure 5.1). The last health advisory for this river was in February 2009.

[2] The telemetered flow recorder sites are based around established gauging stations at Valley Road (Whakatāne River) and Te Teko (Rangitāiki River).

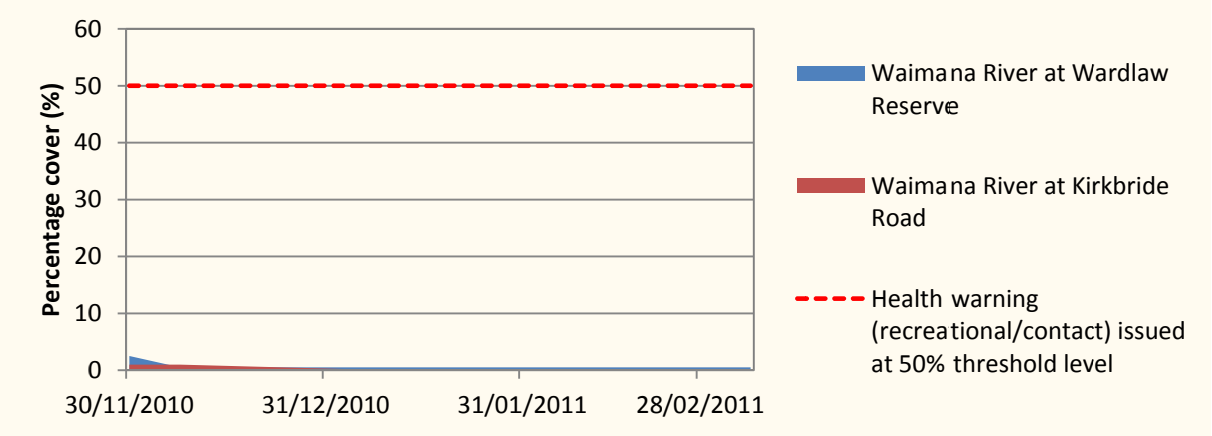


Figure 5.1 Percentage Phormidium cover, Waimana River

5.4.2 Whakatāne River

The Whakatāne River is monitored at two sites including Reid Memorial Reserve and Pekatahi Bridge.

Phormidium was recorded at low levels at both monitoring sites in 2010/2011 (Figure 5.2). Growths, where present, were generally restricted to individual cobbles and did not reach levels seen the previous summer. The last health advisory, covering both the Whakatāne and Waimana Rivers, was issued in December 2008.

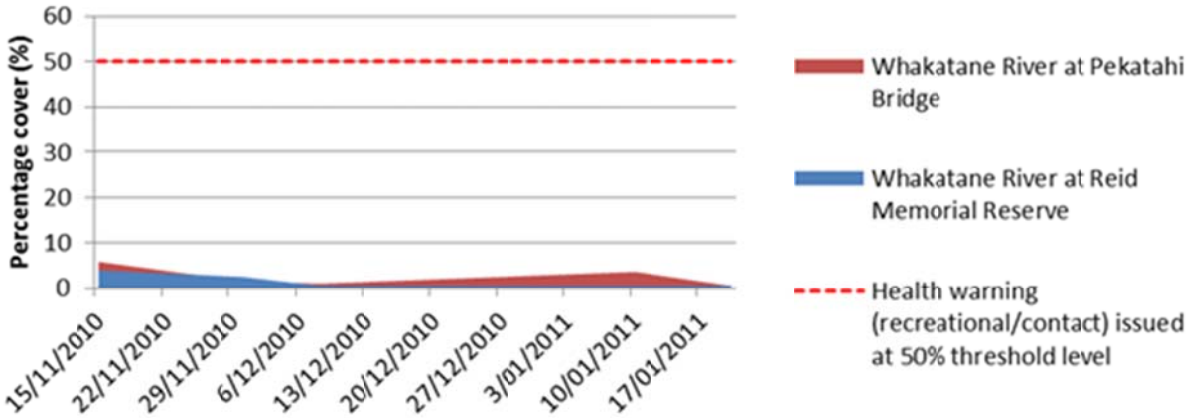


Figure 5.2 Percentage Phormidium cover, Whakatāne River

No other Eastern Bay rivers including the Otara and the Waioeka recorded significant bloom activity over the 2010/2011 monitoring period.

5.4.3 Rangitāiki River

The Rangitāiki River is monitored at six sites including at Edgecumbe Playing Fields, Edgecumbe Substation, Te Teko (occasional), Rabbit Bridge (occasional), Galloway's farm and above the Murupara State Highway 38 road bridge.

No *Phormidium* was observed in the lower Rangitāiki over the 2010/2011 monitoring season (Figure 5.3). Moderate mat development occurred at upstream sites including at the SH38 river side reserve at Murupara and further downstream at Galloway's farm. On no occasion did levels trigger health warnings. Mat development at Murupara reached 20% cover in January, well under levels that would trigger a health advisory. Cover then steadily declined to very low levels by the end of February.

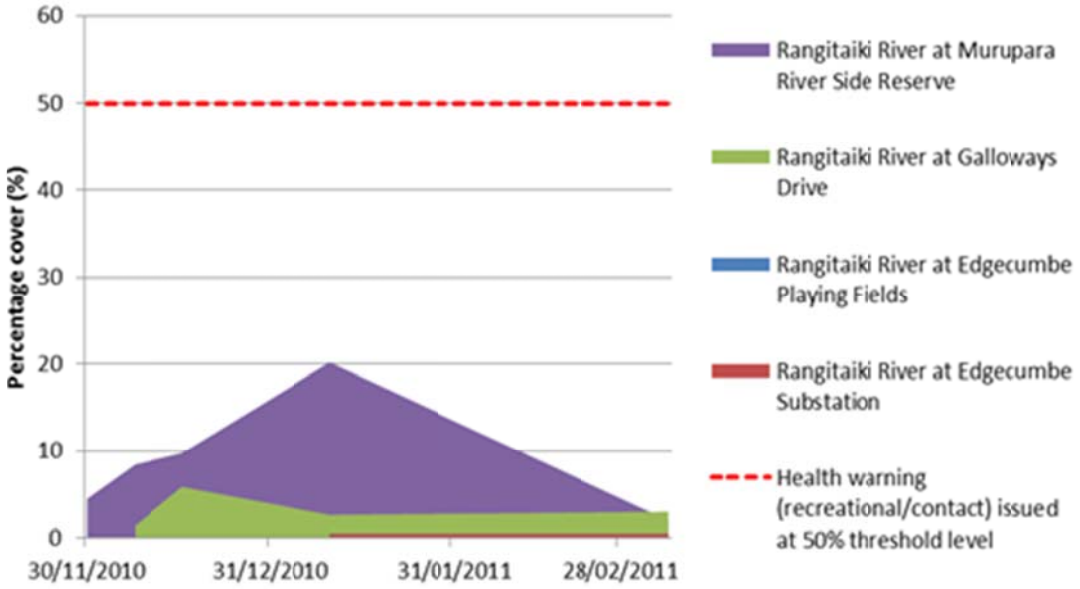


Figure 5.3 Percentage Phormidium cover, Rangitāiki River

5.4.4 Western Bay of Plenty rivers

Te Rereatukahia Stream was added to the *Phormidium* monitoring programme along with three other western Bay of Plenty sites in 2010. The stream runs through Sapphire Springs, a popular thermal spring and camping ground. While the thermal springs are probably the main attraction for campers and locals, the stream runs through the complex and contains pools and run sections attractive for bathing. A second site further downstream (off Tetley Road) is situated close to a marae and is also used for bathing.

A gradual build-up of mats occurred in Te Rereatukahia Stream in the weeks prior to floods in January/February. At its highest level (53%) the mats marginally exceeded the contact recreation threshold for *Phormidium* of 50% (Figure 5.4). A health warning was not issued on the basis that heavy rain was due. The high flows that resulted from the late January floods (the last being on 30 January) removed almost all of the mats.

Phormidium mats have been shown to recover quickly where conditions remain favourable and in some cases mats have been shown to reform within one week. A week on from the flood no noticeable recovery had occurred but by 22 February cover had again reached 20%. This site was not able to be revisited through autumn so it is not known when *Phormidium* cover declined.

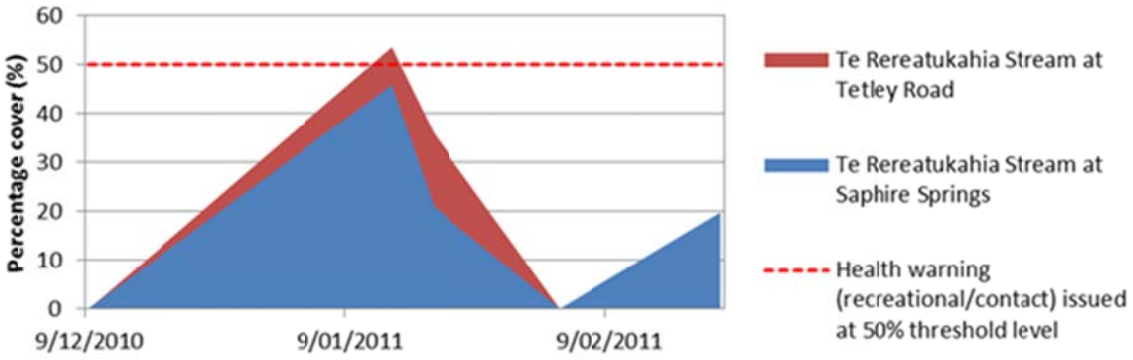


Figure 5.4 Percentage Phormidium cover, western rivers

No other western Bay of Plenty sites recorded extensive *Phormidium* development over the monitoring period.

Part 6: Shellfish

6.1 Sampling and analysis

Collection of shellfish occurred at a number of open coastal and estuarine sites in 2010/2011. At each site sampling was conducted over a 20 m transect of the shellfish bed/area. A minimum of 24 individual shellfish were taken per site to make up at least 200 g of flesh. The species sampled were:

- Cockle (*Austrovenus stuchburyi*); found throughout muddier intertidal and subtidal areas, only abundant in harvestable numbers at a few locations.
- Pipi (*Paphies australis*); often abundant around the mouth of the estuaries but extend to sandy areas of the inner estuary.
- Oyster (*Tiostrea chilensis lutria*); commonly found cemented to rocks or mangroves in the intertidal zone.
- Tuatua (*Paphies subtriangulata*); found on open coastal beaches, most commonly in the surf zone.

Shellfish were analysed for *E.coli*, faecal coliforms and enterococci and the results expressed as MPN (most probable number) per 100 g of flesh.

The standard used for shellfish quality for consumption is based on the 'Ministry of Health Microbiological Reference Criteria for Food' (1995). This standard is listed in the 13th schedule of the Regional Coastal Environment Plan. To comply with the standard faecal coliform levels in flesh should be less than 330 MPN/100 g, and levels from 230 to 330 MPN/100 g are marginally acceptable.

Microbiological limits have also been specified by NZFSA (2006)[3]. Faecal coliform limits have been used historically for shellfish quality assessment but these have been abandoned in recent years in favour of *E.coli*. The *E.coli* median MPN of the shellfish samples must not exceed 230 per 100 g and no more than 10% of the samples must exceed an MPN of 700 per 100 g.

6.2 Results

Table 6.1 gives the results for shellfish sampled over the 2010/2011 summer.

Faecal coliform concentrations in shellfish were found to be over the MoH safe consumption guideline (330 MPN/100g) at five sites; Waioeka Estuary, Waiotahi Estuary, Ōhiwa Harbour, Plumbers Point/Te Puna and Ōhope Beach. The Te Puna/Plumbers Point samples were collected following rainfall while the high result for Ōhope Beach is likely to be the result of an extended easterly storm surge around that time. Similar faecal coliform levels were also experienced last season at Waiotahi Estuary, although this occurred after rain.

Samples from four sites were also analysed for viral and F-specific-RNA phage. RNA genome detection techniques can be used to detect human viruses as well as F-RNA bacteriophages (bacterial viruses that can be derived from both human and animal sources). These have both been used as an indicator of on-site wastewater contamination.

[3] New Zealand Food Safety Animal Products (Specifications for Bivalve Molluscan Shellfish) Notice 2006

No shellfish samples tested positive for human enteric viruses. The sample from Waihī Estuary was positive for F-specific-RNA GI and GII, indicating human and animal sources of faecal contamination although the faecal indicator results were only moderately elevated. There was also a positive F-specific-RNA GII result indicating bias towards a human derived source.

Table 6.1 Shellfish indicator bacteria results. Samples exceeding the MoH guideline are indicated in red

Site		Sampled	Shellfish type	*E.coli* (MPN/100g)	ENT (MPN/100g)	FC (MPN/100g)
Waioeka Estuary	River entrance	23/11/10	Oyster		28	37
Waioeka Estuary	River entrance	15/12/10	Oyster	300	80	**500**
Waiotahi Estuary	Reserve	15/12/10	Pipi	1600	30	**1600**
Ohiwa Harbour	Eastern harbour	15/12/10	Pipi	900	26	**900**
Pukehina Beach	Mid beach	17/02/11	Tuatua	140	30	140
Tauranga Harbour	Pios Beach	18/11/10	Cockles	4	2	4
Tauranga Harbour	Waipu Bay Cockles	18/11/10	Cockles	1	50	300
Tauranga Harbour	Waipu Bay Cockles	31/03/11	Cockles	22	140	240
Tauranga Harbour	Pio's Beach - Yellow Point	18/11/10	Pipi	1	1	1
Tauranga Harbour	Tilby Point/Otumoetai	18/11/10	Pipi	9	4	14
Tauranga Harbour	Tilby Point/Otumoetai	31/03/11	Pipi	140	50	170
Tauranga Harbour	Plumber Point/ Te Puna	17/02/11	Oysters	500	43	**500**
Tauranga Harbour	Opposite Pilot Bay	18/11/10	Pipi	8	2	8
Tauranga Harbour	Opposite Pilot Bay	31/03/11	Pipi	7	2	11
Tauranga Harbour	Waikareao entrance	31/03/11	Pipi	14	170	140
Ohope Beach	Moana Road	18/01/11	Tuatua	170	1600	**1600**
Maketū Estuary	Main channel	18/01/11	Pipi	50	13	80
Waihī Estuary	Campground (Waihi)	18/01/11	Pipi	240	170	240

Table 6.2 Virus and F-specific RNA results

Site		Sampled	Norovirus		Adeno -virus	F-specific RNA phage			
			Group I	Group II		Group I	Group II	Group III	Group IV
						Animal	Human	Human	Animal
Maketū Estuary	Main channel	18/01/11	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Waihī Estuary	Campground (Waihi)	18/01/11	Neg	Neg	Neg	Positive	Positive	Neg	Neg
Pukehina Beach	Mid beach	18/01/11	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Waioeka Estuary	River entrance	15/12/10	Neg	Neg	Neg	Neg	Positive	Neg	Neg

Part 7: Discussion and conclusions

The 2010/2011 bathing surveillance season has shown that most sites have low levels of faecal contamination, confirming that recreational water quality is generally good. However, water quality with respect to faecal contamination is variable across the regions popular bathing sites.

Lake sites consistently showed a very low level of contamination with only three sites exceeding the orange alert level. River and stream sites exceeded this level on more occasions and one site, the Waimapu River, was on average above the orange alert level. For many river and stream sites the microbiological guidelines were exceeded after rainfall events indicating that there is an elevated risk to health when swimming within 48-hours of rainfall.

Open coastal sites showed excellent water quality with respect to faecal contamination with only four sites registering a value above the orange alert guideline. Estuarine sites also displayed low level faecal contamination for most of the summer. No estuarine sites triggered the red alert mode of the microbiological guidelines.

Suitability for Recreation Grading of marine sites for the last five seasons has shown one site in the ‘very poor’ grade and three in the ‘poor’ grade. Five marine sites are graded as ‘fair’ reflecting their days out of compliance ranging from four to nine percent of the time. Seven sites did not reach the Ten Year Plan key performance indicator (KPI) of 95% compliance, although the average percentage of days in compliance was 97%.

The Ten Year Plan KPI of 95% compliance for lake sites was met. No lakes sites are graded ‘poor’ or ‘very poor’ and only one site is ‘fair’ reinforcing the generally good microbiological water quality of the lakes. Two new sites at Lake Rerewhakaaitu do not yet have enough data to be graded.

River sites have the highest number of ‘very poor’ (three) and ‘poor’ (twelve) grades. Over the 2010/2011 season only one site was lower than the Ten Year Plan KPI of 85% (the lower Waimapu River). The average percentage of days in compliance for river sites over the past five years was 93%.

Shellfish at five open coastal and estuarine sites were found to have indicator bacteria levels above safe consumption guidelines. No viruses were detected in four samples analysed, but F-specific RNA phage indicative of human faecal contamination was found at Waihi Estuary and the Waioeka Estuary.

Phormidium has generally only been found at low levels in rivers in the Bay of Plenty. The algae, which forms expansive black/brown leathery mats across large expanses of river substrate, was also found to be growing in western Bay of Plenty streams in 2010/2011 at levels near to the interim recreational threshold. Sites in the east of the region had low levels of coverage compared to previous years.

Part 8: Future monitoring

The current surveillance programme for faecal contamination of water is working well in providing guidance to health authorities on the status of bathing sites. However, the programme does not meet the sampling frequency recommended by MfE/MoH for all sites (20 per season, 100 over five years). To assist in addressing this, surveillance monitoring of lake and open coastal sites will now be reduced from annually to every three years (see Table 8.1) as these have consistently shown low levels of faecal contamination. This will allow resources to be focused on the poorer quality river and estuarine sites (including source tracking) and allow the sampling frequency to be increased.

Table 8.1 Sites for three year sampling rotation for faecal contamination

Site	Description	Site No.
Lake Rotoma	Matahi Lagoon Road, Beach	160050
Lake Rotoma	Whangaroa	160052
Lake Rotoiti	Hinehopu, Jetty	160053
Lake Rotoiti	Gisborne Point	160054
Lake Rotoiti	Ruato	160055
Lake Rotoiti	Okawa Bay	160056
Lake Rotoiti	Otaramarae	160058
Lake Okataina	Beach	160059
Lake Okareka	Jetty	160062
Lake Tikitapu	Beach	160063
Lake Tarawera	Rangiuru Bay	160072
Lake Rotorua	Mourea	160065
Lake Rotorua	Ohinemutu	160068
Lake Rotorua	Hamurana	160070
Lake Okaro	Ski Area	160073
Lake Rerewhakaaitu	Pump Station Boat Ramp	160077
Omaio Bay Domain	Omaio	160004
Te Kaha Beach Maraetai Bay	Te Kaha	160003
Waihau Bay	Waihau	160001
Whanarua Bay	Whanarua Bay	160002

The surveillance programme has identified several sites that experience faecal contamination above the microbiological guidelines on a regular basis. Catchment surveys and microbial source tracking studies (see example laboratory report in Appendix 2) are required to further identify potential contamination sources. These sites are Kaiate Falls, Waimapu River at Greerton and the Tarawera River mouth at the coast.

Further investigation into contaminant sources in these catchments will be conducted and the information generated will be used to help achieve improvements in water quality.

Part 9: References

American Public Health Association (2005): Standard Methods for the Examination of Water and Wastewaters. APHA 21st Edition, 2005.

American Public Health Association (1985): Recommended Procedures for the Examination of Seawater and Shellfish. APHA 4th Edition, 1985.

Heath, M. (2009): Mat forming toxic benthic cyanobacteria in New Zealand. MSc Thesis, Victoria University.

McIntosh, J. (1999): Shellfish Quality Assessment. Bay of Plenty Regional Council, Environmental Report 99/08.

Ministry for the Environment and Ministry of Health (2003): Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment Publication number: ME 474.

Ministry for the Environment and Ministry of Health (2009): Cyanobacteria in Recreational Fresh Waters – Interim Guidelines. Prepared for the Ministry for the Environment and the Ministry of Health by SA Wood, DP Hamilton, WJ Paul, KA Safi and WM Williamson. Wellington: Ministry for the Environment.

New Zealand Food Safety Authority: NZFSA Animal Products (Specifications for Bivalve Molluscan Shellfish) Notice 2006.

The Australian New Zealand Food Standards Code (2010).

Wood, S.A., and Heath M. H. (2010). Benthic Cyanobacteria and Anatoxin-a and Homanatoxin-a Concentrations in Five Southland Rivers. Cawthron Report No. 1841. 15pp plus appendices

Appendices

Appendix 1: Grading tables

Table A1.1: Grades - Marine

District	Site	Description	BOP Site Number	P	MAC	SIC	SFRG	% Days in Compliance 2010/11
Opotiki	Hikuwai Beach End of Snell Road	Hikuwai	160005	62.4	B	Moderate	**Good**	100
Opotiki	Omaio Bay Domain	Omaio	160004	55.2	B	Moderate	**Good**	100
Opotiki	Te Kaha Beach Maraetai Bay	Te Kaha	160003	25.3	A	Very Low	**Very Good**	100
Opotiki	Waihau Bay	Waihau	160001	39.6	A	Very Low	**Very Good**	100
Opotiki	Waiotahi Beach Estuary	Waiotahi Est	160008	215	C	Moderate	**Fair**	91
Opotiki	Waiotahi Beach Surf Club	Waiotahi	160007	31	A	Low	**Very Good**	91
Opotiki	Whanarua Bay	Whanarua Bay	160002	18	A	Very Low	**Very Good**	100
Tauranga	Mt Maunganui Ocean Beach Surf Club	Mount	160025	34.6	A	Very Low	**Very Good**	100
Tauranga	Omanu Beach	Omanu Surf Club	900096	29.6	A	Very Low	**Very Good**	94
Tauranga	Otumoetai Beach reserve end of Beach	Otumoetai	160021	525.5	D	Moderate	**Poor**	90
Tauranga	Papamoa Beach Surf Club	Papamoa	160026	58.9	B	Very Low	**Very Good**	100
Tauranga	Pilot Bay Mid Beach	Pilot Bay	160042	133.3	B	Moderate	**Good**	100
Tauranga	Rangataua Bay	Maungatapu	160049	325.5	C	Very Low	**Fair**	90
Tauranga	Tilby Point Reserve	Tilby Pt	160020	180	B	Very Low	**Very Good**	94
Tauranga	Waimapu Estuary Motel-Motor Camp	Waimapu	160019	190	B	Low	**Good**	80
WBOP	Anzac Bay Bowentown Domain	Anzac Bay	160028	53	B	Very Low	**Very Good**	100
WBOP	Athenree Opposite Motor Camp	Athenree	160030	460	C	Low	**Fair**	90
WBOP	Little Waihi Domain Boat Ramp	Little Waihi	160016	209	C	Moderate	**Fair**	100
WBOP	Maketu Surf Club	Maketu	160017	174	B	Moderate	**Good**	100
WBOP	Omokoroa Beach	Omokoroa	160022	26.7	A	Very Low	**Very Good**	100
WBOP	Ongare Point Harbour View Road	Ongare Pt	160032	309	C	Low	**Fair**	100
WBOP	Pahoia End of Beach	Pahoia	160023	182.5	B	Low	**Good**	100
WBOP	Pukehina Beach Surf Club	Pukehina	160015	32	A	Very Low	**Very Good**	100
WBOP	Tanners Point Beach	Tanners Pt	160031	95.3	B	Very low	**Very Good**	100
WBOP	Waihi Beach Surf Club	Waihi Beach	160027	51.6	B	Low	**Good**	100
WBOP	Waihi Beach	3 Mile Creek	900077	337	C	High	**Poor**	100
WBOP	Waitui Reserve	Te Puna	160293	149.8	B	High	**Follow-up**	95
Whakatane	Ohiwa Harbour Reserve Boat Ramp	Ohiwa	160009	79.7	B	Very Low	**Very Good**	100
Whakatane	Ohope Beach Surf Club	Ohope 2	160011	164	B	Moderate	**Good**	100
Whakatane	Ohope Beach Surf 'n Sand Motor Camp	Ohope 1	160010	77	B	Very Low	**Very Good**	100
Whakatane	Piripai Beach Ocean Beach	Piripai	160014	79.4	B	Very Low	**Very Good**	100
Whakatane	Whakatane Heads Oceanside of Boat Ramp	Whakatane	160013	518.4	D	Moderate	**Poor**	83
Whakatane	River Mouth	Tarawera River	110125	594	D	High	**Very Poor**	100

Table A1.2: Grades - Rivers

District	Site	Description	BOP Site Number	P	MAC	SIC	SFRG	% Days in Compliance 2010/11
Kawerau	Ruruanga Stream	Cricket Pavilion	160111	370	C	High	**Poor**	100
Kawerau	Tarawera River	Boyce Park	160110	131.5	B	Very Low	**Very Good**	100
Opotiki	Haparapara River	Omaio d/s SH35 Bridge	160100	449.5	C	Low	**Fair**	90
Opotiki	Otara River	d/s SH35 Bridge	160101	275	B	Moderate	**Fair**	91
Opotiki	Waioeka River	bend near Waioeka Pa	160102	1115	D	Moderate	**Poor**	91
Opotiki	Waioeka River	SH2 Bridge	160103	640	D	High	**Very Poor**	94
Rotorua	Awahou Stream	Glouster Road	160118	161	B	Very Low	**Very Good**	100
Rotorua	Kaituna River	Trout Pool Rd	160112	466	A	Very Low	**Very Good**	100
Rotorua	Ngongotaha Stream	Railway Bridge	160114	1557	D	Moderate	**Poor**	95
Rotorua	Ohau Channel	SH 33 Bridge	160119	116.8	A	Very Low	**Very Good**	100
Rotorua	Puarenga Stream	Whakarewarewa	160113	1278	D	Moderate	**Poor**	86
Rotorua	Utuhina Stream	Lake Road	160117	955	D	Moderate	**Poor**	85
Rotorua	Waitangi Springs	Lake Rotoehu	160120	212	B	Very Low	**Very Good**	100
Rotorua	Waiteti Stream	Ngongotaha	160115	782	D	Moderate	**Poor**	98
Tauranga	Waimapu River	Greerton Park Footbridge	160150	1143	D	High	**Very Poor**	69
Tauranga	Wairoa River	Bethlehem	160122	820	D	Moderate	**Poor**	85
WBOP	Kaituna River	Te Matai Rail Bridge	160129	210	B	Moderate	**Good**	90
WBOP	Ngamuwahine River	at Reserve	160125	1240	D	Moderate	**Poor**	90
WBOP	Tuapiro Stream	McMillan Road	160126	465	C	Moderate	**Fair**	100
WBOP	Uretara Stream	Katikati	160123	600	D	Moderate	**Poor**	90
WBOP	Wairoa River	below McLaren Falls Dam	160124	1600	D	Moderate	**Poor**	90
WBOP	Kaiate Stream	Kaiate Falls	160130	2260	D	High	**Very poor**	85
WBOP	Pongakawa River	SH2	110030	651.5	D	Moderate	**Poor**	92
Whakatane	Rangitaiki River	Te Teko	110018	80	A	Very Low	**Very Good**	100
Whakatane	Rangitaiki River	Thornton Domain	160109	304	C	High	**Poor**	100
Whakatane	Waimana River	Waimana Gorge Picnic Area	160105	347.5	C	Fair	**Very Good**	90
Whakatane	Whakatane River	Landing Road Bridge	160106	494.5	C	Poor	**Very Poor**	93
Whakatane	Whakatane River	Ruatoki Bridge	110010	112.5	A	Moderate	**Good**	100

Table A1.3: Grades - Lakes

Site	Description	Site No.:	P	MAC	SIC	SFRG	% Days in Compliance 2010/11
Lake Rotoma	Matahi Lagoon Road, Beach	160050	58.4	A	Very Low	**Very Good**	100
Lake Rotoma	Whangaroa	160052	83.3	A	Very Low	**Very Good**	100
Lake Rotoiti	Hinehopu, Jetty	160053	17	A	Very Low	**Very Good**	100
Lake Rotoiti	Gisborne Point	160054	21.2	A	Very Low	**Very Good**	100
Lake Rotoiti	Ruato	160055	111	A	Very Low	**Very Good**	100
Lake Rotoiti	Okawa Bay	160056	87.4	B	Very Low	**Very Good**	100
Lake Rotoiti	Otaramarae	160058	103.6	A	Very Low	**Very Good**	100
Lake Okareka	East end of dwellings	160061	177	A	Very Low	**Very Good**	100
Lake Okareka	Jetty	160062	48.2	A	Very Low	**Very Good**	100
Lake Tikitapu	Beach	160063	40.3	A	Very Low	**Very Good**	100
Lake Tarawera	Rangiuru Bay	160072	21	A	Very Low	**Very Good**	100
Lake Tarawera	Te Karamea	160291	120	A	Very Low	**Very Good**	100
Lake Rotorua	Mourea	160065	42.3	A	Very Low	**Very Good**	100
Lake Rotorua	Holdens Bay	160066	260	B	Moderate	**Good**	100
Lake Rotorua	Ohinemutu	160068	219	B	Moderate	**Good**	100
Lake Rotorua	Ngongotaha	160069	410	C	Moderate	**Fair**	100
Lake Rotorua	Hamurana	160070	214	B	High	**Follow-up**	100
Lake Okaro	Ski Area	160073	46.2	A	Very Low	**Very Good**	100
Lake Rerewhakaaitu	Sports Ground	160078				**Not graded**	100
Lake Rerewhakaaitu	Brett Road Boat Ramp	160079				**Not graded**	100

Appendix 2: Microbial source tracking report

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Microbial Source Tracking Laboratory Report

Cawthron quote number: N/A
Client order number: N/A

Date: 26 November 2010

Client name: Bay of Plenty Regional Council
For attention of: Paul Scholes
P.O.Box 364
Whakatane

Interpretation of MST Marker Results is contained on a separate page at the end of this report

Results

Sample ID	Date	Description	MST Markers						
			General	Ruminant	Duck (wildfowl)	Gull	Human		
			GBAC	RBAC	Duck	Gull	HBAC	HMBs	HPyV
105666	11/11/2010	River, McLarens	+	-	-	-	+	-	-
105667	11/11/2010	River, Karite	+	+	+	-	+	-	-

Note: *The results presented here indicate the presence/absence of a molecular marker(s) within the samples provided. Temporal and spatial variability in the presence of markers can occur in natural systems. Some cross-reactivity can also occur, where contamination from an organism that the marker is not targeting results in a false-positive (eg the ruminant bacteroides marker has been shown to cross-react with faecal material from brushtail possums). For these reasons, replicate sampling, the use of multiple markers, and an understanding of the surrounding land uses and hydrology of the area can aid in confirming contamination sources.*

Project number 14556 *1 of 2*

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Date: 26 November 2010

Interpretation of MST Marker Results

Both samples appear to be contaminated by faecal material as indicated by the GBAC marker (Figure 1).

Sample 105666: contaminations appear to be originating from human source as indicated by HBAC marker (Figure 1). Negative results for other human markers might be due to the low levels of faecal contamination, or input originating from limited number of individuals. No ruminant or avian markers were detected. Note that low levels of cross-reactivity in the HBAC marker can occur with other organisms (possums and rabbits): further sampling is recommended to confirm presence of human contamination.

Sample 105667: appears to contain contamination from human (HBAC), ruminant (RBAC) and wildfowl sources (Figure 1). It should be noted that the duck marker may also be released by other sources such as geese and some other wildfowl.

Samples did not appear to contain any significant levels of PCR inhibitors, as general Bacteroides marker (GBAC) was detected in all samples tested (Figure 1). Therefore negative results were unlikely due to the inhibition.

Caution should be used when interpreting results based on single samples as contamination from cross-reacting animals can not be ruled out.

Signed: _____

Dr Marek Kirs
Environmental Microbiologist – Microbial Source Tracking

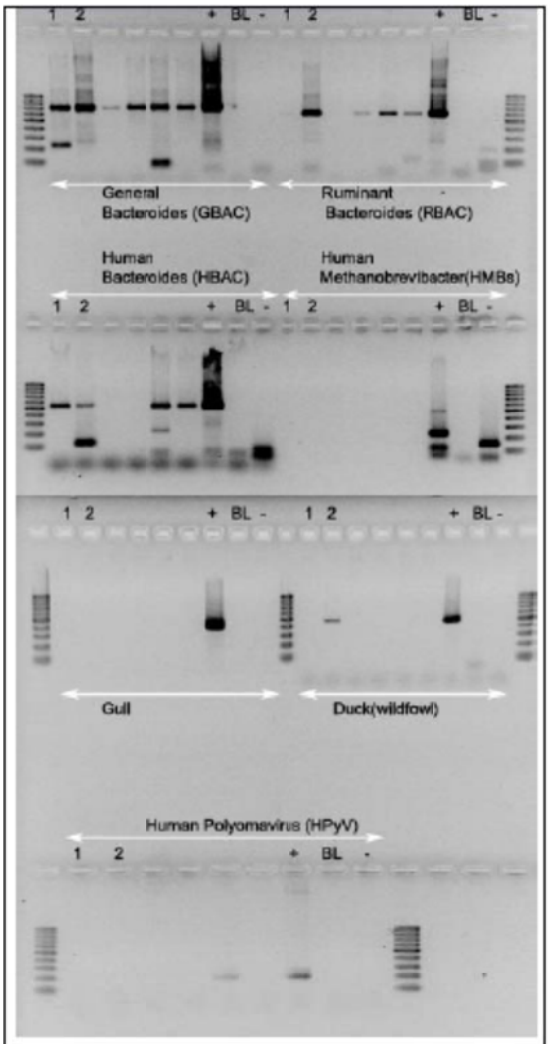

Figure 1. Results of MST marker analyses.

Labels 1 & 2 indicate samples tested (105666 and 105667 respectively).
BL indicates extraction blank; + positive control; - negative control.

Project number 14556