Bathing and Shellfish Surveillance Report 2009-2010

Environment Bay of Plenty
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Bay of Plenty REGIONAL COUNCIL

Working with our communities for a better environment
E mahi ngatahi e pai ake ai te taiao

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Cover Photo: Moko and bathers, Whakatane River.

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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 serve to monitor and identify the risk to public health from faecal contamination within waterways popular for recreational activities in the context of national monitoring protocols. Monitoring information can then be used by public health services, local authorities and the public to assess the risk of using these waters, as well as providing information on the potential or existing risk.

Agencies involved in the monitoring and reporting of recreational waters are regional councils, district councils, district health boards and the medical officer of health. The surveys monitor aspects of the water quality of water bodies in line with the Regional Policy Statement, the Regional Coastal Environment Plan, the Regional Water and Land Plan and the Ten Year Plan. They also provide a basis to assess the effects of discrete discharges and diffuse run-off from land-use activities.

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 2009-2010 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).
- Marine waters – Enterococci.

In 2009-2010 lake sites consistently showed a very low level of contamination with only three sites exceeding the orange alert level. Other freshwater sites had a greater number of exceedances with one site, Kaiate Falls, being above the orange alert level on average. For most sites exceedance of the microbiological guidelines occurred after rainfall events indicating that there is an elevated risk to health when swimming within 48-hours of rainfall.

Open coastal sites showed excellent microbiological water quality with respect to faecal contamination with only one site registering a value above the orange alert guideline. Estuarine sites also displayed low level faecal contamination for most of the summer with one site (Whakatāne River at the Heads) triggering the red alert mode.

The Ten Year Plan Key Performance Indicator (KPI) of 95% compliance with microbiological water quality guidelines was met for all lake sites but not for five marine sites. Only one river site did not meet the 85% Ten Year Plan KPI.

Faecal coliform concentrations in shellfish have been over the safe consumption guideline in three locations on three occasions. Waiotahi Estuary pipi had elevated faecal coliform levels with levels likely to be increased due to rainfall around the time of sampling. Rainfall also explains elevated results for *E.coli* and faecal coliforms in pipi at Maketu Estuary and Waihi Estuary.

Metal levels in shellfish showed no risk to human health based on current guidelines (only available for arsenic and lead).

Health warnings or health advisories due to toxic mat forming benthic cyanobacteria occurred over the 2009-2010 season in two Eastern Bay of Plenty Rivers.

In the recreational surveillance season of 2008/2009 Bay of Plenty Regional Council staff trailed the B2P™ Coliform *E.coli* test using the MicroMagic incubator and reader and Watercheck™ J test kits. Results attained by the B2P™ *E.coli* enumeration system were comparable to results obtained by standard membrane filtration. Hence, this new E.coli enumeration method may be a cost effective addition to water quality testing undertaken by regional councils.

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Part 1: Introduction

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 serve to monitor and identify the risk to public health from faecal contamination within waterways popular for recreational activities in the context of national monitoring protocols. Monitoring information can then be used by public health services, local authorities and the public to assess the risk of using these waters, as well as providing information on the potential or existing risk.

The Ten Year Plan 2009-2019 has a KPI (Key Performance Indicator) for performance of the regions recreational bathing sites against the Ministry of the Environment/Ministry of Health guidelines. For marine and lake sites the compliance level targeted is 95% while for rivers the level is 85%. There are also a number of regional plans that have objectives based on a contact recreation standard, these are;

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

An assessment of risk to recreational water users has been presented in previous bathing grading reports. This report summarises the annual bathing survey monitoring results for the 2009/20010 season and also presents recent shellfish monitoring results.

1.1 Legislative framework and responsibilities

Agencies involved in the monitoring and reporting of recreational waters 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. Based on these responsibilities, the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (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 and is for the most part being implemented.

1.2 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.
- 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.
- To assist in monitoring areas of poor water quality to help identify causes so remedial action can be initiated.
- Monitor the suitability of shellfish for human consumption.

Site locations are displayed on the maps below.

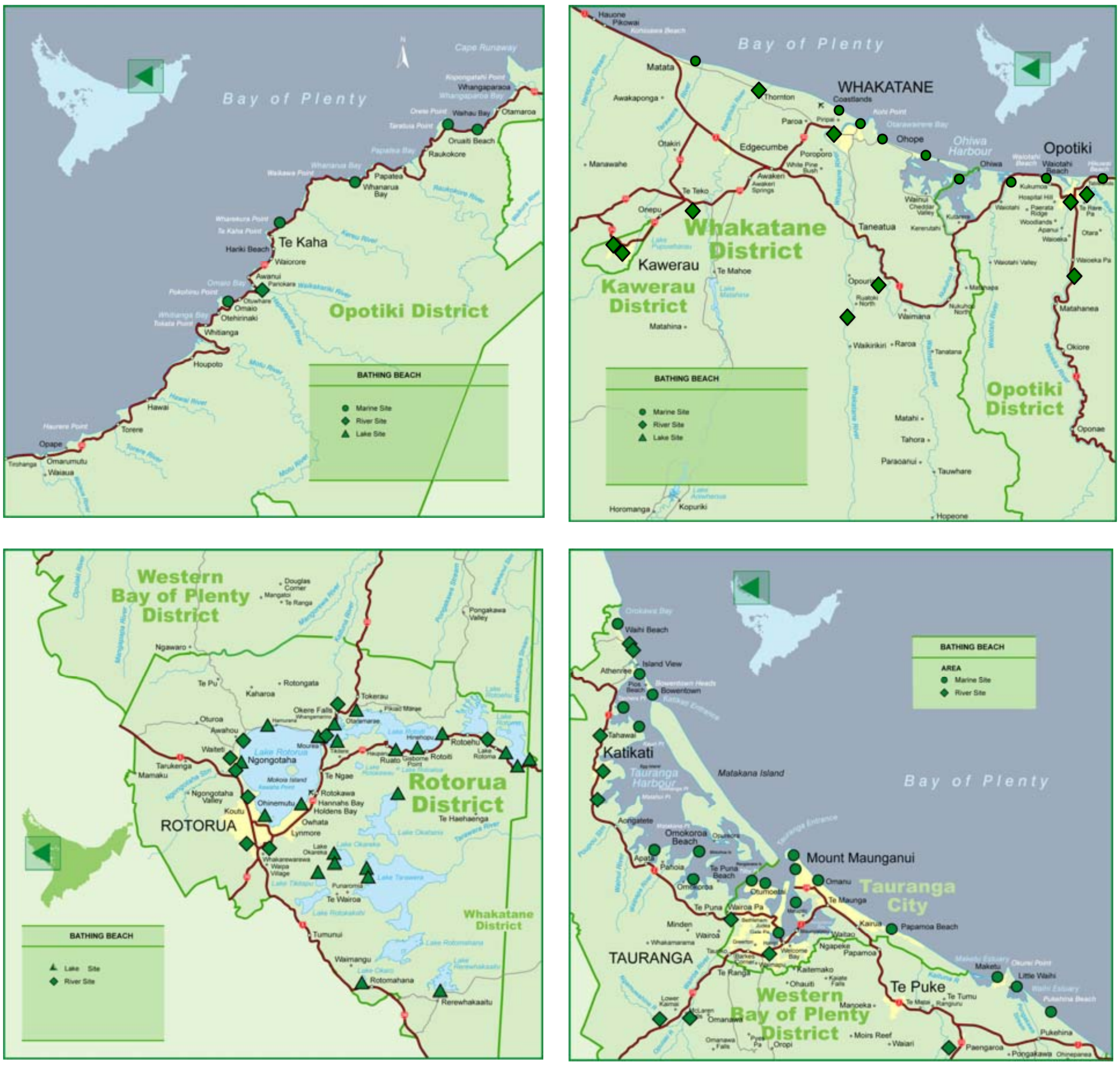


Figure 1 Bathing surveillance site location maps.

Part 2: Methods

2.1 Sampling and analysis

Sampling and analyses where performed in accordance with established Bay of Plenty Regional Council procedures. Most analyses were performed by the Bay of Plenty 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) **Faecal coliform (FC)**	Membrane filtration, Standard Methods for the Examination of Water & Wastewaters (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 Bay of Plenty Regional Council microbiological laboratory within six hours.

Shellfish were analysed for *Escherichia coli*, entercocci and faecal coliforms using the most probable number method of analysis (MPN) as per standard methods for the examination of water and wastewater (2005) for faecal coliforms and enterococci. For *E.coli* the MPN method is based on the recommended procedures for the examination of seawater and shellfish (1985).

Part 3: Microbiological guidelines and indicators

3.1 Introduction

If human or animal excreta finds its way into recreational waters there is a risk that recreational water users will be exposed to a diverse range of pathogenic (disease causing) micro-organisms. A variety of organisms are present in excreta 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 excreta. 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).
- Marine waters – Enterococci.

The use of these two indicators is stipulated in the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas, 2003 (the Guidelines) written by the Ministry for the Environment and The Ministry for Health (MfE/MoH). 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 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 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 100mL)	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 100mL)	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 guidelines and issuing of health warnings will be dependant on the circumstances surrounding any contamination event.

3.2 Bathing surveillance grading

The MfE/MoH (2003) 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 already been determined for recreational sites in the Bay of Plenty region since 2005. Updated SFRGs reflecting the 2009/10 microbiological water quality results are summarised in Appendix 2.

3.3 Additional risk to recreational users

Monitoring throughout the bathing surveillance season has been undertaken in accordance with the Microbiological Water Quality Guidelines (2003). These guidelines are not inclusive of the risks posed by toxic algal blooms which can pose health risks to the public exposed to contaminated drinking and recreational waters. Health risks posed by cyanobacteria to recreational water users are covered by the New Zealand Guidelines for Cyanobacteria in Recreational Freshwater (Ministry for the Environment and the Ministry of Health, 2008).

Bay of Plenty Regional Council monitors lakes with a high probability of planktonic algal blooms occurring. Monitoring is carried out in several of the higher risk Rotorua Lakes and in the Kaituna River and these results are reported in the annual Lakes Water Quality Report. When monitoring indicates levels are high enough to put water users at risk, a health warning or health advisory is issued for the affected lake. Media releases, websites and telephone recorded 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 rivers including the Rangitāiki, Whakatāne, Otara and Waimana. The beds of these rivers have been found with substantial mats of this toxin producing algae at times of low flow. The mats 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).

Part 4: 2009/2010 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 19 October 2009 and ran until 12 March 2010. 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. Bay of Plenty Regional Council assists with these tasks where possible.

4.2 Results

Monitoring results are presented here 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. The 2009/2010 results can also be compared to previous years in Appendix 1 (note the number of samples may vary between years).

4.2.1 River sites

River 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, Kaiate Stream, had a median *E.coli* concentration above the orange alert level. Of the 27 sites monitored 13 had individual instances of alert levels occurring and 12 of these had results over 550 *E.coli* cfu/100ml (red alert level).

The Waimapu stream was the second most contaminated of the river sites. A warning sign was installed at this site over the bathing season recommending that contact recreation be avoided.

The Utuhina River at Lake Road, within the Rotorua urban area, had one result above the red alert level but like many other sites this occurred after a period of intense rainfall.

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

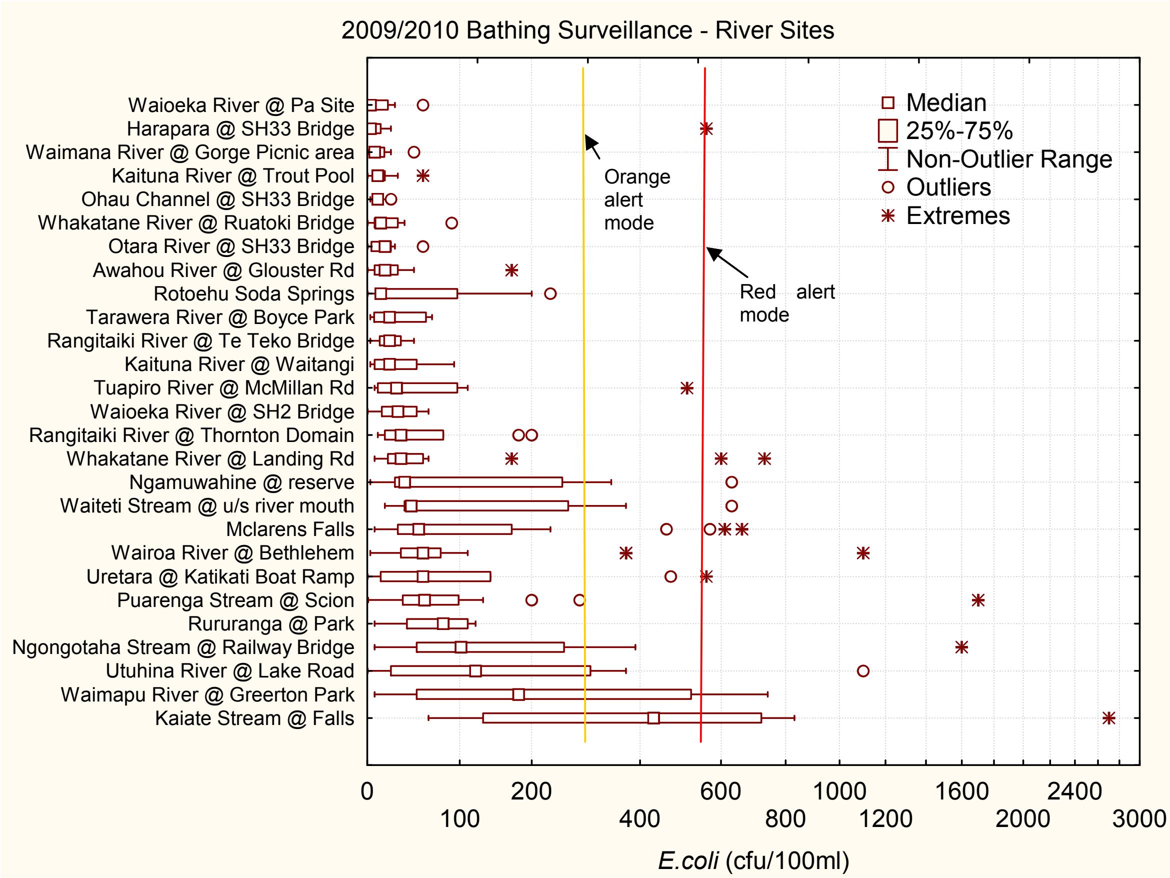


Figure 4.1 *Box-whisker plots of E.coli concentrations, river sites 2009/2010 bathing season.*

4.2.2 Lake sites

Sampling occurred at 22 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 sites had samples above the orange alert level; Te Karamea at Lake Tarawera, Holdens Bay at Lake Rotorua and Pump Station at Lake Rerewhakaaitu. No sites exceeded the red alert mode.

Lake Rerewhakaaitu had the highest median and 75th percentile *E.coli* concentrations of the lake sites. Median *E.coli* concentrations were below 10 cfu/100ml indicating that all of the lake sites on average have a very low level of faecal contamination.

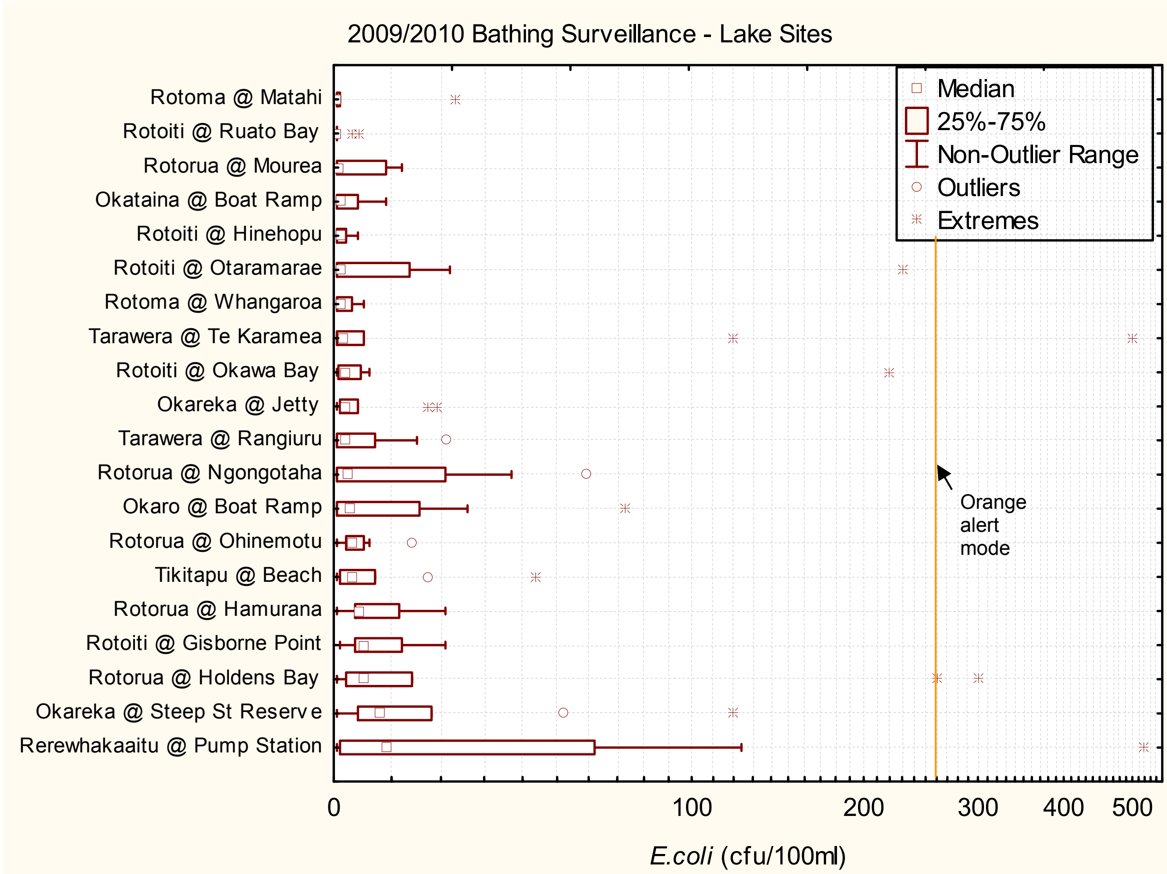


Figure 4.2 Box-whisker plots of E.coli concentrations, lake sites 2009/2010 bathing season

4.2.3 Marine sites

Of the 15 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.

Individual samples from two open coastal sites reached the orange alert level; Hikuwai Beach and Waihī Beach at Three Mile Creek. The median enterococci concentrations were all below 10 cfu/100ml. Most sites remain below 20 enterococci cfu/100 ml, the exception being Pukehina Beach (Figure 4.3). No sites reached the red alert mode.

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). Only one site triggered the red alert mode (Whakatāne Heads), although six 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. Elevated results with respect to other estuarine site occurred at the Tarawera River mouth and in the Waihī estuary at the Little Waihī camp (Figure 4.4).

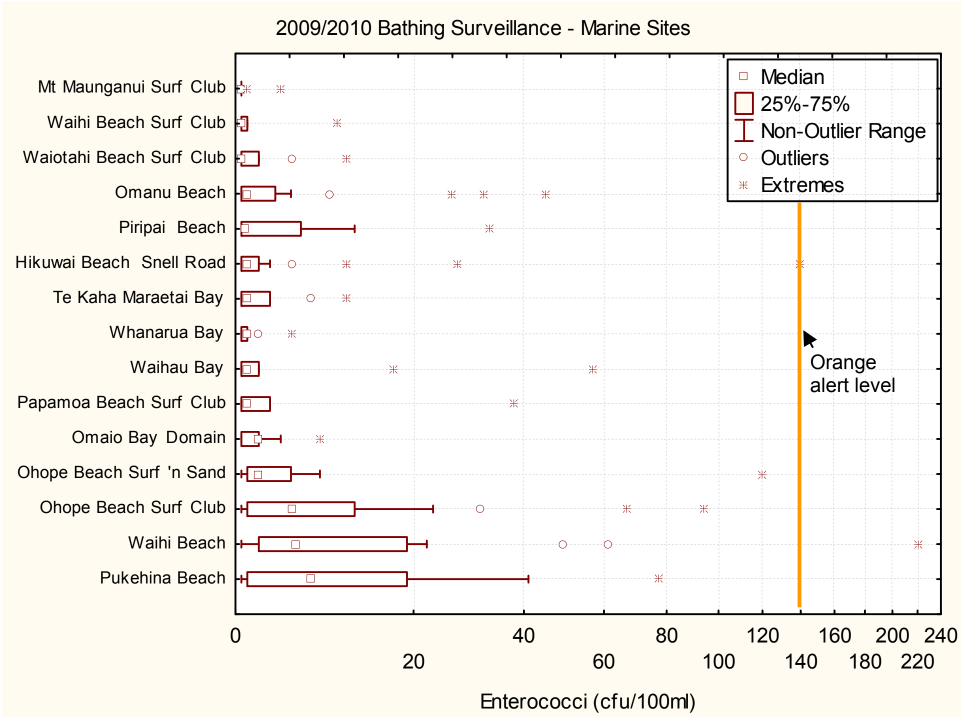


Figure 4.3 *Box-whisker plots of enterococci concentrations, coastal marine sites 2009/2010 bathing season*

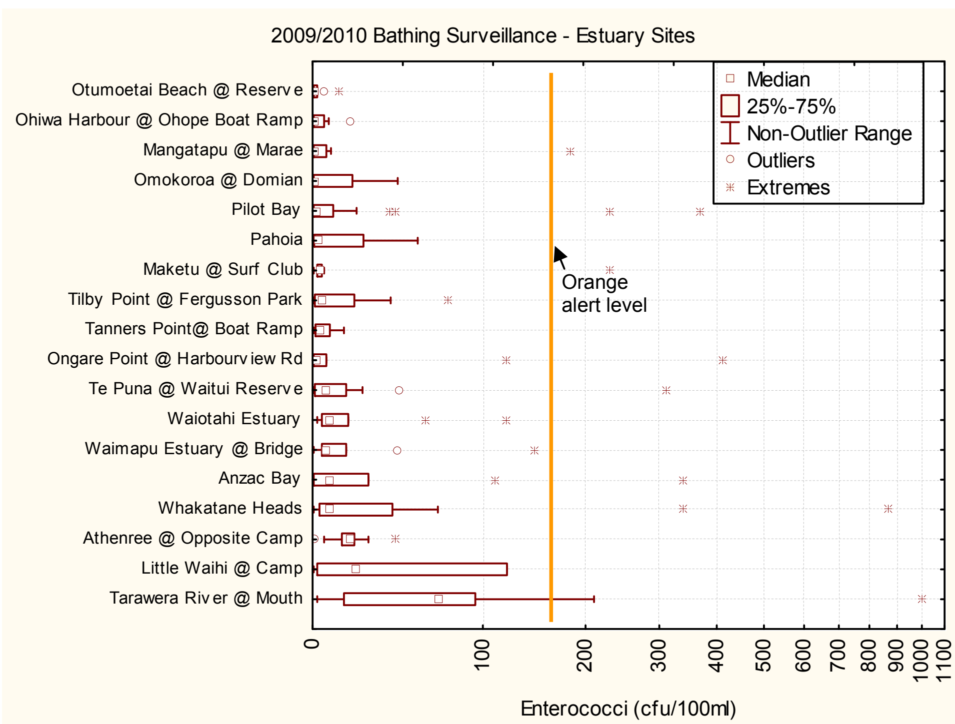


Figure 4.4 *Box-whisker plots of enterococci concentrations, estuarine sites 2009/2010 bathing season*

4.3 Trends in indicator bacteria

Plots of historical data for indicator bacteria over the past 6-7 years are given in Appendix 1. The plots are not statistically robust indicators of trends but have been plotted to provide a guide to any potential changes in levels with time.

For the lakes sites there are two observations which show some potential change. At Okawa Bay (Lake Rotoiti) *E.coli* levels have consistently improved since 2004. This may be in part due to improved management of septic tanks followed by reticulation of this community in 2008. Lake Rotorua at Ngongotaha shows a similar improving trend with the exception of the 2007/2008 season.

There has been a trend of decreasing *E.coli* levels in the Kaituna River at Waitangi which is consistent with monthly monitoring conducted as part of the river water quality monitoring programme. Two other river sites, the Waimana River at Wardlaws Reserve and the Whakatane River at Landing Road Bridge, show a decreasing trend in *E.coli* over the past six years. Both sites belong to the same river system and this apparent trend may reflect changes in land use practices. The estuarine site on the Whakatane River also shows a decreasing trend.

Other estuarine sites show no real trends over the past five seasons, however Waihi Estuary did show elevated enterococci levels in 2009-2010 compared to previous seasons.

Part 5: River algae monitoring programme

5.1 Introduction

Bay of Plenty Regional Council monitors rivers and lakes over summer and autumn for blue-green algae (cyanobacteria).

Blue-green algae are widespread throughout New Zealand. 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 forms (seen as dark olive green or light brown mats covering the river bed) of potentially toxic blue-green algae.

Extensive areas of blue-green algal mats of *Phormidium* spp. have been identified in the Rangitaiki, Waimana, and Whakatane Rivers.

If extensive mats of blue-green algae are found, the Medical Officer of Health will issue a health warning. This will advise the public not to drink or use affected water and to keep away from the areas affected.

When a Health Warning is issued, the district council places signs at major public access points along the river or around the lakes. Updated information on warnings is also posted on the Bay of Plenty Regional Council and Toi Te Ora Public Health web sites and on telephone recorded messages.

5.2 Field method

Benthic cyanobacteria are monitored at sites along the Rangitaiki, Whakatāne, Waimana and Otara Rivers. Monitoring involves estimating the percentage cover of benthic 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.

5.3 Results

5.3.1 Waimana River

The Waimana River is monitored at three sites including Wardlaw Reserve, Lowe Road (occasional) and Kirkbride Road (Figure 5.1). Moderate *Phormidium* cover was observed at Kirkbride Road and Wardlaw Reserve during 2009-2010 but did not at any time exceed the 50% recreational threshold. However, caution was advised due to increased *Phormidium* cover in upper regions of the river. In the previous two seasons (2007-2008, 2008-2009), elevated levels of *Phormidium* at Kirkbride Road led to health advisories warning against water consumption or recreational contact in the river.

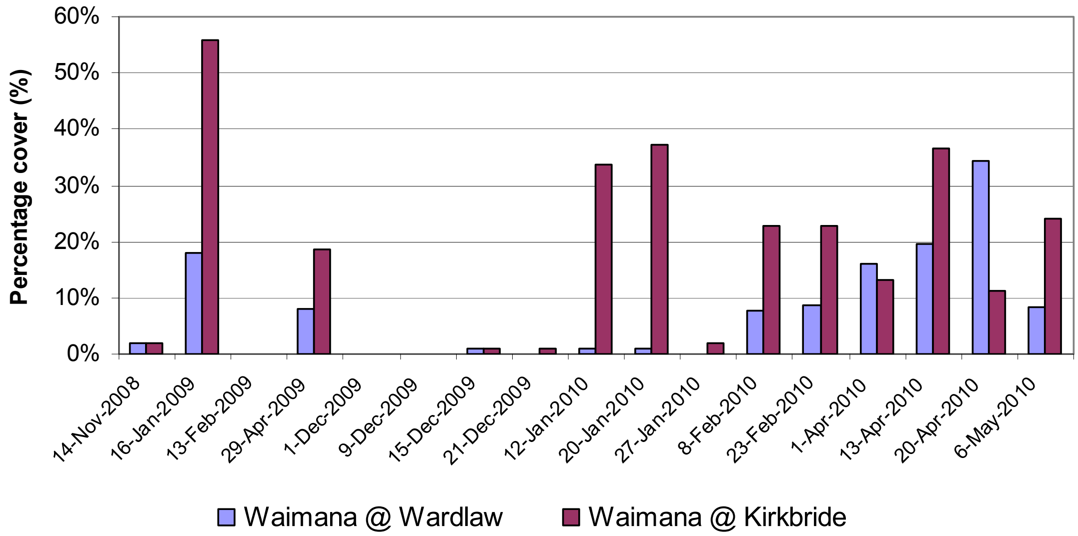
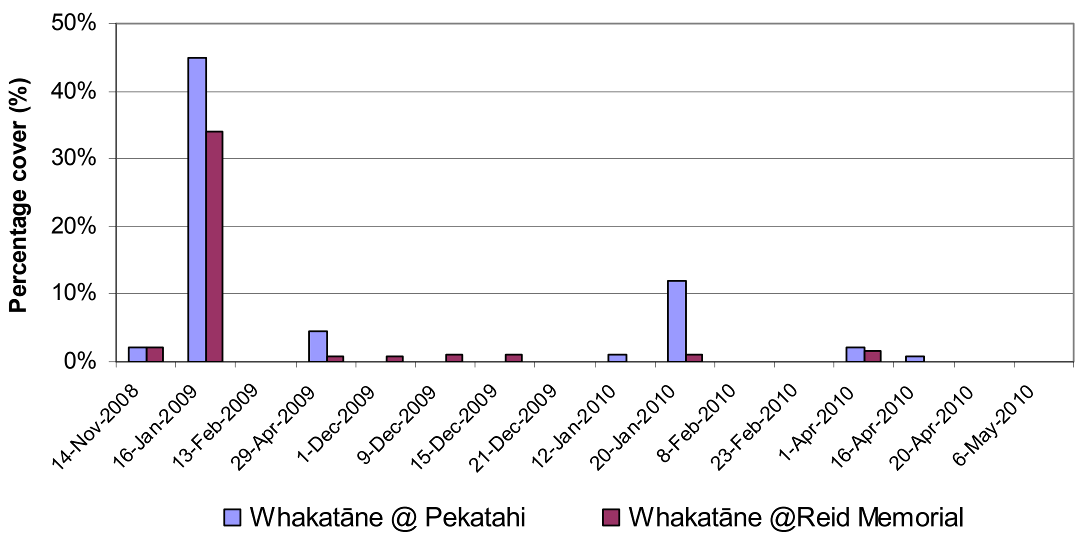


Figure 5.1 Percentage Phormidium cover, Waimana River

5.3.2 Whakatāne River

The Whakatāne River is monitored at two sites including Reid Memorial Reserve and Pekatahi Bridge. Over the 2007-2008 season *Phormidium* cover exceeded 70% in several of the river's downstream reaches[2]. Since that period, the highest level recorded in the Whakatāne was in January 2009 where percentage cover exceeded 40% at the Pekatahi Bridge site (Figure 5.2). Despite a dry summer and autumn and the fact that elevated *Phormidium* levels were recorded in the Waimana River[3], *Phormidium* cover only once exceeded 10% in the Whakatane in the 2009-2010



season.

[2] These were observations made before the rapid field assessment was developed in 2008.
[3] Which is a major tributary of the Whakatāne River.

Figure 5.2 Percentage Phormidium cover, Whakatane River

5.3.3 Rangitāiki River

The Rangitāiki River is monitored at six sites including at Edgecumbe Playing Fields, Edgecumbe Substation, Te Teko (occasional), Rabbit Bridge (occasional), Galloways Drive and Murupara. Little or no *Phormidium* was observed in the lower Rangitāiki in the 2009-2010 season (Figure 5.3). Elevated *Phormidium* levels have however been recorded at upstream sites over 2009-2010 including at the Murupara and Galloways Drive sampling stations. A health warning for the Upper Rangitāiki River was issued in December 2009, advising against water consumption or recreational contact. The health warning was lifted in late January 2010.

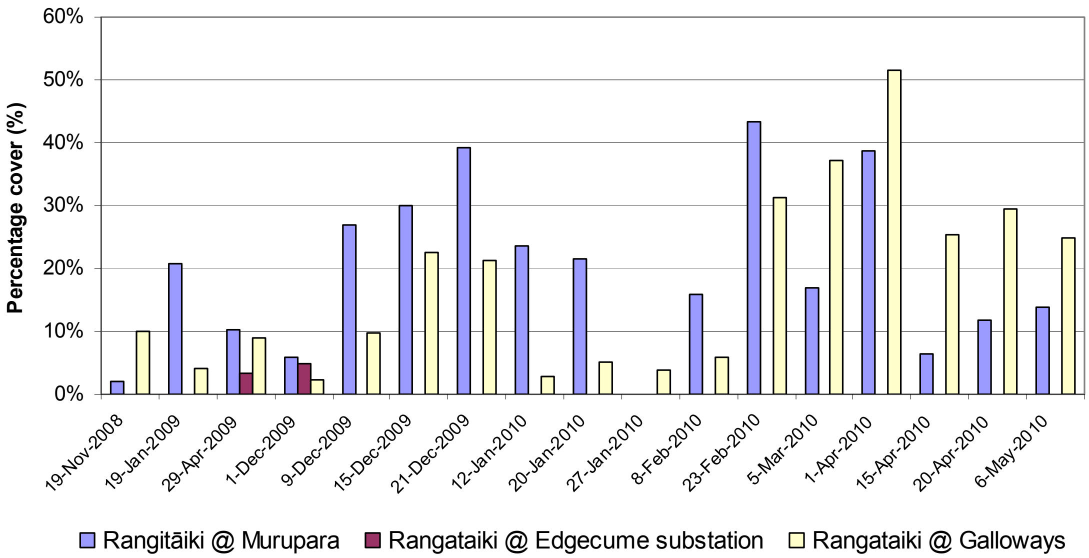


Figure 5.3 Percentage Phormidium cover, Rangitāiki River

5.3.4 Future Monitoring

Future monitoring will include the Waioeka and Otara Rivers, the latter of which registered low levels of *Phormidium* early in the 2009-2010 bathing season.

Part 6: Shellfish

6.1 Sampling and analysis

Collection of shellfish occurred at a number of open coastal and estuarine sites in 2009-2010. At each site sampling was conducted at five different locations within the shellfish bed/area, with each location at least five metres from others. A minimum of 24 individual shellfish were taken per site to make up at least 200g of flesh. The species sampled were:

- Cockle (*Austrovenus stuchburyi*): found throughout intertidal and subtidal muddier 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 in location cemented to rocks or mangroves in the intertidal 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. Some estuarine samples were also analysed for heavy metals (arsenic, copper, chromium, nickel, lead and zinc).

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/100g, and levels from 230 to 330 MPN/100g are marginally acceptable.

Microbiological limits have also been specified by NZFSA (2006)[4]. 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 *E.coli* per 100g and not more than 10% of the samples must exceed an MPN of 700 per 100g.

The Australian New Zealand Food Standards Code (ANZFSC, 2010) has standards for metals (inorganic) arsenic, cadmium and lead but not for the other metals monitored.

6.2 Results

Table 6.1 shows the results for shellfish sampled over the 2009/2010 summer. Faecal coliform concentrations in shellfish have been over the safe consumption guideline in three locations on three occasions. Waiotahi Estuary pipi had elevated faecal coliform levels although *E.coli* levels were well under the NZFSA guideline. Levels were likely to be increased due to rainfall around the time of sampling. Rainfall also explains elevated results for *E.coli* and faecal coliform in pipi at Maketu Estuary and Waihi Estuary.

Elevated *E.coli* results also occurred at Pukehina and Te Puna/Plumbers Point. Around 50mm of rainfall is likely to have influenced the results at Te Puna.

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

Table 6.1 Shellfish indicator bacteria and metal results

				Metal Concentration (wet weight)						Indicator Bacteria		
Site		**Collect Date**	**Shellfish type**	**As (mg/kg)**	**Cr (mg/kg)**	**Cu (mg/kg)**	**Ni (mg/kg)**	**Pb (mg/kg)**	**Zn (mg/kg)**	***E.coli* (MPN/100g)**	**ENT (MPN/100g)**	**FC (MPN/100g)**
Waiotahi Estuary	Reserve	02/12/09	Pipi							90	220	700
Pukehina Beach	Mid beach	10/02/10	Pipi							300	37	300
Tauranga Harbour	Pios Beach	28/01/10	Cockles	1.6	0.16	0.62	0.64	0.034	4.2	23	14	23
Tauranga Harbour	Waipu Bay Cockles	28/01/10	Cockles	1.3	0.15	1.6	0.74	0.05	6.5	1	2400	170
Tauranga Harbour	Pio's Beach - Yellow Point	28/01/10	Pipi	0.89	0.24	1.3	0.52	0.075	4.9	2	8	2
Tauranga Harbour	Tilby Point/Otumoetai	28/01/10	Pipi	0.76	0.3	1.6	1.2	0.073	4.9	240	2	240
Tauranga Harbour	Tilby Point/Otumoetai	22/10/09	Pipi	1	0.12	0.86	0.27	0.028	4.6	23	2	30
Tauranga Harbour	Plumber Point/ Te Puna	22/10/09	Oysters	0.94	0.05	4.3	0.11	0.043	120	300	50	300
Tauranga Harbour	Opposite Pilot Bay	28/01/10	Pipi	0.9	0.088	0.57	0.47	0.024	5.2	4	13	4
Ohope Beach	Maraetōtara	09/02/10	Tuatua							1	4	1
Ohope Beach	Maraetōtara	02/12/09	Tuatua							170	700	300
Maketu	Main channel	22/10/09	Pipi	0.88	0.05	0.5	0.18	0.022	4.3	50	4	50
Maketu	Main channel	03/12/09	Pipi							800	130	900
Maketu	Mid estuary	08/02/10	Cockles							30	17	30
Little Waihi	Campground (Waihi)	22/10/09	Pipi	1	0.49	2.2	0.63	0.19	7.3	240	22	240
Little Waihi	Campground (Waihi)	03/12/09	Pipi							14000	16000	14000

The arsenic concentrations in shellfish were relatively uniform. Results are for total recoverable arsenic and will be composed of organic and inorganic arsenic species. Previous analysis of these fractions showed inorganic arsenic typically made up around 10% of the total recoverable arsenic[5]. Hence, concentrations of inorganic arsenic are below the ANZFSC specification of 1 mg/kg.

Lead is the only other metal surveyed that has an ANZFSC guideline. All analyses are under the 2 mg/kg guideline, with one sample from Waihi Estuary slightly elevated compared to other samples. Copper was also elevated in the Waihi Estuary and Te Puna samples.

Te Puna was the only site where oysters were sampled. Previous monitoring (McIntosh, 1999) has shown that oysters are elevated with respect to copper and zinc compared to other bivalve shellfish. This may be a function of the oysters being attached to a surface above sediment as opposed to being in the sediment as is the case for pipi and cockles.

[5] Maketū Estuary Environmental Baseline Monitoring Report, 1990/91.

Part 7: Discussion and conclusions

The 2009/2010 bathing surveillance season has shown that there is variable water quality across the regions popular swimming sites. Most sites have low levels of faecal contamination confirming that recreational water quality is generally good.

Lake sites consistently showed a very low level of contamination with only three sites exceeding the orange alert level. Other freshwater sites had a greater number of exceedances with one site, Kaiate Falls, being above the orange alert level on average. For most sites exceedance of the microbiological guidelines occurred after rainfall events indicating that there is an elevated risk to health when swimming within 48-hours of rainfall.

Open coastal sites showed excellent microbiological water quality with respect to faecal contamination with only one site registering a value above the orange alert guideline. Estuarine sites also displayed low level faecal contamination for most of the summer with one site (Whakatāne River at the Heads) triggering the red alert mode of the microbiological guidelines.

Suitability for recreation grading of marine sites for the last five seasons has one site in the ‘very poor’ grade and one site as ‘poor’. Seven sites are graded as ‘fair’ reflecting their days out of compliance ranging from four to eight percent of the time. Five sites did not reach the Ten Year Plan KPI of 95% compliance.

No lakes are graded ‘poor’ or ‘very poor’ and only one site is ‘fair’ reinforcing the general good microbiological water quality of the lakes. Hence, the Ten Year Plan KPI of 95% compliance was achieved. Predictably river sites have the highest number of ‘very poor’ (three) and ‘poor’ (eleven) grades. These sites are in compliance with the microbiological guidelines 86% to 97% of the time with the exception of Kaiate Falls which has a 60% compliance record.

Shellfish contamination as indicated by faecal indicator bacteria was variable at the sites monitored. Three sites showed elevated indicator bacteria after rainfall with levels being above safe consumption guidelines. Enterococci results were often different to faecal coliform and *E.coli* results with the cockles at Waipu Bay (Tauranga Harbour) returning a relatively high enterococci result compared to *E.coli*. This may indicate that contamination has occurred and thermotolerant bacteria species have died off more quickly than the enterococci bacteria, or that vegetative enterococci species are present.

Arsenic and lead levels in shellfish showed no risk to human health based on current guidelines.

A number of health warnings or advisories have been issued for the Eastern Bay of Plenty rivers due to cyanobacterial (*Phormidium*) mat growth. These have been associated with low flow conditions and warmer temperatures. Other factors, including nutrient levels, are likely to influence growth and cyano-toxin production, but the interactions are known to be complex (Heath, 2009). Future research in this area will help understand the mechanisms for growth of this nuisance phytoplankton.

Part 8: Recommendations

The current recreational waters surveillance programme is working well in providing the community and public agencies with information to help protect public health. The programme does not meet the recommended MfE/MoH sampling frequency for all sites (20 per season, 100 over five years). However, the current monitoring programme is prioritising high risk sites to achieve the minimum recommended sampling frequency, after which time other sites can be then be targeted for greater sampling frequencies.

Given the excellent microbiological water quality found at many of the lake and open coastal sites it is recommended that monitoring of these occurs every three years (see Table 8.1). This will allow resources to be focused on the poorer quality river and estuarine sites, and also increase the sampling frequency to better meet MfE/MoH guideline recommendations.

The surveillance programme has identified several sites that experience faecal contamination above the health guidelines on a regular basis. Catchment surveys and microbial source tracking studies are required to identify potential contamination sources. These sites are Kaiate Falls, Waimapu River at Greerton and the Tarawera River mouth.

Further investigation into contaminant sources in these catchments will be conducted and the information generated will be used to help target reduction in contaminant levels.

Table 8.1 Proposed Sites for Three Year Sampling Rotation

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

Over the 2008/2009 bathing surveillance season a ‘B2P MicroMagic’ incubator with ‘WaterCheck’ test kits was trialled for *E.coli* enumeration in parallel with the standard laboratory membrane filtration method. A detailed report is given in Appendix 3. Disregarding a few anomalous results, the trial showed that the MicroMagic system is adequate for use in bathing surveillance and may also be useful for a number of other applications including;

- Compliance monitoring
- Stream projects
- Community projects
- Shellfish monitoring
- Educational monitoring

Based on the results of the trial Toi Te Ora Public Health is satisfied with the use of the MicroMagic system in Bathing Surveillance monitoring. The Medical Officer of Health for the Bay of Plenty Region commented; “based on your report I suggest it would be a useful initiative to use the “B2P” test kit. As you indicate it does have some real advantages”.

There are a range of options for deployment of the MicroMagic system. The most obvious would be for bathing surveillance monitoring of the lakes and stream in the Rotorua area. MicroMagic incubators could be located in Rotorua and collection of samples could then be made by Rotorua based personnel, saving transportation costs to the Whakatane laboratory.

It is recommended that this technology be further investigated for use in bathing surveillance monitoring.

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.

Microbiological Water Quality Guidelines. Ministry for the Environment and Ministry of Health, 2003.

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

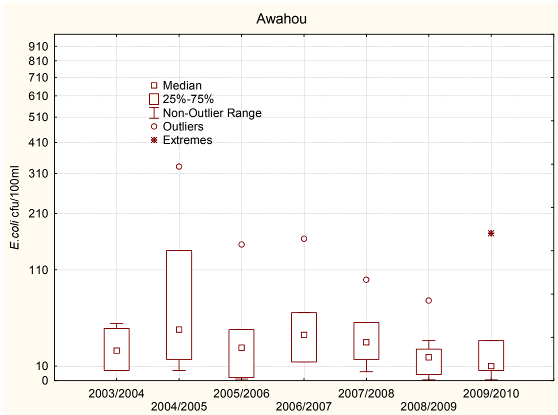
New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters. Ministry for the Environment and Ministry of Health, 2009. ME 981.

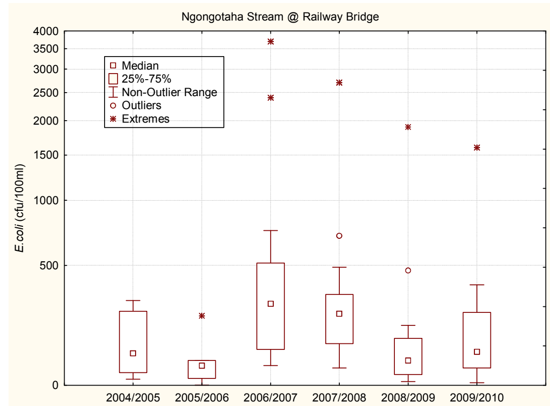
The Australian New Zealand Food Standards Code (2010).

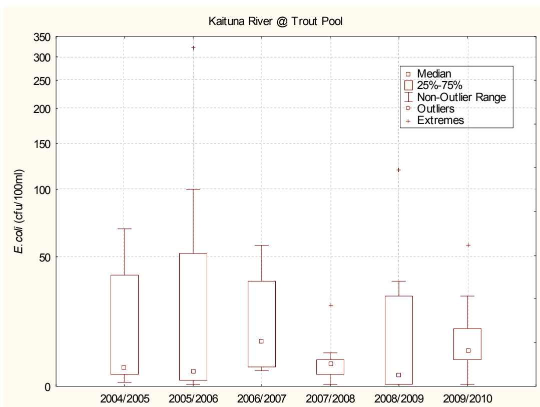
Appendices

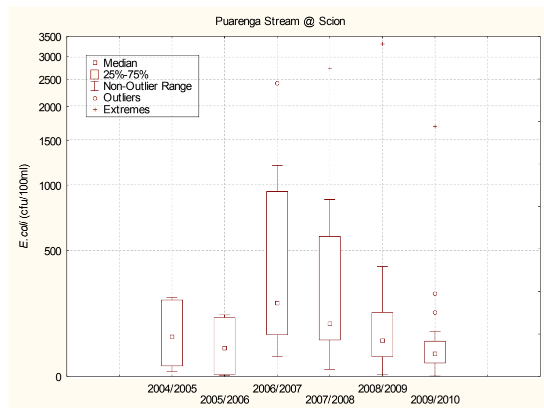
Appendix 1: Plots of seasonal ranges and medians

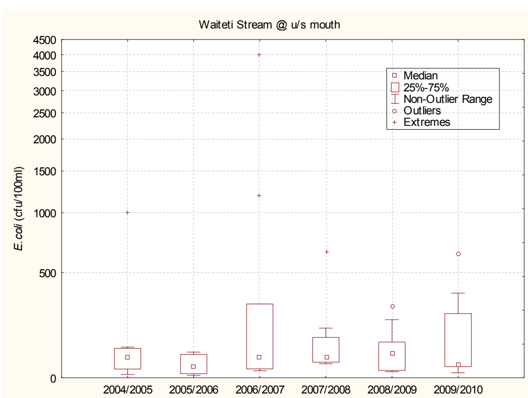
Note: The number of samples (n) is not equal for each monitoring season Rotorua Rivers

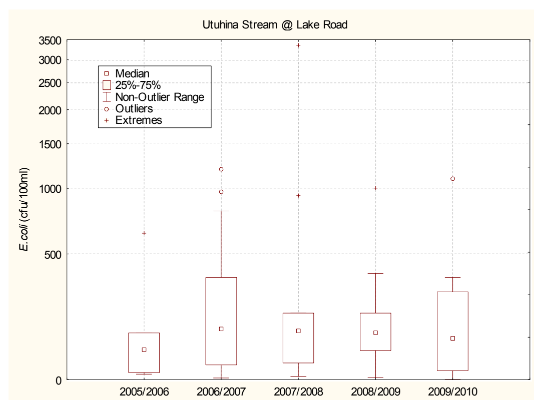


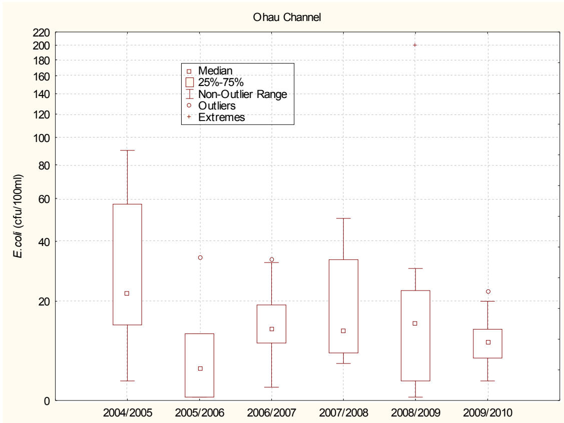


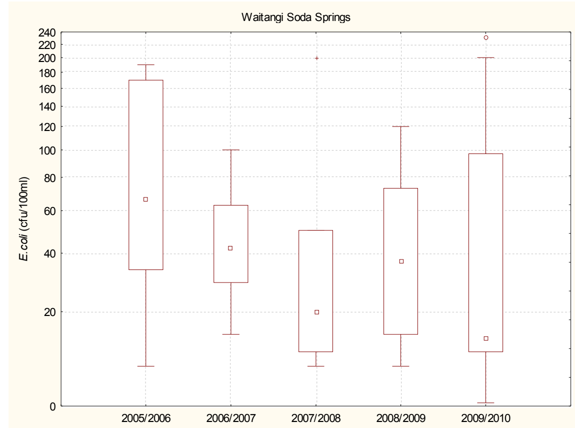




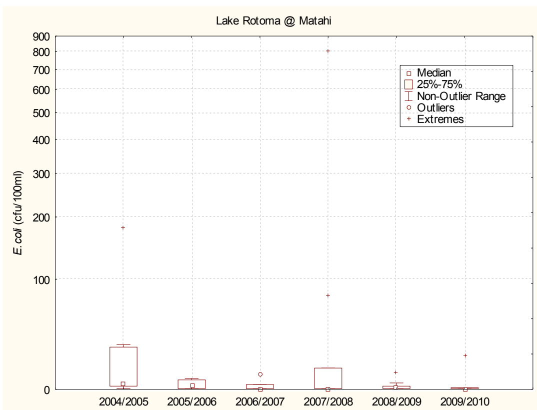


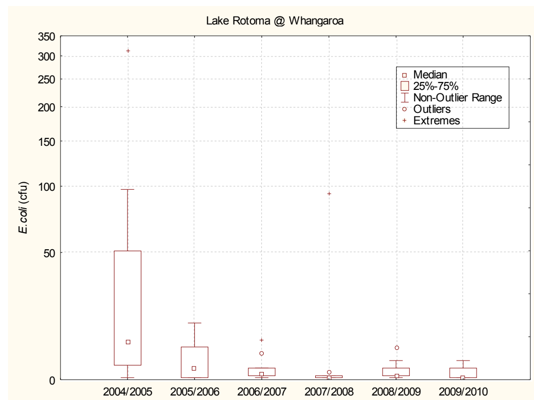


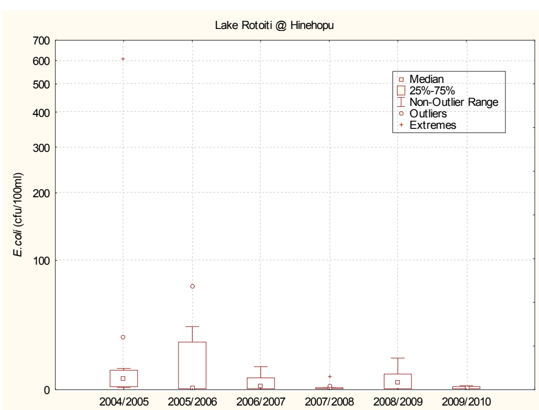


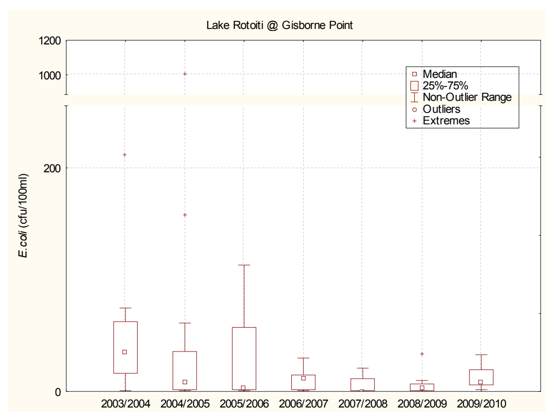


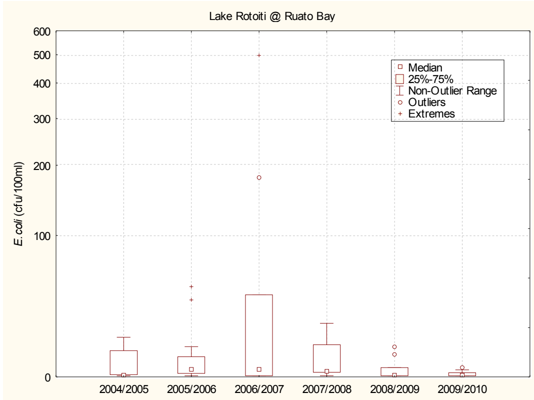
Rotorua Lakes

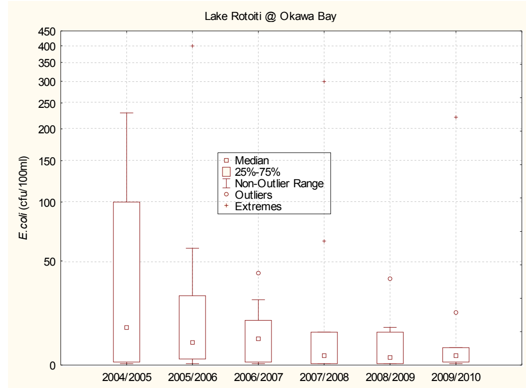


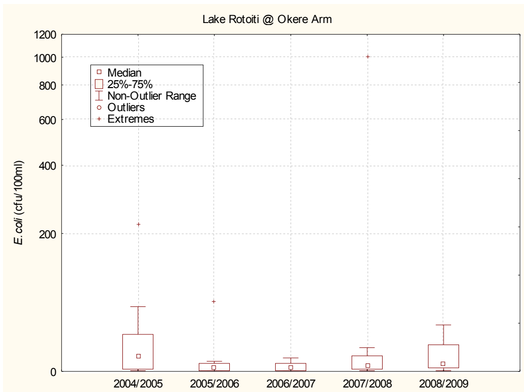


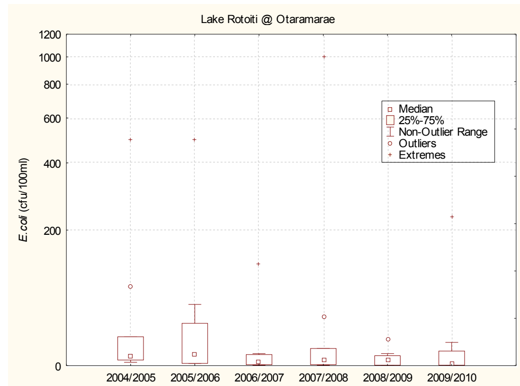


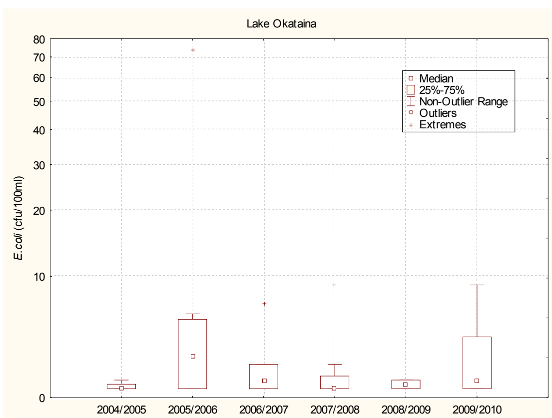


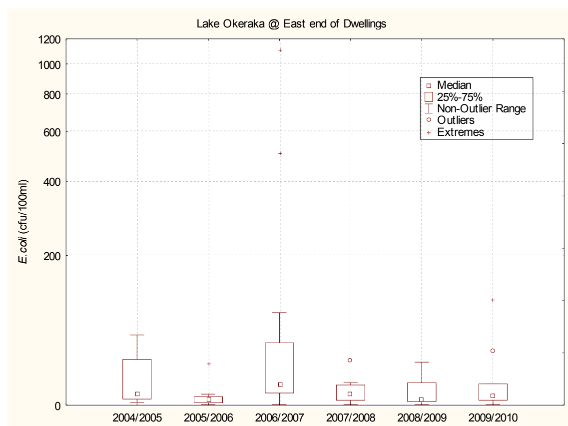

Lake Rotoiti @ Ruato Bay
E. coli (cfu/100ml)
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010

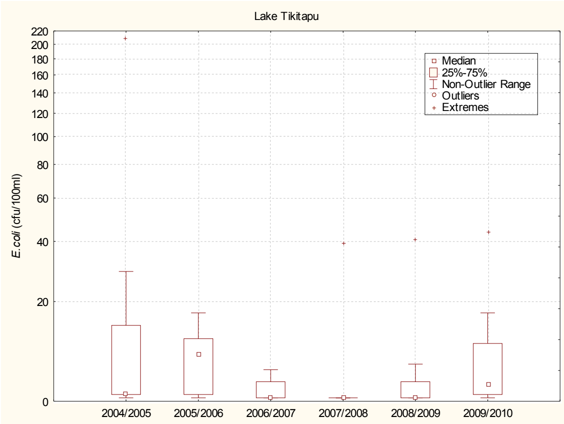

Lake Rotoiti @ Okawa Bay
E. coli (cfu/100ml)
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010

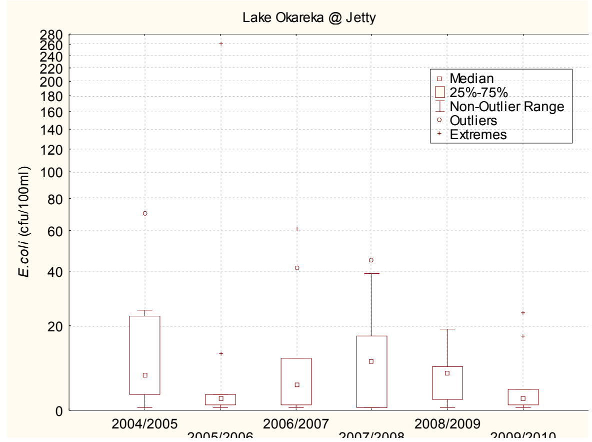

Lake Rotoiti @ Okere Arm
E. coli (cfu/100ml)
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009

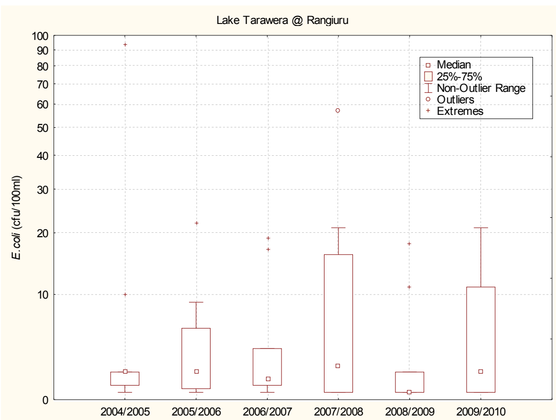

Lake Rotoiti @ Otaramarae
E. coli (cfu/100ml)
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010

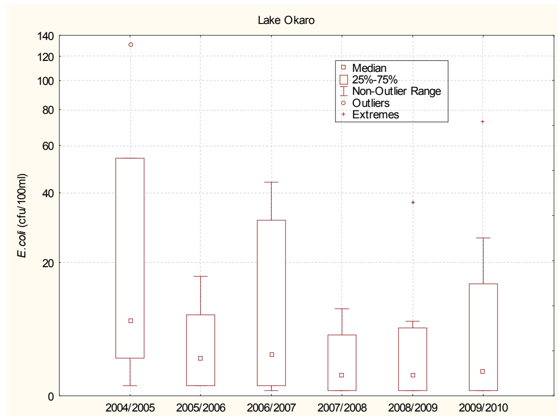

Lake Okataina
E. coli (cfu/100ml)
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Lake Okeraka @ East end of Dwellings
E. coli (cfu/100ml)
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Lake Tikitapu
E.coli (cfu/100ml)
220
200
180
160
140
120
100
80
60
40
20
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Lake Okareka @ Jetty
E.coli (cfu/100ml)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Lake Tarawera @ Rangiuru
E.coli (cfu/100ml)
100
90
80
70
60
50
40
30
20
10
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010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E.coli (cfu/100ml)
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100
80
60
40
20
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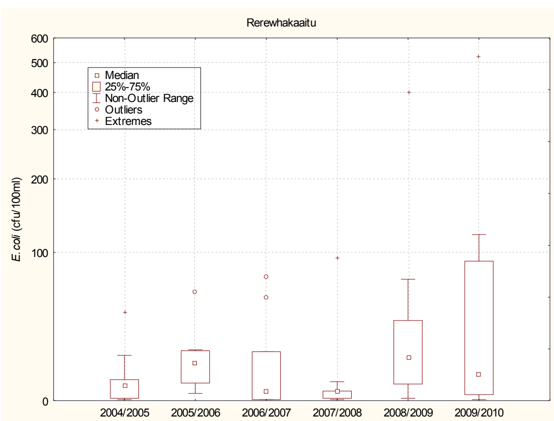
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Rerewhakaaitu
E.coli (cfu/100ml)
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500
400
300
200
100
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Median
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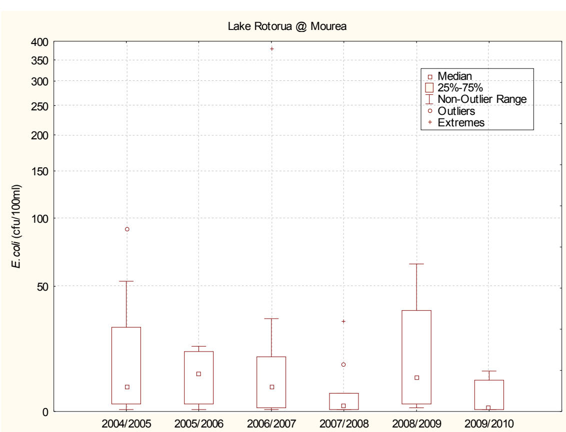
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Lake Rotorua @ Mourea
E.coli (cfu/100ml)
400
350
300
250
200
150
100
50
0
Median
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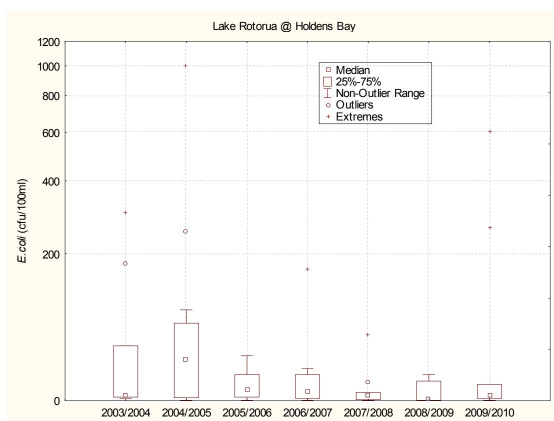
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Lake Rotorua @ Holdens Bay
E.coli (cfu/100ml)
1200
1000
800
600
400
200
0
Median
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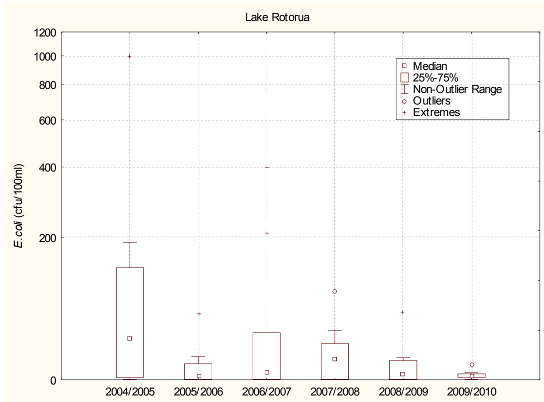
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Lake Rotorua
Median
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Non-Outlier Range
Outliers
Extremes
E. coli (cfu/100ml)
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1000
800
600
400
200
0
2004/2005
2005/2006
2006/2007
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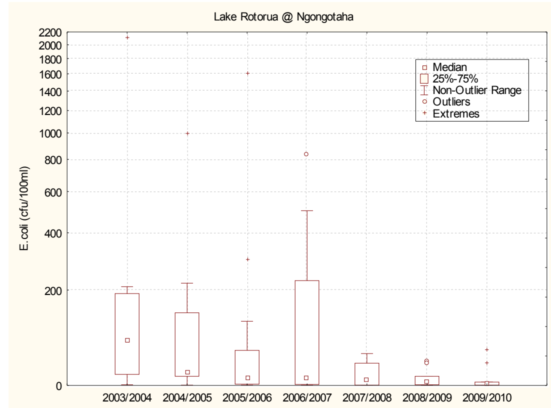
2008/2009
2009/2010


Lake Rotorua @ Ngongotaha
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
E. coli (cfu/100ml)
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
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2003/2004
2004/2005
2005/2006
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2007/2008
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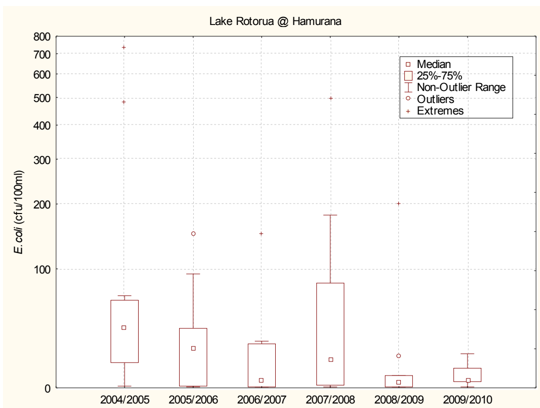
2009/2010


Lake Rotorua @ Hamurana
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
E. coli (cfu/100ml)
800
700
600
500
400
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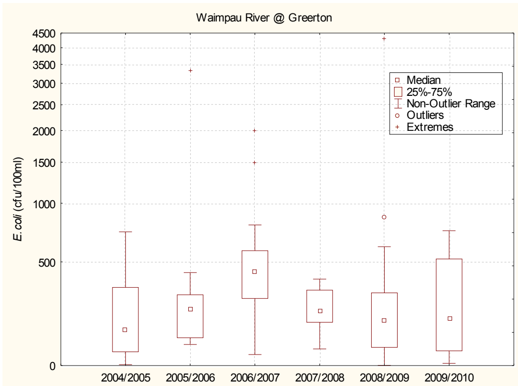
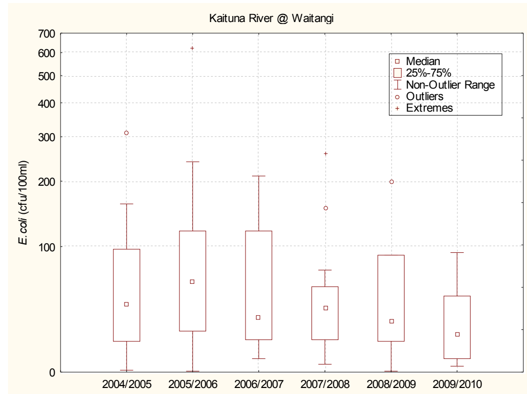
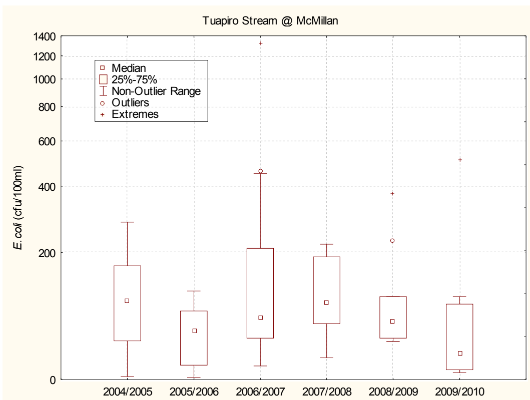
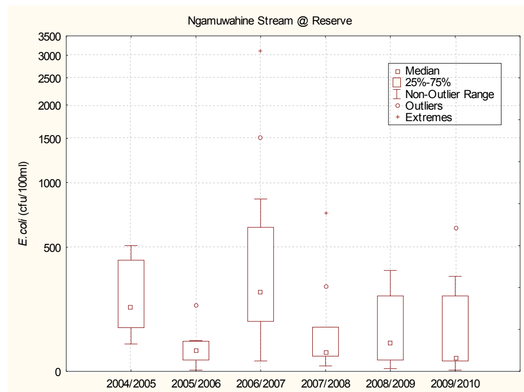
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010

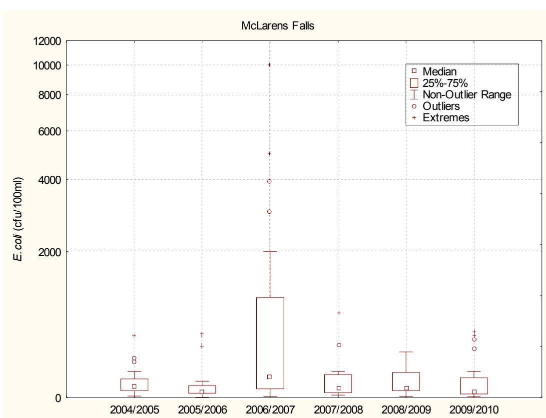
Tauranga/Western Bay of Plenty Rivers

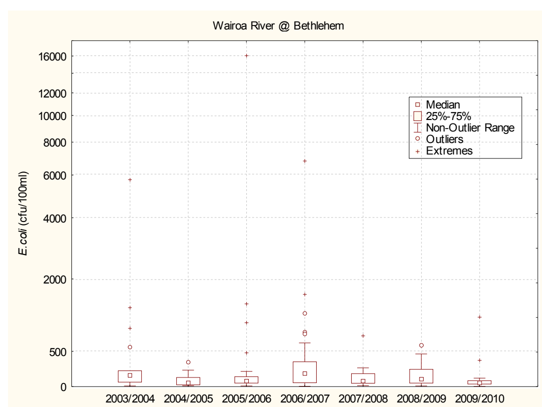


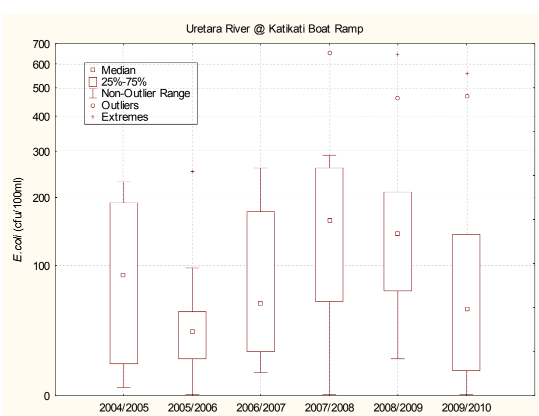




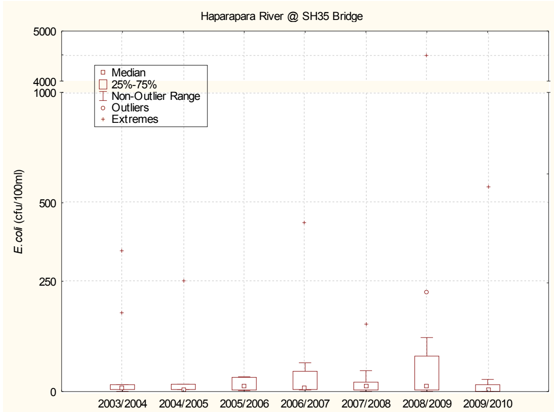


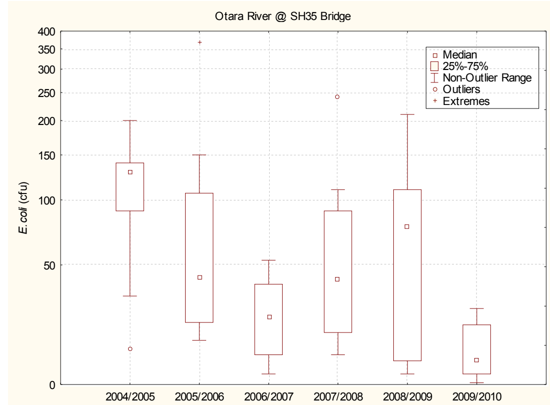


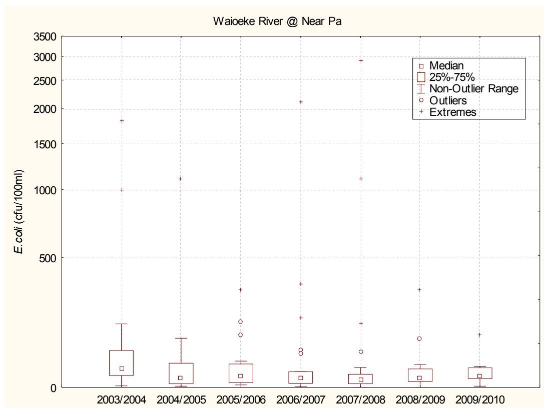


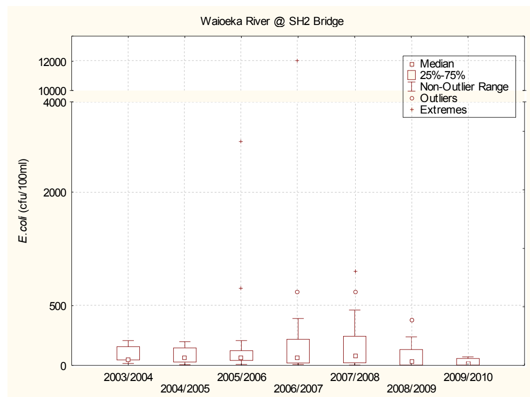


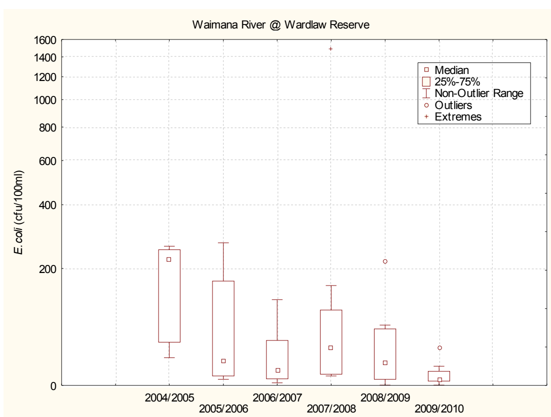
Eastern Bay of Plenty Rivers

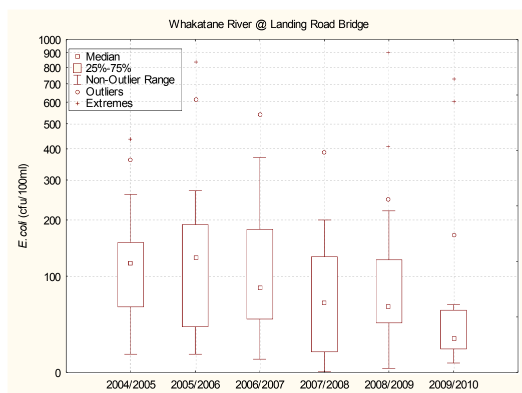


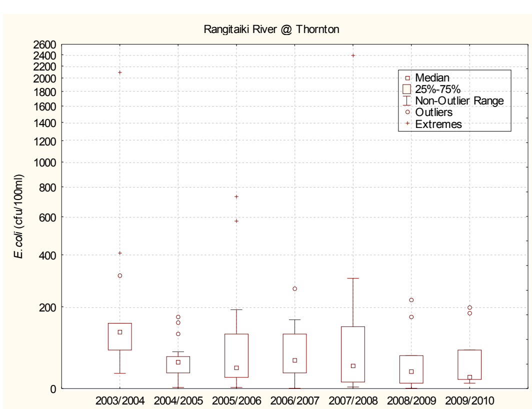


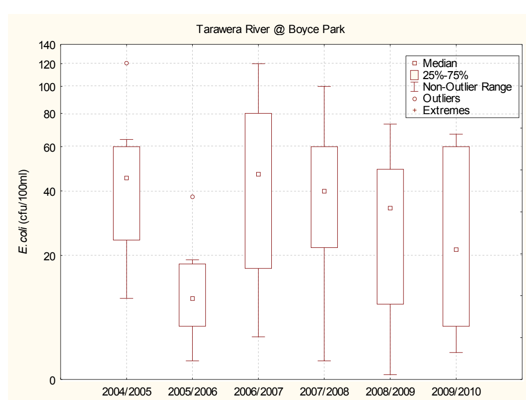


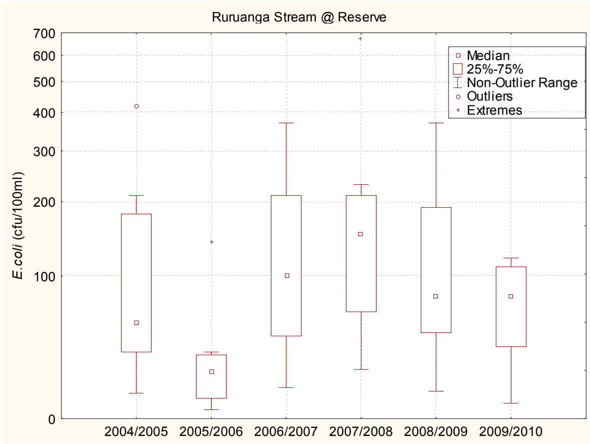












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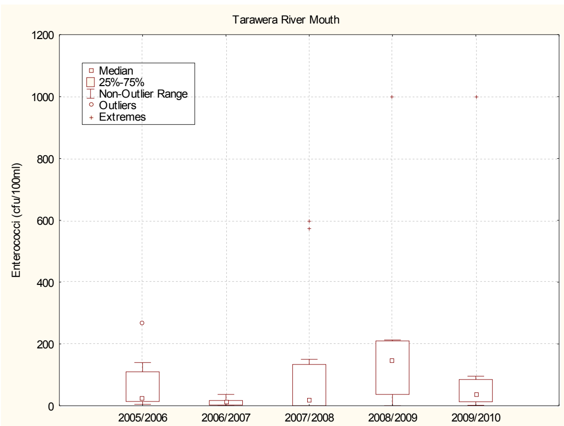
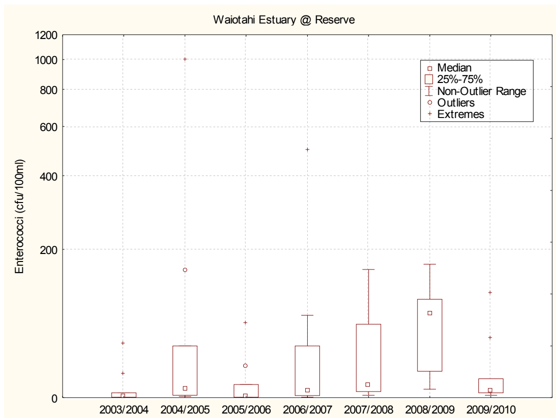
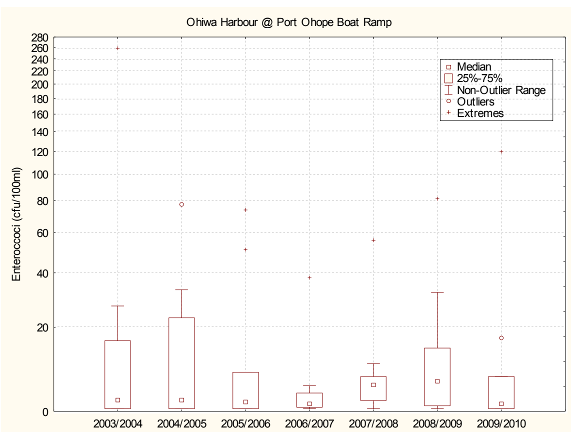
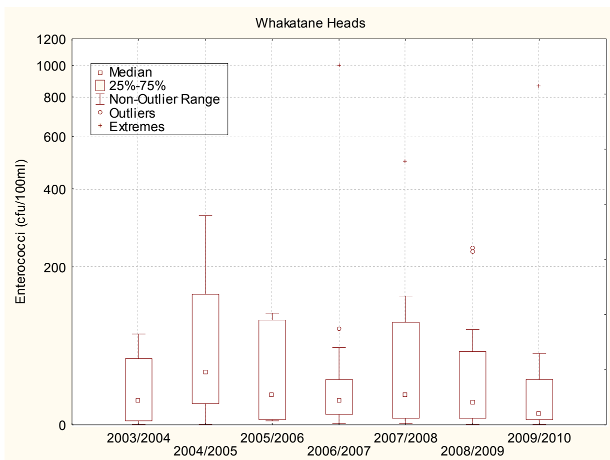
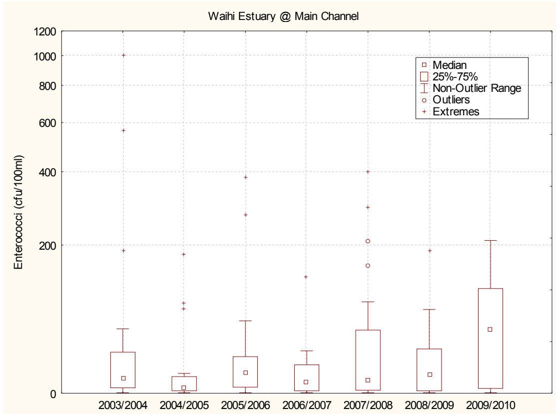
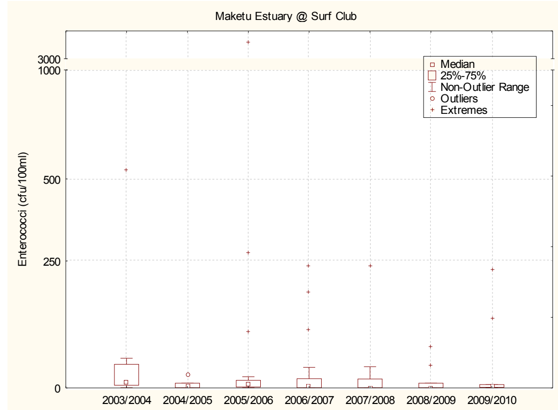


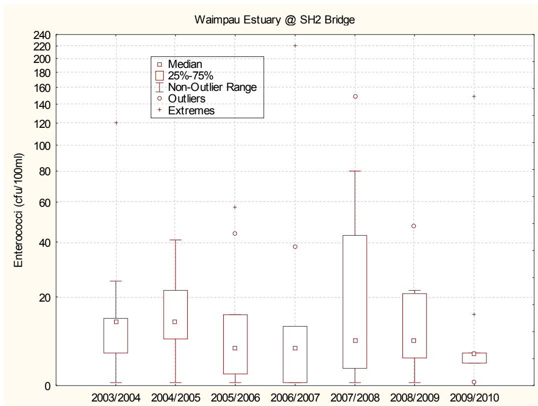


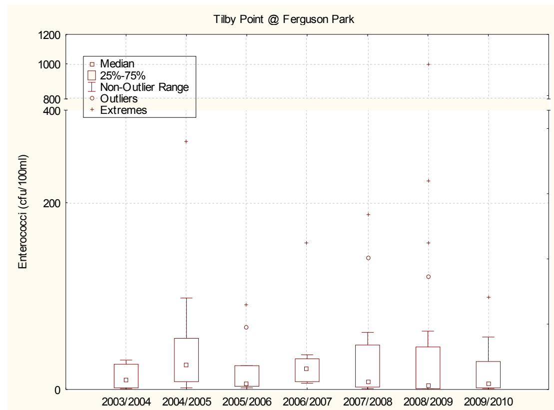





Waihi Estuary @ Main Channel
Enterococci (cfu/100ml)
1200
1000
800
600
400
200
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Maketu Estuary @ Surf Club
Enterococci (cfu/100ml)
3000
1000
500
250
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Waimpau Estuary @ SH2 Bridge
Enterococci (cfu/100ml)
240
220
200
180
160
140
120
100
80
60
40
20
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Tilby Point @ Ferguson Park
Enterococci (cfu/100ml)
1200
1000
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400
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Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
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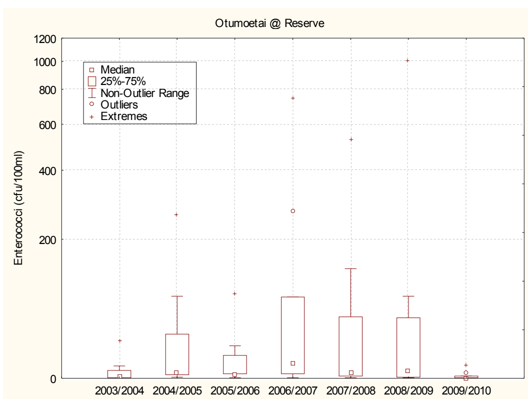
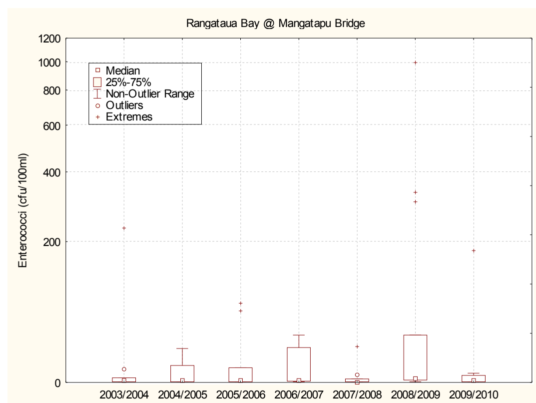
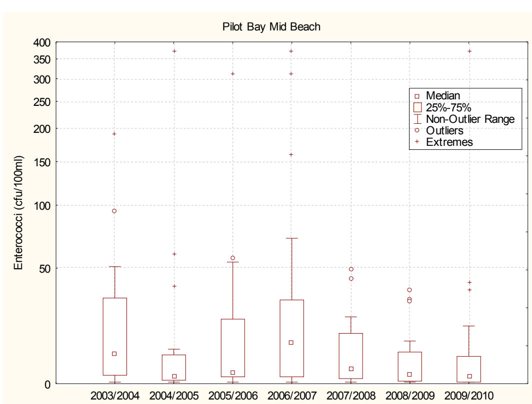
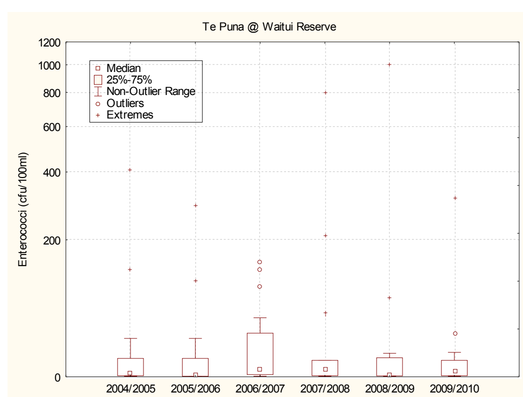

Otumoetai @ Reserve
Enterococci (cfu/100ml)
1200
1000
800
600
400
200
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Rangataua Bay @ Mangatapu Bridge
Enterococci (cfu/100ml)
1200
1000
800
600
400
200
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Pilot Bay Mid Beach
Enterococci (cfu/100ml)
400
350
300
250
200
150
100
50
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Te Puna @ Waitui Reserve
Enterococci (cfu/100ml)
1200
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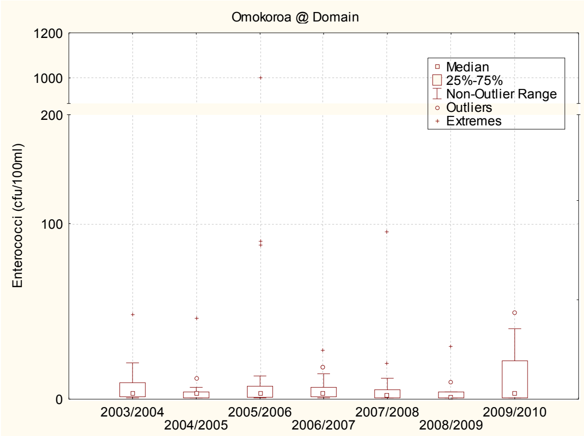
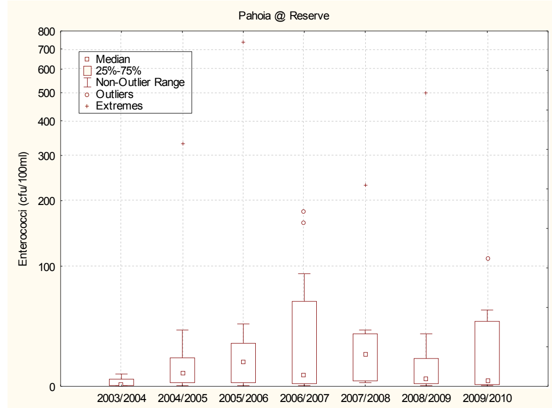
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Omokoroa @ Domain
Enterococci (cfu/100ml)
1200
1000
200
100
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Pahoia @ Reserve
Enterococci (cfu/100ml)
800
700
600
500
400
300
200
100
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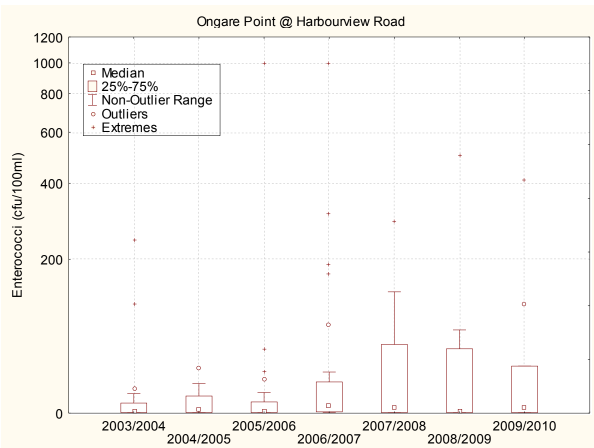
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Ongare Point @ Harbourview Road
Enterococci (cfu/100ml)
1200
1000
800
600
400
200
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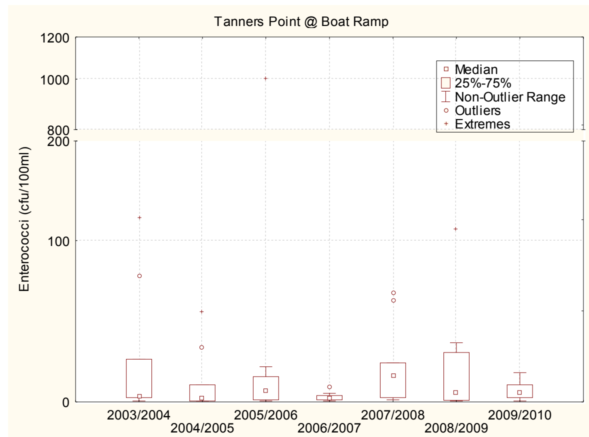
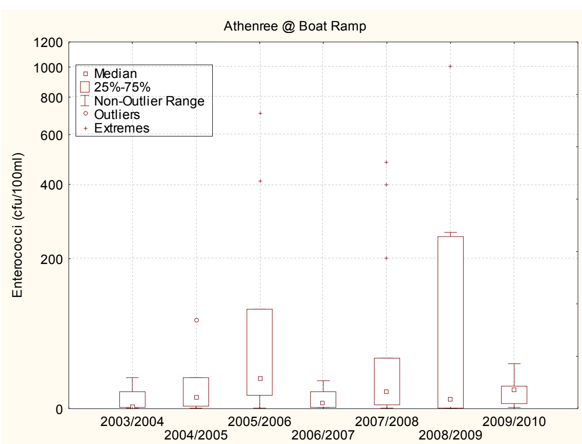
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Tanners Point @ Boat Ramp
Enterococci (cfu/100ml)
1200
1000
800
200
100
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Athenree @ Boat Ramp
Enterococci (cfu/100ml)
1200
1000
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600
400
200
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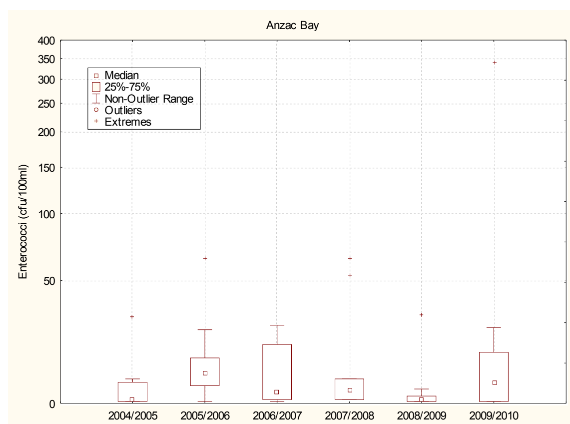
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2003/2004
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010


Anzac Bay
Enterococci (cfu/100ml)
400
350
300
250
200
150
100
50
0
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
2004/2005
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010

Appendix 2: Grading tables

Table A2.1: Grades - Marine

District	Site	Description	BOP Site Number	P	MAC	SIC	SFRG	% Days in Compliance
Opotiki	Hikuwai Beach End of Snell Road	Hikuwai	160005	43.2	B	Moderate	**Good**	98
Opotiki	Omaio Bay Domain	Omaio	160004	52.5	B	Moderate	**Good**	100
Opotiki	Te Kaha Beach Maraetai Bay	Te Kaha	160003	26.2	A	Very Low	**Very Good**	100
Opotiki	Waihau Bay	Waihau	160001	39	A	Very Low	**Very Good**	100
Opotiki	Waiotahi Beach Estuary	Waiotahi Est	160008	160	B	Moderate	**Good**	98
Opotiki	Waiotahi Beach Surf Club	Waiotahi	160007	23.4	A	Low	**Very Good**	100
Opotiki	Whanarua Bay	Whanarua Bay	160002	46.5	B	Very Low	**Very Good**	100
Tauranga	Mt Maunganui Ocean Beach Surf Club	Mount	160025	31.2	A	Very Low	**Very Good**	100
Tauranga	Omanu Beach	Omanu Surf Club	900096	33.7	A	Very Low	**Very Good**	100
Tauranga	Otumoetai Beach reserve end of Beach	Otumoetai	160021	504	D	Moderate	**Poor**	94
Tauranga	Papamoa Beach Surf Club	Papamoa	160026	62.6	B	Very Low	**Very Good**	100
Tauranga	Pilot Bay Mid Beach	Pilot Bay	160042	202	C	Moderate	**Fair**	95
Tauranga	Rangataua Bay	Maungatapu	160049	288.3	C	Very Low	**Follow-up**	94
Tauranga	Tilby Point Reserve	Tilby Pt	160020	140	B	Very Low	**Very Good**	98
Tauranga	Waimapu Estuary Motel-Motor Camp	Waimapu	160019	150	B	Low	**Good**	100
WBOP	Anzac Bay Bowentown Domain	Anzac Bay	160028	64	B	Very Low	**Very Good**	97
WBOP	Athenree Opposite Motor Camp	Athenree	160030	466	C	Very Low	**Follow-up**	90
WBOP	Little Waihi Domain Boat Ramp	Little Waihi	160016	225	C	Moderate	**Fair**	96
WBOP	Maketu Surf Club	Maketu	160017	232.4	C	Moderate	**Fair**	98
WBOP	Omokoroa Beach	Omokoroa	160022	71.4	B	Very Low	**Very Good**	98
WBOP	Ongare Point Harbour View Road	Ongare Pt	160032	340	C	Low	**Fair**	92
WBOP	Pahoia End of Beach	Pahoia	160023	257	C	Low	**Fair**	95
WBOP	Pukehina Beach Surf Club	Pukehina	160015	32	A	Very Low	**Very Good**	100
WBOP	Tanners Point Beach	Tanners Pt	160031	110	B	Very low	**Very Good**	96
WBOP	Waihi Beach Surf Club	Waihi Beach	160027	46.7	B	Low	**Good**	100
WBOP	Waihi Beach	3 Mile Creek	900077	382.5	C	Very High	**Follow-up**	93
WBOP	Waitui Reserve	Te Puna	800087	184.8	B	Very High	**Follow-up**	95
Whakatane	Ohiwa Harbour Reserve Boat Ramp	Ohiwa	160009	56	B	Very Low	**Very Good**	100
Whakatane	Ohope Beach Surf Club	Ohope 2	160011	207.5	C	Moderate	**Fair**	95
Whakatane	Ohope Beach Surf 'n Sand Motor Camp	Ohope 1	160010	42.9	B	Very Low	**Very Good**	100
Whakatane	Piripai Beach Ocean Beach	Piripai	160014	79.1	B	Very Low	**Very Good**	100
Whakatane	Whakatane Heads Oceanside of Boat Ramp	Whakatane	160013	364	C	Moderate	**Fair**	94
Whakatane	River Mouth	Tarawera River	110125	594	D	High	**Very Poor**	90

Table A2.2: Grades - Rivers

District	Site	Description	BOP Site Number	P	MAC	SIC	SFRG	% Days in Compliance
Kawerau	Ruruanga Stream	Cricket Pavilion	160111	370	C	High	**Poor**	97
Kawerau	Tarawera River	Boyce Park	160110	96.1	A	Very Low	**Very Good**	100
Opotiki	Haparapara River	Omaio d/s SH35 Bridge	160100	299.5	C	Low	**Fair**	97
Opotiki	Otara River	d/s SH35 Bridge	160101	205	B	Moderate	**Good**	100
Opotiki	Waioeka River	bend near Waioeka Pa	160102	599.5	D	Moderate	**Poor**	95
Opotiki	Waioeka River	SH2 Bridge	160103	640	D	High	**Very Poor**	94
Rotorua	Awahou Stream	Glouster Road	160118	154	B	Very Low	**Very Good**	100
Rotorua	Kaituna River	Trout Pool Rd	160112	46	A	Very Low	**Very Good**	100
Rotorua	Ngongotaha Stream	Railway Bridge	160114	1840	D	Moderate	**Poor**	89
Rotorua	Ohau Channel	SH 33 Bridge	160119	123.5	A	Very Low	**Very Good**	100
Rotorua	Puarenga Stream	Whakarewarewa	160113	1200	D	Moderate	**Poor**	81
Rotorua	Utuhina Stream	Lake Road	160117	982	D	Moderate	**Poor**	90
Rotorua	Waitangi Springs	Lake Rotoehu	160120	200	B	Very Low	**Very Good**	100
Rotorua	Waiteti Stream	Ngongotaha	160115	815	D	Moderate	**Poor**	93
Tauranga	Waimapu River	Greerton Park Footbridge	160150	861	D	High	**Very Poor**	87
Tauranga	Wairoa River	Bethlehem	160122	786.5	D	Moderate	**Poor**	90
WBOP	Kaituna River	Te Matai Rail Bridge	160129	238.5	B	Moderate	**Good**	97
WBOP	Ngamuwahine River	at Reserve	160125	850	D	Moderate	**Poor**	86
WBOP	Tuapiro Stream	McMillan Road	160126	472.5	C	Moderate	**Fair**	97
WBOP	Uretara Stream	Katikati	160123	565	D	Moderate	**Poor**	93
WBOP	Wairoa River	below McLaren Falls Dam	160124	2550	D	Moderate	**Poor**	85
WBOP	Kaiate Stream	Kaiate Falls	160130	2640	D	High	**Very poor**	60
Whakatane	Rangitaiki River	Te Teko	110018	80	A	Very Low	**Very Good**	100
Whakatane	Rangitaiki River	Thornton Domain	160109	356	C	High	**Poor**	95
Whakatane	Waimana River	Waimana Gorge Picnic Area	160105	191.2	B	Very Low	**Very Good**	97
Whakatane	Whakatane River	Landing Road Bridge	160106	585	D	High	**Very Poor**	94
Whakatane	Whakatane River	Ruatoki Bridge	110010	198.5	B	Moderate	**Good**	100

Table A2.3: Grades - Lakes

Site	Description	Site No.:	P	MAC	SIC	SFRG	% Days in Compliance
Lake Rotoma	Matahi Lagoon Road, Beach	160050	18	A	Very Low	**Very Good**	97
Lake Rotoma	Whangaroa	160052	12.5	A	Very Low	**Very Good**	100
Lake Rotoiti	Hinehopu, Jetty	160053	27	A	Very Low	**Very Good**	100
Lake Rotoiti	Gisborne Point	160054	31.4	A	Very Low	**Very Good**	100
Lake Rotoiti	Ruato	160055	96.8	A	Very Low	**Very Good**	100
Lake Rotoiti	Okawa Bay	160056	252	B	Very Low	**Very Good**	100
Lake Rotoiti	Otaramarae	160058	129.8	A	Very Low	**Very Good**	97
Lake Okataina	Beach	160059	8.1	A	Very Low	**Very Good**	100
Lake Okareka	East end of dwellings	160061	272	C	Very Low	**Follow-up**	97
Lake Okareka	Jetty	160062	51.4	A	Very Low	**Very Good**	100
Lake Tikitapu	Beach	160063	29.1	A	Very Low	**Very Good**	100
Lake Tarawera	Rangiuru Bay	160072	21.4	A	Very Low	**Very Good**	100
Lake Rotorua	Mourea	160065	60.4	A	Very Low	**Very Good**	100
Lake Rotorua	Holdens Bay	160066	192.5	B	Moderate	**Good**	100
Lake Rotorua	Ohinemutu	160068	144	B	Moderate	**Good**	100
Lake Rotorua	Ngongotaha	160069	430	C	Moderate	**Fair**	97
Lake Rotorua	Hamurana	160070	187	B	High	**Follow-up**	100
Lake Okaro	Ski Area	160073	42	A	Very Low	**Very Good**	100
Lake Rerewhakaaitu	Pump Station Boat Ramp	160077	248.2	B	Very Low	**Very Good**	100

Appendix 3 MicroMagic trial

Introduction

In the recreational surveillance season of 2008/2009 Bay of Plenty Regional Council staff trailed the B2P™ Coliform *E.coli* test using the MicroMagic incubator and reader and Watercheck™ J test kits. The B2P system was used in parallel with the standard laboratory membrane filtration method used to enumerate *Escherichia coli (E.coli)*.

The aim of the project was to test if the B2P™ *E.coli* enumeration system is adequate to replace or supplement other standard laboratory *E.coli* enumeration methods for the purposes of reporting on contamination of recreational freshwaters.

A system such as the B2P™ system has several advantages over conventional laboratory methods:

- the system does not require trained laboratory staff;
- results are ready after 14 hours or quicker for waters with higher bacterial loadings;
- testing can proceed as soon as the sample reaches a power source (e.g. car battery);
- no media or other preparation required;
- potential transportation cost saving as no transport back to a central laboratory is required;
- reduced liaison with a laboratory service required.

Compliance monitoring and other monitoring function of regional councils may also benefit from the advantages of the B2P™ *E.coli* enumeration system.

B2P™ Coliform E.coli enumeration system

B2P™ Coliform *E.coli* Enumeration System consists of essentially two parts: the MicroMagic Incubator and reader unit and the WaterCheck™ J Test jar.

J Test jar is plastic jar having a blue screw top lid, clear middle section capable of holding 100 millilitres of sample and a bottom pink section containing sanatiser. The sterilised jar can be used to collect sample directly of have sample added to it. The lid is removed, a plastic stopper is taken out and disposed off, sample is then added to the 100 millimetre mark through the sieve screen, the lid is replaced and a blue button in the lid is depressed to release the test media. Mixing of the media and sample is required for approximately two minutes until solution turns blue. The jar can then be inserted into the MicroMagic Incubator. Once the test is complete the jar can be removed and the pink button can be depressed releasing the sanatiser allowing the jar to be disposed of safely.

The MicroMagic incubator is incubator unit and reader which bring the sample up to 37 ºC and holds it at that temperature over the 14 hour incubation period while scanning continuously. Media reacts with the coliform bacteria (if present), changing the colour of the sample over time. It is this change as detected by the reader that allows a set of algorithms to enumerate the number of *E.coli* present.

A keypad and digital display allow the user to set test parameters, name the sample and begin the test. Test results are then read from the digital display and/or downloaded to a memory stick via a USB port and downloaded to computer.

Methodology

For the use of any new test method for the enumeration of *E.coli* the Microbiological Water Quality Guidelines for Recreations Waters (2003) states “new methods must be proven to provide results equivalent in sensitivity and specificity to those of the preferred test methods for the water being tested”.

To ascertain if the B2P™ method for *E.coli* enumeration would meet the criteria for use in testing recreational freshwaters analyses of freshwater recreational samples taken during the course of Bay of Plenty Regional Council’s annual recreational waters was undertaken. Samples taken from a range of stream, rivers and lakes were transported back to the Bay of Plenty Regional Council IANZ accredited laboratory following Microbiological Water Quality Guidelines for Recreations Waters (2003) protocols. Samples where split and tested by the B2P™ method and by membrane filtration using Standard Methods for the Examination of Water and Wastewaters (2005).

The Guidelines for Recreations Waters (2003) suggests examination of a new test method should be by paired t-test analysis. Since the Guidelines were formulated Ministry of Health commissioned NIWA to develop a statistically defensible measure of concordance. In a NIWA report (McBride, 2005) Lin’s concordance correlation coefficient is described as the best measure of agreement for two methods measuring the same continuous variable. Agreement would be described as perfect is all data lie on a 1:1 line.

Using the McBride developed Lin’s concordance correlation coefficient, the B2P method and membrane filtration method for *E.coli* enumeration are compared using software available on the NIWA website at: http://www.niwa.co.nz/our-services/online-services/statistical-calculators/lins-concordance

The NIWA report on Lin’s concordance correlation coefficient also proposes strength of agreement criteria as follows:

Strength-of agreement	Continuous Variable	Quanti-Tray methods
Almost perfect	>0.99	>0.90
Substantial	0.95 – 0.99	0.8 – 0.9
Moderate	0.90 – 0.95	0.65 – 0.8
Poor	<0.90	<0.65

Quanti-Tray™ are semi-automated *E.coli* quantification methods based on the Standard Methods Most Probable Number (MPN) model. After incubation, the number of positive wells is converted to an MPN using a table provided or by using the MPN Generator program.

Previous comparative studies examining quantification of *E.coli* have compared membrane filtration methods with Most Probable Number such as is used in the Quanti-Tray™ method (Fricker et al, 1997; Al-Turki and El-Ziney, 2009). Hence for the purposes of this study it is considered appropriate to compare Lin’s concordance correlation coefficient results generated from this study with the strength-of-agreement table above using the Quanti-Tray methods column.

Results

Sampling of a range of Bay of Plenty water bodies was undertaken between January 2008 and September 2009. Two samples were from inter-laboratory comparison tests and these were high counts.

Over 60 samples were analysed by both membrane filtration and Micromagic to yield an *E.coli* count. Several samples have been excluded from the analysis dataset due to failure to achieve an enumeration result. The final data set used for analysis was from 56 samples. McBride in his paper on Lin's Concordance suggests a sample set of at least 50 to achieve a robust correlation.

Table 1 displays the results for two data sets run using the NIWA Lin's Concordance calculator. A correlation coefficient using all 56 data pairs was pc = 0.7989 falls into the 'moderate' category according to McBride (2005). To remove the influence of the higher *E.coli* results (*E.coli* > 10,000 cfu/100ml) an analysis was run without these with a pc = 0.6977, also in the 'moderate' category.

Table 1 Lin's Concordance Results

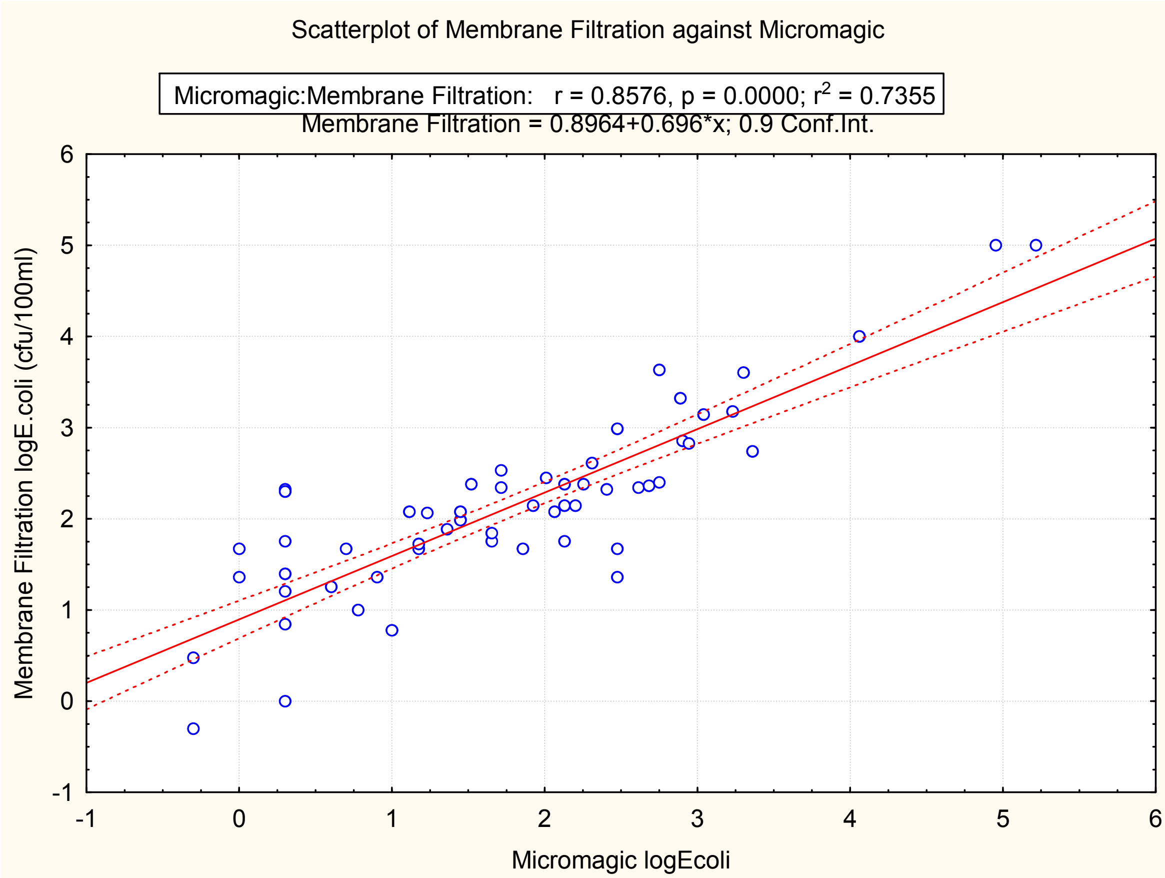
Concordance Results for all data
Sample concordance correlation coefficient (ρc) = 0.7989
Lower one-sided 95% CL for ρc = 0.7265
Lower two-sided 95% CL for ρc = 0.7126

Concordance Results for data < 10,000 cfu/100ml
Sample concordance correlation coefficient (ρc) = 0.6977
Lower one-sided 95% CL for ρc = 0.5941
Lower two-sided 95% CL for ρc = 0.5743

Resultant enumeration pairs where also analysed using Statistica software to produce a scatterplot and correlation coefficient. This correlation method used a correlation matrix and linear regression and indicates a good correlation between the pairs r = 0.8576 ($p < 0.001$). Full multiple regression results are listed below.

Multiple Regression Results for all E.coli data

R = .85763026
F = 150.1817
R^2= .73552966
df = 1,54
No. of cases: 56
adjusted R^2 = .73063207 p = .000000
Standard error of estimate: .517728846
Std.Error: .1229676 t (54) = 7.2899 p = .0000



Discussion

Results attained by the B2P™ *E.coli* enumeration system were comparable to results obtained by membrane filtration. Regression analysis and Lin's concordance correlation coefficent method were significant for the detection of *E.coli* in predominantly environmental water samples.

Using the system suggested by McBride (2005) for Lin's concordance correlation coefficient results in a *moderate* correlation.

It may be possible to achieve a better correlation between the two methods by using a comparison of like dilution cases in the membrane filtration. This trial used a range of dilution cases and as such some results will vary in accuracy of *E.coli* enumeration.

Temperature is likely to have been another factor impacting correlation results. The Micromagic incubator uses a thermocouple in the outside of the incubator cup the sample sits in. This may have impacted resuscitation times particularly for the samples with low *E.coli* counts. B2P™ have rectified this by now measuring with an infrared sensor directly into the sample.

Other differences can be explained by the B2P™ *E.coli* enumeration system increased specificity compared to membrane filtration. The system detects all *E.coli* so if species such as *E.coli* 157 are present these will also be quantified, unlike membrane filtration.

Not examining sensitivity and specificity of the enumeration of *E.coli* is a limitation of this trial.

Interference of elements such as aluminium, iron and organic matter can impact the enumeration results. Algorithms that calculate the coliforms in the sample are based on colour changes. Elements that interfere with the colour change process could alter results. B2P™ are continuously improving their algorithms in this regard which should result in increased reliability of *E.coli* enumeration.

References

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