Freshwater contact recreational water quality at Taranaki sites State of the Environment Monitoring Report 2016-2017 Technical Report 2017-01

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Executive summary

This survey of sixteen recognised freshwater contact recreational sites in the Taranaki region was the twenty-first of an on-going programme designed to annually monitor the bacteriological quality of lakes, rivers and streams at popular contact recreational sites during each bathing season. It forms a component of the State of the Environment bathing beaches trend monitoring programme, which commenced in the 1995-1996 summer period. Two sites (at Lakes Ratapiko and Opunake) were monitored in this programme during this 2016-2017 period for the eleventh time, partly as a component of the more recently instituted cyanobacteria programme (covering four lakes) instigated after consultation with Taranaki District Health Board. A site in the lower Waitara River was added in the 2010-2011 period at the joint request of Taranaki Healthcare and NPDC and two additional sites in the lower reaches of the Waiwhakaiho River and Te Henui Stream (both adjacent to the New Plymouth walkway) were included in the programme in the 2012-2013 period. The sixteen sites have been graded for recreational suitability (SFRG) according to MfE, 2003 guidelines, in part based upon the immediately preceding five seasons of monitoring data (where such data existed) although short-comings of this grading methodology are acknowledged. A re-assessed SFRG also has been provided by inclusion of the current season's data for comparative purposes and this showed minimal change of the microbiological water quality guideline over this latest five year period.

The Waimoku Stream site is sampled on a three-yearly frequency and it was monitored during the period under review. This stream is known to carry extremely high levels of bacterial contamination due to its resident waterfowl population (pukekos, ducks), and a warning sign advising against recreational use of the stream is permanently in place. It is now monitored primarily for its potential impact on Oakura beach's water quality (refer *Bathing Beach Water Quality State of the Environment Monitoring Report Summer 2016-2017*, technical report 2017-2).

A further site (Lake Rotokare) has been monitored since 2007, principally for planktonic cyanobacteria. Additional comprehensive flowing water benthic cyanobacteria monitoring (at nine river/stream sites) was undertaken in the current period for the fourth time in this state of the environment programme.

Changes were made in 2016-2017 to follow protocols for reporting on the Land and Water Aotearoa (LAWA) website: sampling frequency at four of the most popular sites (Lake Rotomanu, Waiwhakaiho River at Merrilands Domain, and Kaupokonui and Waingongoro river mouths) was increased to weekly, mainly in dry weather, from December to February inclusive.

The results of the 2016-2017 survey have continued to illustrate variability in bacteriological water quality, with the highest quality achieved at the Urenui River estuary and lower Patea River sites where marked seawater intrusion is the norm (under high tide conditions), Lake Ratapiko and the Waiwhakaiho River (at Merrilands Domain). Impacts on bacteriological water quality at some sites, particularly the lower reaches of the Waiwhakaiho River and Te Henui and Waimoku Streams, were due principally to resident wild fowl populations in the vicinity of recreational usage sites (as confirmed previously by inspections and DNA marker surveys).

In terms of *E. coli*, bacteriological water quality in the latest survey period was lower than normal in comparison with historical surveys. The total number of samples falling within the "Alert" or "Action" categories (36% of samples, or 40% if the samples of the Waimoku are included) across the 16 recognised bathing sites was the highest recorded. However, it should be noted that the "Action" category is the only category for which swimming is not recommended. In the 2016-2017 season, 86% of all samples (ie excluding the Waimoku) met the national bathing guideline, and this is a lower rate of non-compliance than in the previous two years. Of the 14% of samples that exceeded the guideline, 10% arose from just two sites- the two New Plymouth urban sites. Bird life was mainly responsible for the exceedances at these sites, where on occasions recreationalists have fed the birds.

Two sites recorded all single samples in either the 'Alert' or the 'Action' mode of the MfE, 2003 guidelines (Waimoku Stream at Oakura, and Te Henui Stream near East End beach), while one site (Waiwhakaiho River opposite Lake Rotomanu) recorded ten single samples in those modes. Eleven other sites from time to time exhibited single sample entries, mainly into the 'Alert' mode of the 2003 guidelines, at some time during the season. Seven of these sites had counts which entered the 'Action' mode, a slight increase in the number and frequency of guideline exceedances in comparison with many previous seasons' results.

To a certain extent these exceedances were probably a feature common to the mid and lower reaches of rivers and streams draining developed (particularly agricultural) catchments throughout New Zealand.

Notably, no exceedances of the MfE 'Action' guideline were found in the Waiwhakaiho River at Merrilands Domain (mid urban New Plymouth and downstream of agricultural land), whereas 8 of 13 samples exceeded this guideline near this river's mouth. Minimal follow-up sampling was performed when deemed necessary following exceedances of the 'Action' limit, as in most cases bacteriological quality was found to have returned to typical levels within short time frames or the causes were well established from historical data. Permanent health warning signage had been erected by the New Plymouth District Council (on the direction of Taranaki District Health Board) following past exceedances of 'Action' levels at the lower Waiwhakaiho River, Waimoku Stream, and Te Henui Stream sites, and of 'Alert' levels at Waitara. Temporary signage was required at the Lakes Rotomanu, Ratapiko and Opunake, and at Oakura, upper Patea and upper Waingongoro Rivers sites following single sample 'Action' levels, but single sample 'Alert' level exceedances at other sites were not necessarily signposted.

Temporal trends over the 1996-2017 period have been evaluated on the basis of seasonal median *E. coli* count for the sixteen sites that have ten years or more data (and will continue to be assessed annually). Two sites (Waimoku Stream and lower Waiwhakaiho River) have shown a statistically significant increasing trend. No other sites have shown statistically significant trends (positive or negative) in seasonal median *E. coli* counts.

Elevated enterococci to faecal coliform ratios have typified ponded sites near the stream/river mouths from time to time (and in the current season), possibly as a result of vegetative sources of enterococci and/or more prolonged survival in ponded freshwater environments, under high tidal conditions and often where saltwater penetration occurred.

Additional sampling (in accordance with the MfE, 2003 guidelines for datasets for grading purposes) at four principal usage sites (Lake Rotomanu and Waiwhakaiho, Kaupokonui and Waingongoro Rivers) coincided on a few occasions with wet weather conditions and

resulted in large increases in the overall median bacteriological numbers at the Lake Rotomanu and Waiwhakaiho River sites. Up to three additional exceedances of the 'Action' limit occurred at these sites as poorer bacteriological water quality followed the wet weather events.

Cyanobacteria blooms were recorded at Lake Rotokare on most monitoring occasions from November 2016 to February 2017 and at Lake Rotomanu in March 2017. These numbers necessitated warning notices to avoid contact recreation in these waters during most of the recreational period. Low to moderate numbers of cyanobacteria were found in Lake Opunake, with a few instances of low numbers present in Lake Ratapiko.

Benthic cyanobacteria were found occasionally in most of the nine rivers and streams monitored, but did not reach public health warning levels. Monitoring frequency was increased from fortnightly to weekly in response to 'Alert' levels found on several occasions. One site (Kaupokonui River at mouth) exceeded the 'Alert' level for bed coverage on a total of three occasions. Exposed mats triggered the 'Alert' level at four sites (Waingongoro River at Ohawe, Kaupokonui River at the mouth, and Waiwhakaiho River at the last riffle and at Merrilands Domain) on a total of 17 individual site surveys, and detaching or detached mats accumulating on the river's edge triggered the 'Alert' level at the same four sites on a total of 15 surveys. Levels of cyanobacteria were lower than in the previous four seasons; the improvement was probably caused by above-average rainfall causing a large number of freshes that scoured streambeds of periphyton.

Timely reporting of the results of bacteriological water quality and cyanobacteria numbers/cover was undertaken by use of the Taranaki Regional Council website (www.trc.govt.nz) and LAWA website (www.lawa.org.nz) as well as liaison with territorial local authorities and the Health Protection Unit of Taranaki District Health Board throughout the survey season of 2016-2017.

For the second time, this report also discusses the monitoring results in the light of the criteria for primary recreational use of water bodies ('swimmability') set out in the National Objectives Framework that is attached to the *National Policy Statement for Freshwater Management 2014*. This report also discusses the monitoring results in the light of proposed criteria released for public discussion and submission in February 2017 (ie towards the end of the bathing period).[1] It should be noted that these new criteria are still subject to public consultation and review.

It is recommended that annual bacteriological monitoring of selected freshwater sites be continued (in conjunction with the coastal bathing water programme) by use of a similar sampling format over a five month (November to March inclusive) contact recreational period to provide information for trend detection purposes and for assessment of suitability for contact recreational usage. Cyanobacteria monitoring at the four lakes sites and nine stream/river sites at a lesser frequency is also recommended to continue. A further recommendation involves appropriate scheduling of the annual round of dairy wastes disposal systems and advice provided in relation to stock access to watercourses to attempt to reduce the frequency of exceedances of recreational limits particularly in catchments where historical problems from this source have been located. Another specific recommendation relates to proposed faecal source tracking investigations at the Waingongoro River, Eltham

[1] *Clean Water: 90% of rivers and lakes swimmable by 2040*, Ministry for the Environment 2017

site to provide information for future management/abatement initiatives in the mid Waingongoro River catchment.

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1. Introduction

The microbiological water quality at bathing beaches along the Taranaki coast has been monitored by the Taranaki Regional Council (and its predecessors) since 1979, with systematic surveys undertaken since 1987. A more comprehensive annual bathing beach monitoring programme was first implemented during the 1995-1996 summer as an ongoing component of the state of the environment monitoring (SEM) programme for the Taranaki region.

Freshwater bathing and recreational sites were added during the 1996-1997 summer and integrated within the bathing beach bacteriological water quality monitoring programme in order to maximise the efficiency of field sampling procedures and protocols. This format has been continued in the summer periods since this date, with an additional component of cyanobacteria monitoring instituted at three lake sites since the 2006-2007 summer and an additional lake site in 2007-2008, and nine river and stream sites monitored for the benthic cyanobacteria component of the SEM periphyton programme. These results are also reported as appropriate in the current report.

The SEM bathing water quality programme has three objectives:

- to characterise the bacteriological and cyanobacterial quality of principal recreation waters in the Taranaki area, and more specifically to determine their suitability for contact recreation;
- to identify changes in contact recreational bacteriological water quality over time. Therefore the detection of trends is an important component in programme design; and
- to assess water quality in relation to recreational water quality guidelines.

[***Note**: Contact recreation concerns water-based activities involving a high probability of accidental water ingestion. This mainly applies to bathing, but may also include water- and jet-skiing, surfing, boardsailing, etc. Bathing, kayaking, and water skiing are the principal freshwater contact recreational usages identified. More recently, the term 'swimmability' has entered popular usage to denote waters used for primary contact recreation.*]

2. Contact recreation water quality standards and guidelines

Prior to 2003, the Council used guidelines for the management of recreational and marine shellfish-gathering waters (MfE, 1998) which replaced the provisional guidelines (DOH, 1992). These guidelines were developed (by MfE and MoH) to assist water managers to implement the Resource Management Act (1991) and the Health Act (1956) for the purposes of shellfish-gathering and contact recreation (refer to previous annual reports for more information on these historical guidelines). New guidelines issued in 2003 are now relevant to this programme. These guidelines are detailed below.

2.1 Freshwater microbiological water quality guidelines (2003)

Guidelines have been prepared by Ministry for the Environment in conjunction with the Ministry of Health (MfE, 2003). Changes to the *E. coli* freshwater recreational guideline values were made for the purpose of regularly assessing single samples against suitability for recreation, and thus providing information on current (ie, at time of sampling) suitability for recreational use. The current freshwater guidelines are now more reflective of New Zealand conditions. 'Alert' and 'Action' guideline levels are used for surveillance throughout the bathing season. They may be summarised as follows (with the marine levels included within the table as some of the Taranaki sites monitored are in the lower, tidal reaches of rivers and streams).

Mode	Acceptable (green)	Alert (amber)	Action (red)
Freshwater (*E. coli*/100mL)	≤260	261-550	>550
Marine (enterococci/100mL)	≤140	141-280	>280 (2 consecutive samples)
Procedure	• Continue routine monitoring	• Increase sampling to daily • Undertake sanitary survey • Identify sources of contamination • Consult CAC to assist in identifying possible source	• Increase sampling to daily • Undertake sanitary survey • Identify sources of contamination • Consult CAC to assist in identifying possible source • Erect warning signs • Inform the public through the media that a public health problem exists

CAC = Catchment Assessment Checklist

It is important to understand if bacteriological quality enters the 'Alert' status, it is still deemed suitable for swimming and other recreational uses. If bacteriological quality enters the 'red' (Action) level then the bathing area will be considered highly unsuitable for recreation, a public health problem is deemed to exist, and swimming is not recommended[2].

Sampling is generally conducted weekly, but with the proviso that it should be under conditions when the river is suitable and used for bathing. For example, this

[2] Pages C3, E8, and E9, '*Microbiological Water Quality Guidelines*, MfE (2003).

precludes sampling under conditions of river freshes when high flows and turbid conditions would make bathing hazardous and in any case people would be less inclined to bathe. The Council endeavours to collect 13 samples per season under bathing conditions. In addition, at two of the most popular sites a further 7 samples are collected between November and March regardless of prevailing weather and river conditions, to facilitate the calculation of the Microbiological Assessment Category (see next section). Also, weekly sampling regardless of weather and river conditions was undertaken between December 2016 and February2017 at four of the most popular sites, to align with **and assess** the reporting protocols for the LAWA website and to enhance the provision of timely information to the public during holiday periods.

2.2 Suitability for recreation grading (SFRG) of sites

Components of the guidelines include sanitary surveys/inspections together with assessments of historical microbiological data which, when combined, provide an overall suitability for recreation grade, which describes the general condition of a site based on both risk and indicator bacteria counts. The *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas* (MfE, 2003) provide for the grading of recreational water bodies utilising Microbiological Assessment Categories (using historical data), and Sanitary Inspection Categories which generate a measure of the susceptibility of water bodies to faecal contamination (ranging from high to low risk). The SFRG therefore describes the general historical and perceived potential risk condition of a site based on both risk factors and indicator bacteria water quality (worst-case over the long term). A grade is established on the basis of the most recent five years' data and recalculation of a grade may be performed annually, although grades should be reassessed on a five-yearly basis.

SFRGs categories are very good, good, fair, poor, and very poor. Sites graded very good are those where it is believed they will almost always comply with the guideline values for recreation, and there are few sources of faecal contamination in the catchment. Consequently, there is a low risk of illness from bathing. Sites graded very poor are in catchments with significant sources of faecal contamination, and it is generically considered that they will rarely pass the guidelines. The risk of illness from bathing at these sites is deemed within the Guidelines to be high, and swimming is not recommended. For the remaining beaches (good, fair and poor) it is recommended that weekly monitoring be carried out during the bathing season to the extent that is practicable. The public is to be informed when guideline values are exceeded and swimming is not recommended (MfE, 2003).

All of the freshwater sites included in the bathing sites programme have been graded by the Council according to these criteria, using all historical SEM microbiological water quality data extending over the November 2011 to March 2016 period (i.e. the five years immediately preceding the current season as required by the Guidelines). The single site added in 2009-2010, Waimoku Stream, has limited historical bacteriological data and only two years' data have been collected for this site over the recent five year period. The relevant information is provided in Appendix 1 and is summarised in Table 1.

Table 1 Suitability for recreation grade for freshwater sites for the period November 2011 to March 2016

Site	Sanitary Inspection Category	Microbiological assessment *E.coli* (cfu/100ml)			SFR Grade	% of all samples not exceeding 'Action' level (ie: ≤ 550 *E.coli*)
		95 %ile	Number of samples	Category		
L Rotomanu: western beach	High	802	65	D	Very poor	89
Waiwhakaiho R: Merrilands domain	High	220	65	B	Poor	98
Waiwhakaiho R at L.Rotomanu	High	3075	65	D	Very poor	27
Te Henui S: mouth	High	4525	66	D	Very poor	16
Patea R: King Edward Park	High	528	65	C	Poor	96
Patea R. boatramp, Patea	High	80	65	A	Poor	100
Waingongoro R: Eltham camp	High	392	65	C	Poor	100
Waingongoro R: Ohawe beach	High	662	65	D	Very poor	93
Kaupokonui R: Beach domain	High	482	65	C	Poor	98
L Opunake: adjacent boat ramp	High	570	65	D	Very poor	95
Timaru S: Lower Weld Road	High	690	65	D	Very poor	92
Oakura R: d.s SH45	High	812	65	D	Very poor	93
Waitara R: Town wharf	High	638	65	D	Very poor	95
Urenui R: estuary	High	60	65	A	Poor	100
Manganui R: Everett Park	High	348	65	C	Poor	96
L Ratapiko: boatramp	High	230	60	B	Poor	100
L Rotokare: adjacent boatramp	Low	196	42	B	Very good	100

Although all but one of the sites' SFRGs suggest possible high risks associated with contact recreational usage, the poor to very poor gradings have been very strongly influenced by the underlying agricultural nature of the catchments in question (within the Sanitary Investigation Category). The 5-year microbiological data, however, indicate that all but two sites (Te Henui Stream and lower Waiwhakaiho River) would not have entered the 'Action' guideline (ie would have exceeded guidelines) on more than 8% of all sampling occasions, that is, fourteen sites achieved the guideline on 92% or more of occasions. That is, the data shows the SFRG gradings to be highly precautionary.

The Eltham camp site in the mid reaches of the Waingongoro River, the Urenui River estuary site, the Patea River estuary site, and the Lake Ratapiko site have not reached the 'Action' mode during the previous five seasons, under the sampling protocols of the SEM programme, and the Waiwhakaiho River Merrilands domain site, the Everett Park site in the Manganui River, the Patea River King Edward Park Stratford site, and the Kaupokonui River beach domain site entered this 'Action' level on only one or two occasions during the same five-year period.

As explained above, in general, these data indicate shortcomings in the grading system set out within the Guidelines for these sites based upon landuse/perceived impacts and the use of extremes (95 % confidence levels) in bacteriological quality data (ie the 'worst case' data), rather than actual monitoring or representative data measured throughout the bathing seasons. Council's contact recreational water quality programme results confirm that the Guideline gradings do not reflect the recreational water quality experienced by recreational users. They show only susceptibility and predominantly reflect perceptions and suppositions about how some land uses might influence quality, as designated 'risk factors'. It is the view of the Council that when there is regular and systematic testing of the actual quality, those results reflect actual levels and are far more informative to recreational water

users. Gradings should not be used to make any statement about how safe water actually is for recreational purposes. Rather, the Council emphasises the importance of results of systematic and on-going testing and timely public notification in terms of the reporting of actual contact recreational water quality and assessments against guidelines.

2.3 Cyanobacteria guidelines

In 2009, the Ministry for the Environment released an interim guidance document entitled "*New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters*" (MfE, 2009). These guidelines provide a national alert–level framework for assessing the public health risk from cyanobacteria associated with contact recreation in lakes and rivers. Table 2 below shows the alert-level framework for benthic cyanobacteria.

Table 2 Alert level framework for benthic cyanobacteria

Alert level[a]	Actions
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. • Take scrapings every second survey for microscopic identification, to compare with visual assessments in order to ensure cyanobacteria are being recorded accurately, and to provide an indication of the species present.
Alert (amber mode) 20−50% coverage of potentially toxigenic cyanobacteria attached to substrate.	• Notify the public health unit. • Increase sampling to weekly. • Recommend erecting an information sign that provides the public with information on the appearance of mats and the potential risks. • Consider increasing the number of survey sites to enable risks to recreational users to be more accurately assessed. • If toxigenic cyanobacteria dominate the samples, testing for cyanotoxins is advised. If cyanotoxins are detected in mats or water samples, consult the testing laboratory to determine if levels are hazardous.
Action (red mode) *Situation 1:* Greater than 50% coverage of potentially toxigenic cyanobacteria attached to substrate; or *Situation 2:* up to 50% where potentially toxigenic cyanobacteria are visibly detaching from the substrate, accumulating as scums along the river's edge or becoming exposed on the river's edge as the river level drops.	• Immediately notify the public health unit. • If potentially toxic taxa are present then consider testing samples for cyanotoxins.. • Notify the public of the potential risk to health.

a The alert-level framework is based on an assessment of the percentage of river bed that a cyanobacterial mat covers at each site. However, local knowledge of other factors that indicate an increased risk of toxic cyanobacteria (e.g., human health effects, animal illnesses, prolonged low flows) should be taken into account when assessing a site status and may, in some cases, lead to an elevation of site status (e.g., from surveillance to action), irrespective of mat coverage.

Over the relatively short period that planktonic cyanobacteria monitoring of lakes has been undertaken, the guidelines outlined in Table 3 have been utilised (TDHB, 2006), as agreed with all parties at the time of the inception of this addition to the programme, until the 2014-2015 period when the volumetric guidelines were also included.

Table 3 Planktonic cyanobacteria guidelines for lake monitoring

Mode	Cells (per ml)	Biovolume (mm^3/L)
Low risk	Less than 2,000	<0.5
Medium risk	2,000 and 15,000	0.5 -1.8
High risk	More than 15,000	>1.8

3. Programme design

3.1.1 Trend detection

It should be noted that the existing programme was designed and implemented prior to the release of the 1998 and 2003 guidelines. Therefore, for trend detection monitoring purposes, consistency in programme design is essential and will be maintained where possible. Results are interpreted in this report with reference to the 2003 guidelines for the purposes of comparative assessment with contact recreational guidelines.

The locations of the sixteen sites sampled by the various components of the 2016-2017 programme are shown in Figure 1 and summarised in Table 4.

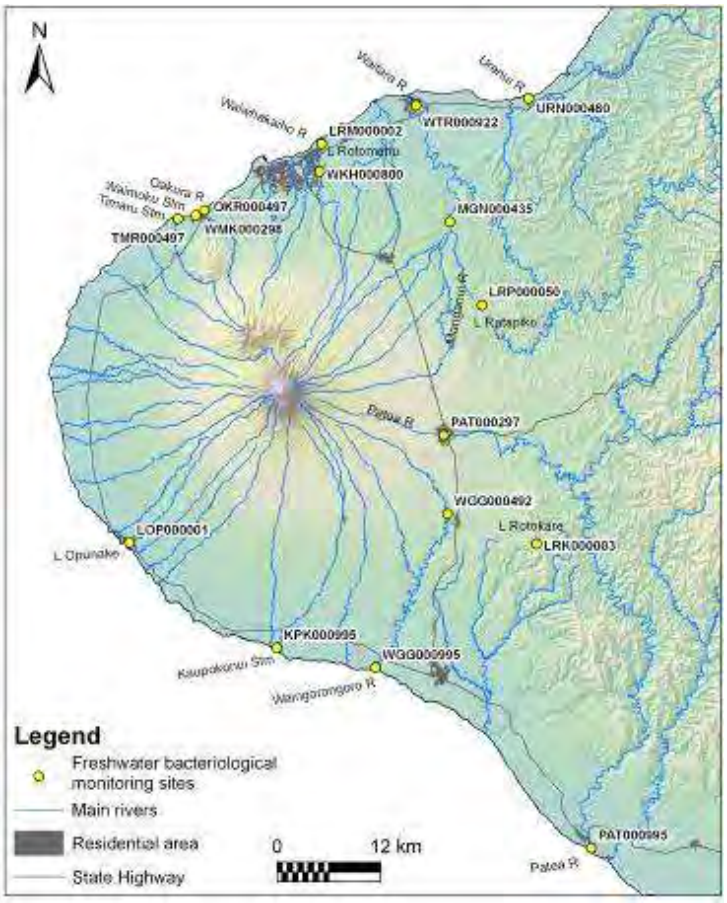


Figure 1 Location of freshwater contact recreation survey sites in 2016-2017

Having established its general state and the degree of influence on the nearby coastal waters of Oakura beach, sampling of the Waimoku Stream site at Oakura Beach was reduced in intensity from 2011 with sampling programmed for every third season thereafter (ie sampled in 2013-2014 and the current season). Given the permanent warning signs at the Waimoku Stream, and its extremely shallow nature, the Waimoku Stream is not a designated bathing site in its own right. Two sites (Te Henui Stream at the mouth and lower Waiwhakaiho River adjacent to Lake Rotomanu) were added to the 2011-2012 programme, in recognition of increased recreational usage of these areas.

For sampling convenience all sites were included with the coastal bathing beaches runs undertaken over the same five month period from early November 2016 to mid April 2017. Ten sites, relatively close to stream mouths, were potentially affected by tidal influences (see conductivity data later in this report).

Table 4 Location of bathing water bacteriological and cyanobacteria sampling sites

Site	GPS Location		Site code	Bacteriological	Benthic Cyanobacteria	Planktonic Cyanobacteria
L Rotomanu: western beach	E 1696309	N 5678128	LRM000002	✓		✓
Waiwhakaiho R: Merrilands domain	E 1696059	N 5674931	WKH000800	✓	✓	
Waiwhakaiho R at L.Rotomanu	E 1696587	N 5678336	WKH000950	✓	✓	
Te Henui S: mouth, East End	E 1694213	N 5677047	THN000499	✓	✓	
Patea R: King Edward Park	E 1710433	N 5644464	PAT000297	✓	✓	
Patea R. boat ramp, Patea	E 1727517	N 5596784	PAT000995	✓		
Waingongoro R: Eltham camp	E 1710861	N 5635349	WGG000492	✓	✓	
Waingongoro R: Ohawe beach	E1702531	N 5617624	WGG000995	✓	✓	
Kaupokonui R: Beach domain	E 1691110	N 5619893	KPK000995	✓	✓	
L Opunake: adjacent boatramp	E 1674029	N 5632022	LOP000001	✓		✓
Timaru S: Lower Weld Road	E 1697622	N 5669438	TMR000497	✓		
Waimoku Stream*: Oakura Beach	E 1681725	N 5669851	WMK000298	✓		
Oakura R: d/s SH45 bridge	E1682721	N 5670440	OKR000497	✓	✓	
Waitara R: Town wharf	E 1707203	N 5682572	WTR000922	✓		
Urenui R: estuary	E 1720245	N 5683370	URN000480	✓		
Manganui R: Everett Park	E1711149	N 5669127	MGN000435	✓	✓	
L Ratapiko: boatramp	E1714913	N 5659488	LRP000050	✓		✓
L Rotokare: adjacent boatramp	E 1721182	N5631898	LRK000003	(✓)		✓

[Notes: ( ) sporadic; * monitored for its influence on water quality along Oakura Beach]

Sample collection, field measurements, and analyses were undertaken according to documented Taranaki Regional Council procedures. It was intended that, on average, three samples would be collected from each of the sites in each month when hydrological flow conditions permitted, within two hours of high tide (due to the format of the coastal programme). Sampling commenced in early November 2016 with three of the sampling surveys performed prior to January 2017. The majority of the surveys were performed over the latter half of the summer and early autumn period. Bathing water samples were taken between the hours of 0900 and 1600 hours (NZDT) with none collected within a three day period following significant river/stream fresh conditions. [NB: regional differences in rainfall patterns have caused difficulties at various sites in the past as localised rainfall may impact on bacteriological quality on isolated occasions]. Where necessary, a 2 metre sampling pole was used for bacteriological sample collection immediately beneath the water surface and at a minimum of calf depth at the sites. Thirteen samples were collected from all sites.

Samples were analysed for enterococci, *E. coli* and faecal coliform bacteria, turbidity and conductivity. In addition, at each of the sites the following information was recorded: time, water temperature, weather, colour/appearance, estimation of algal cover on the streambed, number of bathers and other users, presence of wildfowl etc., and flow characteristics. All sites' locations (map references and GPS) and descriptions are stored in the Council's Taradise and ESAM computer databases and

all analytical results were stored in the Lab database following standard sample registration procedures.

Results were posted on the Taranaki Regional Council website (http://www.trc.govt.nz/#mapTab6), for both public and local health authority notification, as soon as data checking had been completed. The results were also included on the new national Land, Air, Water Aotearoa (LAWA) website (http://www.lawa.org.nz/explore-data/taranaki-region/river-quality/). The Taranaki District Health Board no longer posted the results on its recreational water safety webpage after 2015-2016, instead introducing links to the regional and district councils' and national websites, and continuing to give general advice on water safety. In 2016-2017, the three district councils (New Plymouth, Statford and South Taranaki) developed sections on recreational water quality on their respective websites, using the data produced by the regional council.

In previous monitoring years, where results fell in the 'Action' mode, further investigations (e.g. sampling and inspections) were performed when considered necessary i.e. where historical databases and staff expertise indicated this was warranted. From December 2016 onwards, health risk warning signs were erected by District Councils as soon as practicable after receiving a single 'Action' level result, whether for freshwater or marine recreational sites. The signs were removed after a single result below 'Action' level.

Cyanobacteria information was included on the regional council website for all lake sites and river/stream sites.

3.2 Additional monitoring (MfE guidelines)

The revised guidelines (MfE, 2003) require weekly surveillance monitoring during the 5-month recreational period, with a minimum of 20 data points collected, regardless of weather conditions or state of the tide, also facilitating the calculation of the Microbial Assessment Category. Following consultation with the three territorial local authorities and Taranaki District Health Board, TRC undertook to add seven sampling occasions to the SEM protocol (13 dry weather samples per season, representing conditions most conducive to bathing) at two of the most popular freshwater recreational sites (Lake Rotomanu and Waiwhakaiho River at Merrilands Domain) in the 2003-04 period and this additional monitoring has continued annually since. These seven sampling occasions were systematically selected (one per week), where possible in weeks not sampled by the SEM programme and were performed regardless of prior weather conditions or tides but adhering to all other SEM programme protocols and using documented sampling methods. Both sites were signposted advising the public of monitoring activity. Also, the additional data were included on the TRC website [Note: These additional data have not been used for trend detection purposes as they do not comply with the format of the originally established SEM programme].

3.3 Weekly monitoring (2016-2017)

In the 2016-2017 period, monitoring frequency was increased to at least weekly between December and February at four of the most popular freshwater recreational sites (Lake Rotomanu, Waiwhakaiho River at Merrilands Domain, Kaupokonui River

at mouth, and Waingongoro River at Ohawe), to align fully with the MfE guidelines and the reporting protocols for the LAWA website. Monitoring over the Christmas to New Year period was specifically included to increase the provision of timely information on suitability for bathing to the public during holiday periods. When possible, the SEM protocol of dry weather monitoring (near high water for estuarine sites) was followed. In weeks when weather or tide did not meet the SEM protocol, sampling occurred no later in the week than Thursday to allow posting of results on local and national websites before the weekend. [Note: These additional data have not been used for trend detection purposes as they do not comply with the format of the originally established SEM programme].

3.4 Cyanobacteria monitoring

After consultation with Taranaki District Health Board, cyanobacteria monitoring commenced at each of the three lake sites in the 2006-2007 bathing season and has continued to date, including an additional lake site (Lake Rotokare). Cyanobacteria can produce toxicity in recreational waters which pose risks to humans and animals by contact or consumption during recreational activities. Lake samples were collected for microscopic analysis and enumeration which were performed in the TRC biological laboratory. A more comprehensive benthic cyanobacteria monitoring programme for the river and stream sites was instigated in the 2013-2014 period and continued over 2016-2017, the results of which are included in this report.

As part of the State of the Environment Freshwater Nuisance Periphyton monitoring programme, the Council undertakes a series of benthic cyanobacteria surveys during the recreational period each year. Monitoring is undertaken at nine sites within the Taranaki region that are established as popular for swimming and other fresh water-based activities.

The sampling period extends from 1 November to 31 March each year. Initially, the surveys are carried out in accordance with the sample frequencies listed in Table 5, which then may vary depending upon the percentage cover of benthic cyanobacteria detected previously at a site.

Table 5 Frequency of sampling for benthic cyanobacteria

Percentage of cyanobacterial mat cover per site	Level (MfE guidelines)	Frequency of sampling
Up to 20%	Surveillance [green mode]	Monthly
20-50%	Alert [amber mode]	Fortnightly
>50%	Action [red mode]	Weekly

At each site, measurements at four transects, using five evenly spaced viewing circles, were made across the streambed to a maximum depth of 0.6m. Two transects were established in riffle habitat and two transects in run habitat. Percentage cover of benthic cyanobacteria was estimated in each viewing circle for cyanobacteria mats greater than 1mm thick. Samples of benthic cyanobacteria were taken for laboratory analysis where species could not be identified on site. An average percentage cover per transect was calculated from which an average percentage cover for the site also was calculated. Average percentage cover results were then interpreted using the MfE level framework guidelines in Table 5. Monitoring was also extended to include information on exposed and detaching mats in accordance with relevant criteria.

4. Results

4.1 Introduction

Sampling times in relation to tidal conditions (particularly for estuarine sites, see Appendix II), weather conditions and sites' usage information are contained in Appendices III and IV. Timing of sampling in relation to river flows is illustrated by Figure 8, Figure 22, Figure 30, Figure 34, Figure 41, Figure 51, Figure 62, and Figure 69. Those illustrate that the majority of the sampling occasions coincided with steady to low river recession flow conditions. In 2016-2017, sampling was not known to be affected by localised rainfall, or by a prior increase in river flows, except at the lower Waitara River site where delayed effects of rainfall are known to occur. However, where possible, no sampling was undertaken within three days following significant river freshes. A total of 13 samples was collected at each site during the period from early November 2016 to mid April 2017.

Sampling was confined to weekdays during the period, with one exception on a Sunday, and no public holidays were included due to sampling personnel and laboratory schedules' requirements. For these reasons, recreational usage of the waters was generally less intensive, often with no apparent usage at the time of sampling. However, all sites are known to be regularly utilised for bathing and other contact recreational activities, particularly at weekends, dependent on suitable weather conditions (see Appendix IV of TRC, 1999). The two additional sites included in the 2001-2002 programme (Patea River at Stratford and Waingongoro River at Eltham), and monitored annually since then, have been identified as used locally for bathing and other recreational purposes. The two lake sites (Ratapiko and Opunake) added to the 2006-2007 programme are also used for these purposes, while Lake Rotokare (added in the 2007-2008 season for cyanobacteria monitoring) is used extensively for recreational boating activities. The lower Patea River site (added in 2007-2008 year as a result of a Patea Wastewater Treatment Plant consent monitoring condition) is used principally for boating purposes. The lower Waitara River site (added in 2009-2010) is used for boating and bathing purposes, more so after the construction of a new wharf in the town. The Te Henui Stream and lower Waiwhakaiho River sites (added in 2011-2012) are both used for bathing (the latter more particularly) as the New Plymouth coastal walkway has provided improved access.

From time to time, public interest has focused on additional sites where sporadic sampling may be undertaken as a consequence after appropriate consideration (see Appendix VII).

4.2 Presentation of results and discussion

All results are presented and discussed on a site-by-site basis for the sampling period, which extended from 1 November 2016 to 11 April 2017 and totalled thirteen sampling occasions at each site. The results for the sites with the additional (eleven) sampling occasions are also presented within the discussion for the four appropriate sites.

4.2.1 Lake Rotomanu

4.2.1.1 SEM programme

At the times of the surveys, conducted mostly in early to mid-morning, there was limited bathing usage of the lake recorded, with boating, jet-skiing, and dog walking activities occurring on some occasions. Picnicking has been observed in previous seasons.

Ducks were present on the lake or in the vicinity of the lake edge throughout most the period. Public feeding of the ducks was not observed, as has occurred in previous seasons, possibly as public use of the lake was low at the time of sampling. Gulls were common of the banks on several occasions. Lake levels were relatively consistent throughout the period. A wetland had been created in recent years at Peringa Park to improve the quality of stormwater runoff entering the lake.

A recreational water quality advisory sign was erected by NPDC on the access road to the lake in June 2017, in addition to the existing TRC sign at the monitoring site (Photo 1, the original sign on the right is in the far background on the left).

Photo 1 Signs at Lake Rotomanu, June 2017

The data for this site are presented in Table 6 and illustrated in Figure 2, with a statistical summary provided in Table 7.

Table 6 Analytical results for Lake Rotomanu

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	0830	11.0	17	3	17	18.3	6.0
30.11.16	1200	10.1	2200	450	2400	17.8	12
05.12.16	1025	10.2	31	8	31	22.2	5.3
12.01.17	1120	10.6	290	120	300	22.8	13
30.01.17	1310	10.2	1100	140	1100	21.7	9.4
01.02.17	0910	10.3	490	150	490	20.9	11
10.02.17	1030	9.9	77	48	77	20.6	7.9
16.02.17	1025	10.1	31	1200	34	21.9	5.9
27.02.17	1240	11.3	270	91	270	24.4	6.1
02.03.17	0920	10.6	34	11	37	24.3	8.1

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
17.03.17	0950	10.7	84	71	88	19.9	6.9
02.04.17	0945	11.0	74	60	80	20.5	5.0
11.04.17	1130	10.6	92	57	92	18.5	3.1

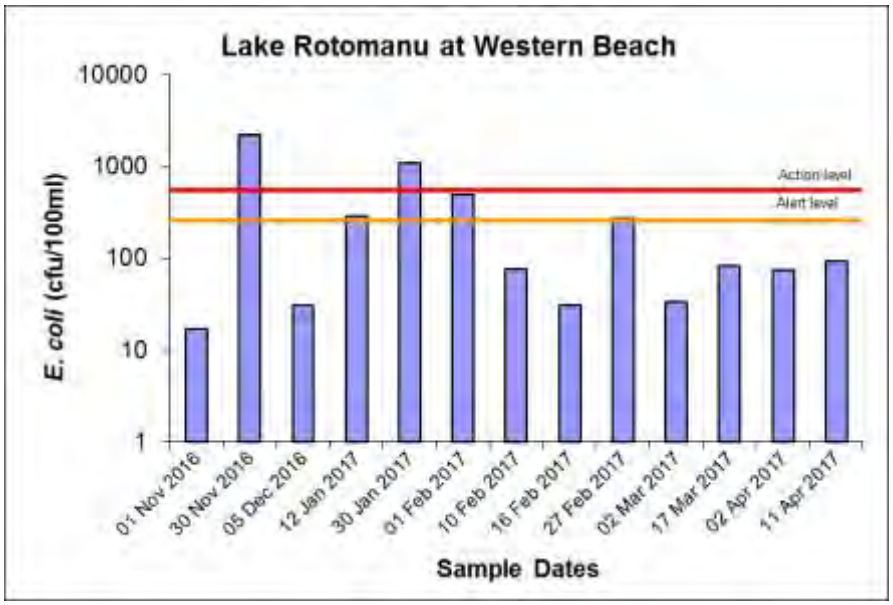


Figure 2 *E. coli* numbers for Lake Rotomanu during the regular season

Table 7 Statistical results summary for Lake Rotomanu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	9.9	11.3	10.6
E. coli	cfu/100ml	13	17	2200	84
Enterococci	cfu/100ml	13	<3	1200	71
Faecal coliforms	cfu/100ml	13	17	2400	88
Temperature	°C	13	17.8	24.4	20.9
Turbidity	NTU	13	3.1	13	6.9

The lake, which is close to the coast, is replenished from time to time by inflow from the nearby Waiwhakaiho River. Water quality was relatively good although it was generally slightly turbid (median turbidity: 6.9; range: 10 NTU), possibly as a result of fluctuating concentrations of suspended algae and/or fine sediment. Water temperatures were relatively high (above 20°C) through most of the period with a maximum of 24.4°C (in late February 2017) and a range of 6.6°C. Conductivity had a narrow range through the season.

Generally, bacteriological quality was relatively good considering that the inflow to the lake is from the lower reaches of a river draining a developed catchment. However, elevated numbers of *E. coli* (in the 'Action' mode) were found on two monitoring occasions, in late November 2016 and late January 2017. Ducks appeared to be the cause. NPDC signage discouraging lake usage was required to be erected

on both occasions. Resampling on 5 and 6 December 2016 returned *E. coli* numbers of 31 then 17 per 100ml, back to 'Surveillance' level. Resampling on 1 February 2017 returned *E. coli* numbers of 490 per 100ml, back to 'Alert' level, and the signs were removed.

4.2.1.2 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 8.

Table 8 Bacterial guidelines performance at Lake Rotomanu [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	3 [23]	2 [15]

(Designation: freshwater contact recreational area)

Two single samples exceeded the 'Action' mode during the period, and three samples were recorded within the 'Alert' mode.

4.2.1.3 Comparison with previous summers' surveys

A statistical comparison of all of the seasons' *E. coli* surveys data is presented graphically in Appendix VI for all sites. These summer data for the Lake Rotomanu site are summarised in Table 9 and illustrated in Figure 3.

Table 9 Summary of *E. coli* bacteriological water quality data (cfu/100ml) for all summer surveys at Lake Rotomanu to date

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum	3	12	7	7	1	31	9	20	<3	6	
Maximum	890	740	200	140	90	980	2200	5500	220	380	
Median	32	46	79	25	14	110	92	120	11	68	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	7	54	51	23	6	46	23	8	20	54	17
Maximum	3000	1200	6000	3600	150	2300	430	120	120	690	2200
Median	72	180	220	100	34	120	100	60	43	120	84

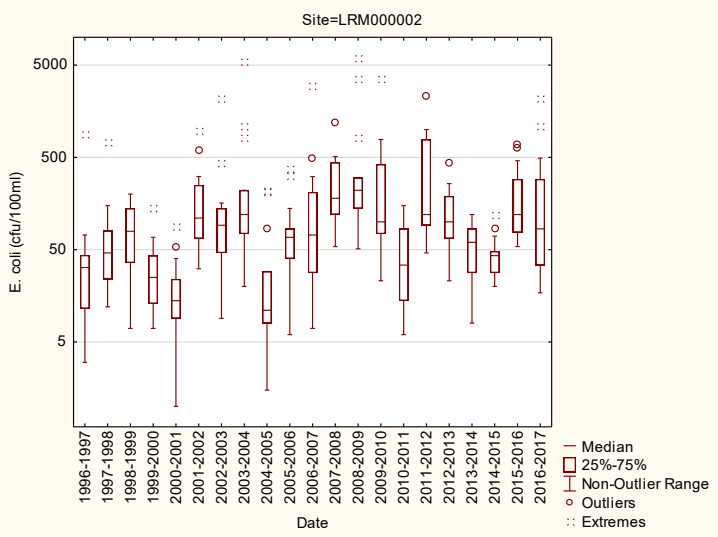
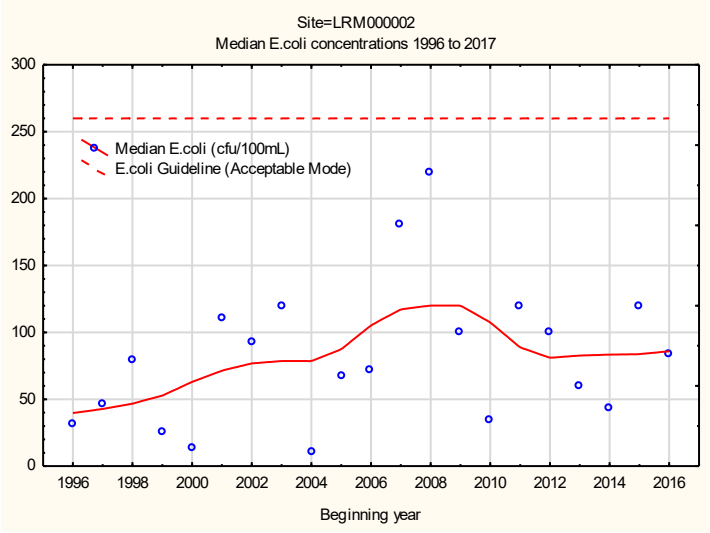


Figure 3 Box and whisker plots for all summer SEM surveys of *E. coli* bacteria numbers at Lake Rotomanu

The trend of moderately high median *E. coli* numbers in recent years re-occurred over the summer of 2016-2017, with a wide range of counts recorded by this survey. The median value and the maximum count were both near the middle of the range. However, the median value remained well below the 'Alert' level of the 2003 MfE guidelines.

Trend analysis of these median *E. coli* numbers has been performed for the twenty seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 4) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.



N = 21
Kendall Tau = +0.221
p level = 0.161 [>FDR, p = 0.456]
N/S at p < 0.05

Figure 4 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Lake Rotomanu for the 1996-2017 period

Overall, a positive trend, but not statistically significant or important increase in median *E. coli* numbers has been found over the twenty-one seasons of monitoring. None of these seasonal medians has exceeded the 'Alert' or 'Action' modes.

4.2.1.4 MfE guidelines additional sampling

For the purpose of MfE monitoring, twelve additional samples were collected at regular intervals under varying weather conditions during the survey season. Limited recreational use, some boating and jet-skiing, was noted on three of these occasions. Ducks were present in widely varying numbers on the lake, and a few gulls, on some but not all occasions. Four surveys occurred by chance during or shortly after wet weather.

The data from these additional surveys are presented in Table 10, and illustrated and statistically summarised (with the 13 SEM samples' data) in Figure 5 and Table 11 respectively.

Table 10 Lake Rotomanu additional twelve water quality samples' results

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
22.11.16	1030	10.0	20	4	20	18.4	12
15.12.16	1215	10.2	210	810	210	19.3	6.5
21.12.16	1015	10.6	1000	820	1000	21.6	14
28.12.16	0815	10.0	150	31	150	21.2	14
05.01.17	1035	9.9	410	92	410	20.5	12
09.01.17	1245	10.8	660	220	690	21.4	14
18.01.17	0910	11.0	200	68	210	22.0	10
26.01.17	1020	10.0	880	390	920	19.2	9.0
07.02.17	1040	9.8	290	66	300	22.4	9.1
21.02.17	1030	10.3	140	140	140	23.5	4.8
07.03.17	0920	11.0	66	19	68	21.5	6.5
20.03.17	1150	10.8	260	140	260	20.3	11

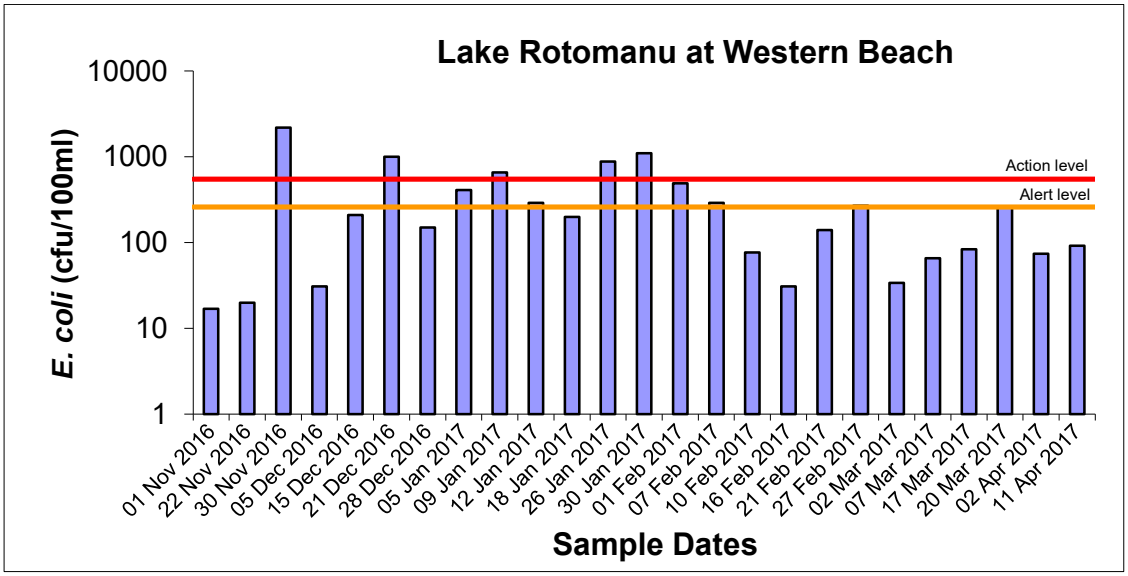


Figure 5 *E. coli* numbers for Lake Rotomanu for the 25-sample extended survey

Table 11 Summary statistics for SEM and additional samples at Lake Rotomanu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	25	9.8	11.3	10.3
E. coli	cfu/100ml	25	17	2200	200
Enterococci	cfu/100ml	25	<3	1200	91
Faecal coliforms	cfu/100ml	25	17	2400	210
Temperature	°C	25	17.8	24.4	21.2
Turbidity	NTU	25	3.1	14	9.0

The additional sampling resulted in a large increase (from 84 to 200 *E.coli* per 100 ml, or 240%) in the overall seasonal median bacteria number, possibly due to the proximity of wet weather on several of the sampling survey occasions. The median turbidity of the additional samples was higher (10 NTU) and the turbidity range wider (4.8 to 14 NTU) than for the standard SEM sampling surveys.

4.2.1.5 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 12.

Table 12 Bacterial guidelines performance at Lake Rotomanu [% of 25 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Simgle sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	5 [20]	5 [20]

(Designation: freshwater contact recreational area)

The number of exceedances of the single sample 'Alert' and 'Action' modes increased with the additional monitoring, as two additional exceedances of the 'Alert' level and three of the 'Action' level occurred. NPDC deployed health warning signs at four locations around the lake after each 'Action' level, once in December 2016 (for 7 days) and twice in January 2017 (for 7 and 4 days), which remained in place until a survey result below 'Action' level was reported.

4.2.1.6 Cyanobacteria

Planktonic cyanobacteria levels during the recreational monitoring year had a high degree of variability, with bio-volumes fluctuating between low and moderate levels, apart from one sample in early March which recorded a high bio-volume. Normally, Lakes Rotomanu, Ratapiko and Opunake are sampled on the same date and have the same number of sampling occasions (seven samples are scheduled) but due to public interest two additional samples were collected.

Planktonic cyanobacteria were monitored on nine occasions throughout the season with results presented in Table 13 and Figure 6.

Table 13 Cyanobacteria counts and biovolumes for Lake Rotomanu

Date	Cyanobacteria total cell count (cells/mL)	Biovolume (mm^3/L)	Principal species by biovolume	Mode
22/11/2016	4221	1.0	*Limnococcus*	Medium Risk
07/12/2016	0	0	No cyanobacteria	Low Risk
21/12/2016	9882	1.7	*Limnococcus*	Medium Risk
05/01/2017	4045	0.8	*Limnococcus*	Medium Risk
18/01/2017*	2302244	1.4	*Picocyanobacteria*	Medium Risk
26/01/2017	254141	0.5	*Limnococcus*	Low Risk
07/02/2017	919120	0.8	*Picocyanobacteria*	Medium Risk
07/03/2017	131808	2.8	*Microcystis*	High Risk
20/03/2017*	285699	0.3	*Limnococcus*	Low Risk

* Additional samples

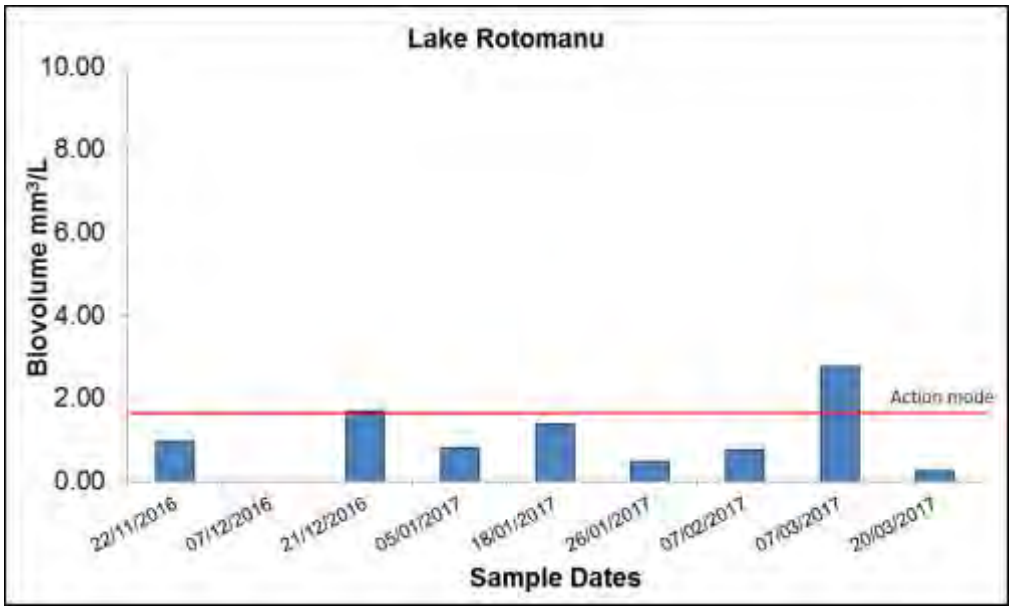


Figure 6 Cyanobacteria bio-volume at Lake Rotomanu

Following the high cyanobacteria bio-volume detected in March 2017, health warning signs were erected by NPDC at four locations around the lake, including the western beach and at the boat launching ramp, for about 10 days until the cyanobacteria bio-volume reduced to below 'Action' level.

4.2.2 Waiwhakaiho River at Merrilands Domain

4.2.2.1 SEM programme

Minimal usage of this site was recorded at the time of the sampling surveys, with bathing noted on two occasions. The dog-walking that was common in 2015-2016 was recorded only once. No birdlife was noted on any but one occasion, when a few ducks were observed downstream. The weather was overcast or drizzling on eight of the thirteen monitoring occasions.

The data for this site are presented in Table 14 and illustrated in Figure 7, with a statistical summary provided in Table 15. River flow information is illustrated in Figure 8. There were several freshes in mid-January (five between the 12th and the 25th) which precluded dry weather sampling.

Table 14 Analytical results for the Waiwhakaiho River at Merrilands Domain

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	0810	10.8	130	13	130	12.1	0.84
30.11.16	1320	10.3	150	13	160	13.8	0.46
05.12.16	1010	11.5	60	9	60	17.2	0.58
12.01.17	1230	12.7	57	12	57	19.7	0.64
30.01.17	1415	11.7	14	23	14	17.7	0.55
01.02.17	0845	12.0	130	92	130	17.2	0.48
10.02.17	1140	11.7	120	42	120	16.5	1.3
16.02.17	1000	12.1	160	60	160	16.8	0.41
27.02.17	1300	12.7	63	12	63	20.6	0.95
02.03.17	0900	13.2	27	5	27	18.2	0.7
17.03.17	0920	11.3	98	95	100	15.3	2.1
02.04.17	1010	12.0	40	23	40	16.8	0.72
11.04.17	1330	11.2	56	37	56	15.7	0.68

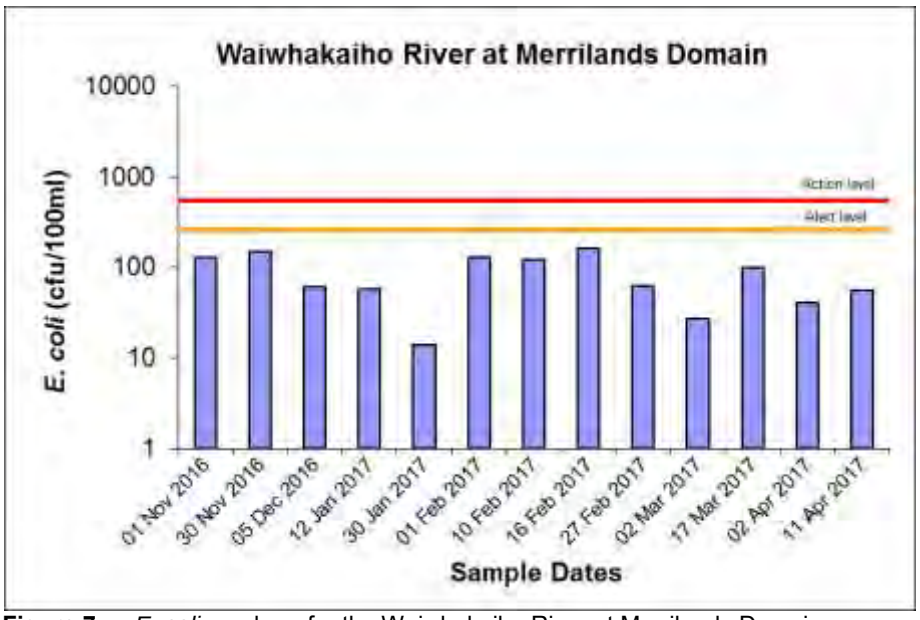


Figure 7 *E. coli* numbers for the Waiwhakaiho River at Merrilands Domain during the regular survey season

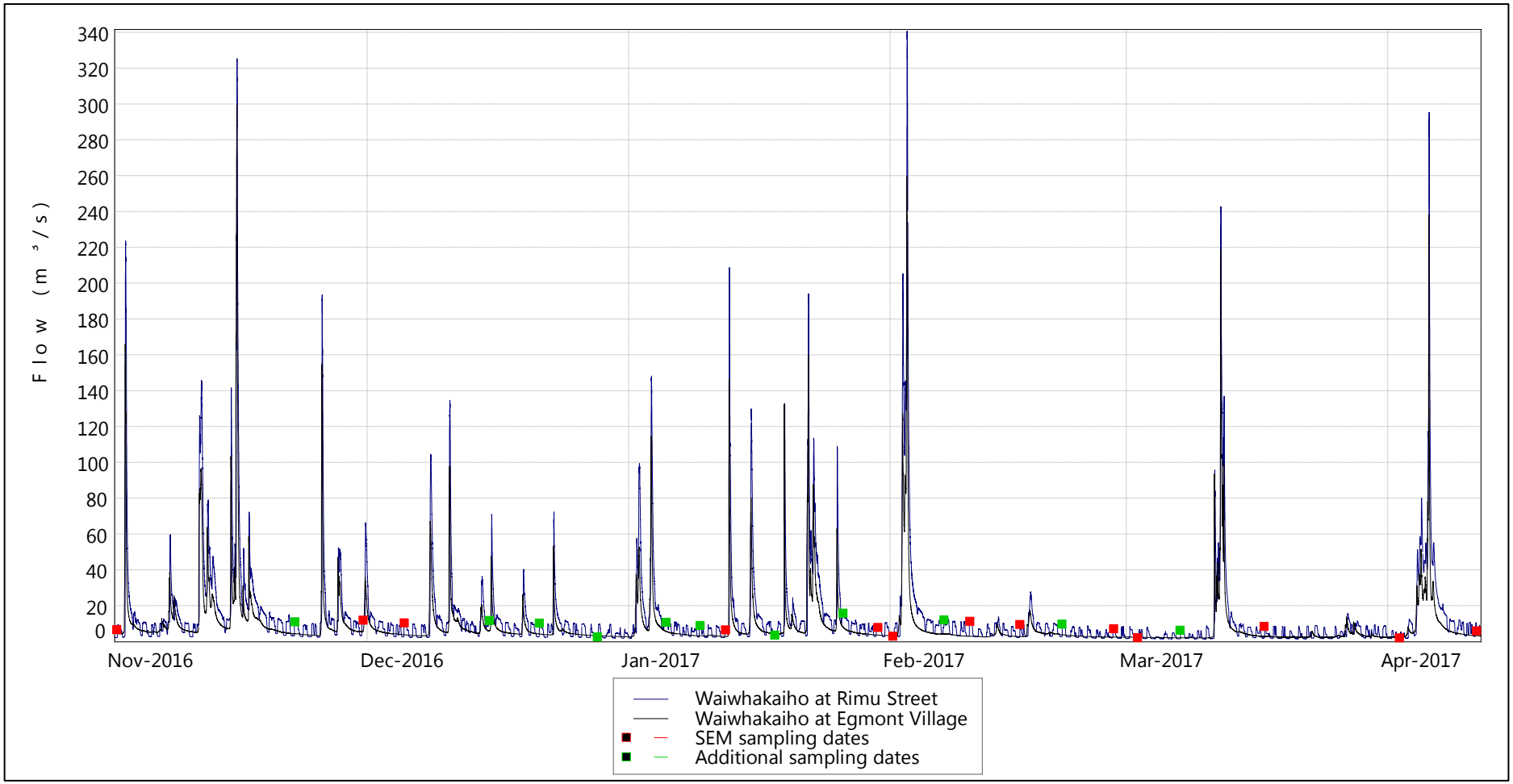


Figure 8 Flow in the Waiwhakaiho River during the survey period

Table 15 Statistical results summary for the Waiwhakaiho River at Merrilands Domain

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	10.3	13.2	11.7
E. coli	cfu/100ml	13	14	160	63
Enterococci	cfu/100ml	13	5	95	23
Faecal coliforms	cfu/100ml	13	14	160	63
Temperature	°C	13	12.1	20.6	16.8
Turbidity	NTU	13	0.4	2.1	0.7

This river drains an extensively developed farmland catchment prior to flowing through two kilometres of urban New Plymouth upstream of this popular domain and recreational area sited in the lower reaches of the river nearly 4 km from the sea.

Water temperatures varied over a moderate range of 8.5°C between early November and mid April, with a relatively low maximum of 20.6°C in early afternoon in late February 2017. Conductivity and turbidity results were indicative of very clean, clear, relatively high water quality, but moderate to widespread algal cover (up to 70% mats) was common throughout the period during flow recessions.

Considering the influence of agricultural activities, particularly dairying in the catchment, bacteriological water quality was relatively high. Bacterial numbers were not excessive, remaining within a relatively narrow range through the season with a maximum recorded *E.coli* count of 160 per 100 ml.

4.2.2.2 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 16.

Table 16 Bacterial guidelines performance at the Waiwhakaiho River Merrilands Domain site [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	0 [0]	0 [0]

(Designation: freshwater contact recreational area)

No single samples were recorded within the 'Action' mode or the 'Alert' mode during the season. Bacteriological water quality measured at this site was therefore within the 'Surveillance' mode for contact recreational usage for all sampling occasions during the survey period.

4.2.2.3 Comparison with previous summers' surveys

A statistical comparison of all of the summers' surveys data is presented graphically in Appendix VI for all sites. These data for the Waiwhakaiho River site are summarised in Table 17 and illustrated in Figure 9.

Table 17 Summary of *E. coli* bacteriological water quality data (cfu/100 ml) for all summer surveys in the Waiwhakaiho River at Merrilands domain to date

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum	16	16	26	8	6	17	3	34	11	15	
Maximum	970	1800	330	100	270	420	130	320	330	160	
Median	42	84	69	39	23	60	29	77	54	34	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	8	28	19	23	4	8	11	3	8	26	14
Maximum	510	110	110	570	200	120	3000	200	350	250	160
Median	48	48	46	110	54	40	52	51	37	63	63

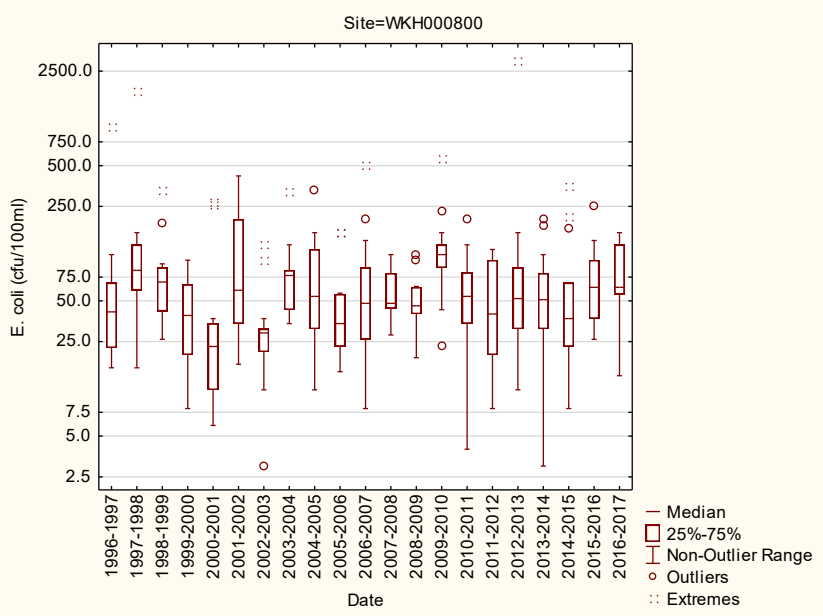


Figure 9 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers in the Waiwhakaiho River at Merrilands Domain

The median *E. coli* number in the 2016-2017 period was the same as for 2015-2016 and was slightly higher than most recorded to date, though was well below the maximum of the range of historical medians (Table 17 and Figure 9), all of which have been much lower than the 'Alert' level of the 2003 MfE guidelines.

Trend analysis of these median *E.coli* numbers has been performed for the twenty-one seasons of data by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 10) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

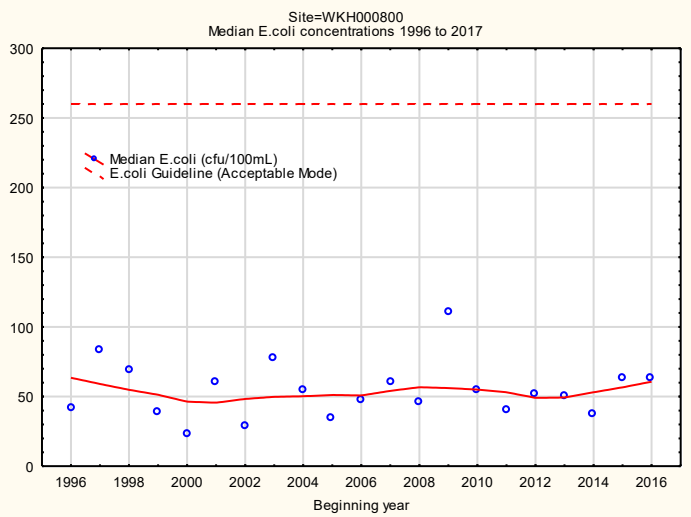


Figure 10 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Waiwhakaiho River, Merrilands Domain for the 1996 to 2017 period

A statistically insignificant and unimportant temporal trend of a minimal decrease in median *E.coli* numbers has been found over the twenty-one seasons of monitoring. None of these seasonal medians exceeded the 'Alert' or 'Action' modes.

4.2.2.4 MfE guidelines additional sampling

For the purpose of MfE monitoring, eleven additional samples were collected at regular intervals and under varying weather conditions (six of which by chance followed wet weather events during the previous five days) during the survey season.

Recreational activities noted included persons exercising (up to two) dogs on three occasions. Swimming was observed once. No birdlife was present, except for one duck on one occasion.

The data from these additional surveys are presented in Table 18, illustrated in Figure 11, and statistically summarised (together with the 13 SEM samples' data) in Table 19.

Table 18 Waiwhakaiho River at Merrilands Domain additional eleven water quality samples' results

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
22.11.16	1050	10.2	31	5	31	15.7	0.6
15.12.16	1225	9.1	3500	600	3900	14.8	1.2
21.12.16	1050	10.5	280	12	280	17.2	1.1
28.12.16	0745	10.7	66	8	66	16.2	0.7
05.01.17	1110	8.6	1000	92	1000	16.4	1.2
09.01.17	1210	11.5	51	24	54	16.8	0.7
18.01.17	0830	11.2	100	32	100	17.8	0.7
26.01.17	1100	9.0	2000	390	2100	16.2	1.4
07.02.17	1020	11.5	300	250	300	17.7	0.8
21.02.17	1000	11.8	220	150	230	18.7	0.8
07.03.17	0945	13.8	150	94	150	17.7	1.7

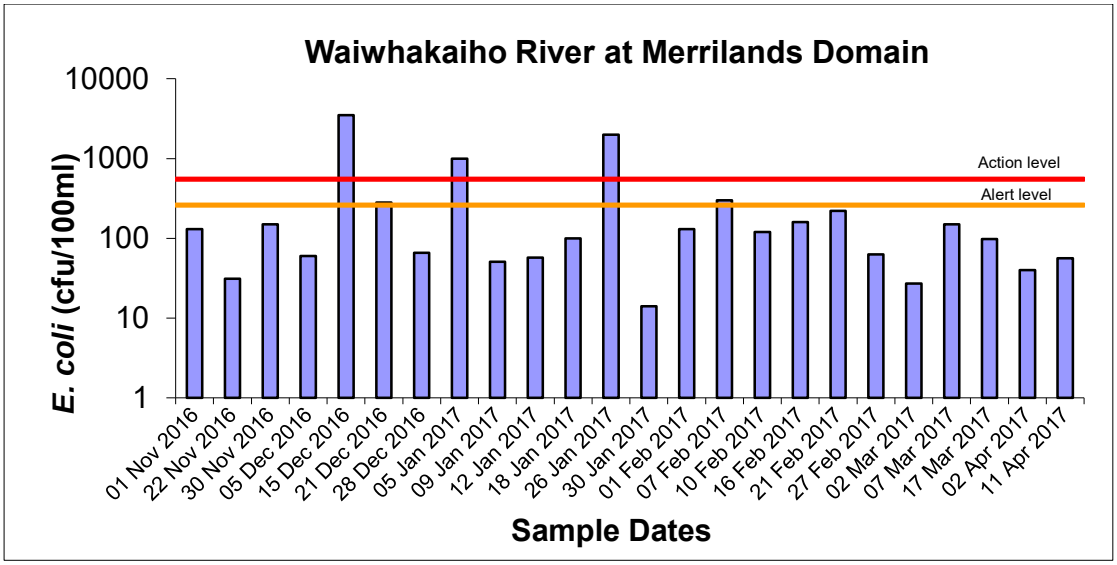


Figure 11 *E. coli* numbers for the Waiwhakaiho River at Merrilands Domain for the 24-sample extended survey

Table 19 Summary statistics for SEM and additional samples in the Waiwhakaiho River at Merrilands Domain

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	24	8.6	13.8	11.5
E. coli	cfu/100ml	24	14	3500	110
Enterococci	cfu/100ml	24	5	600	28
Faecal coliforms	/100ml	24	14	3900	110
Temperature	°C	24	12.1	20.6	16.8
Turbidity	NTU	24	0.4	2.1	0.7

These eleven additional samples resulted in a large (75%) increase in the seasonal median *E. coli* numbers in comparison with the regular SEM programme results (Table 15). Enterococci numbers also increased, by a lesser amount (22%). The ranges for all three bacteria species increased markedly due to elevated counts recorded throughout the monitoring period, under higher river flow conditions after recent wet weather (Figure 8).

4.2.2.5 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 20.

Table 20 Bacterial guidelines performance in the Waiwhakaiho River at Merrilands Domain [% of 24 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	2 [8]	3 [12]

(Designation: freshwater contact recreational area)

Three exceedances of the single sample 'Action' mode (550 *E. coli* per 100 ml) occurred after rainfall. Follow-up samples collected after the exceedances in the course of the SEM and additional sampling programmes found much lower counts which were within the guidelines. Health warning signage was displayed after the exceedances, irrespective of preceding weather conditions, until monitoring results were within the guidelines.

4.2.2.6 Benthic cyanobacteria

Benthic cyanobacteria were monitored on 14 occasions during the 2016-2017 season. Results are presented in Table 21 and illustrated in Figure 12.

Table 21 Percentage benthic cyanobacteria cover for the Waiwhakaiho River, at Merrilands Domain site

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
07/11/2016	8	No	Minor	Amber (Alert
18/11/2016	0	No	No	Green (surveillance)
24/11/2016	6	No	No	Green (surveillance)
12/12/2016	13	Minor	No	Amber (Alert)
21/12/2016	14	No	Minor	Amber (Alert)
05/01/2017	6	No	Minor	Amber (Alert)
12/01/2017	17	No	Minor	Amber (Alert)
18/01/2017	6	No	Minor	Amber (Alert)
26/01/2017	9	No	No	Green (surveillance)
07/02/2017	1	No	No	Green (surveillance)
27/02/2017	16	No	Minor	Amber (Alert)
09/03/2017	4	No	No	Green (surveillance)
16/03/2017	1	No	No	Green (surveillance)
30/03/2017	5	No	No	Green (surveillance)

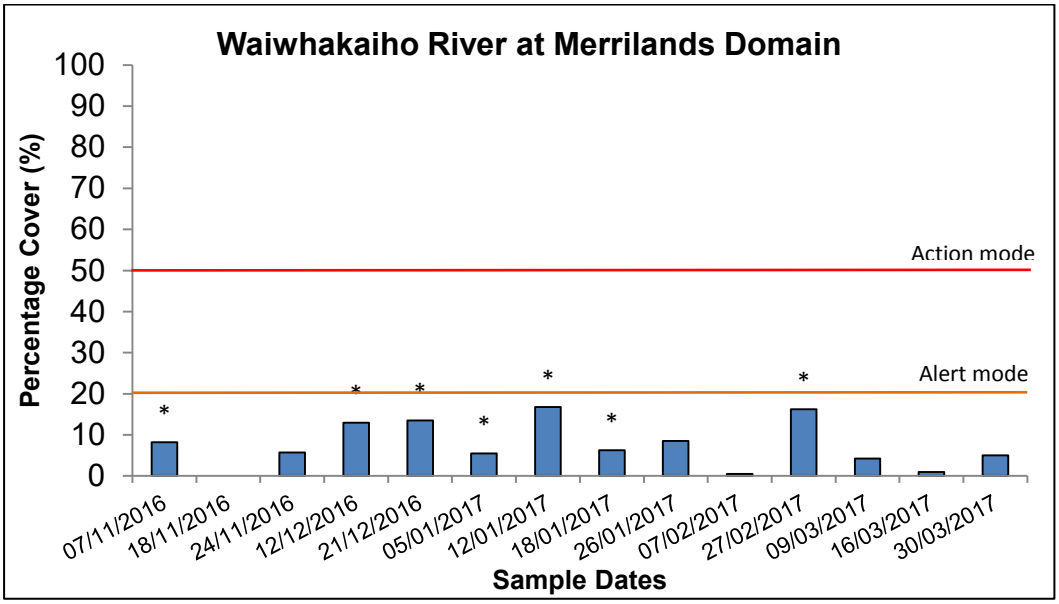


Figure 12 Percentage benthic cyanobacteria cover at the Waiwhakaiho River at Merrilands Domain site

Note that 'Action' and 'Alert' mode lines are for percentage cover only. The symbols * and $^{+}$ over a bar indicate where the status been raised to 'Alert' or 'Action' mode, respectively due to detaching or exposed mats.

Benthic cyanobacteria coverage was low at the start of the monitoring period and rose slightly during summer to moderate levels before decreasing during autumn (range from 0 to 17%). The benthic cyanobacteria found were a *Phormidium* sp. The 'Action' and 'Alert' levels were never exceeded for percentage cover. Detaching mats reached minor levels on one occasion which triggered the 'Alert' level. Minor levels of exposed mats were visible on six occasions which triggered the 'Alert' level. In total the 'Alert' level was triggered on seven occasions.

Photos 2 and 3 Exposed cyanobacteria mats, Waiwhakaiho River at Merrilands Domain

The cause of the high number of exposed mats (Photos 1 and 2) when the cover percentage was moderately low can be attributed to the daily fluctuations in flow caused by consented releases from the upstream Mangorei hydro electric power scheme. When the hydro scheme was not releasing water (e.g. in early morning), river levels were low and mats were exposed. The mats were present on the top of boulders so that no cyanobacteria were immersed in water during these low flows. Higher flows would inundate the top of the boulders and thus stop the cyanobacteria from drying out. It appeared that other algae (green algae and diatoms) could not compete with the *Phormidium* sp. under this hydrological regime. The problem was not as severe as in the 2014-2015 monitoring period, when exposed mats were present throughout the mid and latter part of the monitoring period.

4.2.3 Waiwhakaiho River adjacent to Lake Rotomanu

Photo 4 A typical gull population immediately upstream of the Waiwhakaiho River, Lake Rotomanu site

Minor usage of this site was recorded at the time of the sampling surveys, with some whitebaiting (in season) and dog-walking on the banks of the river. Seagulls (extremely abundant) were frequently present at this site with large numbers of gulls present along the lower reaches of the river upstream of this site (Photo 3). Ducks were present on three occasions.

The data for this site are presented in Table 22 and illustrated in Figure 13, with a statistical summary provided in Table 23. River flow information is illustrated in Figure 8 as it is also applicable to this site.

Table 22 Analytical results for the Waiwhakaiho River adjacent to Lake Rotomanu

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	0840	10.6	200	28	200	14.2	0.8
30.11.16	1215	10.2	250	130	260	14.4	0.5
05.12.16	1035	11.2	250	77	250	18.6	0.6
12.01.17	1130	12.2	560	270	740	21.4	2.4
30.01.17	1320	11.7	1100	500	1100	18.0	0.6
01.02.17	0920	12.0	470	280	480	17.6	0.6
10.02.17	1045	11.7	750	710	780	16.3	1.2
16.02.17	1025	11.5	1600	1400	1700	17.3	0.5
27.02.17	1230	12.9	1900	1700	2500	20.1	1.0
02.03.17	0935	13.9	900	500	970	19.8	1.1
17.03.17	1000	11.2	1900	480	1900	16.6	0.9
02.04.17	0950	12.8	270	100	290	17.5	0.5
11.04.17	1145	11.6	610	200	620	15.8	0.7

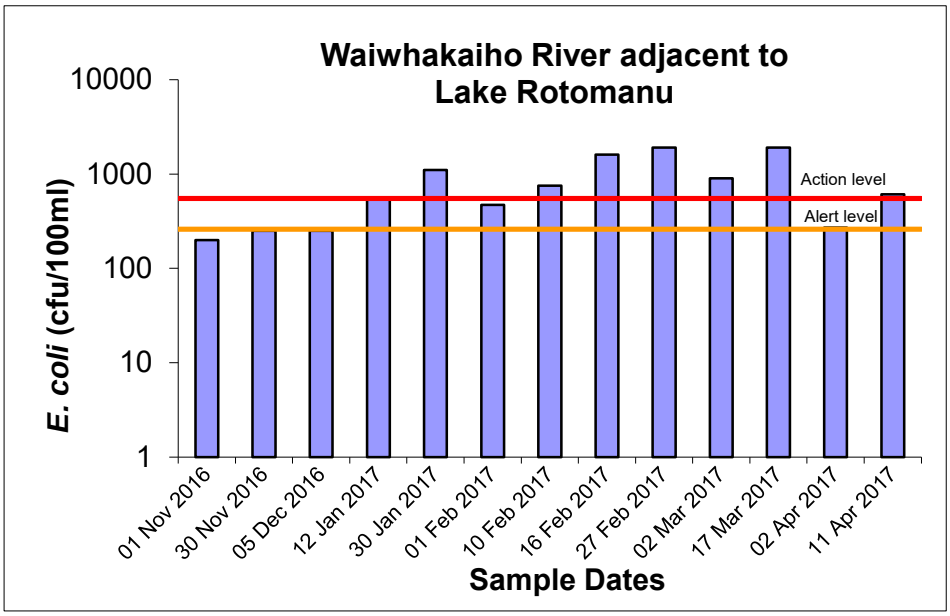


Figure 13 *E. coli* numbers for the Waiwhakaiho River adjacent to Lake Rotomanu during the regular survey season

Table 23 Statistical results summary for the Waiwhakaiho River adjacent to Lake Rotomanu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	10.2	13.9	11.8
E. coli	cfu/100ml	13	200	1900	610
Enterococci	cfu/100ml	13	28	1700	280
Faecal coliforms	cfu/100ml	13	200	2500	740
Temperature	°C	13	14.2	21.4	17.5
Turbidity	NTU	13	0.5	2.4	0.7

This river drains an extensively developed farmland catchment prior to flowing through six kilometres of urban New Plymouth upstream of this popular recreational area sited in the lower reaches of the river about 700m from the sea. Large flocks of seagulls are known to roost on the river bed in the lower reaches between Merrilands and this site near the more recently constructed walkway bridge.

[Note: During the 2011-2012 period (TRC, 2012) faecal source DNA tracking marker analyses found that the Merrilands Domain samples contained bacteria only indicative of ruminants origin on one occasion and of ruminants and wildfowl origin on another occasion. However, samples from the lower river site (adjacent to Lake Rotomanu) were found to contain bacteria very specifically of gull origin on both occasions and a faint indication of ruminants origin on the latter sampling occasion. No bacteria of human origin were found at either site on either sampling occasion.]

In the current survey period, water temperatures varied over a moderate range of 7.2˚C between early November and mid April, with a maximum of 21.4˚C in mid January 2017. Conductivity and turbidity results were indicative of clean, clear, relatively high water quality, but significant algal cover (mainly moderate to widespread mats) was noted through the majority of the period. There were no instances of partial seawater ingress during the period.

Bacteriological water quality was poor with numbers varying over very wide ranges with a high median *E. coli* value of 610 per 100 ml, particularly in comparison with numbers found at the upstream Merrilands Domain site (median: 63 per 100ml; maximum: 160 per 100ml). Individual sample *E.coli* counts exceeded 290 per 100 ml on all but three occasions, coincident with the presence of large gull populations. The marked river flow fluctuations due to increased morning HEP generation could be expected to exacerbate wildfowl (gull) faecal contamination by inundation of river shingle areas where birds roost during lower flow periods. No follow-up surveys were deemed necessary as the cause of elevated counts (in the 'Action' mode) had been well documented, and permanent public warning signage was in place.

4.2.3.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 24.

Table 24 Bacterial guidelines performance at the Waiwhakaiho River adjacent to Lake Rotomanu site [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	2 [15]	8 [62]

(Designation: freshwater contact recreational area)

Eight single samples were recorded within the 'Action' mode and two samples in the 'Alert' mode during the season. Bacteriological water quality measured at this site was seldom within the acceptable standard for contact recreational usage through the survey period and therefore appropriate warning signage was required at this site adjacent to the walkway throughout the survey period (Photo 4). Appropriately worded signage should be retained on a permanent basis in future.

Photo 5 Health risk signage, lower Waiwhakaiho River

4.2.3.2 Comparison with previous summers' surveys

A statistical comparison of all summers' surveys data is presented graphically in Appendix VI for all sites [Note: These data had been collected prior to the current year from time to time for consent monitoring purposes]. These data for the site in the Waiwhakaiho River adjacent to Lake Rotomanu are summarised in Table 25 and illustrated in Figure 14.

Table 25 Summary of *E. coli* bacteriological water quality data (cfu/100ml) for all summer surveys in the Waiwhakaiho River adjacent to Lake Rotomanu

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum	9	-	52		26		54		46		
Maximum	740	-	510		870		470		1000		
Median	72	-	120		110		210		270		
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	71		160		220	77	230	210	46	230	200
Maximum	1600		2600		3400	2000	5000	2200	7400	2600	1900
Median	320		490		880	460	1100	650	1000	870	610

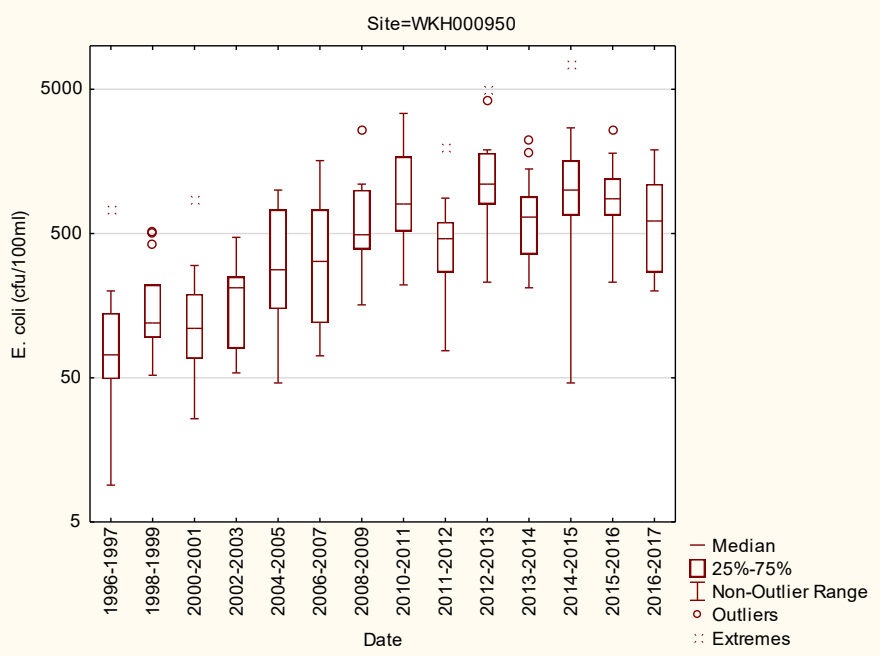
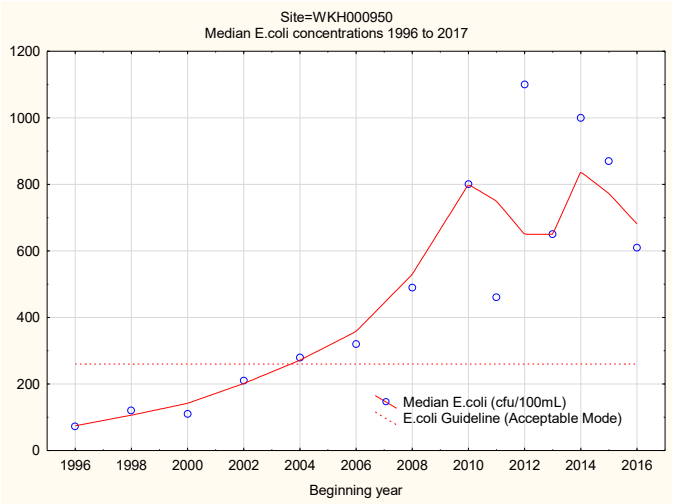


Figure 14 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers in the Waiwhakaiho River adjacent to Lake Rotomanu

The median *E.coli* number in the 2016-2017 period was the fifth highest recorded to date, maintaining a trend of high medians in more recent years (Table 25 and Figure 14). Most medians had been below the 'Action' level of the 2003 MfE guidelines, but since 2003-2004 all medians have been within, or exceeded the 'Alert' level, with the latest five medians in excess of the 'Action' guideline. The minimum *E. coli* number in 2016-2017 was the fifth highest recorded, indicating a high baseline.

Trend analysis of these median *E.coli* numbers has been performed for the fourteen seasons of data by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 15). Testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discover Rate (FDR) analysis has been performed.



N = 14
Kendall Tau = +0.714
p level = 0.0004 [FDR, p = 0.0032]
Significant at p < 0.01 after FDR

Figure 15 LOWESS trend plot of median *E.coli* numbers (per 100 ml) at the Waiwhakaiho River, adjacent to Lake Rotomanu for the 1996 to 2017 period

There has been a very significant trend ($p << 0.01$) of increasing median *E.coli* numbers over the fourteen seasons of monitoring, which is of importance given that four of these more recent seasonal medians have exceeded the 'Alert' mode and another six are within the 'Action' mode.

4.2.3.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on 15 occasions throughout the season. Results are presented in Table 26 and illustrated in Figure 16.

Table 26 Percentage benthic cyanobacteria cover for the Waiwhakaiho River adjacent to Lake Rotomanu site

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
07/11/2016	2	No	Minor	Amber (Alert)
18/11/2016	0	No	No	Green (surveillance)
24/11/2016	12	No	No	Green (surveillance)
12/12/2016	6	Minor	No	Amber (Alert)
21/12/2016	8	No	Minor	Amber (Alert)
05/01/2017	0	No	Minor	Amber (Alert)
12/01/2017	2	No	Minor	Amber (Alert)
18/01/2017	6	No	Minor	Amber (Alert)
26/01/2017	4	No	No	Green (surveillance)
07/02/2017	1	No	No	Green (surveillance)
27/02/2017	6	No	Minor	Amber (Alert))
09/03/2017	6	No	No	Green (surveillance)
16/03/2017	1	No	Minor	Amber (Alert)
24/03/2017	3	No	No	Green (surveillance)
30/03/2017	2	No	No	Green (surveillance)

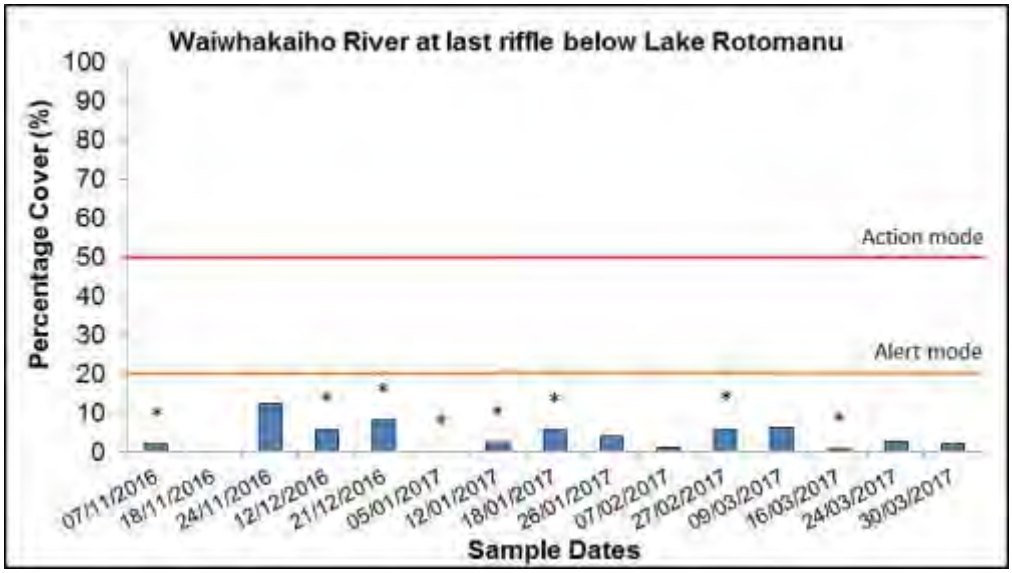


Figure 16 Percentage benthic cyanobacteria cover at the Waiwhakaiho River adjacent to Lake Rotomanu site

Note that 'Action' and 'Alert' mode lines are for percentage cover only. The symbols * and $^{+}$ over a bar indicate where the status been raised to 'Alert' or 'Action' mode, respectively due to detaching or exposed mats.

Benthic cyanobacteria coverage was generally low throughout the season with only one occasion where it exceeded 10% (range from 0 to 12%). The benthic cyanobacteria found were a *Phormidium* sp. The 'Action' or 'Alert' level was never exceeded for percentage cover. However, detaching mats reached minor levels on one occasion, which triggered the 'Alert' level. Minor levels of exposed mats were visible on seven occasions which triggered the 'Alert' level. In total, the 'Alert' level was triggered on eight occasions.

4.2.4 Te Henui Stream at the mouth, East End

Low usage of this site was recorded at the time of the sampling surveys, with no bathing noted. The adjacent playground was being used on one occasion, and one or two persons on the banks or bridge on four occasions. This contrasted with walking, picnicking, fishing, or whitebaiting (in season) from the banks of the stream in many past seasons.

Ducks were common at this site on most survey occasions and gulls also were present, where they have been encouraged by people feeding the birdlife.

The data for this site are presented in Table 27 and illustrated in Figure 17, with a statistical summary provided in Table 28.

Table 27 Analytical results for the Te Henui Stream at the mouth, East End

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1010	18.2	720	77	720	12.5	0.4
30.11.16	1125	9.1	870	53	870	14.2	0.4
05.12.16	1150	10.1	520	270	520	17.0	0.4
12.01.17	1020	345	5700	3100	6000	18.1	0.8
30.01.17	1220	54.1	770	460	770	17.4	0.7
01.02.17	1315	54.7	1500	1300	1700	17.1	0.7
10.02.17	0950	73.8	1400	1300	1500	15.0	0.6
16.02.17	1205	10.5	630	640	660	16.3	0.7
27.02.17	1045	1240	1200	930	1200	17.6	1.5
02.03.17	1100	587	1100	1100	1100	18.2	1.2
17.03.17	1105	14.5	860	500	880	15.4	0.5
02.04.17	1325	52.9	1500	1200	1500	17.1	1.2
11.04.17	1050	81.9	1100	540	1100	15.0	0.7

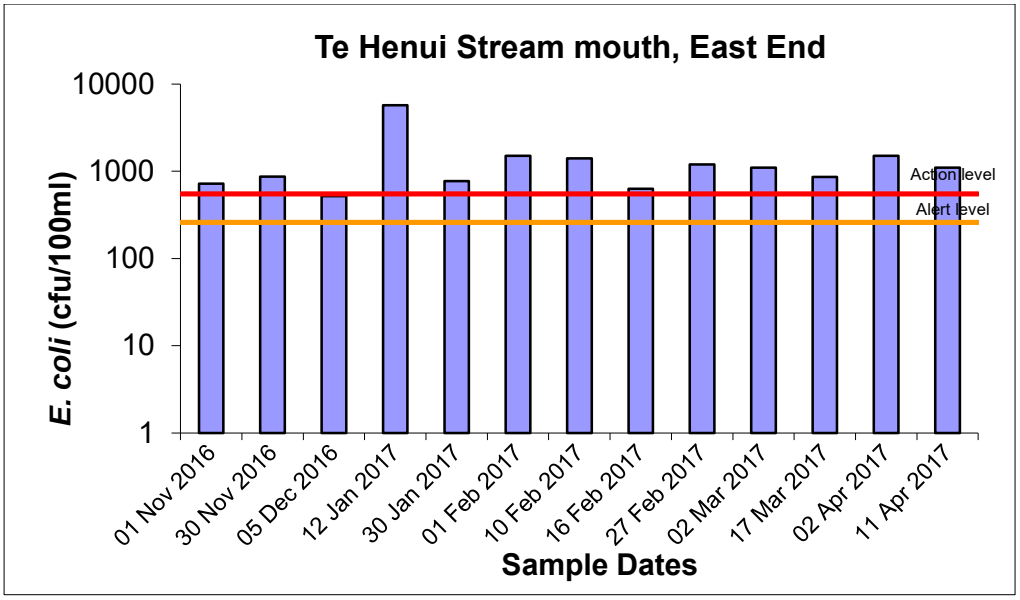


Figure 17 *E.coli* numbers for the Te Henui Stream at the mouth, East End during the regular survey season

Table 28 Statistical results summary for the Te Henui Stream at the mouth, East End

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	9.1	1240	54.1
E. coli	cfu/100ml	13	520	5700	1100
Enterococci	cfu/100ml	13	53	3100	640
Faecal coliforms	cfu/100ml	13	520	6000	1100
Temperature	°C	13	12.5	18.2	17.0
Turbidity	NTU	13	0.4	1.5	0.7

The stream drains an extensively developed farmland catchment prior to flowing through urban New Plymouth upstream of this popular recreational area sited in the lower reaches of the stream at the coast adjacent to the walkway. Poor historical bacteriological quality, considered to be attributable mainly to wildfowl, resulted in two low tide and two high tide surveys' samples in the 2011-2012 season being forwarded to Cawthron Institute, Nelson for faecal source DNA tracking marker analyses. The initial low tide sample (which followed wet weather) contained bacteria of ruminant, gulls, and human origins while the second low tide, fine weather sample's bacteria were of ruminant, wildfowl, and human origins. The high tide, fine weather samples both contained bacteria with slight traces of ruminant origin, while only the second sample's bacteria were of wildfowl, and human origins. While wildfowl, gull, and ruminant derived bacteria might have been expected in the lower reaches of this stream, the presence of bacteria from human origin warranted further investigation (which was discussed and initiated with the Taranaki Area Health Board and New Plymouth District Council). No further incidents of human markers were found at this site near the mouth of the stream nor at several sites upstream and into the rural reaches.

In the current season water temperatures varied over a relatively narrow range of 3.7˚C between early November and mid April, with a low maximum of 18.2˚C in late morning in early March 2017. Conductivity and turbidity results were indicative of

clean, clear, relatively high water quality, subject to tidal incursions of seawater from time to time. The water often appeared green, as a result of extensive algal cover.

Bacterial water quality in the 2016-2017 season was very poor with a wide range of counts and very high median *E. coli* count of 1,100 per 100 ml and a relatively high minimum count.

4.2.4.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 29.

Table 29 Bacterial guidelines performance at the Te Henui Stream mouth, East End

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	1 [8]	12 [92]

(Designation: freshwater contact recreational area)

Only one single sample was recorded below the 'Action' mode during the season, which was at 'Alert' level. Bacteriological water quality measured at this site therefore was outside the acceptable standard for contact recreational usage on 92% of monitoring occasions. No additional sampling surveys were required as the source of these elevated counts was well established and documented. Appropriate signage therefore was required at this site adjacent to the New Plymouth walkway throughout the survey period and was the subject of periodic public enquiries. The coastal bathing waters monitored nearby at East End beach met the enterococci guidelines on all occasions during the season (that is, no occurrences within the 'Action' level). Minimal impact of the stream on the coastal East End beach water quality was indicated by the median *E.coli* number (17 per 100 ml) for the SEM season (TRC, 2017).

4.2.4.2 Comparison with previous summers' surveys

A statistical comparison of fifteen summer's surveys data is presented graphically in Appendix VI for all sites. [Note: prior to the 2011-2012 season these data had been collected to provide interpretative information for nearby coastal beach monitoring data]. The data for the Te Henui Stream site are summarised in Table 30 and illustrated in Figure 18.

Table 30 Summary of *E.coli* bacteriological water quality data (cfu/100 ml) for all summer surveys in the Te Henui Stream at the mouth, East End

Summer	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17
Minimum	150	160	220	260	220	240	550	500	69	350	300	250	250	340	520
Maximum	2600	8700	51000	9300	5200	2500	7700	3400	6800	13000	4200	7900	3400	5500	5700
Median	410	415	890	750	1100	1100	1100	930	985	1100	1500	1000	1300	930	1100

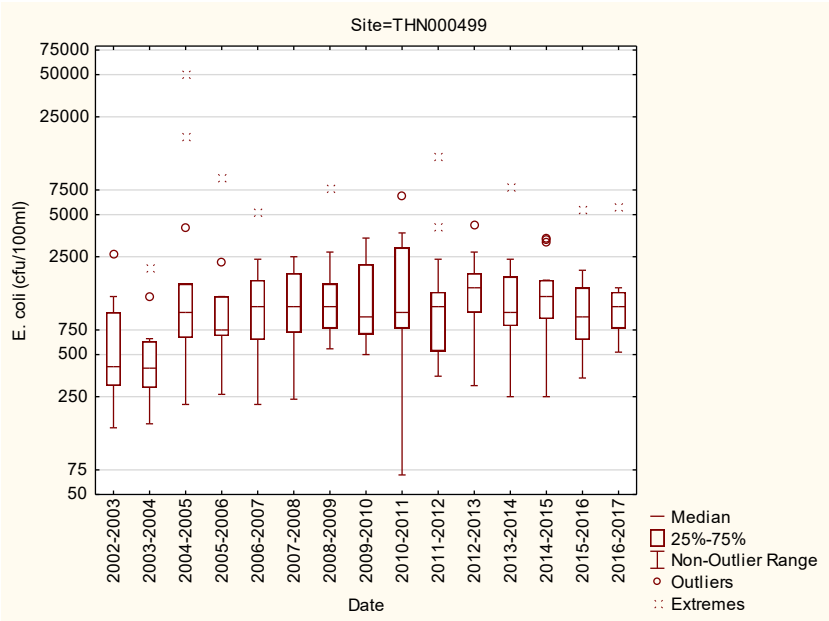
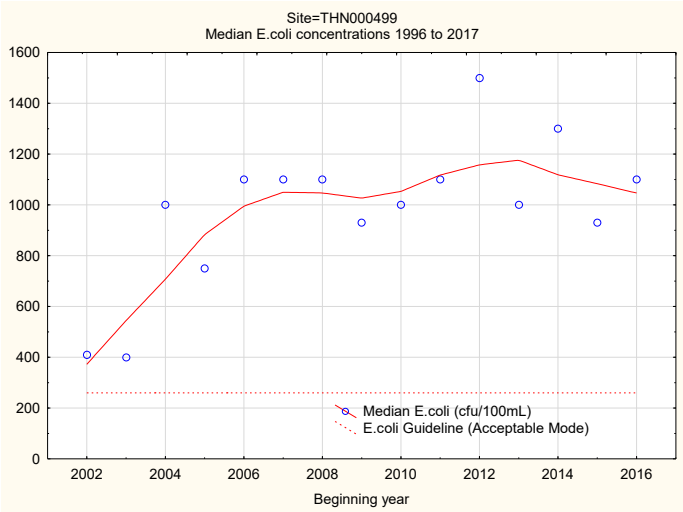


Figure 18 Box and whisker plots for all summer SEM surveys of *E. coli* bacteria numbers in the Te Henui Stream at the mouth, East End

The median *E. coli* number in the 2016-2017 period was typical of the medians recorded over the last 14 seasons (Table 30 and Figure 18), and well above the 'Alert' level of the 2003 MfE guidelines. All but the first two of the 15 median numbers to date have also been in the 'Action' level. A wide range of numbers has also been typical for this site.

Trend analysis of these median *E.coli* numbers has been performed for the fifteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 19) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.



N = 15
Kendall Tau = + 0.399
p level = 0.038 [>FDR, p = 0.216]
Not significant at p < 0.05 after FDR

Figure 19 LOWESS trend plot of median *E.coli* numbers (per 100 ml) at the Te Henui Stream mouth, East End for the 1996 to 2017 period

A temporal trend of increasing median *E. coli* numbers has been found over the fifteen seasons of monitoring. (Note: This trend was statistically significant at $p < 0.05$ but not after FDR analysis, the p level being 0.038, increasing to 0.216 after FDR correction). Only two of these seasonal medians were within the 'Alert' mode with all others exceeding the 'Action' mode.

4.2.4.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on ten occasions during the season. Results are presented in Table 31 and Figure 20.

Table 31 Percentage benthic cyanobacteria cover for the Te Henui Stream at the mouth, East End

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
07/11/2016	0	No	No	Green (surveillance)
24/11/2016	0	No	No	Green (surveillance)
12/12/2016	0	No	No	Green (surveillance)
21/12/2016	0	No	No	Green (surveillance)
05/01/2017	0	No	No	Green (surveillance)
18/01/2017	0	No	No	Green (surveillance)
07/02/2017	0	No	No	Green (surveillance)
27/02/2017	0	No	No	Green (surveillance)
16/03/2017	2	No	No	Green (surveillance)
30/03/2017	0	No	No	Green (surveillance)

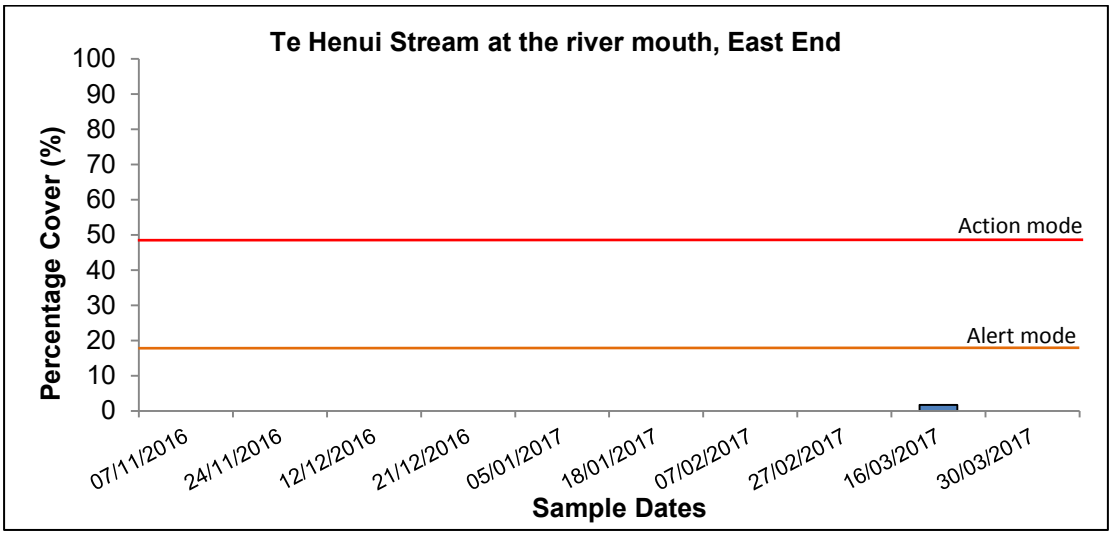


Figure 20 Percentage benthic cyanobacteria cover, at the Te Henui Stream at the mouth, East End site

Benthic cyanobacteria coverage was low throughout the season (ranging from 0% to 2%). The benthic cyanobacteria found were a *Phormidium* sp. The 'Action' or 'Alert' level was never exceeded for percentage cover nor for the presence of exposed or detaching mats and therefore no action at the site was required.

4.2.5 Patea River at King Edward Park, Stratford

Recreational usage of this river site was recorded at the time of one of the sampling surveys (dog walking). No bathing was noted, possibly as cool water temperatures and mostly overcast weather occurred throughout the surveys. A school group was studying life in the river at the time of the mid February 2017 survey.

One or more ducks were observed on the water on two monitoring occasions in March 2017.

Data from the site are presented in Table 32 and illustrated in Figure 22 with a statistical summary provided in Table 33. River flow records are illustrated in Figure 22.

Table 32 Analytical results for the Patea River at Kind Edward Park, Stratford

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1240	8.5	80	7	80	11.8	0.7
30.11.16	1245	8.2	220	17	220	13.8	0.7
05.12.16	1025	8.9	670	100	700	14.0	0.7
12.01.17	1115	8.7	220	46	240	16.1	0.7
30.01.17	0805	8.9	210	110	230	13.3	0.7
01.02.17	0850	9.6	320	120	340	15.1	0.8
10.02.17	1215	8.6	220	70	230	13.3	0.8
16.02.17	1005	9.3	220	120	240	13.5	0.8
27.02.17	1205	9.3	320	190	330	16.7	0.6
02.03.17	0910	9.7	460	280	480	14.4	0.7
17.03.17	0920	8.8	350	240	350	12.9	0.8
02.04.17	1010	9.3	480	420	490	14.3	0.7
11.04.17	1315	9.2	180	180	190	13.9	0.8

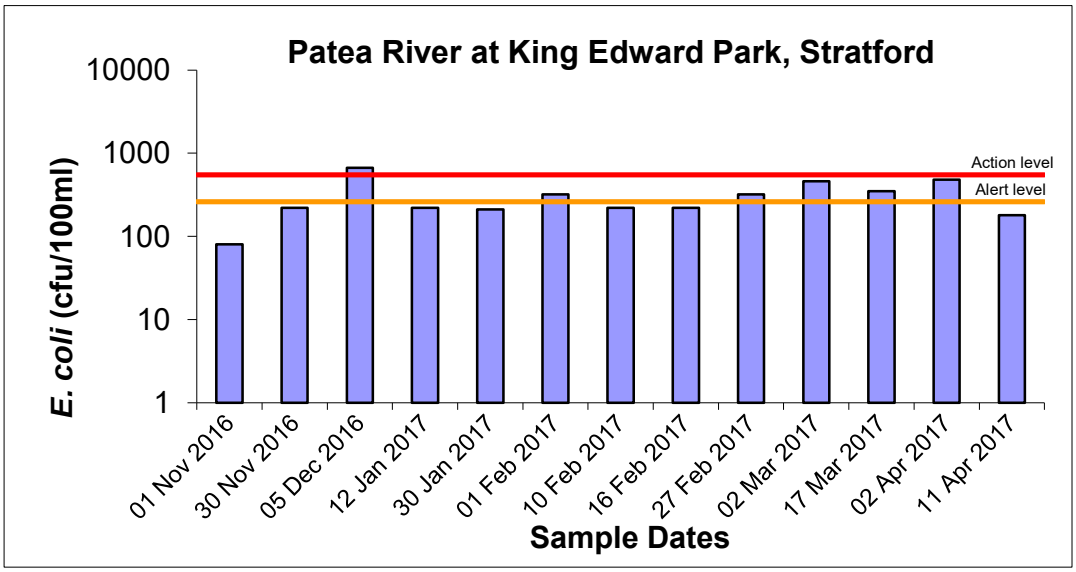


Figure 21 *E. coli* numbers for the Patea River at King Edward Park, Stratford during the survey season

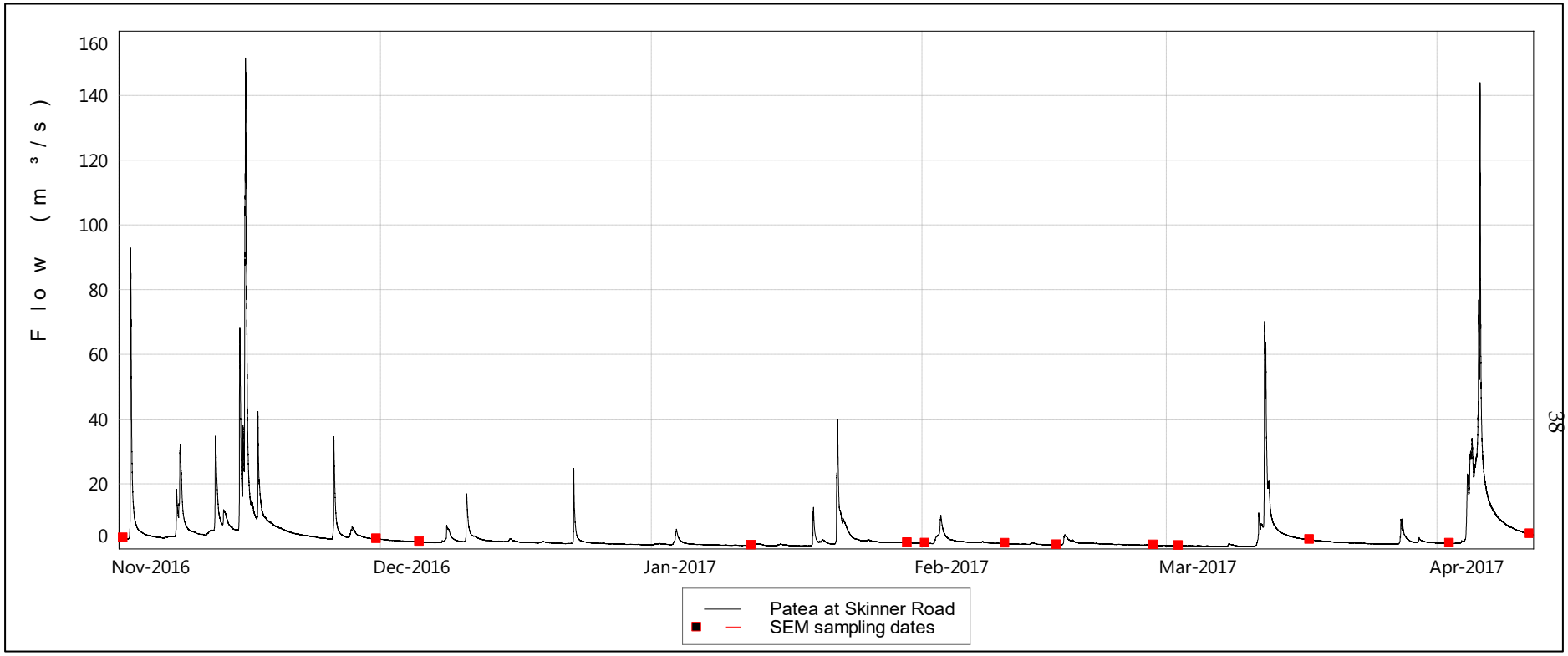


Figure 22 Flow in the Patea River at Skinner Rd during the survey period

Table 33 Statistical results summary for the Patea River at King Edward Park, Stratford

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	8.2	9.7	8.9
E. coli	cfu/100ml	13	80	670	220
Enterococci	cfu/100ml	13	7	420	120
Faecal coliforms	cfu/100ml	13	80	700	240
Temperature	°C	13	11.8	16.7	13.9
Turbidity	NTU	13	0.6	0.8	0.7

This ring plain river drains a developed agricultural catchment. The survey site is situated within King Edward Park in Stratford township, approximately 11 km downstream of the National Park boundary, with several consented dairy ponds' treated wastes discharges in the catchment upstream of the site. River water was generally relatively clear (turbidity of ≤ 0.8 NTU on all occasions) and uncoloured or green or green-brown in appearance with a relatively low and narrow range of conductivity levels.

Water temperatures had a narrow range of 4.9°C for this site (at an elevation of 300 m asl), with a maximum of 16.7°C recorded in late February 2017 (at 1205 hrs). All the samples were collected before 1320 hours and therefore the maximum water temperatures (which tend to occur later in the afternoon) which this site might experience over summer were not recorded.

Bacteriological water quality was moderate to poor for the mid reaches of this Taranaki ring plain river draining a predominantly agricultural catchment. Three moderately high counts were recorded during the survey period. One count exceeded the 'Action' level, in early December, and a health warning sign (Photo 6) was erected immediately by Stratford District Council. A follow-up sample was taken on 7 December 2016, which returned a count at 'Alert' level (440 *E.coli*/100ml). It rained shortly afterwards. After consultation with the TDHB, the warning sign was removed before the annual 'Take a Kid Fishing' promotion on 10 December.

It has been apparent that higher counts have been coincidental with earlier (morning) surveys, indicative of the probable cumulative influence of dairy pond system discharges further upstream. In some previous seasons' surveys it has been necessary to re-inspect a number of dairy farms' disposal systems in smaller upstream catchments, and on several occasions issue abatement notices for non-compliance with consented disposal requirement.

Photo 6 Warning signage at King Edward Park site, 7 December 2016

In 2016-2017, Council had prepared to investigate of the source of high baseline *E. coli*, through DNA faecal source tracking marker analysis. (Refer to recommendation 6 of report TRC16-01). It was planned to take a series of samples at the site through the day, once the routine indicator monitoring showed the presence of an unacceptable high bacterial level in dry weather. However, other than one instance in early December 2016, that was followed by rainfall, action level counts did not occur.

4.2.5.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 34.

Table 34 Bacterial guidelines performance at the Patea River at King Edward Park, Stratford site [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	5 [38]	1 [8]

(Designation: freshwater contact recreational area)

One single sample fell within the 'Action' mode, and another five samples fell in the 'Alert' mode. These counts occurred between early December 2016 and early April 2017, in mid- morning to early afternoon. In terms of the guidelines for contact recreational usage, bacteriological water quality at this site was outside the acceptable level occasionally during the period, with one incursion into the 'Action' level.

4.2.5.2 Comparison with previous summers' surveys

A statistical comparison of all of the summers' survey data is presented graphically in Appendix VI for all sites. A shorter data period (sixteen years) exists for the Patea River (at King Edward Park, Stratford) site which was added to the programme in 2001-2002. These summer data for the Patea River at King Edward Park, Stratford site are summarised in Table 35 and illustrated in Figure 23.

Table 35 Summary *E. coli* bacteriological water quality data (cfu/100 ml) all summer surveys in the Patea River at King Edward Park, Stratford

Summer						2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum						46	120	48	96	100	
Maximum						640	780	580	760	840	
Median						250	190	110	300	310	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	28	46	51	51	54	63	37	62	110	88	80
Maximum	100	690	570	7400	610	440	330	550	760	640	670
Median	200	290	200	250	160	150	180	240	280	200	220

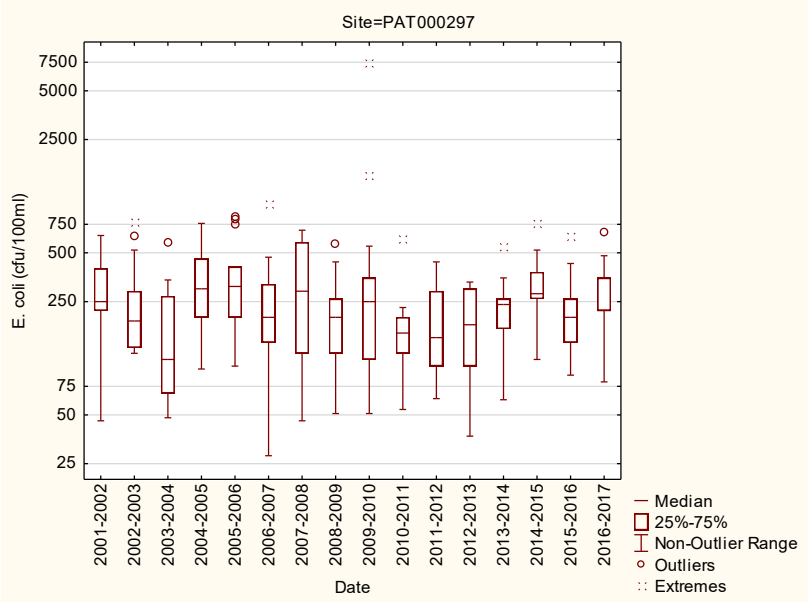
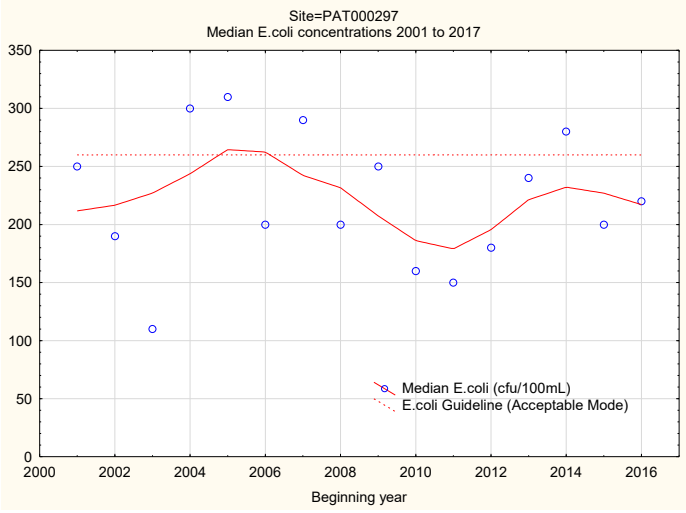


Figure 23 Box & whisker plots for all summer surveys of *E.* coli bacterial numbers for the Patea River at King Edward Park, Stratford

The median *E.* coli number in the 2016-2017 period was typical of the seasonal values recorded for this site. The range of counts was relatively narrow, and the lower 25 percentile value was relatively high.

Trend analysis of these median *E.coli* numbers has been performed for the sixteen seasons of data by first applying LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 24) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.



N = 16
Kendall Tau = - 0.068
p level = 0.714 [>FDR, p = 0.875]
N/S at p < 0.05

Figure 24 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Patea River, King Edward Park site, for the 2001-2017 period

A statistically insignificant temporal trend of decreasing median *E.coli* numbers has been found over the sixteen monitoring seasons. Four of these seasonal medians exceeded the 'Alert' mode but none has exceeded the 'Action' mode.

4.2.5.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on ten occasions during the season. Results are presented in Table 36 and Figure 25.

Table 36 Percentage benthic cyanobacteria cover for the Patea River at King Edward Park, Stratford

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
09/11/2016	0	No	No	Green (surveillance)
24/11/2016	0	No	No	Geen (surveillance)
12/12/2016	0	No	No	Green (surveillance)
21/12/2016	0	No	No	Green (surveillance)
05/01/2017	0	No	No	Green (surveillance)
18/01/2017	0	No	No	Green (surveillance)
07/02/2017	1	No	No	Green (surveillance)
27/02/2017	0	No	No	Green (surveillance)
16/03/2017	0	No	No	Green (surveillance)
30/03/2017	1	No	No	Green (surveillance)

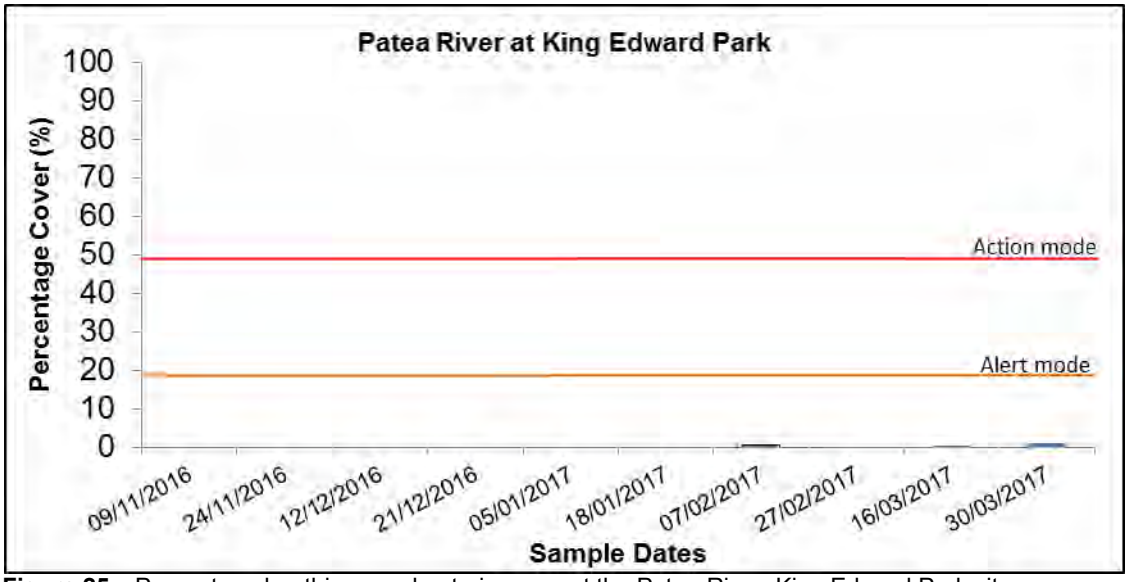


Figure 25 Percentage benthic cyanobacteria cover at the Patea River, King Edward Park site

Benthic cyanobacteria coverage was very low throughout the season (range from 0 to 1%). The benthic cyanobacteria found were a *Phormidium* sp. The 'Action' or 'Alert' level was not exceeded for percentage cover or for the presence of exposed or detaching mats and therefore no action at the site was required.

4.2.6 Patea River at the boat ramp, Patea

Bathing usage of this river site was recorded once at the time of sampling surveys, all of which were before or at midday. Boating and fishing were noted from time to time at this site with boating as the main activity as this is a popular launching site for fishermen, judging by the number of boat trailers often in the parking area.

During the 2011-2012 period Taranaki Regional Council undertook microbial source tracking (MST) using DNA marker techniques at this site and an upstream site at SH3 bridge on two occasions (high and low tides). Faecal coliform bacteria were

found to have been sourced predominantly from cattle on both occasions at the two sites while gulls contributed to populations at the boat ramp site under both tidal conditions and a faint trace of human source derivation was found (downstream of the Patea WWTP treated discharge) at the boat ramp site, but only under low tidal flow conditions.

Data from the site for the 2016-2017 season are presented in Table 37 and illustrated in Figure 26, with a statistical summary provided in Table 38.

Table 37 Analytical results for the Patea River at the boat ramp, Patea

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
01.11.16	0855	248	26	6	28	15.3	8.4
30.11.16	0830	2110	83	51	83	16.1	19
05.12.16	1145	4560	1	1	1	17.5	6.0
12.01.17	0925	4610	41	27	43	19.4	12
30.01.17	0930	4630	4	<2	4	18.3	24
01.02.17	1030	4220	36	15	36	19.0	22
10.02.17	0800	4610	6	<2	6	17.8	17
16.02.17	1115	4760	<2	1	<2	18.6	17
27.02.17	0830	4590	25	15	31	18.9	55
02.03.17	1030	4780	2	<2	2	20.2	25
17.03.17	1040	22.4	100	48	100	19.3	13
02.04.17	1200	4690	2	6	2	19.0	28
11.04.17	0920	30.9	200	34	200	16.6	7.6

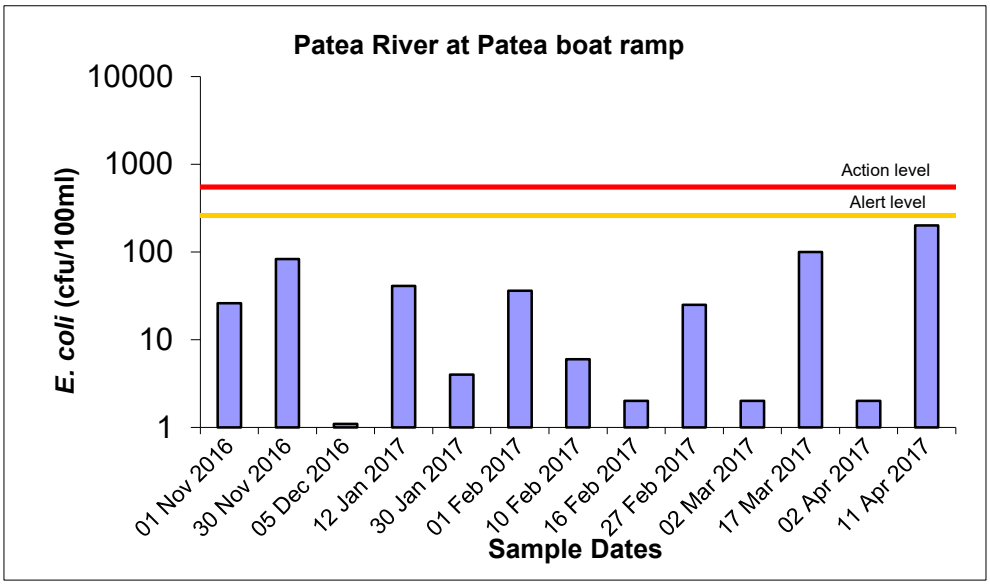


Figure 26 *E.coli* numbers for the Patea River at the boat ramp, Patea during the survey season

Table 38 Statistical results summary for the Patea River at the boat ramp, Patea

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	22.4	4780	4590
E. coli	cfu/100ml	13	1	200	25
Enterococci	cfu/100ml	13	1	51	6
Faecal coliforms	cfu/100ml	13	1	200	28
Temperature	°C	13	15.3	20.2	18.6
Turbidity	NTU	13	6.0	55	17

This ring plain river drains an extensively developed agricultural catchment. The survey site is situated some 45km downstream of the Patea HEP dam and 300 metres upstream of the river mouth. Flows in the lower river are regulated by operational requirements of the HEP station and associated consent conditions. There are consented dairy ponds' treated wastes discharges in the catchment upstream of the site and the consented upgraded Patea Wastewater Treatment Plant discharges upstream of the boat ramp (by about 0.7 km).

River water was usually turbid and milky pale green in appearance. High conductivity levels typical of seawater ingress at high tide occurred on most occasions, with lower conductivity levels at high river flows. Water temperatures had a narrow range of 4.9˚C, a more typical range due to the coastal seawater influence, with a maximum of 20.2˚C recorded at midday in early March 2017 when the river was in very low flow. All of the samples were collected before 1205 hours and therefore maximum river temperatures (which could be anticipated to occur later in the afternoon) were not recorded.

Bacteriological water quality was good for the lower reaches of this Taranaki ring plain river (median: 25 *E.coli* per 100 ml and 6 enterococci per 100 ml) draining a predominantly agricultural catchment. This was due to the coastal seawater influence under high tide conditions and, to a lesser extent, the high bacteriological quality of the upstream lake waters released from the hydro dam. The existing recreational sampling programme was performed around higher tidal conditions for SEM trend purposes (due to its incorporation within the coastal sites programme) at times when aspects of public usage are likely to be more predominant at this site. Poorer bacteriological water quality could be expected under outflowing low tide conditions as emphasised by a consent monitoring programme undertaken at low tide at this site over the same recreational period (under similar sampling protocols) when a median *E. coli* bacterial number of 100 per 100mls (with counts ranging from 39 to 280 per 100 ml) was found with numbers tending to be higher when seawater intrusion was less apparent.

4.2.6.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 39.

No single sample fell within the 'Alert' or 'Action' modes at any time during the monitoring period.

Table 39 Bacterial guidelines performance at the Patea River at the boatramp, Patea site [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	0 [0]	0 [0]

(Designation: freshwater contact recreational area)

The bacteriological water quality at this site was within the acceptable guideline for contact recreational usage throughout the season recognising that all sampling occasions coincided with high tides and therefore a predominance of higher quality saline water mixing with poorer quality river water at this estuarine site. This was comparable with data for the nearby 'Mana' Bay coastal site adjacent to the river mouth monitored in the current season [median *E.coli*: 14 per 100 ml; range *E.coli:* <2-180 per 100 ml] for consent and SEM purposes.

4.2.6.2 Comparison with previous summers' surveys

Nine previous SEM sampling seasons have been surveyed at this site. Otherwise prior sampling has been confined to consent monitoring surveys (TRC 2014a). A statistical comparison of all summers' survey data is presented graphically in Appendix VI for all sites. A much shorter data period exists for this Patea River site (at Patea boat ramp) which was added in 2007-2008. These data are summarised in Table 40 and illustrated in Figure 27.

Table 40 Summary *E. coli* bacteriological water quality data (cfu/100 ml) all summer surveys in the Patea River at the boat ramp, Patea

Summer	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17
Minimum	<1	1	1	<1	1	<1	<1	<1	2	1
Maximum	190	87	82	33	260	84	20	24	80	200
Median	5	9	11	4	16	3	3	5	8	28

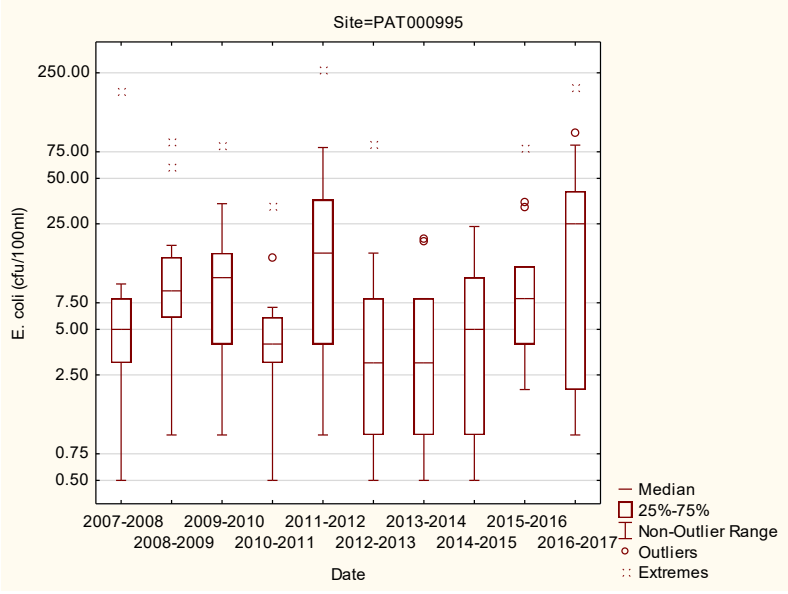


Figure 27 Box & whisker plots for all summer surveys of *E. coli* bacterial numbers for the Patea River at the boat ramp, Patea

Relatively similar (very low) median *E. coli* numbers have been found by these ten seasons' surveys with a moderate range of counts with all the maximum values found to date having remained below the 'Alert' level. The recent season's range of counts was typical of the ranges found in the previous seasons.

The median *E. coli* number in the 2016-2017 season was the highest of the ten seasons' surveys to date (Figure 27), most likely related to higher river flows through the estuary. In terms of the guidelines for contact recreational usage, bacteriological water quality at this site was in compliance with the acceptable level for all of the period.

Trend analysis of these median *E. coli* numbers has been performed for the ten seasons of data by first applying LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 28) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamin-Hochberg False Discovery Rate (FDR) analysis.

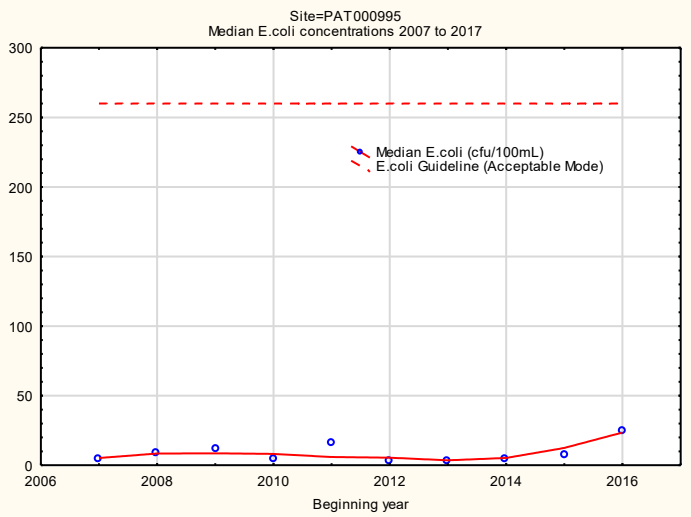


Figure 28 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Patea River at the boat ramp, Patea for the 2007-2017 period

A slight, unimportant, and statistically insignificant increase in median *E. coli* numbers has been found over the ten seasons of monitoring. None of these medians has exceeded the 'Alert' or 'Action' modes.

4.2.7 Waingongoro River at Eltham camp

No bathing usage of this river site was recorded at the time of sampling surveys but camp activities may have included this and other recreational usage as the camp was occupied on several occasions. The site is used as part of the camp's activities.

Sheep were present in the paddock adjacent to this unfenced site on five of the thirteen monitoring occasions, but minimal birdlife was recorded. Data from the site are presented in Table 41 and illustrated in Figure 29 with a statistical summary provided in Table 42. River flow records are illustrated in Figure 30.

Table 41 Analytical results for the Waingongoro River at Eltham camp

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1215	11.2	110	8	110	12.6	1.7
30.11.16	1220	11.1	100	77	100	14.7	1.7
05.12.16	1050	11.6	340	40	340	15.1	1.6
12.01.17	1050	11.0	320	25	320	17.9	1.6
30.01.17	0830	10.9	340	120	350	16.4	1.4
01.02.17	0925	11.1	480	96	480	16.5	1.3
10.02.17	1145	10.9	240	54	290	15.0	1.1
16.02.17	1030	10.9	280	140	290	15.1	1.2
27.02.17	1145	11.7	290	120	300	17.7	1.1
02.03.17	0935	11.6	1600	500	1600	16.7	1.2
17.03.17	0940	10.3	370	270	380	13.6	1.1
02.04.17	1050	11.1	480	240	480	15.7	1.1
11.04.17	1155	11.8	400	260	420	14.0	3.4

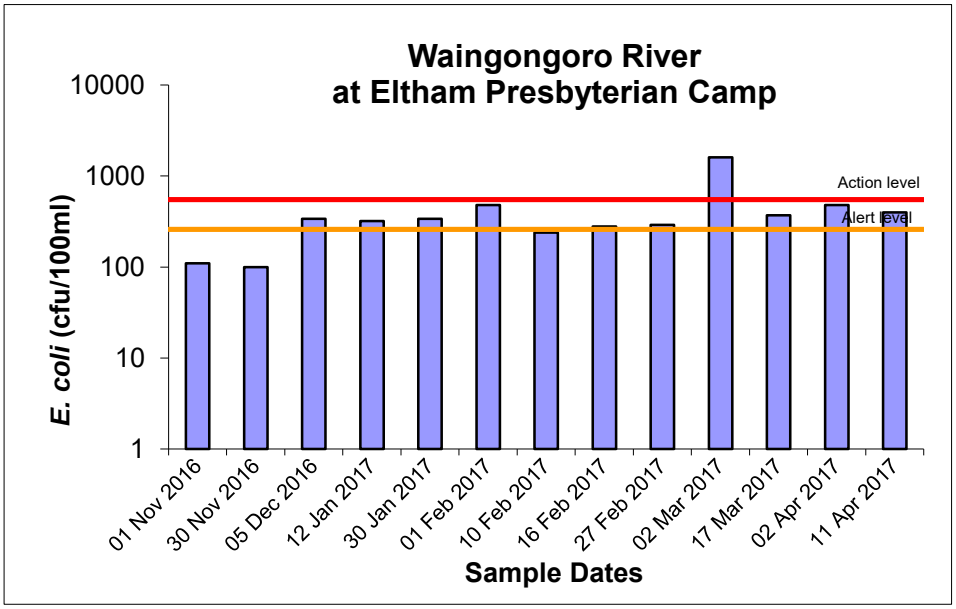


Figure 29 *E. coli* numbers for the Waingongoro River at Eltham Camp during the survey season

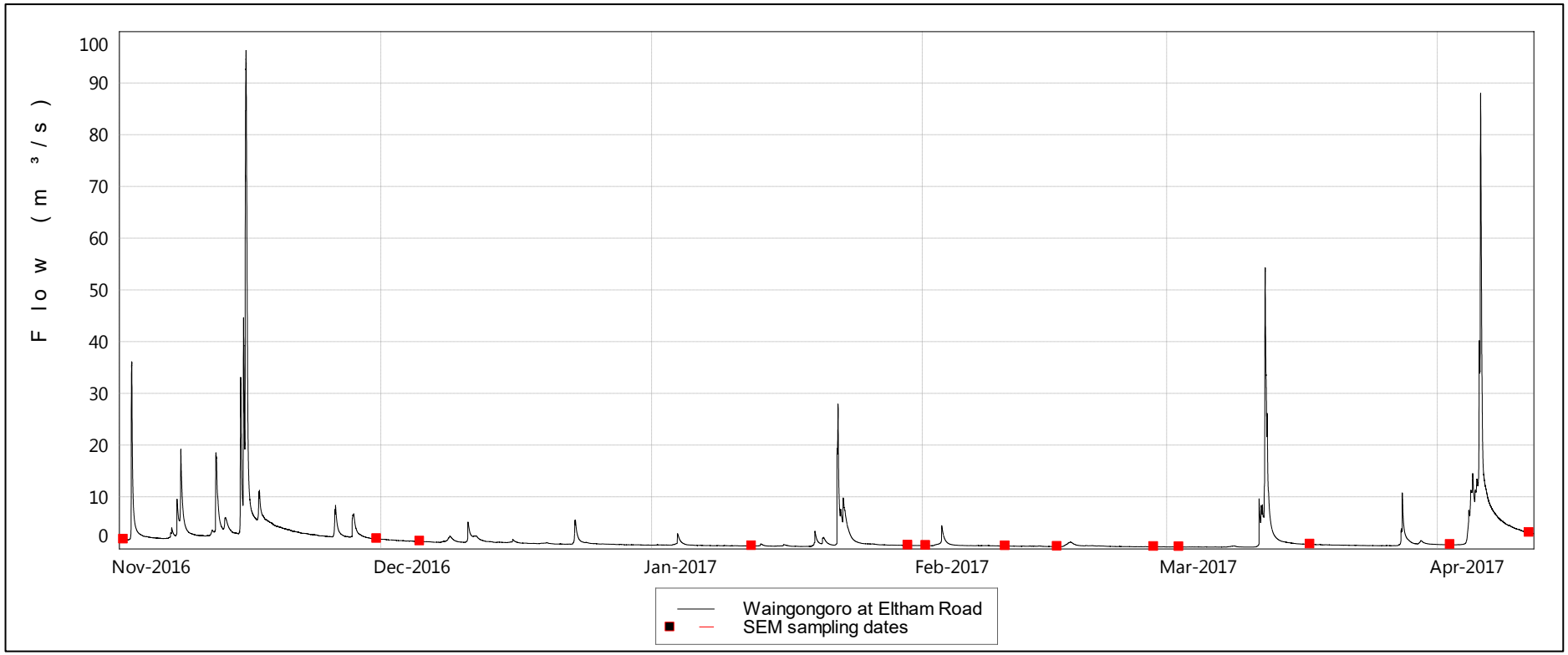


Figure 30 Flow in the Waingongoro River at Eltham during the survey period

Table 42 Statistical results summary for the Waingongoro River at Eltham camp

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	10.3	11.8	11.1
E. coli	cfu/100ml	13	100	1600	340
Enterococci	cfu/100ml	13	8	500	120
Faecal coliforms	cfu/100ml	13	100	1600	340
Temperature	°C	13	12.6	17.9	15.1
Turbidity	NTU	13	1.1	3.4	1.3

This ring plain river drains an extensively developed agricultural catchment, with the survey site situated in Eltham some 21 km below the National Park boundary. River water was generally relatively clear to slightly turbid (occasionally) in appearance with moderate conductivity levels. Water temperatures were within a moderate range (5.1 ˚C) with a maximum of 17.9 ˚C recorded in mid January 2017. All samples were collected before 1225 hours and therefore higher river temperatures (which tend to occur later in the afternoon) were not recorded. **+-+**

Bacteriological water quality was lower (median *E.*coli: 340 per 100 ml) than is typical of the mid reaches of a Taranaki ring plain river draining a predominantly agricultural catchment. This was also apparent in comparison with the nearby Eltham Road (state of the environment physicochemical monitoring) site where a median *E.coli* count of 180 per 100mls (range: 6 to 59000 per 100 ml) has been recorded by monthly sampling since 1995. The higher counts in the current survey tended to occur in the samples taken early in the day under low flow conditions (Figure 29 and Figure 30).

4.2.7.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 43.

Table 43 Bacterial guidelines performance at the Waingongoro River, Eltham Camp [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	9 [69]	1 [8]

(Designation: freshwater contact recreational area)

Nine single samples fell within the 'Alert' mode and one sample reached the 'Action' mode. The highest sample count occurred in early March 2017 during a very low flow period. A health warning sign was erected by STDC. Immediate follow-up sampling was hindered by localised, then widespread, rainfall. Further investigations indicated the possible influence of licensed dairy pond discharges via a tributary that joins about 900 m upstream.

4.2.7.2 Comparison with previous summers' surveys

A statistical comparison of each of all summers' survey data is presented graphically in Appendix VI for all sites.

A shorter data period exists for the Waingongoro River (at Eltham camp) site as this site was added to the programme in 2001-2002. These data are summarised in Table 44 and illustrated in Figure 31.

Table 44 Summary of *E. coli* bacteriological water quality data (cfu/100 ml) for all summer surveys in the Waingongoro River at Eltham camp to date

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum						31	63	23	51	54	
Maximum						870	550	360	1700	430	
Median						230	230	100	170	130	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	23	57	77	57	32	68	74	48	46	28	100
Maximum	290	420	00	270	490	330	430	380	440	470	1600
Median	110	160	130	160	140	150	160	240	260	180	340

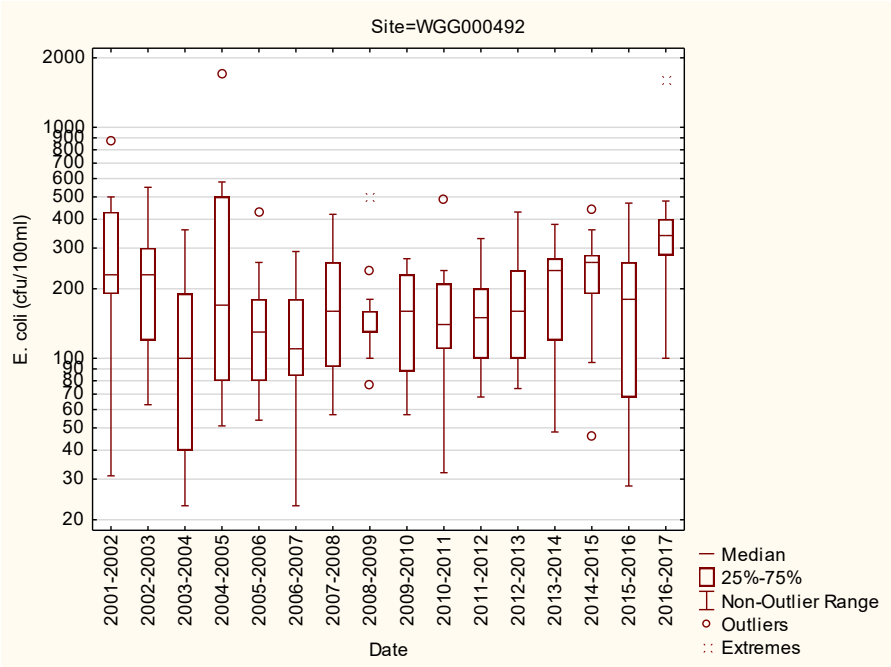


Figure 31 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waingongoro River at Eltham Camp

A deterioration in *E.coli* bacterial water quality in the 2016-2017 season was indicated by a median count which was the highest recorded over the sixteen years of monitoring (Figure 31). Other than the one very high count, there was a relatively narrow inter-quartile range of counts over the 2016-2017 season, suggesting a consistent source.

Trend analysis of these median *E.coli* numbers has been performed for the sixteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of

the median numbers (Figure 32) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

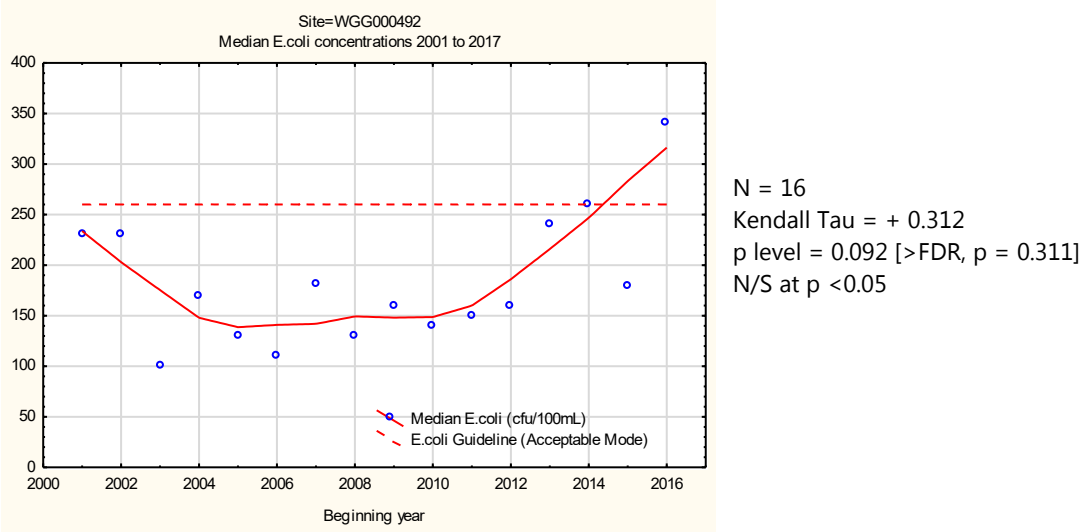


Figure 32 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Waingongoro River, Eltham camp for the 2001 to 2017 period

A statistically insignificant trend of increasing median *E.coli* numbers was found over the sixteen seasons of monitoring. None of these seasonal medians exceeded the 'Action' mode, although the 'Alert' mode was exceeded in the most recent season, for the first time over the monitoring period.

4.2.7.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on ten occasions during the season. Results are presented in Table 45 and Figure 33.

Table 45 Percentage benthic cyanobacteria cover for the Waingongoro River at Eltham Camp

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
09/11/2016	0	No	No	Green (surveillance)
24/11/2016	0	No	No	Green (surveillance)
12/12/2016	0	No	No	Green (surveillance)
21/12/2016	0	No	No	Green (surveillance)
05/01/2017	0	No	No	Green (surveillance)
18/01/2017	3	No	No	Green (surveillance)
07/02/2017	0	No	No	Green (surveillance)
27/02/2017	0	No	No	Green (surveillance)
16/03/2017	0	No	No	Green (surveillance)
30/03/2017	0	No	No	Green (surveillance)

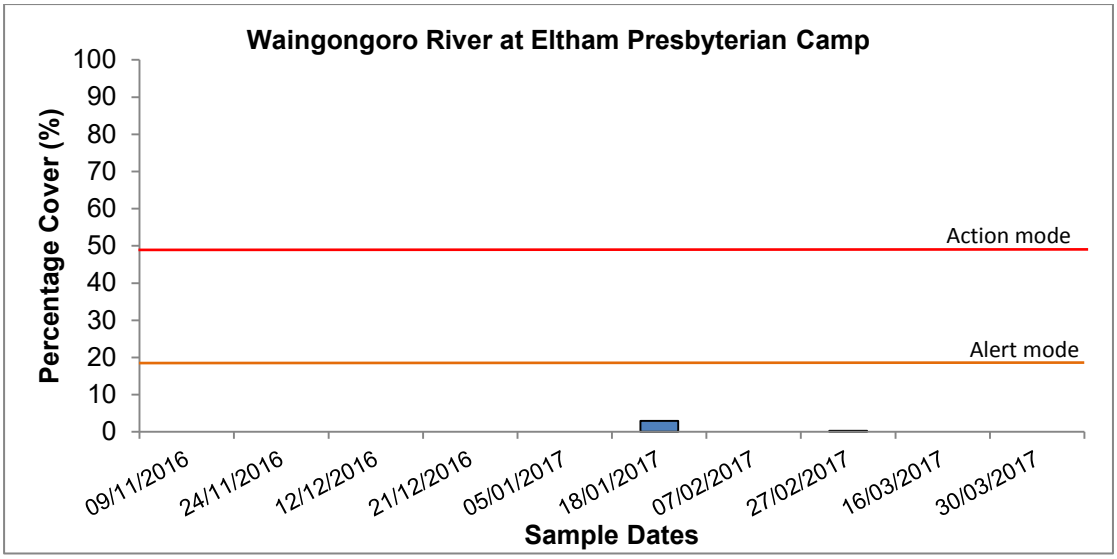


Figure 33 Percentage benthic cyanobacteria cover at the Waingongoro River Eltham camp

Benthic cyanobacteria coverage was low throughout the season (ranging from 0% to 3%). The benthic cyanobacteria found were a *Phormidium* sp. The 'Action' and 'Alert' levels were not exceeded for percentage cover or for the presence of exposed or detaching mats and therefore no action at the site was required.

4.2.8 Waingongoro River at Ohawe Beach

4.2.8.1 SEM programme

No bathing usage of this site was recorded in the 2016-2017 season. Whitebaiting was recorded (in season), and persons walking dogs (twice). Occasionally, livestock have been present in the paddock upstream of the site but during the 2016-2017 season none were noted at the river's edge or in the river as had been the case on occasions in the past (TRC, 2010). A few ducks were also noted on occasions.

In the 2012-2013 season, samples from two separate fine weather, low tide, very low flow conditions (mid to late summer) surveys at sites upstream of the township and near mouth were forwarded to Cawthron Institute, Nelson for faecal source DNA tracking marker analyses. Both surveys found low *E.coli* counts (ranging from 51 to 92 cfu/100 ml upstream and 43 to 60 cfu/100 ml downstream of the township) which comprised bacteria of only ruminant and wildfowl origins, typical for the lower reaches of ringplain streams and not indicative of septic tank waste disposal issues.

The data for this site for the 2016-2017 period are presented in Table 46 and illustrated in Figure 35, with a statistical summary provided in Table 47. River flow records are illustrated in Figure 34.

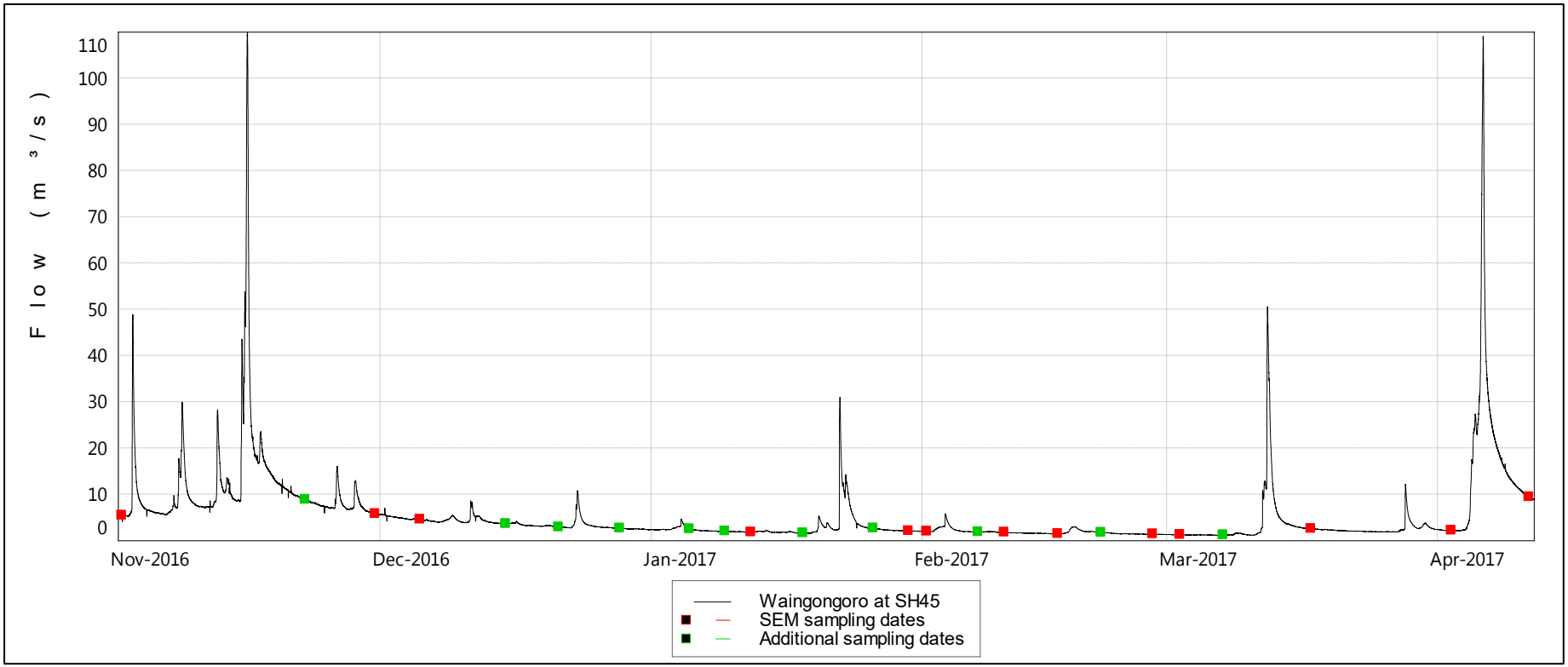


Figure 34 Flow in the Waingongoro River at SH45 during the survey period

Table 46 Analytical results for the Waingongoro River at Ohawe Beach

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1000	16.3	140	23	140	12.6	2.4
30.11.16	0930	15.8	210	52	220	15.0	2.2
05.12.16	1255	16.5	84	62	84	18.2	1.6
12.01.17	1005	17.0	220	100	220	21.0	1.6
30.01.17	1036	16.5	200	160	200	18.7	1.5
01.02.17	1205	17.6	160	150	170	19.3	4.8
10.02.17	0905	17.9	180	100	180	17.6	1.8
16.02.17	1235	18.3	130	60	130	19.1	1.3
27.02.17	0930	19.7	270	280	270	18.8	2.2
02.03.17	1140	18.9	180	180	180	21.0	1.2
17.03.17	1135	16.2	200	200	220	17.0	1.2
02.04.17	1300	17.3	300	220	300	18.6	1.4
11.04.17	1015	15.7	390	690	390	14.5	3.7

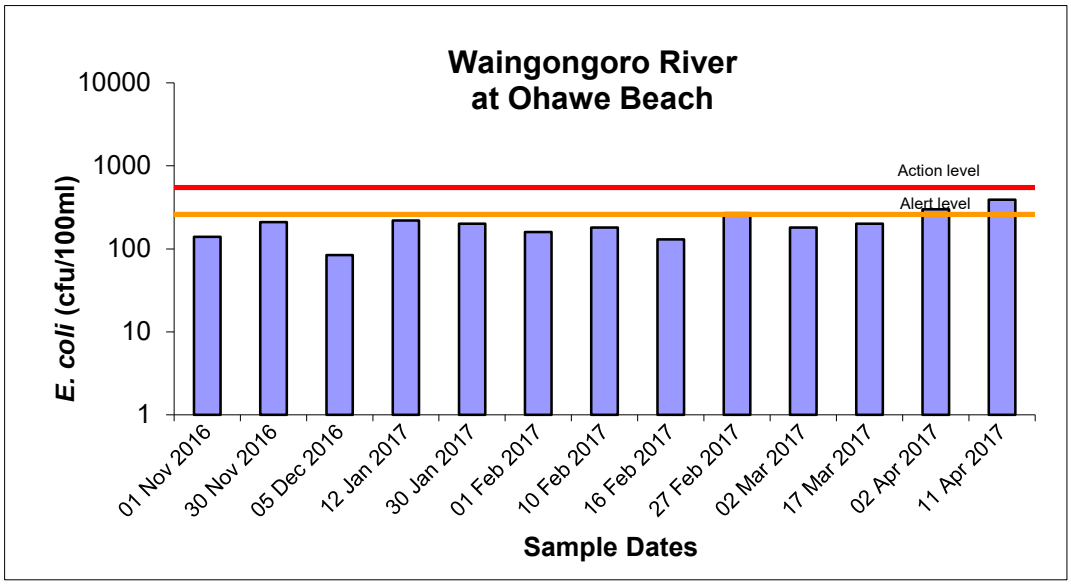


Figure 35 *E.coli* numbers for the Waingongoro River at Ohawe Beach during the survey season

Table 47 Statistical results summary for the Waingongoro River at Ohawe Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	15.7	19.7	17.0
E. coli	cfu/100ml	13	84	390	200
Enterococci	cfu/100ml	13	23	690	150
Faecal coliforms	cfu/100ml	13	84	390	200
Temperature	°C	13	12.6	21.0	18.6
Turbidity	NTU	13	1.2	4.8	1.6

This river drains an extensively farmed catchment and receives point source industrial wastes (in its mid-reaches) and dairy pond wastes (more than 100 treatment systems) discharges. These industrial (meatworks) wastes are predominantly diverted out of the river (to land irrigation) during summer months,

while the Eltham WWTP municipal and industrial wastes discharge was diverted permanently out of the catchment in winter 2010. The site is in the lower reaches of the river immediately upstream of the mouth, but is generally not tidal, although occasional upstream surging in the ponded area has been noted during low river flow and high tidal conditions during late summer.

The range of water temperatures was narrow (4.2˚C) with a maximum of 21.0˚ C recorded in mid morning in mid January and late morning in early March 2017. However, as sampling was not performed after 1300 hrs at this site, this maximum might be expected to have been exceeded later in the day from time-to-time during the period of the survey. Conductivity values were typical of the lower reaches of a Taranaki ring plain and showed minimal salt water influence on any occasion despite sampling low flow conditions coincident with higher tides and upstream surging, particularly in late summer (Appendix III). Turbidity values were indicative of relatively clear water on most occasions, consistent with the presence of some fine colloidal material in suspension (ie: < 2 NTU on most occasions), typical of the lower reaches of a ring plain river.

Bacteriological water quality (Figure 35) was typical of the lower reaches of a Taranaki ring plain river receiving agricultural run-off and point source discharges in the catchment. This was also apparent in comparison with the nearby (state of the environment physicochemical monitoring) site at SH45 where monthly sampling since mid 1998 (under all weather conditions) has recorded a median *E. coli* count of 220 per 100 ml (and range from 3 to 41,000 per 100 ml). Uncontrolled livestock access to the river immediately upstream of this site near the mouth, particularly during low flow periods, was not recorded during the current season, which was an improvement on historical incidents.

4.2.8.2 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 48.

Table 48 Bacterial guidelines performance at the Waingongoro River, Ohawe Beach [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	3 [23]	0 [0]

(Designation: freshwater contact recreational area)

Three single samples were recorded in the 'Alert' category, in February and early April 2017, but no samples were found in the 'Action' mode. Counts were less than 220 *E.coli* per 100 mls until late February under low flow conditions.

Bacteriological water quality at this site was within the acceptable guidelines for contact recreational usage for the entire survey period, coincident with the diversion of the Eltham WWTP discharge out of the catchment, and land irrigation of Riverlands meatworks wastes during the season.

4.2.8.3 Comparison with previous summers' surveys

A statistical comparison of each of the twenty-one summer's survey data is presented graphically in Appendix VI for all sites. These summer data for the Waingongoro River site at Ohawe Beach are summarised in Table 49 and illustrated in Figure 36.

Table 49 Summary of *E. coli* bacteriological water quality data (cfu/100 ml) for all summer surveys in the Waingongoro River at Ohawe Beach to date

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum	88	43	17	34	38	46	3	43	54	31	
Maximum	310	650	300	240	850	660	14000	280	940	380	
Median	185	130	80	180	170	170	110	110	130	96	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	31	9	31	26	8	43	46	34	66	48	94
Maximum	410	5000	870	1000	180	2800	2300	370	630	480	390
Median	100	100	120	96	100	96	110	120	200	140	200

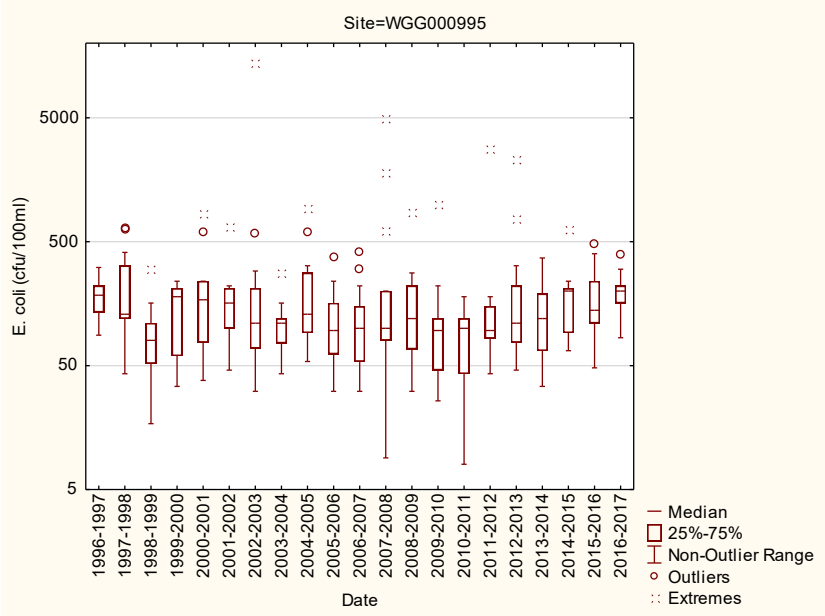


Figure 36 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Waingongoro River at Ohawe Beach

Median *E. coli* bacteria number for the 2016-2017 period was equal to the highest value found over the previous twenty seasons, in 2014-2015 (Figure 36).

A moderately narrow range of *E. coli* numbers was recorded in the recent 2016-2017 period in comparison with past seasons' ranges.

Trend analysis of these median *E.coli* numbers has been performed for the twenty-one seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 37) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

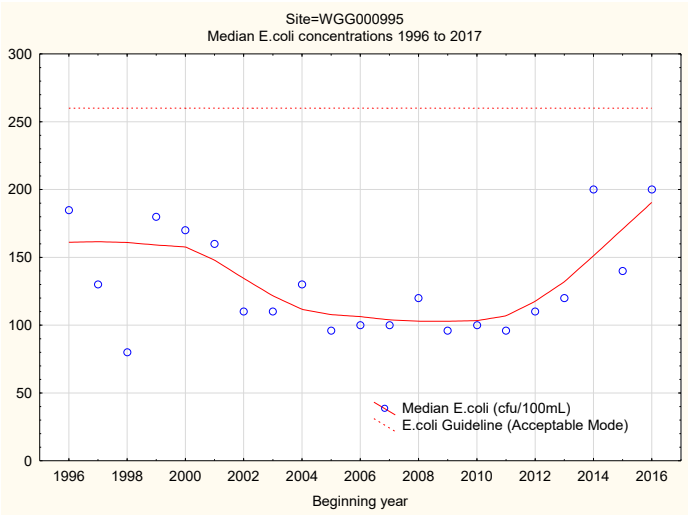


Figure 37 LOWESS trend plot of median *E.coli* numbers (per 100ml) for the 1996 to 2017 period at the Waingongoro River Ohawe beach site

Overall, a statistically insignificant decreasing trend in median *E.coli* number was found over the twenty-one seasons of monitoring. The trend had been statistically significant at the p <0.05 level after the 2012-2013 season, but no longer significant due to the more recent increase in median number. None of these seasonal medians exceeded the 'Alert' or 'Action' modes.

4.2.8.4 MfE guidelines additional sampling

For the purpose of MfE monitoring, eleven additional samples were collected at regular intervals under varying weather conditions during the survey season. Light rainfall occurred within three days of the surveys on six occasions, thrice on the same day as sampling, though in insufficient volume to cause significant run-off from the land to the river.

Recreational activities noted included swimming (on one occasion), whitebaiting (in season) and fishing. Some foaming was noted during most surveys.

The data from these additional surveys are presented in Table 50 and illustrated and statistically summarised (with the 13 SEM samples' data) in Figure 38 and Table 51, respectively.

Table 50 Waingongoro River at Ohawe additional eleven water quality samples' results

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
22.11.16	0945	15.1	100	31	100	16.2	2.7
15.12.16	0816	16.7	220	110	220	16.6	2.0
21.12.16	0948	17.0	120	40	120	16.8	1.8
28.12.16	0909	16.4	240	52	240	17.4	2.4
05.01.17	0850	17.3	280	100	280	16.3	2.5
09.01.17	1000	18.1	200	48	200	17.7	1.9
18.01.17	0816	18.6	180	83	180	19.2	1.1
26.01.17	0924	14.9	220	120	230	16.4	1.8
07.02.17	0915	16.9	240	120	270	21.1	1.4
21.02.17	1115	17.8	180	140	180	21.4	1.6
07.03.17	1005	19.0	240	120	240	18.1	1.5

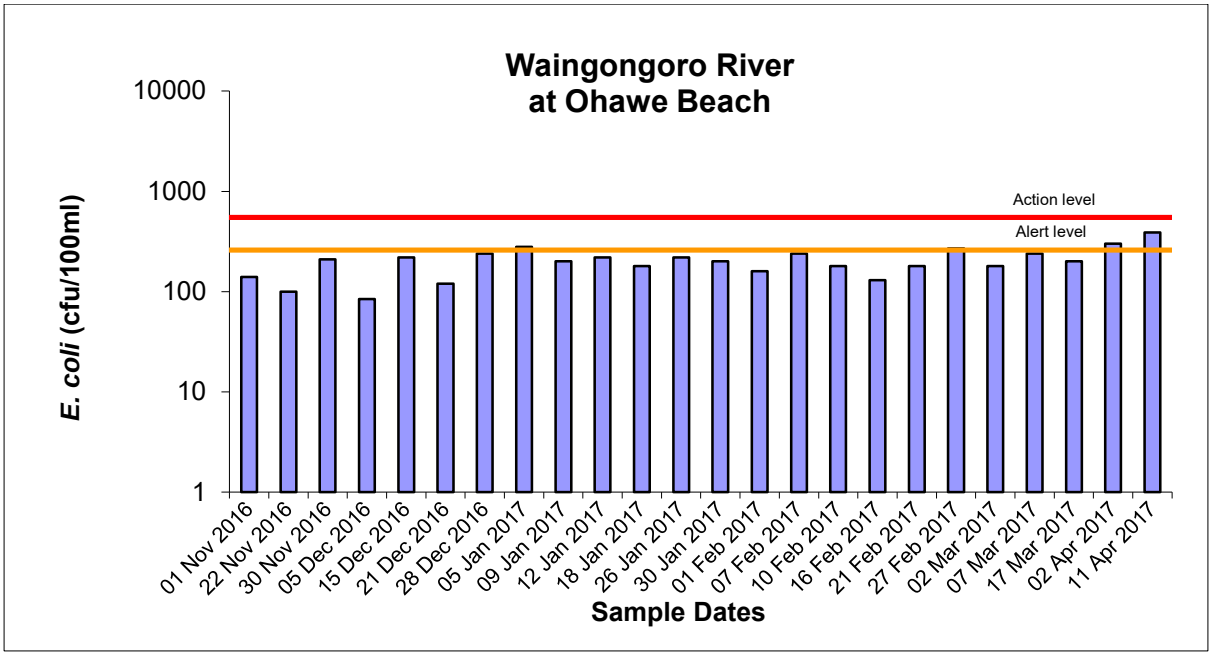


Figure 38 *E. coli* numbers for Waingongoro River at Ohawe for the 24 sample extended survey

Table 51 Summary statistics for SEM and additional samples at Waingongoro River at Ohawe

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	24	14.9	19.7	17.0
E. coli	cfu/100ml	24	84	390	200
Enterococci	cfu/100ml	24	23	690	105
Faecal coliforms	cfu/100ml	24	84	390	210
Temperature	°C	24	12.6	21.4	17.9
Turbidity	NTU	24	1.1	4.8	1.8

These eleven additional samples resulted in no change in the seasonal minimum, maximum or median *E. coli* numbers in comparison with the regular SEM programme results (Table 47). These additional surveys' bacteria counts had a narrower range (100 to 280 *E. coli* per 100 ml) than the standard SEM sampling survey occasions. A slightly higher maximum water temperature (by 0.4°C) was measured during the additional sampling (21.4 °C) in mid February 2017.

4.2.8.5 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 52.

Table 52 Bacterial guidelines performance in the Waingongoro River at Ohawe [% of 24 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	4 [17]	0 [0]

(Designation: freshwater contact recreational area)

There was a slight increase in the number of exceedances of the single sample 'Alert' mode with the additional monitoring, and no exceedance of the 'Action' level occurred.

4.2.8.6 Benthic cyanobacteria

Benthic cyanobacteria were monitored on 14 occasions during the season. Results are presented in Table 53 and Figure 39.

Table 53 Percentage benthic cyanobacteria cover for the Waingongoro River at the Ohawe Beach Domain

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
09/11/2016	0	No	Minor	Amber (Alert)
16/11/2016	0	No	No	Green (surveillance)
24/11/2016	6	No	No	Green (surveillance)
12/12/2016	9	Minor	No	Amber (Alert)
21/12/2016	11	Minor	No	Amber (Alert)
05/01/2017	3	No	Minor	Amber (Alert)
12/01/2017	7	Minor	No	Amber (Alert)
18/01/2017	13	Minor	No	Amber (Alert)
26/01/2017	0	No	No	Green (surveillance)
07/02/2017	1	No	No	Green (surveillance)
27/02/2017	10	Minor	Minor	Amber (Alert)
09/03/2017	4	Minor	No	Amber (Alert)
16/03/2017	0	No	No	Green (surveillance)
30/03/2017	0	No	No	Green (surveillance)

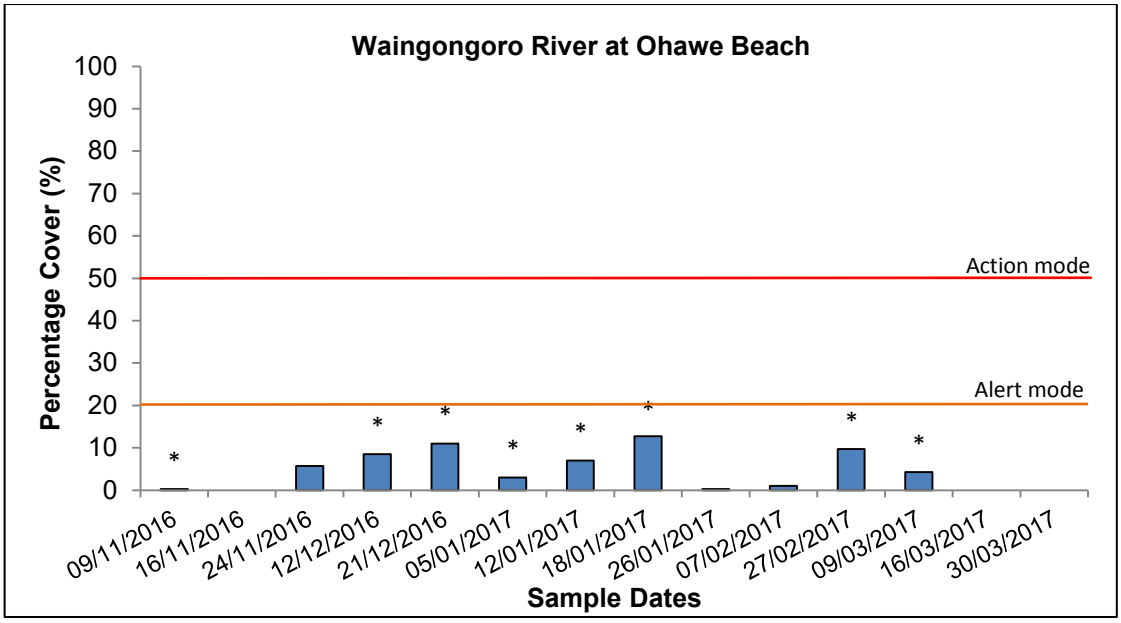


Figure 39 Percentage benthic cyanobacteria cover, for the Waingongoro River Ohawe beach site

Note that 'Action' and 'Alert' mode lines are for percentage cover only. The symbols * and + over a bar indicate where the status been raised to 'Alert' or 'Action' mode, respectively due to detaching or exposed mats.

Benthic cyanobacteria coverage was very low during the start of the monitoring period (range from 0 to 6%), with levels increasing during summer but still remaining at very low to low levels (range from 0 to 13%), until autumn when levels remained consistently very low (range from 0 to 4%). The benthic cyanobacteria found were a *Phormidium* sp. The 'Action' and 'Alert' levels were never exceeded for streambed coverage. Minor levels of detaching mats were observed on six occasions, triggering the 'Alert' level, and minor levels of exposed mats were observed on three occasions, which triggered the 'Alert' response. In total, there were eight surveys that triggered the 'Alert' level.

4.2.9 Kaupokonui River at Beach Domain

4.2.9.1 SEM programme

Minor usage at this site by bathers was recorded at the time of the sampling surveys, and other recreational usage [mainly fishing (whitebaiting in large number in early season, and rod-fishing) and walking the banks] was occurring on several survey occasions at this popular site where the camping ground was consistently in use. The site was characterised by the tidal ponded nature of this reach of the river on the majority of occasions, particularly under high tide and low river flow conditions. No stock access was noted near the river's edge upstream of the domain during the current season. A few ducks and gulls were noted on a few occasions.

During the 2012-2013 season, additional fine weather samples were collected on two separate low tide, very low flow conditions (mid summer and end of the season) at this site and analysed (by Cawthron Institute, Nelson) for faecal source DNA tracking markers. Low *E.coli* counts (26 and 17 nos/100 ml) were found to be coincident with bacteria of only ruminant and wildfowl origin indicative of no septic tank wastes disposal issues at the beach, with numbers typical of the lower reaches of ringplain streams.

River flow records for the current 2016-2017 season are provided in Figure 41, from the hydrometric site xx km upstream at Upper Glenn Road. Data from the water sampling site are presented in Table 54 and illustrated in Figure 40, with a statistical summary provided in Table 55.

Table 54 Analytical results for the Kaupokonui River at the beach domain

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1030	15.6	23	17	23	14.8	1.0
30.11.16	1005	14.4	190	72	200	14.9	1.4
05.12.16	1315	15.2	88	13	88	20.8	1.9
12.01.17	0910	57.2	480	410	480	20.6	1.6
30.01.17	1108	14.2	290	88	300	18.9	1.4
01.02.17	1245	28.7	150	64	160	19.6	1.1
10.02.17	0950	158	220	110	230	16.8	1.4
16.02.17	1300	15.8	140	48	150	19.3	1.5
27.02.17	1000	33.9	230	110	230	19.0	1.1
02.03.17	1215	272	110	40	110	21.1	1.2
17.03.17	1205	13.7	100	84	100	18.9	1.6
02.04.17	1330	14.4	310	200	310	19.7	1.0
11.04.17	1100	17.4	460	260	460	15.5	1.4

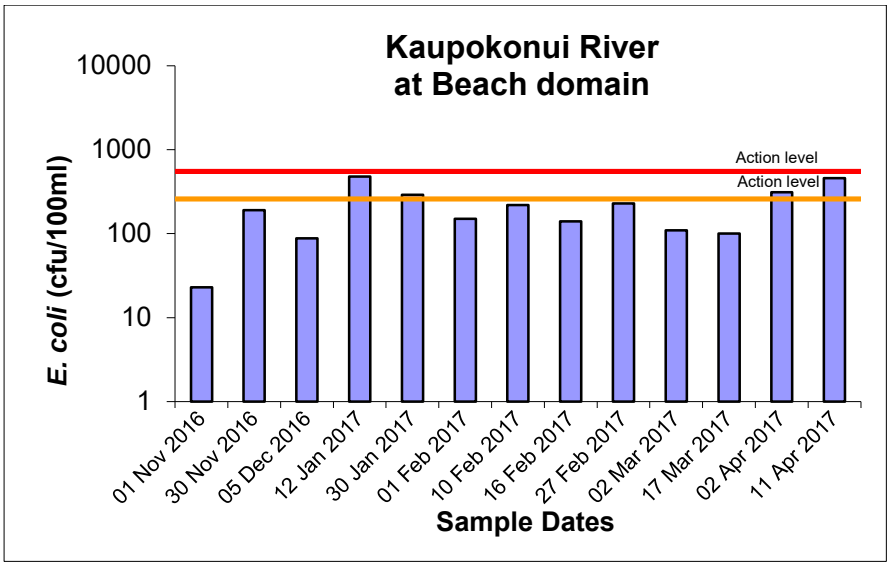


Figure 40 *E. coli* numbers for the Kaupokonui River at the beach domain during the survey season

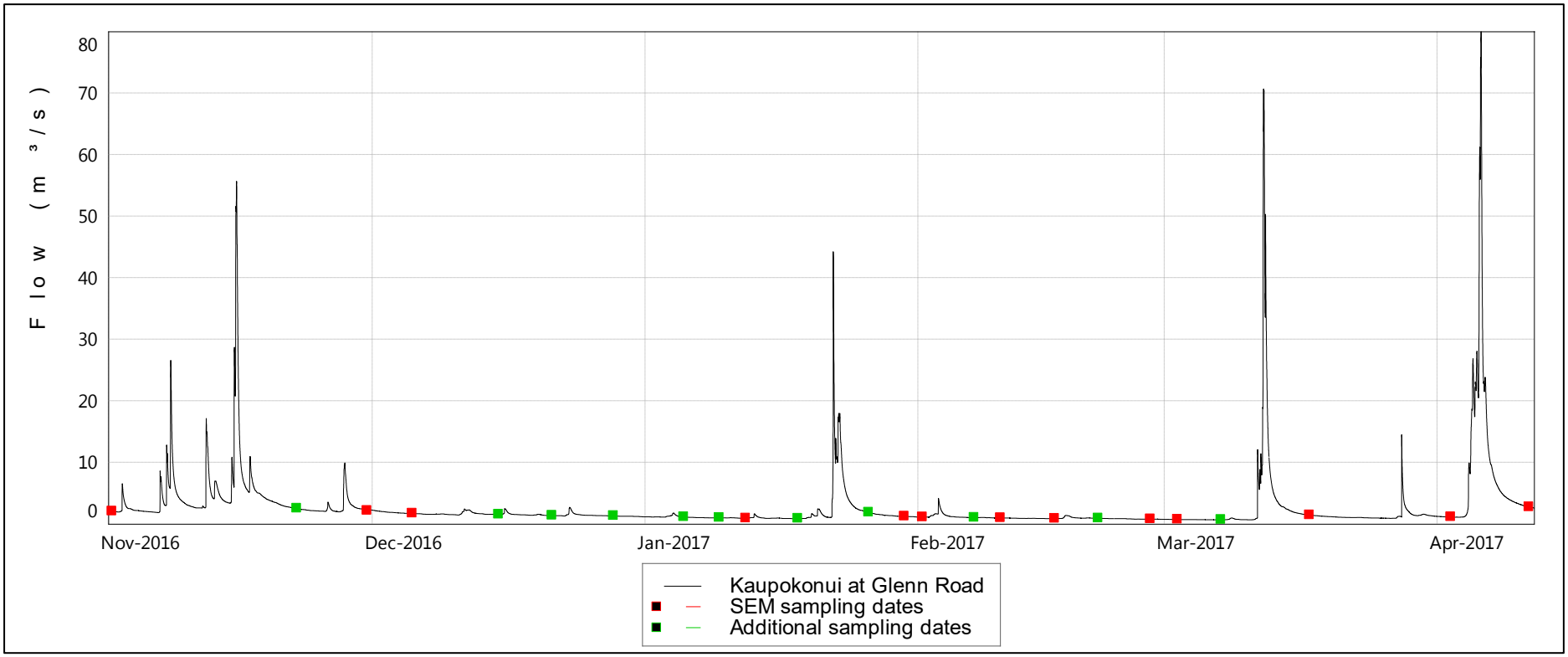


Figure 41 Flow in the Kaupokonui River at Glenn Rd during the survey period

Table 55 Statistical results summary for the Kaupokonui River at the beach domain

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	13.7	272	15.8
E. coli	cfu/100ml	13	23	480	190
Enterococci	cfu/100ml	13	13	410	84
Faecal coliforms	cfu/100ml	13	23	480	200
Temperature	°C	13	14.8	21.1	19.0
Turbidity	NTU	13	1.0	1.9	1.4

This river also drains an extensively farmed catchment and receives point source wastes discharges from dairy pond wastes treatment systems, and in its mid-reaches from Fonterra Kapuni Company (cooling waters) and the Kaponga township municipal upgraded wastewater treatment system.

The site is located in the lower reach of the river near the mouth and on several occasions was noted as tidal (incoming surges, upstream or very slow flow) in terms of flow conditions. Elevated conductivity levels on five occasions indicated some seawater influence near high tide under low flow conditions during mid summer–early autumn. Otherwise, these conductivity levels were relatively stable (13.7 to 17.4 mS/m at 20°C) and typical of the lower reaches of a Taranaki ring plain river.

Turbidity levels were typical of lower ring plain river reaches throughout the period with minimal impacts of suspended algal matter, unlike conditions noted in several previous survey periods, with one exception in mid January. Foaming was seldom noticeable in the ponded reach of the river and toward the edges, unlike in previous periods when foaming and suspended algal matter reduced the aesthetic quality of this reach from time to time. Water temperatures varied over a moderate range of 6.3°C with a maximum of 21.1°C recorded in early March 2017. This temperature was recorded at 1215 hrs and would be expected to have increased later in the day and on other occasions, particularly as most of the surveys were performed before 1335 hrs at this site.

Bacteriological water quality was moderately good and slightly better than that recorded in the lower reaches of the nearby Waingongoro River (see section 4.2.8), and better than found from time to time in the lower reaches of a Taranaki ring plain river draining a predominantly agricultural catchment.

Previous surveys have noted that bacteriological water quality deteriorated in this tidal pool reach of the river, probably as a result of the ponding of the flow and 'accumulation' of slugs of poorer quality downstream flow. This may have been as a result of upstream stock access, point source dairy effluent discharges and/or various other non-point source runoff, emphasising the importance of control and surveillance of dairy shed wastewater disposal practices, particularly in lower reaches of ring plain catchments utilised for bathing and recreational purposes. As well, many flocks of ducks have been recorded in reaches of the river upstream of this site. It has also been noted in the past that lower faecal coliform to enterococci ratios than usual have been recorded at this (and other) tidal ponded sites, possibly as a result of vegetative enterococcal sources and/or better enterococci survival in tidal pool environments, particularly sites characterised by ebbing and flowing within the ponded river mouth reach. This was not apparent in the 2016-2017 monitoring period (Table 54).

Four 'Alert' levels were recorded, two in January and two in April 2017, but no samples were found at 'Action" level. There was tidal surging on each occasion.

Relatively poor aesthetic water quality has been noted from time-to-time at this site, mainly in the form of surface froth (particularly toward the river margins) and fragments of periphyton suspended in the water column. These aspects of physical water quality were not as apparent during the 2016-2017 season.

4.2.9.2 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 53.

Table 56 Bacterial guidelines performance at the Kaupokonui River beach domain site [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	4 [31]	0 [0]

(Designation: freshwater contact recreational area)

No individual sample fell within the 'Action' mode, and four were recorded in the 'Alert' mode during the season. No rainfall immediately preceded the elevated counts, which all occurred during tidal pooling.

In summary, bacteriological water quality at this ponded lower river site was within guidelines for contact recreational usage throughout the the survey period.

4.2.9.3 Comparison with previous summers' surveys

A statistical comparison of each of the twenty-one summer's survey data is presented graphically in Appendix VI for all sites. These summer data for the Kaupokonui River site at the Beach Domain are summarised in Table 54 and illustrated in Figure 42.

Table 57 Summary of *E. coli* bacteriological water quality data (cfu/100ml) for all summer surveys in the Kaupokonui River at the Beach Domain

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum	26	31	3	7	17	46	46	<8	40	14	
Maximum	360	2100	580	780	2000	400	630	200	880	280	
Median	110	360	130	80	120	110	130	77	92	160	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	26	15	29	20	20	17	28	11	54	34	23
Maximum	2500	850	890	440	340	290	540	270	490	900	480
Median	140	77	210	100	76	120	140	110	120	110	190

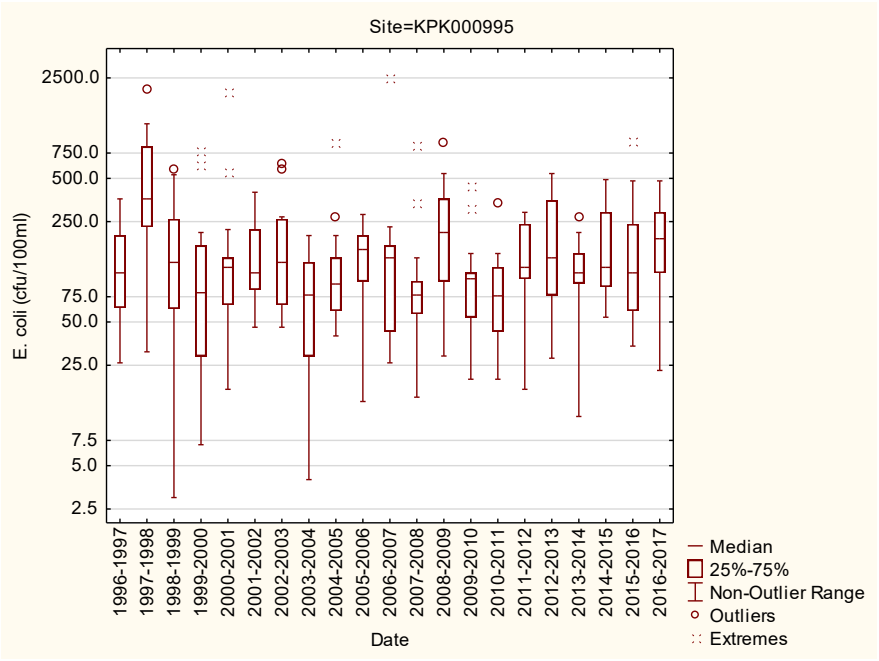


Figure 42 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Kaupokonui River at the Beach Domain

Typical *E. coli* bacterial water quality in terms of median number, but a moderate range compared with many of the previous nineteen survey seasons, was recorded over the 2016-2017 season (Figure 42). The median *E. coli* count was the third highest of all other seasons' medians to date (Table 54) and the seasonal maximum was in the mid range of those for the twenty-one years of record.

Trend analysis of these median *E. coli* numbers has been performed for the twenty-one seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 43) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

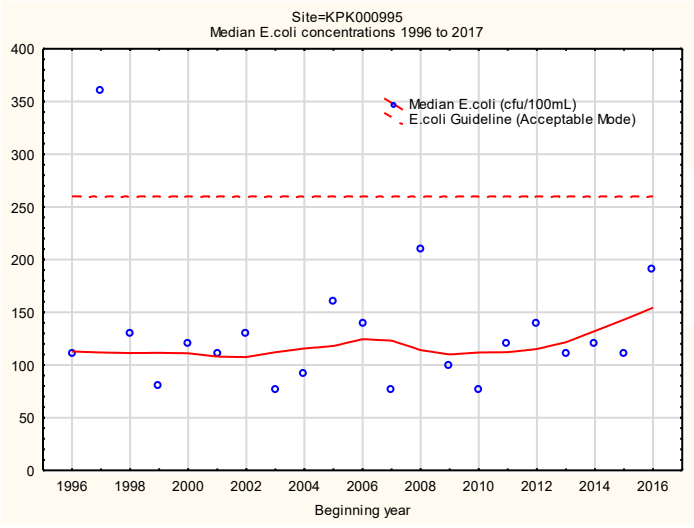


Figure 43 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Kaupokonui River beach domain site for the 1996 to 2017 period

A very slight, unimportant, and statistically insignificant decreasing trend in median *E. coli* counts was found over the twenty-one seasons of monitoring. One of these seasonal medians (1997-1998 season) exceeded the 'Alert' mode but none has exceeded the 'Action' mode, nor has any approached the 'Alert' mode since 1997-1998.

4.2.9.4 MfE guidelines additional sampling

For the purpose of MfE monitoring, eleven additional samples were collected at regular intervals under varying weather conditions during the survey season. Light rainfall occurred within three days of the surveys on six occasions, thrice on the same day as sampling, though in insufficient volume to cause significant run-off from the land to the river on all but one occasion (5 January 2017). Eight of the additional surveys occurred within two hours of low tide.

Recreational activities noted included bathing (once), and walking along the banks on most occasions. A few ducks or gulls were present on three occasions.

The data from these additional surveys are presented in Table 58, illustrated in Figure 44, and statistically summarised (together with the 13 SEM samples' data) in Table 59.

Table 58 Kaupokonui River at beach domain additional eleven water quality samples' results

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
22.11.16	1015	16.1	57	35	57	17.7	1.0
15.12.16	0830	16.0	430	160	440	17.0	0.9
21.12.16	1030	15.4	66	23	66	18.5	1.0
28.12.16	0958	14.6	500	350	500	18.5	1.2
05.01.17	0915	16.1	140	27	140	17.4	1.8
09.01.17	0915	16.7	240	54	260	17.5	1.2
18.01.17	0850	18.2	320	56	320	19.2	1.2
26.01.17	1020	14.0	350	120	350	16.1	3.7
07.02.17	0950	15.4	220	81	220	20.8	1.2
21.02.17	1145	18.6	88	40	88	22.3	1.0
07.03.17	1030	16.6	160	90	160	18.7	1.5

Figure 44 *E. coli* numbers for the Kaupokonui River beach domain for the 24 sample extended survey

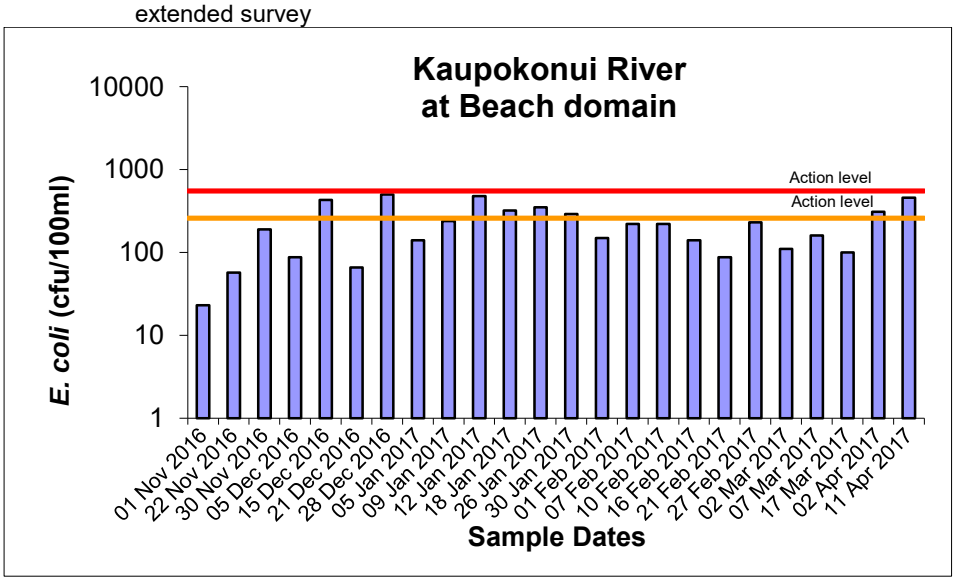


Table 59 Summary statistics for the SEM and additional samples in the Kaupokonui River beach domain

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	24	13.7	272	16.0
E. coli	cfu/100ml	24	23	500	205
Enterococci	cfu/100ml	24	13	410	76
Faecal coliforms	cfu/100ml	24	23	500	210
Temperature	°C	24	14.8	22.3	18.8
Turbidity	NTU	24	0.9	3.7	1.2

These additional samples resulted in a very slight increase in the seasonal maximum and median *E. coli* numbers in comparison with the regular SEM programme results (Table 55). A slightly lower median turbidity (by 0.2 NTU) was measured during the additional sampling (1.2 NTU), possibly as a result of less disturbance of sediment from the tidal surging that often occurs during the regular sampling programme.

4.2.9.5 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 60.

Table 60 Bacterial guidelines performance in the Kaupokonui River beach domain [% of 24 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	8 [33]	0 [0]

There was a proportionate increase in the number of exceedances (about 33%) of the single sample 'Alert" mode with the additional monitoring, and there was no exceedance of the 'Action level.

4.2.9.6 Benthic cyanobacteria

Benthic cyanobacteria were monitored on 14 occasions during the season. Results are presented in Table 61 and Figure 45.

Table 61 Percentage benthic cyanobacteria cover for the Kaupokonui River, Beach Domain site

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
09/11/2016	0	No	No	Green (surveillance)
24/11/2016	9	No	No	Green (surveillance)
12/12/2016	21	Minor	No	Amber (Alert)
21/12/2016	43	Minor	Minor	Amber (Alert)
05/01/2017	24	Minor	No	Amber (Alert)
12/01/2017	6	No	No	Green (surveillance)
18/01/2017	10	Minor	No	Amber (Alert)
26/01/2017	3	No	No	Green (surveillance)
07/02/2017	15	Minor	No	Amber (Alert)
17/02/2017	20	Minor	No	Amber (Alert)
27/02/2017	14	Minor	No	Amber (Alert)
09/03/2017	6	No	No	Green (surveillance)
16/03/2017	1	No	No	Green (surveillance)
30/03/2017	9	No	No	Green (surveillance)

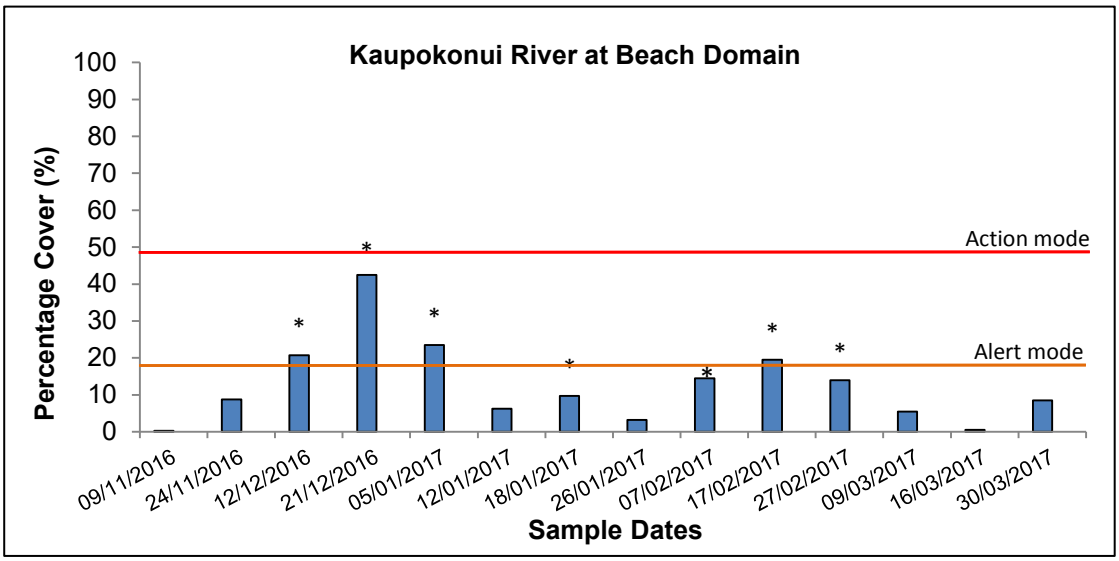


Figure 45 Percentage benthic cyanobacteria cover for the Kaupokonui River at the Beach Domain site Note that 'Action' and 'Alert' mode lines are for percentage cover only. The symbols * and + over a bar indicate where the status been raised to 'Alert' or 'Action' mode, respectively due to detaching or exposed mats.

Benthic cyanobacteria coverage was moderately low at the start of the monitoring period (range from 0 to 9%) but rose to reasonably high levels through most of summer (range from 3 to 43%) until levels tapered off in autumn (range from 1 to 9%). The benthic cyanobacteria found were a *Phormidium* sp. The lower cyanobacteria biomass in mid-summer was correlated with either high green filamentous levels, and it would appear that the long filamentous algae were out-competing the cyanobacteria, or recent significant freshes were removing the cyanobacteria. The

'Action' level was never exceeded for percentage cover, but the 'Alert' level was exceeded on four occasions. The 43% streambed coverage recorded on 21 December 2016 was the highest recorded value for any site during the 2016-2017 monitoring year. Minor detaching mats were observed on seven occasions, which triggered the 'Alert' level, and minor levels of exposed mats were observed on one occasion, triggering the 'Alert' response. In total, the 'Alert' level was triggered on seven occasions.

4.2.10 Lake Opunake

No bathing or boating usage of the lake was noted on any occasion, nor picnicking activities as has been recorded occasionally (sometimes with dogs present) at the time of sampling surveys in previous years. Ducks were noted regularly on the lake or in the vicinity of the lake edge and numbers were high on most occasions. A flock of Canadian geese, a swan, and a pukeko were recorded separately, each on one occasion. Large numbers of these wildfowl frequently have been present on the picnic area grass verge adjacent to the lake edge, attracted from time to time by food provided by picnickers. There was no repeat of the thick unsightly, algal scum prevalent on the lake surface for several weeks during mid to late summer in the 2010-2011 season (TRC, 2011) although some suspended algae and/or weed was noted at the beginning of the monitoring period.

Data from this site are presented in Table 62 and illustrated in Figure 46, with a statistical summary provided in Table 63.

Table 62 Analytical results for Lake Opunake

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1130	13.4	37	23	37	13.9	1.6
30.11.16	1120	13.8	220	73	220	15.0	1.1
05.12.16	1435	13.6	63	40	63	20.1	0.8
12.01.17	0835	12.3	610	2400	610	19.4	1.5
30.01.17	1144	13.4	260	1400	260	16.3	1.1
01.02.17	1350	13.6	350	1000	350	17.8	1.2
10.02.17	1055	14.4	110	540	110	16.8	1.2
16.02.17	1405	14.5	440	510	440	18.5	1.0
27.02.17	1100	14.8	410	900	410	19.2	1.2
02.03.17	1325	14.9	96	670	96	21.1	1.1
17.03.17	1300	13.6	210	630	210	16.9	1.1
02.04.17	1430	13.0	200	770	200	18.3	0.9
11.04.17	1205	14.6	220	440	220	15.8	1.1

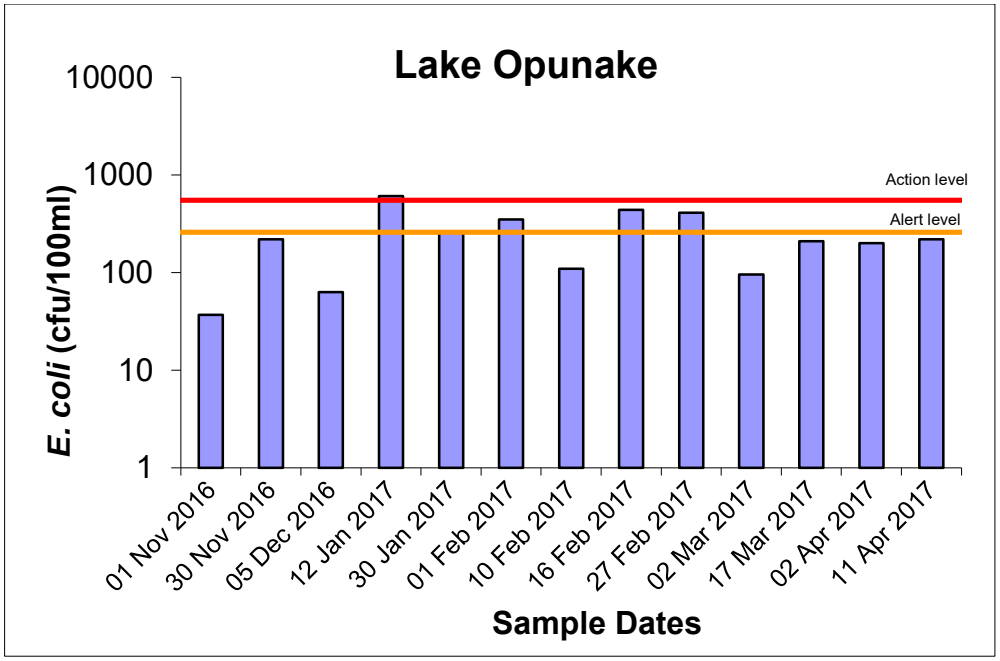


Figure 46 *E. coli* numbers for Lake Opunake during the survey season

Table 63 Statistical results summary for Lake Opunake

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	12.3	14.9	13.6
E. coli	cfu/100ml	13	37	610	220
Enterococci	cfu/100ml	13	23	2400	630
Faecal coliforms	cfu/100ml	13	37	610	220
Temperature	°C	13	13.9	21.1	17.8
Turbidity	NTU	13	0.8	1.6	1.1

The lake is formed by the diversion of water from the nearby Waiaua River (as a component of the Waiaua HEP scheme) and is close to the coast.

Water clarity was good (median turbidity: 1.1 NTU; range of turbidity: 0.8 NTU) with a very narrow range, as a result of minimal sediment disturbance and/or limited suspended algae in the water column. Good water quality was due, in part, to the lake's short residence time, with regular replenishment as a result of local hydroelectric power scheme usage. Median water temperature (17.6°C) was the second lowest recorded, with a narrower range (7.2°C) and lower maximum (21.1°C) value than usual, possibly as a result of fewer samples being taken in January, or of cloudier weather. Conductivity varied over a narrow range (2.6 mS/m @ 20°C) reflecting river inflow conditions.

Generally, bacteriological quality was moderate, the median count (220 *E. coli* per 100 ml) being equal to the highest recorded, over a relatively narrow range, influenced in part by the inflow to the lake originating from the lower reaches of a river draining a developed catchment and also by the local wildfowl population, with one exception. A high count of 610 *E. coli* per 100 ml, was returned for a sample taken in mid January when a large number of ducks were in the immediate vicinity. In previous seasons, marked fluctuations in counts have occurred which were most likely associated with this bird population, particularly in instances where ducks had been

attracted to the immediate vicinity of the monitoring site by picnickers feeding the birds.

4.2.10.1 Comparison with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 58.

Table 64 Bacterial guidelines performance at Lake Opunake [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100 ml
E. coli	3 [23]	1 [8]

(Designation: freshwater contact recreational area)

One single sample exceedance of the 'Action' mode occurred during the period, and three single samples were recorded within the 'Alert' mode. The single very high count was followed by the installation of 'health warning' signage by STDC. Publicity was given to the state of the lake on the STDC, LAWA and TRC websites. Additional sampling subsequent to the 'Action' level showed elevated *E. coli* numbers (350 and 770 per 100 ml on 16 and 18 January, respectively), while large numbers of ducks were present and were being fed from the banks. The signage was left in place for the remainder of the season, although the last three counts were within 'Surveillance' mode.

In terms of the guidelines for contact recreational usage, bacteriological water quality at this site was in compliance with the acceptable level for most of the period, with one incursion into the 'Action' level.

4.2.10.2 Comparison with previous summers' surveys

A statistical comparison of all summers' *E. coli* survey data is presented graphically in Appendix VI for all sites. The eleven summers of data collection for the Lake Opunake site are summarised in Table 65 and illustrated in Figure 47.

Table 65 Summary of *E. coli* bacteriological water quality data to date (cfu/100 ml) for all summer surveys at Lake Opunake to date

Summer	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17
Minimum	33	26	54	64	8	40	17	<8	4	11	37
Maximum	720	1300	2800	320	3800	2000	500	430	390	2000	610
Median	110	130	210	220	80	80	120	100	66	51	220

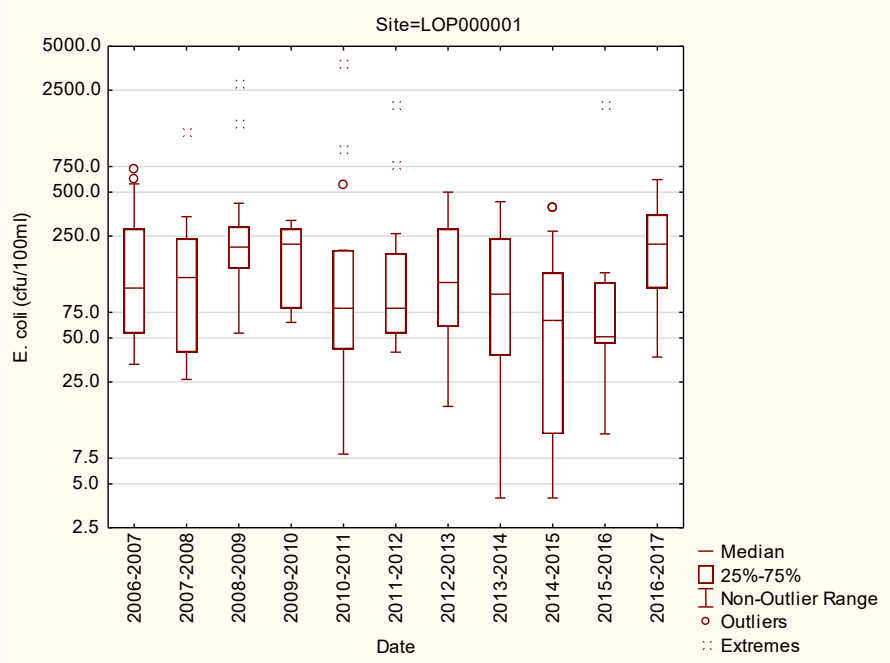
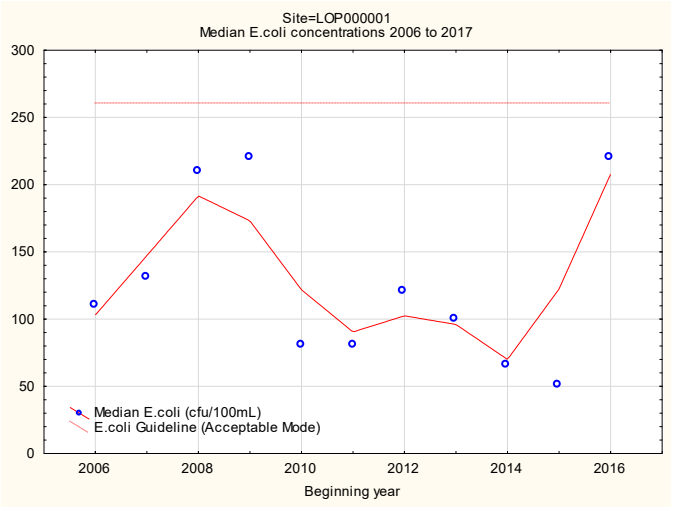


Figure 47 Box and whisker plots for the summer SEM survey of *E. coli* bacteria numbers at Lake Opunake

The median *E. coli* number in the 2016-2017 season was equal to the highest for the eleven seasons' surveys to date, following the lowest median *E. coli* number in 2015-2016 (Figure 47).

Trend analysis of these median *E.coli* numbers has been performed for the ten seasons of data by first applying LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 48) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.



N = 11
Kendall tau = -0.241
p level = 0.303 [>FDR, p = 0.571]
N/S at p < 0.05

Figure 48 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Lake Opunake site, for the 2000-2017 period

Overall, a statistically insignificant decreasing trend in median *E. coli* counts was found over the eleven seasons of monitoring. The trend was stronger, but not significant upon FDR application, after the 2015-2016 season. None of these seasonal medians has exceeded the 'Alert' mode.

4.2.10.3 Cyanobacteria

Planktonic cyanobacteria were monitored on seven occasions throughout the season with results presented in Table 66 and Figure 49.

Table 66 Cyanobacteria counts and biovolumes for Lake Opunake

Date	Cyanobacteria total cell count (cells/ml)	Biovolume (mm^3/L)	Principal species by biovolume	Mode
22/11/2016	0	0	No cyanobacteria	Low Risk
07/12/2016	0	0	No cyanobacteria	Low Risk
21/12/2016	0	0	No cyanobacteria	Low Risk
05/01/2017	0	0	No cyanobacteria	Low Risk
26/01/2017	0	0	No cyanobacteria	Low Risk
07/02/2017	29636	0.9	*Microcystis*	Medium Risk
07/03/2017	8	0	*Limnococcus*	Low Risk

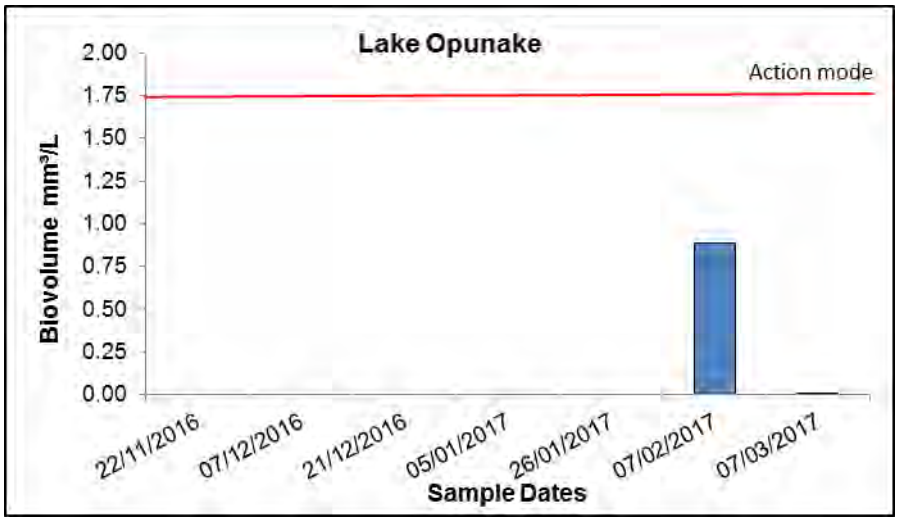


Figure 49 Cyanobacteria biovolume at Lake Opunake

Planktonic cyanobacteria were not detected for the majority of the recreational monitoring period, with a moderate bio-volume level of *Microcystis* recorded on the second to last sampling occasion in February and a very low bio-volume of *Limnococcus* recorded in March.

No cyanobacteria had been found in this lake during the 2006-2007, 2008-2009, 2009-2010, 2010-2011, 2011-2012, 2012-2013 or 2015-2016 seasons, but their presence (in low numbers) in the latter part of the 2007-2008 and 2015-2016 seasons and in the middle of the 2013-2014 (once in excess of 6000 cells/mL) seasons followed lengthy, extremely low flow periods. However, these numbers did not reach levels requiring the issue of 'health warnings' during those two seasons. The relatively short lake water residence time (due to hydroelectric power generation usage) may be a controlling factor for these populations.

4.2.11 Timaru Stream at Weld Road (near mouth)

Some bathing usage was noted at this site on two sampling occasions, while some walking along the stream banks and surfing at the mouth was recorded on other occasions during the season. The site had been a popular camping area (until it was closed by NPDC during early 2005) and access point to the sea coast but camping had occurred from time to time across on the true left bank. The site, to a certain extent tidal, showed varying degrees of saltwater penetration, particularly under very low flow recession conditions toward late summer. The general direction of flow was upstream or six of the thirteen monitoring occasions. Gulls and terns, sometimes in large numbers, and oystercatchers and swallows were present on occasions, with dogs in the water from time to time. There was light rainfall (0.5 to 4.5 mm) at some time over the previous day on six occasions, and at some time over the previous three days (0.5 to 10.5 mm) on eleven occasions.

Previously, analyses for faecal source DNA tracking markers (by Cawthron Institute, Nelson) were undertaken on two fine weather, low tide, samples collected under very low flow conditions in January and early April 2013. Low *E.coli* counts (80 and 40 per 100 mls) were found to be coincident with bacteria of ruminant and wildfowl origin, typical of sites in the lower reaches of streams and rivers elsewhere on the ringplain.

River flow records for the 2016-2017 season are provided in Figure 51. Data from this site for the 2016-2017 season are presented in Table 67 and illustrated in Figure 50, with a statistical summary provided in Table 68.

Table 67 Analytical results for the Timaru Stream at Weld Road

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1220	41.6	80	9	80	14.8	0.3
30.11.16	0830	8.6	330	53	330	14.3	0.2
05.12.16	1400	8.7	34	21	34	19.4	0.3
12.01.17	0810	85.3	380	540	380	18.0	0.6
30.01.17	1020	22.1	460	280	460	17.8	0.7
01.02.17	1050	30.2	340	180	340	17.3	1.5
10.02.17	0800	69.6	550	140	550	15.5	0.7
16.02.17	1415	55.8	110	320	110	18.3	0.4
27.02.17	0815	71.5	470	240	470	16.9	0.6
02.03.17	1335	600	280	190	290	19.6	1.4
17.03.17	1305	9.9	120	88	130	18.0	1.2
02.04.17	1115	56.4	420	470	440	16.9	0.4
11.04.17	0900	29.3	310	520	310	14.9	0.5

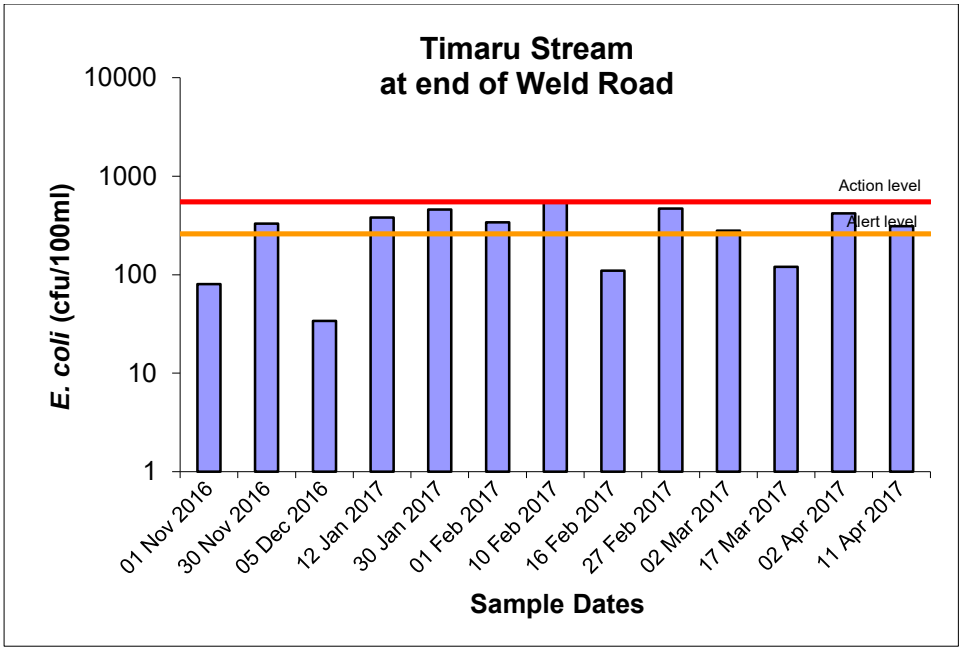


Figure 50 *E.coli* numbers for the Timaru Stream at Weld Road during the survey season

Table 68 Statistical results summary for the Timaru Stream at Weld Road

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	8.6	600	41.6
E. coli	cfu/100ml	13	34	550	330
Enterococci	cfu/100ml	13	9	540	190
Faecal coliforms	cfu/100ml	13	34	550	330
Temperature	°C	13	14.3	19.6	17.3
Turbidity	NTU	13	0.2	1.5	0.6

This river drains a moderately farmed catchment (five consented dairy farm discharges) receiving point and non-point source discharges from dairy farms, although it is relatively short in length, rising partly in the nearby Kaitake range and the north-western area of Egmont National Park. Conductivity levels varied markedly in response to saltwater penetration at this site and were elevated on all but three occasions during the season and particularly in mid to late summer-autumn under low stream flow conditions. Turbidity levels were very low on all but three occasions through the season, consistent with the generally clear appearance of the river. Minimal algal cover was noted in association with the good aesthetic appearance of the river due to the sandy substrate at this deeper, ponded site. Water temperature varied over a moderate range of 5.5°C with a maximum water temperature of 19.6°C recorded in early afternoon in early March 2017. This maximum could have been expected to have been exceeded on other occasions during summer as all sampling was undertaken before 1420 hrs and the majority in the mornings.

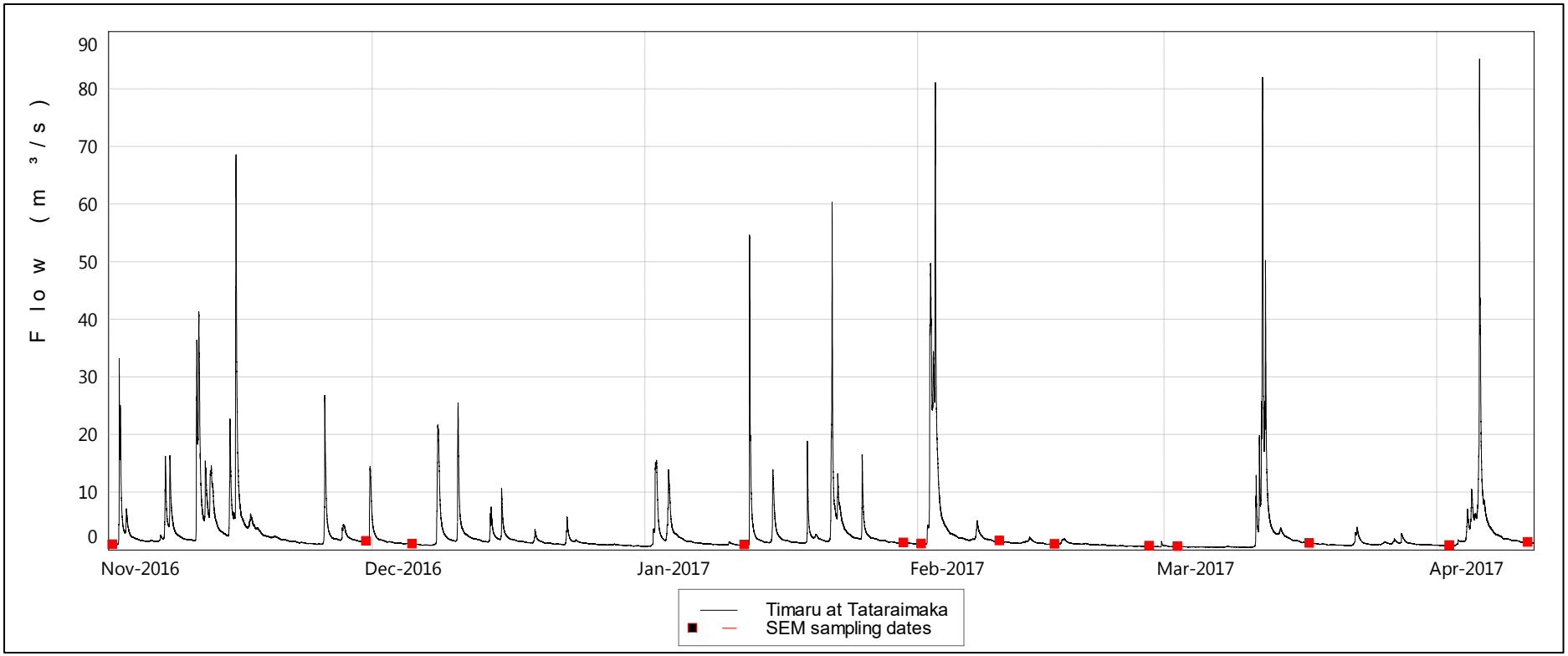


Figure 51 Flow in the Timaru Stream at Tataraimaka during the survey period

Bacteriological water quality at this site was generally below average and probably poorer than typical of the lower reaches of other Taranaki ring plain streams draining agricultural catchments. *E. coli* numbers tended to be lower in samples taken relatively late in the day, with the only counts within 'Surveillance' mode in the 2016-2017 season being returned for four of the five samples taken after midday.

Stock access to the lower stream (which was crossed to reach adjacent farmland at times) during the prolonged dry period of the 2007-2008 season (requiring remedial action after incidents were reported by the general public) was not repeated or recorded in any subsequent seasons nor in the current season. Surveys in other rivers with tidal pool reaches have found that bacteriological water quality may deteriorate probably as a result of ponding of the flow and 'accumulation' of slugs of poorer quality downstream flow, and several high *E. coli* counts were coincidental with more ponded conditions (during elevated conductivity events). It has also been noted at these tidal river pool sites that lower faecal coliform to enterococci ratios than usual have been recorded possibly due to vegetative sources and/or better enterococci survival in pool environments characterised by the ebb and flow in the ponded river/stream mouth.

4.2.11.1 Comparison with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 63.

Table 69 Bacterial guidelines performance at the Timaru Stream, Weld Road site [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	9 [69]	0 [0]

(Designation: freshwater contact recreational area)

Nine single samples were recorded in the 'Alert' mode, and no sample was recorded in the 'Action' mode during the period. Poorer bacteriological water quality tended to coincide with sampling earlier in the day.

In terms of the 2003 contact recreation guidelines, the bacteriological water quality at the site was relatively poor, although partly affected by the ponding caused by the site's proximity to the sea coast.

4.2.11.3 Comparison with previous summers' surveys

A statistical comparison of each of the summers' survey data is presented graphically in Appendix VI for all sites. These summer data for the Timaru Stream site at the end of Weld Road (which has been monitored for twenty summers) are summarised in Table 70 and illustrated in Figure 52.

Table 70 Summary of *E. coli* bacteriological water quality data to date (cfu/100ml) for all summer surveys in the Timaru Stream at lower Weld Road

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum		40	23	31	77	31	140	77	84	38	
Maximum		410	710	1400	540	660	1000	410	1000	460	
Median		280	210	160	180	180	260	220	260	220	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	43	46	92	46	28	34	26	54	63	66	34
Maximum	480	930	440	560	410	440	550	660	2000	1500	550
Median	200	180	230	290	180	160	250	200	210	230	330

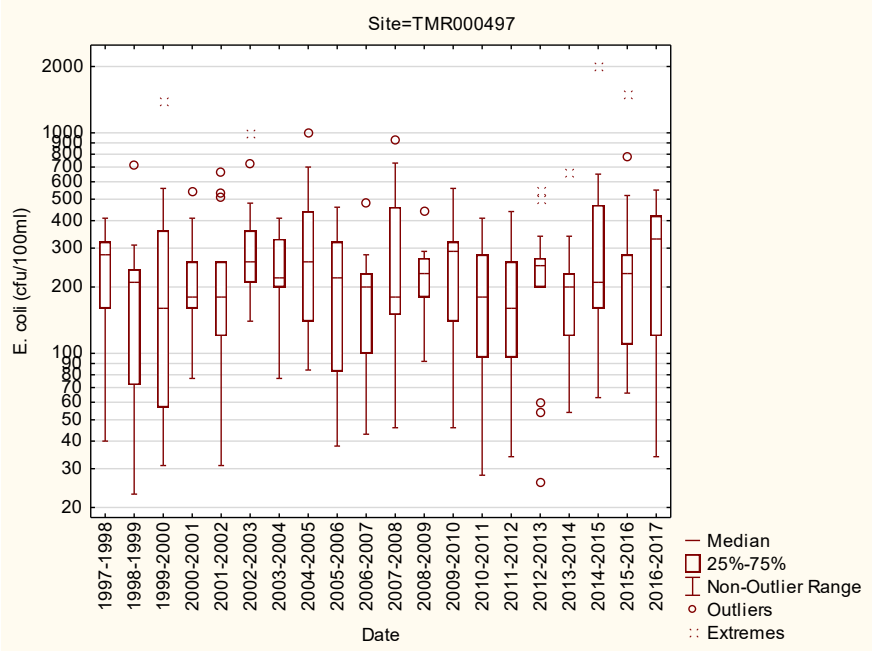
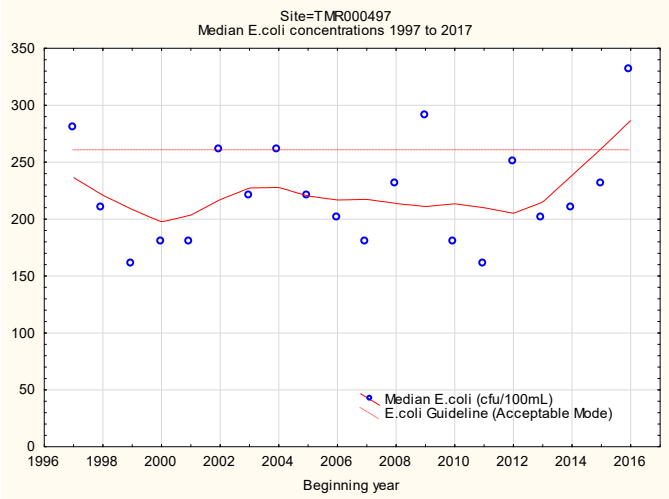


Figure 52 Box and whisker plots for all summer surveys of *E.coli* bacterial numbers in the Timaru Stream at lower Weld Road

The median *E. coli* count for the 2016-2017 season was the highest recorded over twenty years of monitoring (Table 70). Counts over the 2016-2017 season had a narrow range (Figure 52), with no count reaching the 'Action' mode.

Trend analysis of these median *E. coli* numbers has been performed for the twenty seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 53) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.



N = 20
Kendall tau = 0.120
p level = 0.461 [>FDR, p = 0.783]
N/S at p < 0.05

Figure 53 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Timaru Stream, lower Weld Road site for the 1997 to 2017 period

An overall very slight, unimportant, increasing trend in median *E. coli* numbers has been found over the twenty seasons of monitoring which has not been statistically significant. None of these seasonal medians exceeded the 'Action' mode, although the medians for the initial, 2008-2009 and the most recent seasons entered the 'Alert' mode and three others have been very close to the 'Alert' mode from time to time at this site.

4.2.11.4 Benthic cyanobacteria

No benthic cyanobacteria surveys were performed at this site as it is often ponded above a sandy substrate due to tidal influences.

4.2.12 Waimoku Stream at Oakura beach

The easy access to this small and very shallow stream which flows and often ponds across Oakura beach, the most popular recreational beach in north Taranaki, provides a convenient contact recreational area for children in particular. Bacteriological monitoring and various investigation surveys have been performed at this site from time-to-time, particularly in relation to septic tank wastes disposal in Oakura, the interpretation of coastal bathing beach water quality, and for assessment of the effectiveness of Council's water policies. Such a survey at the mouth and upstream of Oakura township during the 1998-1999 bathing period, and two more recent catchment surveys in the 2004-2005 (TRC, 2005) and 2009-2010 periods (TRC, 2010a) indicated that the relatively high bacterial counts found in the stream at the coast were also apparent in the Waimoku Stream upstream of the township, where some stock access and extensive wildfowl populations contributed to high bacterial numbers. This was particularly apparent in certain tributaries upstream of the coastal township and therefore not attributable to domestic wastes disposal practices within Oakura township. Historical data have highlighted the poor bacteriological water quality regularly exhibited in this stream, resulting in considerable publicity. More appropriate, permanent health warning signage was erected by NPDC in consultation with the Area Health Board early in the 2009-2010 season in positions of public prominence. As a consequence, bacteriological samples collected during the

first half of the 2009-2010 programme were also analysed by Cawthron Institute, Nelson using faecal source DNA tracking marker techniques in association with high *E.coli* counts at this site. All samples were found to contain bacteria indicative of wildfowl (principally ducks and other species) origin, with minimal ruminant (cattle) sources and no indications of human origin. (Note: Currently, there are no markers available for specific pukeko faecal identification). These results were consistent with the conclusions of the catchment survey reports referenced above. Planting of streamside vegetation as a component of a riparian management scheme (in cooperation with landowners) although contributing to aspects of bacteriological water quality improvement in the lower reaches of the stream may also provide habitat for wildfowl species. Management of dairy farm wastes in the catchment will also continue to be monitored in conjunction with bathing water quality as a long-term component of the SEM programme. The completion of a reticulated sewerage system (by NPDC in 2010), with Oakura domestic wastewater collected and pumped to the New Plymouth WWTP, will also ensure that surface water bacteriological water quality will not be compromised by septic tank effluent seepages in the township.

The frequency of monitoring at this site was reduced to triennial surveys following the 2010-2011 survey, with the most recent 2016-2017 survey being the second at this frequency.

The Council continues to monitor the site for its prospective influence upon the water quality of Oākura Beach.

No contact recreation was observed at this very shallow stream site at the time of the 2016-2017 sampling visits. Although people were present on the beach in the immediate vicinity of the stream mouth on only three sampling occasions, this site is known to be popular with children and families during favourable weather conditions at holiday periods and weekends (see, TRC 2009a and TRC, 2010). The channel flowed directly across the beach for most of the 2016-2017 season, but the stream migrated northwards later in the season, toward the Wairau Stream (TRC, 2017, Photo 11).

Data from the site are presented in Table 71 and illustrated in Figure 54, with a statistical summary provided in Table 72.

Table 71 Analytical results for the Waimoku Stream at Oakura beach

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1155	15.7	5700	560	5800	13.3	4.7
30.11.16	0930	14.8	920	460	920	14.6	2.6
05.12.16	0920	14.8	770	520	870	14.6	2.3
12.01.17	0840	14.6	970	1500	1100	16.1	2.1
30.01.17	1050	14.8	900	900	900	17.3	2.1
01.02.17	1140	14.5	1300	1000	1300	16.0	2.6
10.02.17	0825	13.8	1500	1300	1600	14.9	4.2
16.02.17	1350	14.2	1100	730	1100	15.6	2.4
27.02.17	0845	14.8	1700	2600	1800	15.4	4.3

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
02.03.17	1305	14.4	820	1500	840	16.9	4.1
17.03.17	1240	14.2	1000	1500	1000	16.4	6.4
02.04.17	1130	14.7	1400	2500	1400	16.7	2.8
11.04.17	0930	14.5	1300	1600	1300	15.4	5.7

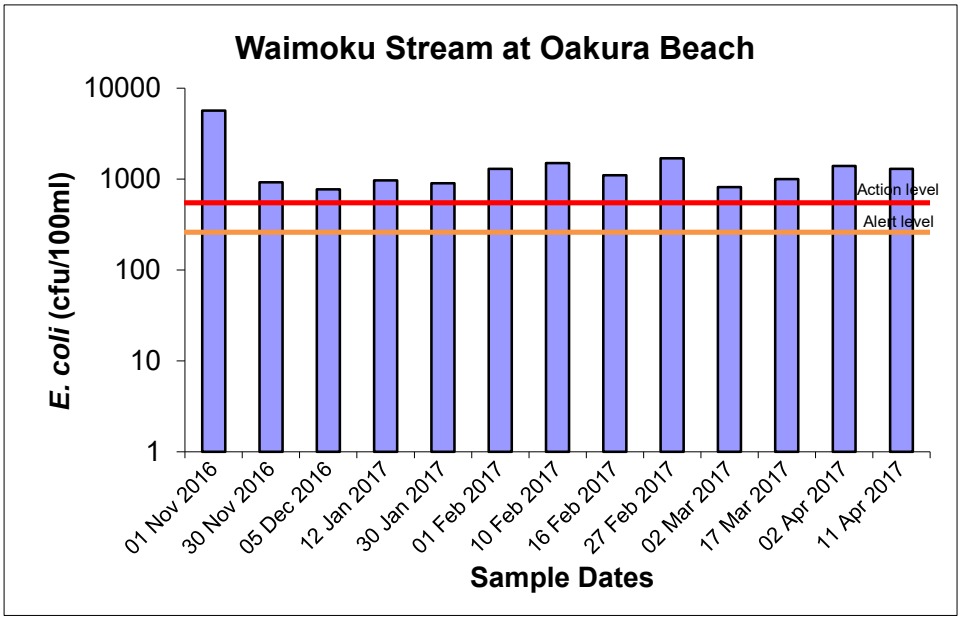


Figure 54 *E.coli* numbers for the Waimoku Stream at Oakura beach during the survey season

Table 72 Statistical results summary for the Waimoku Stream at Oakura beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20° C	mS/m	13	13.8	15.7	14.6
E. coli	cfu/100ml	13	770	5700	1100
Enterococci	cfu/100ml	13	460	2600	1300
Faecal coliforms	cfu/100ml	13	840	5800	1100
Temperature	˚C	13	13.3	17.3	15.6
Turbidity	NTU	13	2.1	6.4	3.6

This stream drains a catchment receiving very few dairy point source discharges together with non-point source run-off from these dairy farms over a relatively short distance from its source in the Kaitake Range to the sea. The stream flows for a short distance through Oakura township where sewage disposal is mainly via a pumped reticulation system (transferring sewage to the New Plymouth Wastewater Treatment Plant) that was completed by NPDC in 2009, although not all domestic wastes have been connected to this system. Wildfowl (ducks and pukeko in particular) are present in significant numbers on the stream or at the stream edges, particularly in some of the smaller tributaries (TRC, 2005 and TRC, 2010a), and have been confirmed as major sources of faecal contamination by DNA marker investigations.

Conductivity levels were very stable throughout the survey period with no salt water intrusion recorded. The stream was relatively clear in appearance. The streambed had widely varying cover (0 to 100%) of periphyton growth, depending on the proximity of sampling time to freshes. Water temperatures varied over a relatively narrow range of 4.0°C with a maximum water temperature of 17.3°C recorded in late morning in late January 2017. Water temperatures later in the day could be anticipated to exceed the maximum recorded as all sampling at this site was performed prior to 1355 hrs.

Bacteriological water quality was very poor throughout the survey period, and characterised by high enterococci, *E. coli* and faecal coliform counts. Although elevated counts have also been found in other ponded tidal reaches of ringplain rivers and streams, counts in this small stream were comparatively much higher. On-site farm dairy waste disposal practices during the season indicated a good standard of compliance. However, the presence of ducks (and other wildfowl (particularly pukeko)) and possibly some stock access to this small stream and tributaries upstream of the survey site could be expected to have contributed substantially to these elevated bacterial counts (see TRC, 2005 and TRC, 2010a).

4.2.12.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in .

Table 73 Bacterial guidelines performance at the Waimoku Stream, Oakura beach [% of 13 sample**s]**

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	0 [0]	13 [100]

(Designation: freshwater contact recreational area)

All thirteen single samples were recorded in the 'Action' mode.

In summary, bacterial water quality at this site at the mouth of this small stream consistently failed to achieve the guidelines for contact recreational usage throughout the survey period as it has in the past. However, the coastal bathing waters monitored adjacent to the stream mouth (main Oakura beach) met the enterococci 'Surveillance' mode guideline on 21 of 24 sampling occasions (median: 9 per 100 ml), with two individual samples entering the 'Alert' mode and one entering the (first stage of) 'Action' mode in these coastal waters. The proximity of this small inflow from the Waimoku Stream only slightly impacted on the main beach water quality as indicated by the median *E. coli* number of 32 per 100 ml (range: <1 to 360 per 100 ml) for the Oākura Beach for the SEM season (TRC, 2017).

4.2.12.2 Comparison with previous summers' surveys

A statistical comparison of each of the summers' survey data is presented graphically in Appendix V for all sites. These summer data for the Waimoku Stream at Oakura beach, which was monitored from 1996-1997 to provide interpretive information for nearby coastal beach monitoring data, are summarised in Table 74and Figure 55.

Table 74 Summary of *E. coli* bacteriological water quality data (cfu/100ml) for all summer surveys in the Waimoku Stream at Oakura beach to date

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum	220	310	350	200	85	250	300	450	440	560	
Maximum	1800	2400	2100	1700	900	1800	1700	1700	2200	6300	
Median	675	740	740	480	400	730	770	710	900	830	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	390	730	700	1400	1300			430			770
Maximum	3200	8100	4600	6200	13000			3300			5700
Median	930	2100	1600	2800	2700			1600			1100

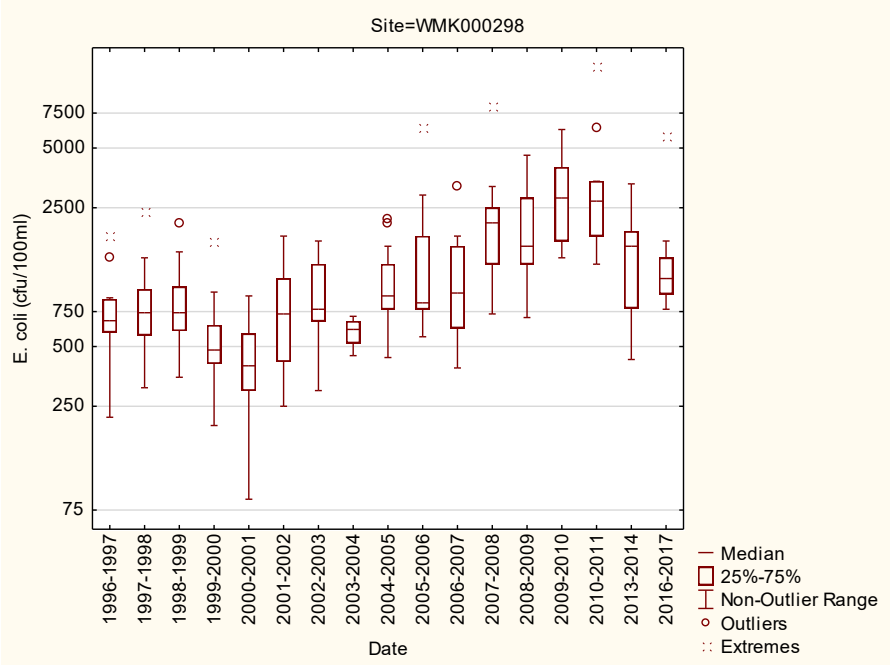
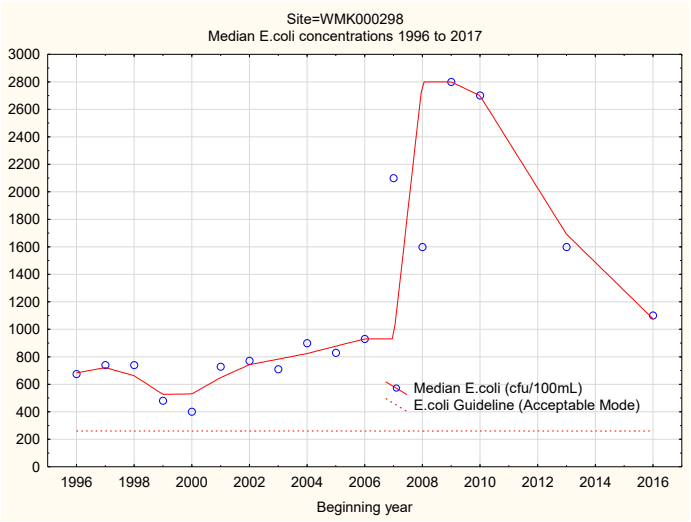


Figure 55 Box and whisker plots for all summer surveys of *E.coli* bacterial numbers in the Waimoku Stream at Oakura beach

The very high median *E. coli* count for the 2016-2017 season continued the more recent seasons' high median bacterial levels, with the equal fifth highest median of the seventeen seasons' surveys and a relatively wide range of counts. The trend of relatively high minimum counts also continued, indicative of poor bacterial water quality, long associated with this small predominantly agricultural catchment stream with high wildfowl numbers. However, the median *E. coli* count reduced consistently in the two recent triennial seasonal surveys, by a factor of about 60% since 2010-2011.

Trend analysis of median *E.coli* numbers has been performed for the seventeen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 46) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.



N =17
Kendall Tau = +0.637
p level = 0.0004 [>FDR, p = 0.0032]
Significant at p<0.01 and after FDR

Figure 56 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Waimoku Stream, Oakura Beach site for the 1996 to 2017 period

A very significant increasing trend in median *E. coli* numbers has been found over the seventeen seasons of monitoring. All of these seasonal medians exceeded the 'Alert' mode and all but two of the earlier seasonal medians have exceeded the 'Action' mode.

4.2.13 Oakura River below SH45

Bathing usage was recorded on one occasion at this site where people were often present on the riverbank at this very accessible tidal site. (Fishing has been observed, including whitebaiting in season, in previous years). Ponding and upstream surging frequently occurred under high tide conditions, and gulls and dogs were recorded occasionally on or in the river. Stock access opposite the site was apparent early in the previous season, but was not recorded during the current period.

Faecal source DNA tracking markers analyses (by Cawthron Institute, Nelson) had been performed on two low tide, fine weather samples collected in mid January 2013 and early April 2013 under very low flow conditions upstream of Oakura township as well as the usual site. *E. coli* counts were low (80 and 23 per 100 mls upstream and 100 and 20 per 100 ml downstream) and found to be coincident with bacteria of ruminant and wildfowl origin only, similar to the lower reaches of ringplain rivers and streams elsewhere.

Data from the site for the 2016-2017 season are presented in Table 75 and illustrated in Figure 57, with a statistical summary provided in Table 76.

Table 75 Analytical results for the Oakura River below SH45

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1125	7.9	42	21	42	12.8	0.5
30.11.16	1015	6.8	11000	56	11000	13.5	0.4
05.12.16	1315	7.8	14	21	23	18.2	0.5
12.01.17	0905	58.1	240	110	280	18.4	0.5
30.01.17	1115	13.0	170	87	170	17.3	0.5
01.02.17	1200	8.1	120	82	120	17.1	0.5
10.02.17	0840	7.6	200000	6400	200000	15.3	1.3
16.02.17	1325	7.7	68	120	68	16.8	0.3
27.02.17	0925	9.0	260	330	270	16.4	1.0
02.03.17	1225	406	71	96	71	18.8	0.6
17.03.17	1215	7.6	71	96	71	16.8	0.8
02.04.17	1215	16.0	88	210	100	17.4	0.5
11.04.17	1000	8.4	280	180	280	14.9	0.9

Table 76 Statistical results summary for the Oakura River below SH45

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	6.8	406	8.1
E. coli	cfu/100ml	13	14	200000	120
Enterococci	cfu/100ml	13	21	6400	96
Faecal coliforms	cfu/100ml	13	23	200000	120
Temperature	°C	13	12.8	18.8	16.8
Turbidity	NTU	13	0.3	1.3	0.5

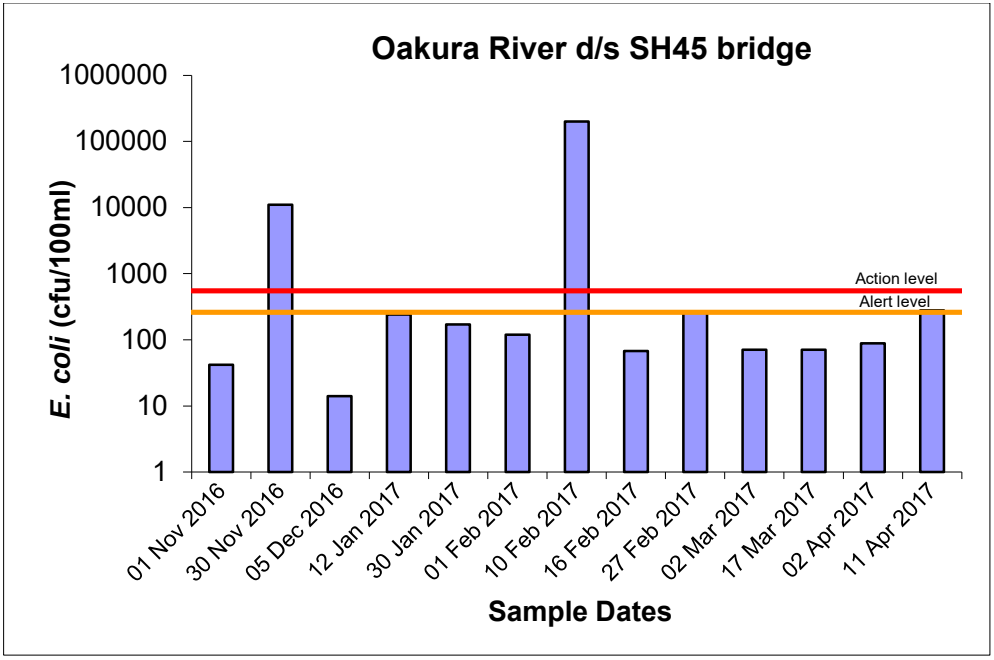


Figure 57 *E. coli* numbers for the Oakura River below SH45 during the survey season

This river drains a mainly agricultural catchment (three consented dairy farm discharges to surface water) with the survey site established in the popular short tidal reach between SH45 and the mouth of the river. The river was noted as tidal with ponding or inflowing obvious on eleven sampling occasions. Conductivity

levels indicated a variable influence of saltwater intrusion on at least two sampling occasions during the season. The more significant intrusion occurred during low flow conditions during the latter part of this season. On each occasion the river was clear in appearance. There was no algal substrate cover, due to the sandy nature of much of the substrate, except for a minor amount at the end of the season. Water temperatures varied over a moderate range (6.0°C) during the period reaching a maximum of 18.8°C in mid morning in early March 2017, but below the maximum water temperature which might be anticipated later in the day as all sampling at this site occurred no later than 1325 hrs.

Bacteriological water quality was generally moderate, but with a wide range of *E. coli* counts that included two very high counts that were unexplained. The other (eleven) *E. coli* counts were all below 290 cfu/100 ml. Bacteriological water quality was not dissimilar to that found elsewhere in ponded tidal reaches of ringplain rivers and streams, probably as a result of the occasional 'accumulation' of slugs of poorer quality downstream flow. This may have resulted from upstream stock access, agricultural non-point source runoff and/or point source discharges. Lower faecal coliform to enterococci ratios (than normally found at flowing river sites) were often recorded possibly as a result of vegetative sources of enterococci and/or better survival rates in tidal pool environments; sites which are characterised by ebbing and flowing within the ponded stream mouth reach.

A high *E. coli* count, but low enterococci count, occurred in late November, coincident with upstream flow of clear freshwater at high tide. Follow-up samples, taken five and six days later after a delay caused by wet weather, returned low *E. coli* counts (14 and 15 per 100 ml, respectively). Another, very high *E. coli* count, this time with a high enterococci number, was recorded in mid February, coincident with downstream surging freshwater flow and slight turbidity. The colonies on the test plates, both coliform and enterococci, were very uniform, suggesting an individual faecal source, rather than a multiple or combined source, such as sewage or cowshed effluent. Follow-up samples, taken three and four days later after a wet weather delay, returned much lower *E.coli* counts (410 and 170 per 100 ml, respectively) with relatively high enterococci counts (600 and 220 per 100 ml, respectively). A sample of the tributary that enters off Hall Terrace returned similar numbers. The source of contamination was not determined.

4.2.13.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 77.

Table 77 Bacterial guidelines performance at the Oakura River, SH45 bridge site [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	1 [8]	2 [15]

(Designation: freshwater contact recreational area)

One single sample fell within the 'Alert' mode, and two samples entered the 'Action' mode. These were all under relatively high flow conditions at times over the entire season. Health warning signage was required to be displayed at this site by NPDC for several days in both instances that the action level was exceeded, and appropriate public advice was provided on the District and Regional Council and LAWA websites.

Photo 7 Warning signage at Oakura River site, 6 December 2016

In terms of the 2003 contact recreation guidelines, the bacteriological water quality at the site was relatively poor, though it was within the acceptable single sample guidelines for contact recreational usage for the majority of the sampling season.

4.2.13.2 Comparison with previous summers' surveys

A statistical comparison of each of the twenty-one summers' survey data is presented graphically in Appendix VI for all sites. These summer data for the Oakura River site below the SH45 bridge are summarised in Table 78 and illustrated in Figure 58.

Table 78 Summary of *E. coli* bacteriological water quality data (cfu/100ml) for all summer surveys in the Oakura River downstream of SH45

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum	7	28	42	24	23	31	26	43	11	46	
Maximum	260	1100	240	540	310	580	420	1200	820	380	
Median	34	110	100	77	80	120	120	120	140	160	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	23	31	34	60	19	11	31	16	48	54	14
Maximum	330	2400	450	2500	290	440	530	220	1600	1900	200000
Median	220	140	180	150	100	140	140	86	120	120	120

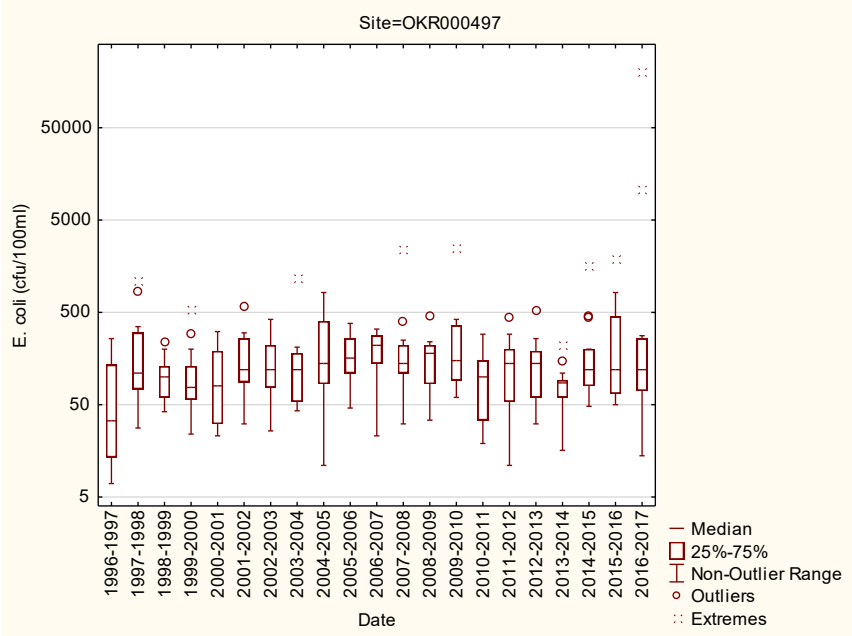
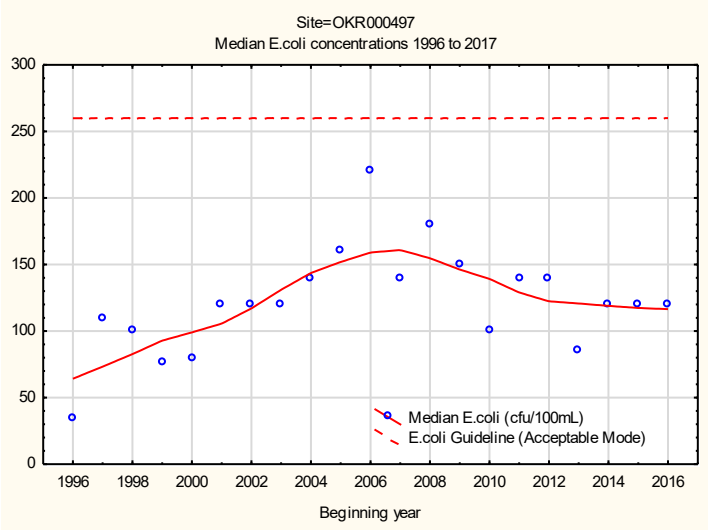


Figure 58 Box and whisker plots for all summer surveys of *E. coli* bacteria numbers in the Oakura River downstream of SH45

The median *E. coli* count was toward the middle of the range of past seasons' results (Figure 58). One of the wider ranges of *E. coli* counts was recorded. No median *E. coli* counts have exceeded the 2003 guidelines for contact recreational usage over the twenty-one seasons of monitoring.

Trend analysis of these median *E. coli* numbers has been performed for the twenty-one seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 59) and testing the significance of any trend using the Mann-Kendall test at 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.



N = 21
Kendall Tau = + 0.271
p level = 0.089[>FDR, p = 0.311]
Not significant at p < 0.05

Figure 59 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Oakura River, SH 45 site for the 1996 to 2017 period

A relatively strong increasing, but no longer significant, overall trend in median *E. coli* counts has been found over the twenty-one seasons of monitoring. However, none of these seasonal medians exceeded the 'Alert' or 'Action' modes. This increasing trend may warrant further investigation if it continues, but it should be noted that there had been a steadily improving trend (decrease) in median *E.coli* counts over an eight year period after medians peaked in the 2006-2007 season.

4.2.13.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on ten occasions during the season in a more appropriate reach, upstream of the SH45 bridge, with results presented in Table 79 and Figure 60.

Table 79 Percentage benthic cyanobacteria cover for the Oakura River at the SH45 Bridge site

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
09/11/2016	0	No	No	Green (surveillance)
24/11/2016	0	No	No	Green (surveillance)
12/12/2016	0	No	No	Green (surveillance)
21/12/2016	0	No	No	Green (surveillance)
05/01/2017	0	No	No	Green (surveillance)
18/01/2017	0	No	No	Green (surveillance)
07/02/2017	0	No	No	Green (surveillance)
27/02/2017	1	No	No	Green (surveillance)
16/03/2017	0	No	No	Green (surveillance)
30/03/2017	0	No	No	Green (surveillance)

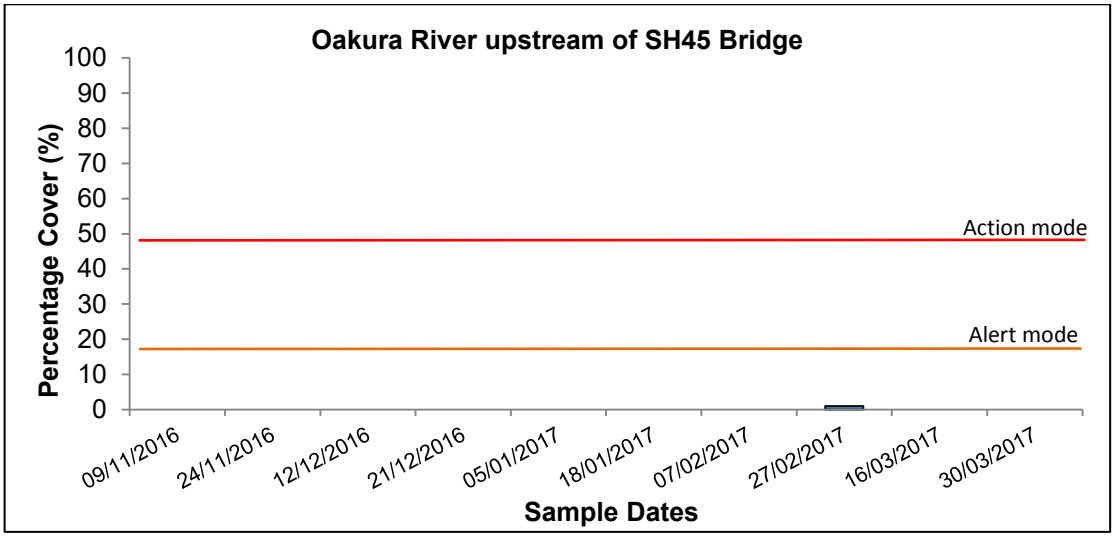


Figure 60 Percentage benthic cyanobacteria cover at the Oakura River upstream of SH45 bridge

Note that 'Action' and 'Alert' mode lines are for percentage cover only. The symbols * and $^{+}$ over a bar indicate where the status been raised to 'Alert' or 'Action' mode, respectively due to detaching or exposed mats.

Benthic cyanobacteria coverage was very low throughout the season (ranging from 0 to 1%). The benthic cyanobacteria found were a *Phormidium* sp. The 'Action' or 'Alert' level was never exceeded for percentage cover, or for detaching and exposed mats.

4.2.14 Waitara River at the town wharf, Waitara

No bathing usage of this river site at the new town wharf was recorded at the time of sampling surveys, the majority of which were prior to midday. Both bathing and fishing (including whitebaiting in season) have been noted from time-to-time in previous seasons at this site with rowing and canoeing as additional activities. Ducks were present on occasions but in low numbers, and gulls once.

Concerns relating to the source of faecal bacteria found at this site by past monitoring, led TRC to undertake additional microbial source tracing (MST) using DNA marker techniques at four sites in the lower Waitara River during the 2010-2011 season (TRC, 2011b). In summary, faecal bacteria found at this Town Wharf site were sourced predominantly from cattle (under all tidal and flow conditions) with some indication of bacteria of human origin under high tide and flood conditions. Upstream (Bertrand Road site) faecal bacteria were totally of cattle origin whilst downstream (on both sides of the river mouth), faecal bacteria of cattle (all occasions), wildfowl and human (occasional) derivation were found.

Regular sampling data from the site for the 2016-2017 season are presented in Table 80 and illustrated in Figure 61 with a statistical summary provided in Table 81. River flow information is illustrated in Figure 62.

Table 80 Analytical results for the Waitara River at the town wharf, Waitara

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1000	579	260	9	270	14.5	11
30.11.16	1005	179	2500	330	2500	15.5	120
05.12.16	1305	270	84	11	92	20.9	11
12.01.17	0845	477	260	48	260	19.9	5.6
30.01.17	1025	644	270	68	280	18.3	12
01.02.17	1145	422	180	52	180	18.8	6.4
10.02.17	0900	503	250	120	250	18.2	7.0
16.02.17	1220	579	130	64	140	19.0	12
27.02.17	1025	765	150	88	150	19.5	6.2
02.03.17	1150	664	180	19	180	21.2	5.4
17.03.17	1145	550	280	51	280	18.2	17
02.04.17	1220	868	100	63	100	18.6	4.8
11.04.17	0955	557	260	100	260	15.4	12

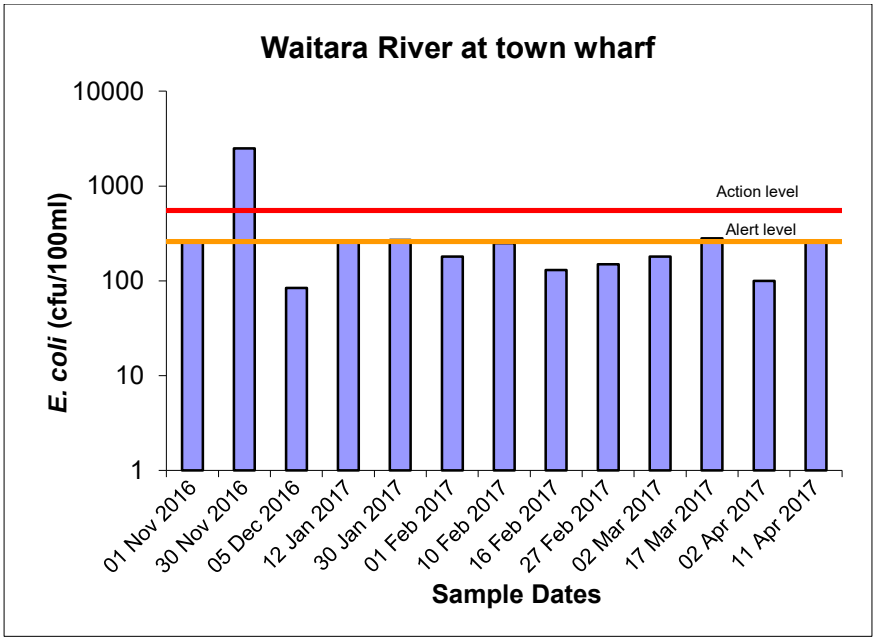


Figure 61 *E.coli* numbers for the Waitara River at the town wharf, Waitara during the survey season

Table 81 Statistical results summary for the Waitara River at the town wharf, Waitara

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20° C	mS/m	13	179	868	557
E. coli	nos/100ml	13	84	2500	250
Enterococci	nos/100ml	13	9	330	63
Faecal coliforms	nos/100ml	13	92	2500	250
Temperature	˚C	13	14.5	21.2	18.3
Turbidity	NTU	13	4.8	120	11

This ring plain and eastern hill country river drains an extensively developed agricultural catchment. The survey site is situated in the lower tidal reaches of this large river, some 1.5 km upstream of the river mouth. There are consented dairy ponds treated wastes discharges in the catchment upstream of the site particularly in the Manganui River sub catchment (see 4.2.16). River water was generally slightly turbid, green-brown to turbid brown in appearance, with the highest median turbidity (11 NTU) over the eight seasons of record. Elevated conductivity levels typical of seawater ingress near high tide occurred on all sampling occasions, and occasionally coincidental with ponded or very slow downstream flow conditions.

Water temperatures had a moderate range of 6.7˚C partly due to the coastal seawater influence, with a maximum of 21.2˚C recorded in early afternoon in early March 2017. All of the samples were collected before 1310 hrs and therefore maximum river temperatures (which tend to occur later in the afternoon) were not recorded.

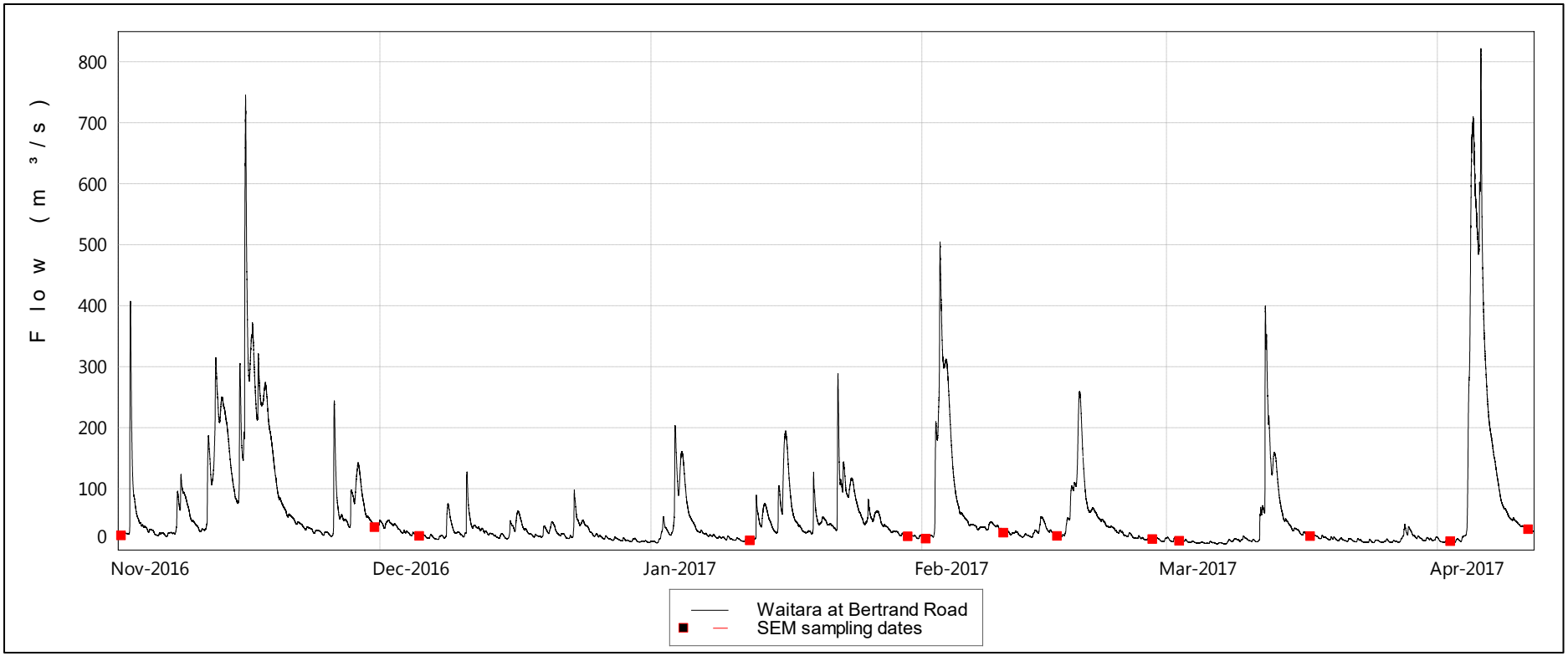


Figure 62 Flow in the Waitara River at Bertrand Road during the survey period

Bacteriological water quality was moderate, and typical for the lower reaches of this large Taranaki eastern hill country and ring plain river draining a predominantly agricultural catchment subject to coastal seawater influence under high tide conditions (median 250 *E.coli* per 100 ml and 63 enterococci per 100 ml). The existing recreational sampling programme was performed around higher tidal conditions for SEM trend purposes (due to its incorporation within the coastal sites programme) at times when public usage is often more predominant at this site. Poorer bacteriological water quality might be expected under outflowing low tide conditions, although monitoring undertaken 6km further upstream (at the flow recorder site at Bertrand Road) over the recreational period 2009-2014 has found a lower median *E.coli* bacterial number of 67 per 100 ml but a wider range of *E. coli* numbers (6 to 5000 per 100 ml).

4.2.14.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 72.

Table 82 Bacterial guidelines performance at the Waitara River at the town wharf, Waitara [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	2 [15]	1 [8]

(Designation: freshwater contact recreational area)

Two single samples fell within the 'Alert' mode and one sample within the 'Action' mode during the monitoring period. The 'Action' mode exceedance occurred in overcast weather less than four days after a substantial rainfall event in the hinterland and coincided with the highest turbidity (120 NTU) recorded during the survey period. It has been noted, during past survey periods, that the three-day post rainfall sampling protocols followed by the SEM programme for the other (ringplain) catchment sites are not necessarily appropriate for baseline assessments of bacteriological water quality at this site near the mouth of this predominantly eastern hill country catchment river as a result of the lag effects of rainfall run-off further upstream within this large catchment.

Photo 8 Warning signage at Waitara River (boat ramp)

These issues have been discussed with the Area Health Board and NPDC staff and appropriately worded health warning signage was permanently installed at the town wharf prior to the 2010-2011 season. (Photo 7). However, the permanency of this signage has been probematical due in part to vandalism.

In summary, the bacteriological water quality at this estuarine site was within guidelines for contact recreation for the majority ot the survey period.

4.2.14.2 Comparison with previous summers' surveys

Seven previous SEM sampling seasons have been monitored at this site. Therefore only a brief statistical comparison can be made with previous data. These data for the Waitara River at the town wharf, Waitara site are summarised in Table 83 and illustrated in Figure 63 for this, the eighth season of monitoring.

Table 83 Summary *E. coli* bacteriological water quality data (cfu/100ml) for summer surveys in the Waitara River at the town wharf, Waitara

Summer	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17
Minimum	92	19	28	3	13	58	100	84
Maximum	1700	570	550	1300	290	1500	900	2500
Median	230	76	150	120	100	140	250	250

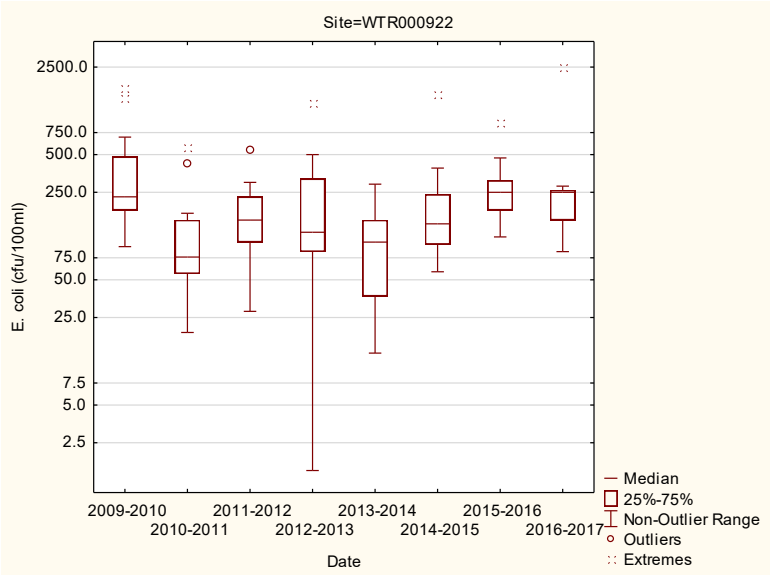


Figure 63 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waitara River at the town wharf, Waitara

The median *E. coli* number found by this eighth season's survey was equal to the highest recorded, and was just below the 'Alert' mode. A similar median value was recorded the previous year, and six years before. A wide range of counts was recorded, due in part to delayed effects of preceding freshes in this large, predominantly hill country catchment, and partly to high turbidity and sometimes cloudy weather reducing the sterilizing effect of sunlight. Trend analysis of median *E.coli* numbers will not be performed until the sampling period has encompassed ten seasons of data collection at this site.

4.2.15 Urenui River at the estuary

No bathing usage was noted and some fishing during the 2016-2017 sampling surveys at this tidal site. This is a very popular site during weekends and holiday periods (see TRC, 1999 and TRC, 2008a), with these and boating, picnicking and other recreational activities taking place.

Data from the site are presented in Table 84 and enterococci counts (as the site is predominantly seawater) are illustrated in Figure 64, with a statistical summary provided in Table 85.

Table 84 Analytical results for the Urenui River at the estuary

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1100	4540	1	1	1	16.7	19
30.11.16	0905	4610	19	1	20	16.0	36
05.12.16	1205	4340	3	<1	3	20.4	3.0
12.01.17	0755	4300	59	13	60	18.0	15
30.01.17	0915	4300	23	9	23	18.6	12
01.02.17	1055	4500	27	8	27	18.9	9.5
10.02.17	1000	4740	12	34	12	19.4	22
16.02.17	1115	4630	17	4	17	19.4	14
27.02.17	0935	4740	7	1	7	20.3	7.0
02.03.17	1100	4740	3	4	3	21.1	3.4
17.03.17	1100	4640	11	7	11	19.9	16
02.04.17	1110	4590	12	7	13	19.9	10
11.04.17	0920	4500	16	20	31	18.3	16

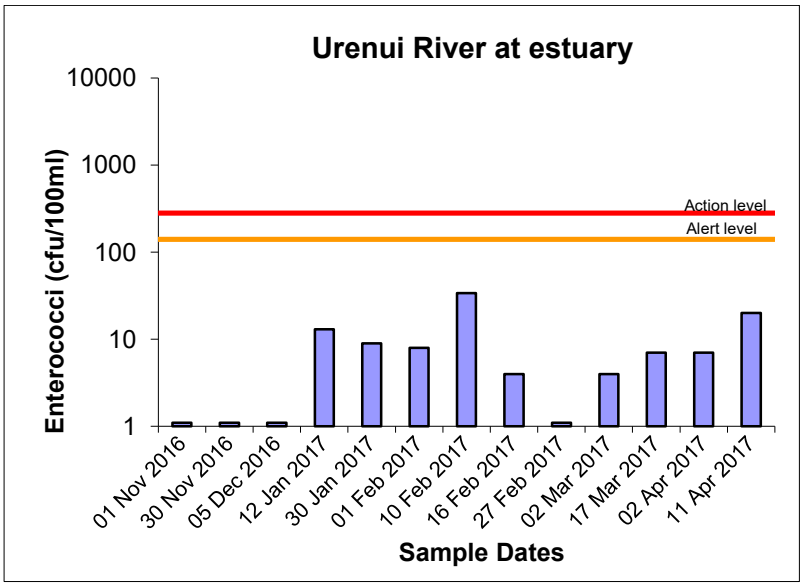


Figure 64 Enterococci numbers for the Urenui River at the estuary during the survey season

Table 85 Statistical results summary for the Urenui River at the estuary

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4300	4740	4590
E. coli	cfu/100ml	13	1	59	12
Enterococci	cfu/100ml	13	<1	34	7
Faecal coliforms	cfu/100ml	13	1	60	13
Temperature	°C	13	16.0	21.1	19.4
Turbidity	NTU	13	3.0	36	14

This hill country catchment river typically is turbid under low tide conditions in the tidal lower reaches of the estuary where it is extensively used by visitors and the holiday population based at the Urenui Beach settlement. High tide conditions resulted in aesthetic improvements within the estuary. Under high tide sampling conditions, the minimum (3.0 NTU) and median turbidity (14 NTU) levels were indicative of moderately turbid conditions typical of mixing of the more discoloured river flow with inflowing, cleaner seawater. The river at this site was generally described as relatively uncoloured to blue-green to green-brown in appearance and varying between clearish to slightly turbid to turbid. Conductivity levels were characteristic of coastal saltwater on all occasions. Moderately high water temperatures (median of 19.4°C), more typical of coastal seawater temperatures, varied over a moderate range of 5.1°C during the sampling period with a maximum of 23.9°C recorded in late morning in early March 2017. All sampling however, was undertaken prior to 1210 hrs when water temperatures could have been expected to have been cooler than later in the day, depending upon the state of the tide.

Bacteriological water quality was generally very good as a result of the seawater tidal intrusion into the estuary. Poorer bacteriological river water quality might be expected under low outflowing tidal conditions as comparative sampling at the semi-tidal upstream SH3 bridge site to date has identified significantly higher numbers of all three bacteriological species (eg medians for *E. coli* [390 per 100 ml] and enterococci [165 per 100 ml]). The existing sampling programme was designed around higher tidal conditions (for SEM trend purposes and due to its incorporation within the coastal sites sampling programme) at times when bathing is more predominant at this site.

4.2.15.1 Comparison with guidelines

Comparison with the 2003 guidelines for contact usage is summarised in Table 76 using the marine guidelines, which are considered to be more appropriate for this estuarine site.

Table 86 Bacterial guidelines performance at the Urenui River estuary site [% of 13 samples]

Parameter	Number of exceedances of enterococci guidelines	
	ALERT Single sample 141-280/100ml	ACTION 2 consecutive single samples >280/100 ml
Enterococci	0 [0]	0 [0]

(Designation: coastal contact recreational area)

No single sample fell within the 'Alert' mode or within the 'Action' mode for saline water at any time during the monitoring period. Also, neither mode was exceeded in terms of the freshwater guidelines (for *E. coli*).

The bacteriological water quality at this site was within the acceptable guidelines for contact recreational usage throughout the season recognising that all sampling occasions coincided with mid to high tides and therefore a predominance of high quality saline water mixing with poorer quality river water at this estuarine site. This was consistent with data for the nearby Urenui Beach coastal site (median enterococci: 3 per 100ml) monitored over seven seasons to date.

4.2.15.2 Comparison with previous summers' surveys

A statistical comparison of each of the twenty-one summers' survey data is presented graphically in Appendix VI for all sites. These summer enterococci data for the Urenui River site at the estuary are summarised in Table 87 and illustrated in Figure 65.

Table 87 Summary of enterococci bacteriological water quality data (cfu/100ml) for all summer surveys in the Urenui River estuary to date

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum	<1	<1	<1	1	<1	<1	<1	<1	1	<1	
Maximum	40	69	82	220	160	27	19	72	640	30	
Median	5	7	3	8	14	8	4	4	5	4	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Maximum	9	36	120	190	150	36	100	51	99	54	34
Median	1	2	11	7	3	4	3	3	3	8	7

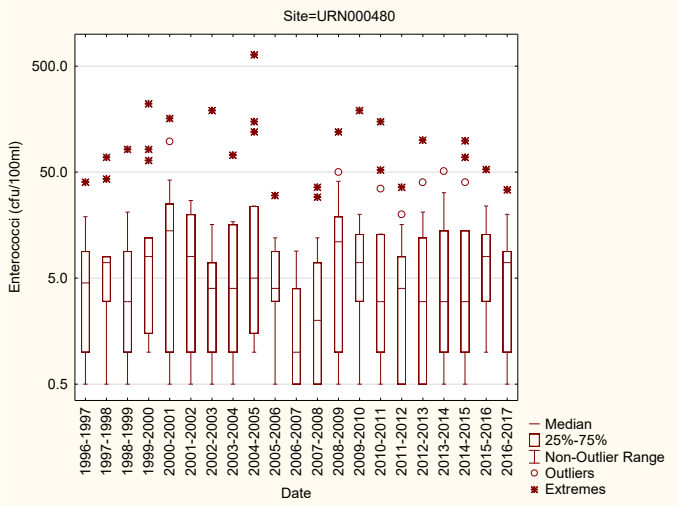
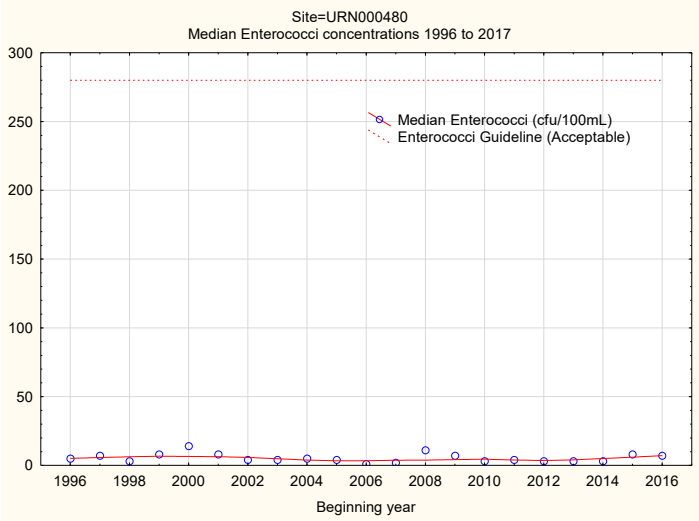


Figure 65 Box and whisker plots for all summer surveys of enterococci bacterial numbers in the Urenui River at the estuary

The high bacteriological water quality of the Urenui River estuary, during high tide conditions, continued during the 2016-2017 season (Figure 65). This has been emphasised by all seasonal median enterococci counts being less than 15 enterococci (per 100 ml). The range was relatively narrow for enterococci during the 2016-2017 season as a result of no single sample counts in excess of 34 enterococci per 100 ml during the period.

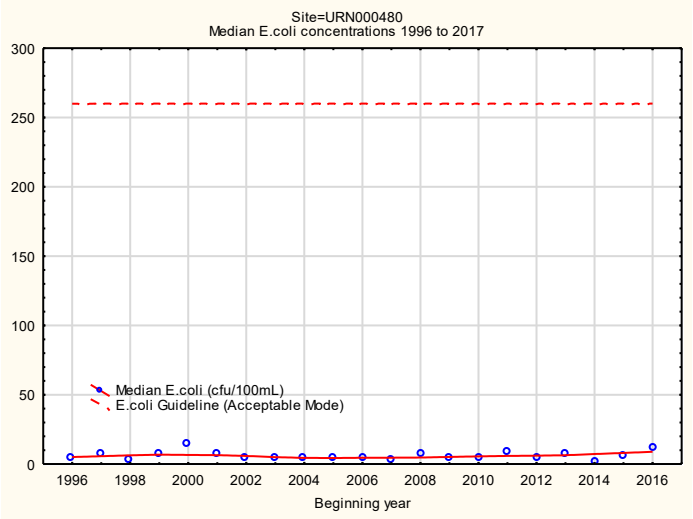
The high bacteriological quality of the coastal sea water intrusion was the major influence on the bacteriological water quality of the lower quality river water at this estuarine site during preferred recreational usage (i.e. higher tide) conditions. Trend analysis of median enterococci and *E. coli* numbers has been performed for the twenty-one seasons of data by first applying a LOWESS fit (tension 0.4) to a time

scatterplot of the median numbers (Figure 66 and Figure 67) and testing the significance of any trend using the Mann-Kendall test at 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.



N = 21
Kendall tau = - 0.167
p level = 0.291 [>FDR, p = 0.571]
Not significant at p < 0.05

Figure 66 LOWESS trend plot of median enterococci (per 100ml) at the Urenui River, estuary site for the 1996 to 2017 period



N = 21
Kendall tau = - 0.035
p level = 0.824 [>FDR, p = 0.875]
Not significant at p < 0.05

Figure 67 LOWESS trend plot of median *E. coli* (per 100ml) at the Urenui River, estuary site for the 1996 to 2017 period

No statistically significant trends in median enterococci or *E. coli* counts (after FDR applications) have been found over the twenty-one seasons of monitoring which have indicated an overall unimportant decrease in enterococci bacteria and a slight decrease in *E.coli* bacteria numbers (both at very low median numbers) over this period. None of these medians exceeded the 'Alert' or 'Action' modes for either marine or freshwater contact recreational usage.

4.2.16 Manganui River at Everett Park (downstream of Kurapete Stream)

No bathing or other usage of this river site was noted at the time of sampling occasions during the survey period despite the proximity of the site to a nearby outdoor adventure camp. Minimal birdlife was noted at this site during the season. Data from the site are presented in Table 88 and illustrated in Figure 68, with a statistical summary provided in Table 89. River flow records are illustrated in Figure 69.

Table 88 Analytical results for the Manganui River at Everett Park (downstream of the Kurapete Stream)

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1200	9.9	96	8	96	13.6	1.0
30.11.16	0825	9.7	410	40	410	14.9	1.0
05.12.16	1120	10.3	220	24	220	16.3	0.7
12.01.17	1100	9.9	190	27	200	18.4	0.9
30.01.17	0830	10.3	280	56	300	15.6	1.0
01.02.17	0955	10.3	280	86	280	17.1	1.0
10.02.17	1100	10.2	200	97	200	15.4	1.0
16.02.17	1015	10.3	210	100	210	16.3	0.9
27.02.17	0825	10.3	250	180	260	16.1	1.0
02.03.17	1000	10.6	500	220	510	17.4	1.3
17.03.17	1005	10.1	210	130	230	15.4	0.9
02.04.17	1015	10.3	300	300	300	16.0	0.8
11.04.17	1145	10.1	180	240	190	15.3	1.2

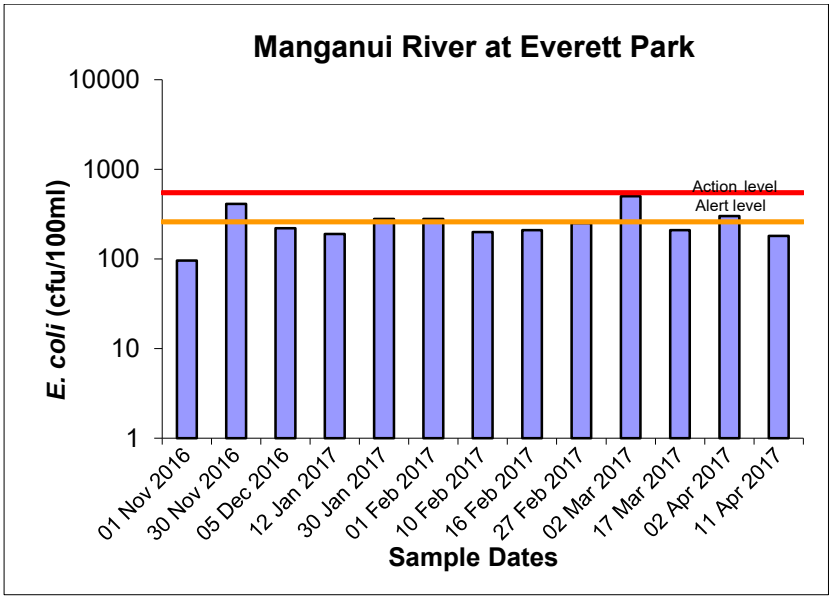


Figure 68 *E. coli* numbers for the Manganui River at Everett Park (downstream of the Kurapete Stream) during the survey season

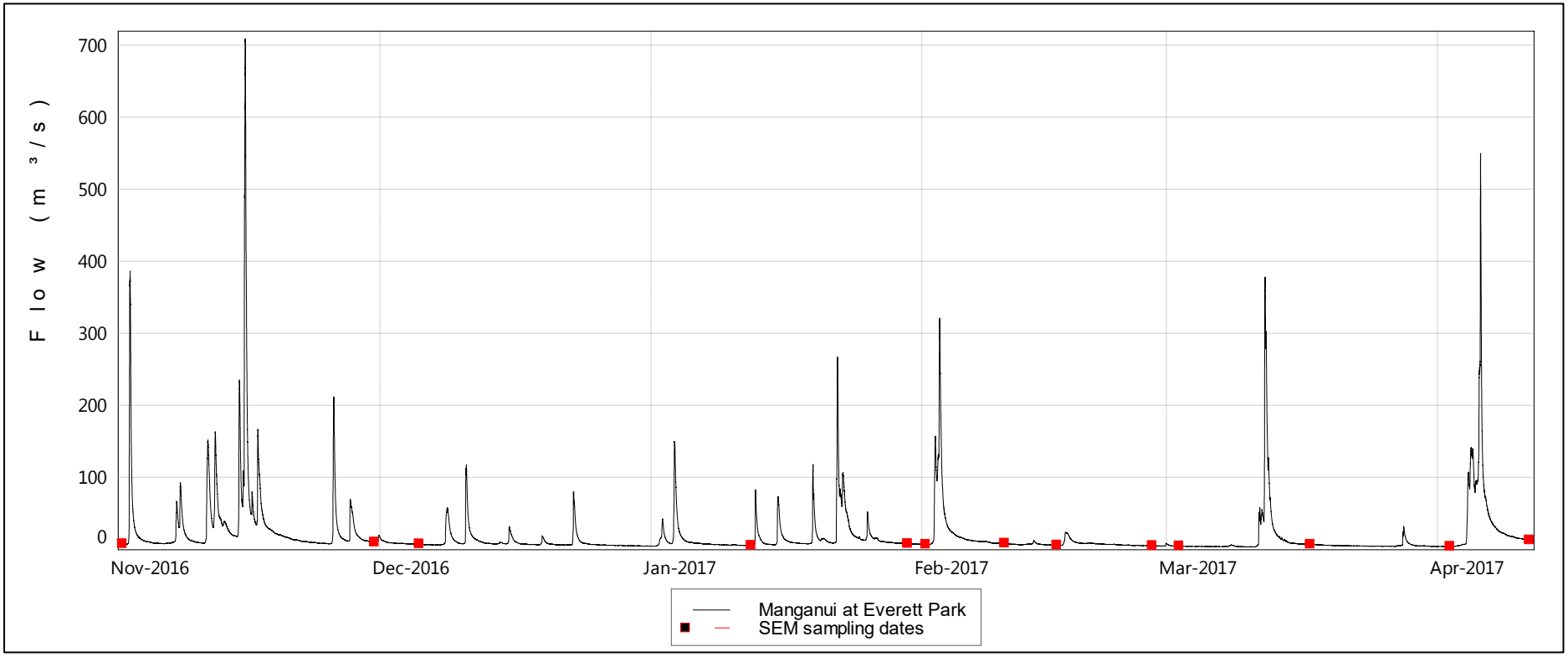


Figure 69 Flow in the Manganui River at Everett Park during the survey period

Table 89 Statistical results summary for the Manganui River at Everett Park (downstream of Kurapete Stream)

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	9.7	10.6	10.3
E. coli	cfu/100ml	13	96	500	220
Enterococci	cfu/100ml	13	8	300	97
Faecal coliforms	cfu/100ml	13	96	510	230
Temperature	°C	13	13.6	18.4	16.0
Turbidity	NTU	13	0.7	1.3	1.0

This ring plain river drains an extensively developed agricultural catchment, the site surveyed being situated at Everett Park approximately 300 m downstream of the Kurapete Stream confluence, and about 500 m below another (less utilised) Manganui River recreational site, upstream of the Kurapete Stream. Since the 1999-2000 season's survey, discharges from the Inglewood municipal oxidation ponds' system into the Kurapete Stream (approximately 8 km upstream of the survey site) have been diverted out of the stream to the New Plymouth wastewater treatment plant.

The river was clear and green-brown or colourless at the time of the majority of the sampling surveys, with relatively low conductivity levels. Water temperatures varied over a narrow range of 4.8°C with the maximum temperature (18.4°C) recorded in late morning in early December 2016. Higher temperatures could be expected later in the day as no sampling surveys were performed after 1145 hrs at this site.

Bacteriological water quality was moderate for this site during the 2016-2017 survey period with none of the counts recorded during the period below 96 *E. coli* per 100 ml (Figure 68). The elevated counts in late November 2016 and early March 2017 coincided with higher flow conditions for the former and localised rainfall for the latter.

4.2.16.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 90.

Table 90 Bacterial guidelines performance at the Manganui River at Everett Park (downstream of Kurapete Stream) [% of 13 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	5 [38]	0[0]

(Designation: freshwater contact recreational area)

Five single samples fell in the 'Alert' mode during the season. The highest count was recorded after less than two days of flow recession following a small fresh caused by local isolated rainfall in early March 2017.

Bacteriological water quality at this site in terms of contact recreational usage was acceptable considering the impacts of farming activities, particularly in relation to the residual flow remaining in the river in mid-catchment downstream of the

Motukawa HEP diversion (i.e., significant abstraction of upper catchment water for hydroelectric power production purposes).

4.2.16.2 Comparison with previous summers' surveys

A statistical comparison of each of the twenty-one summers' survey data is presented graphically in Appendix VI for all sites. These summer data for the Manganui River site at Everett Park are summarised in Table 91 and illustrated in Figure 70.

Table 91 Summary of *E. coli* bacteriological water quality summary data (cfu/100ml) for all summer surveys in the Manganui River at Everett Park to date

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	
Minimum	58	85	76	46	26	100	54	66	83	46	
Maximum	690	2400	830	350	450	970	460	880	730	240	
Median	150	220	160	110	98	210	140	180	180	120	
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Minimum	11	54	100	92	100	34	80	63	100	80	96
Maximum	320	1200	480	370	320	400	760	330	560	270	500
Median	190	160	170	200	170	120	140	140	200	210	220

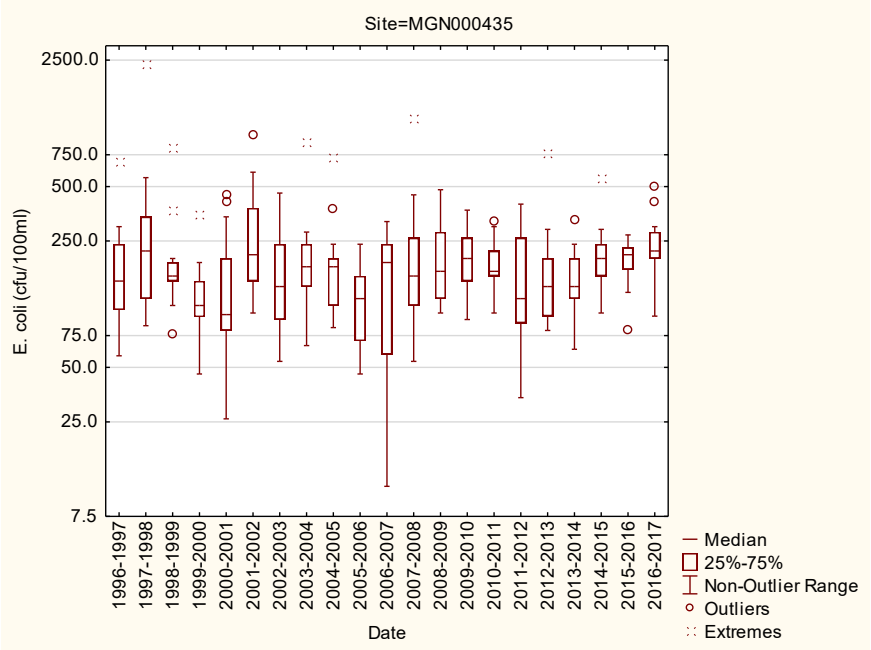


Figure 70 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Manganui River at Everett Park

The median *E. coli* count for the 2016-2017 season was equal to the highest of the twenty-one seasons' medians recorded since the inception of the programme in 1996-97 (Figure 70). The number of single samples entering the alert mode, at five, was one more than the highest previously recorded, in 2008-2009. The range of *E. coli* numbers was typical of those recorded to date, mainly due to a moderate maximum count of 500 per 100 mL, in the mid-range of seasonal maxima recorded to date at this site.

Trend analysis of these median *E. coli* numbers has been performed for the twenty-one seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 71) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hockberg False Discovery Rate (FDR) analysis.

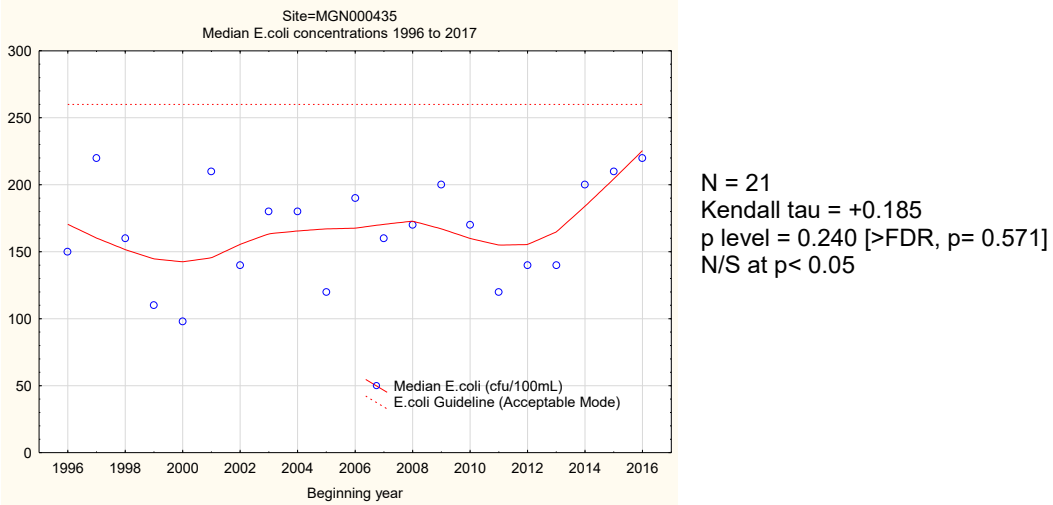


Figure 71 LOWESS trend plot of median *E.coli* numbers (per 100 ml) at the Manganui River, Everett Road site for the 1996 to 2017 period

A slight, unimportant, and statistically insignificant increase in median *E. coli* counts has been found over the twenty-one seasons of monitoring. None of these seasonal medians has exceeded the 'Alert' or 'Action' modes.

4.2.16.3 Benthic cyanobacteria

Benthic cyanobacteria were monitored on ten occasions through the season with results presented in Table 92 and Figure 72.

Table 92 Percentage benthic cyanobacteria cover at the Manganui River, Everett Park site

Date	Average cyanobacteria % cover	Detached mats	Exposed mats	Mode
09/11/2016	1	No	No	Green (surveillance)
24/11/2016	4	No	No	Green (surveillance)
12/12/2016	4	No	No	Green (surveillance)
21/12/2016	8	No	No	Green (surveillance)
05/01/2017	0	No	No	Green (surveillance)
19/01/2017	2	No	No	Green (surveillance)
07/02/2017	0	No	No	Green (surveillance)
27/02/2017	9	No	No	Green (surveillance)
16/03/2017	0	No	No	Green (surveillance)
30/03/2017	5	No	No	Green (surveillance)

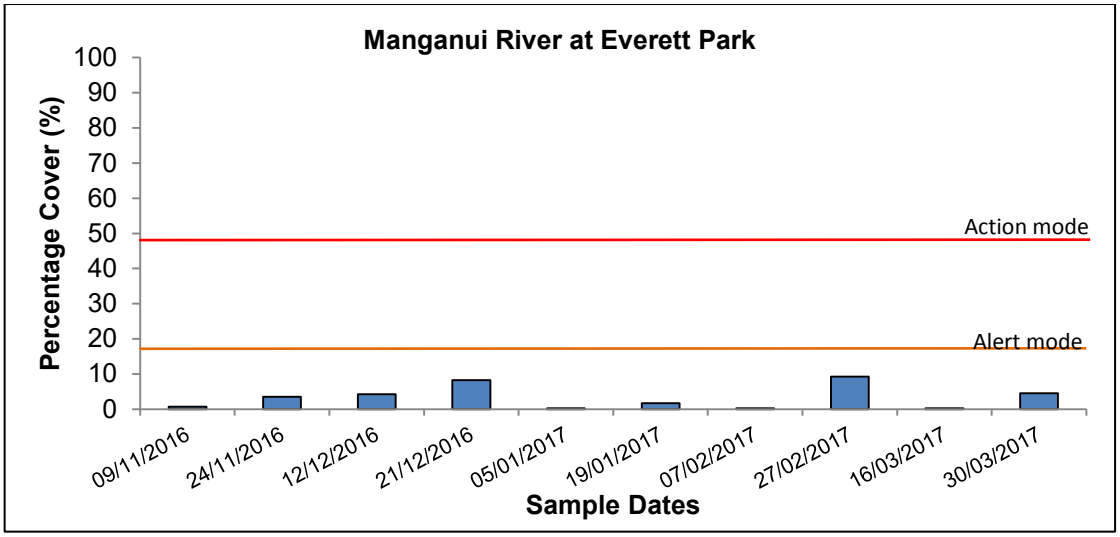


Figure 72 Percentage benthic cyanobacteria cover at the Manganui River, Everett Park site

Note that 'Action' and 'Alert' mode lines are for percentage cover only. The symbols * and $^{+}$ over a bar indicate where the status been raised to 'Alert' or 'Action' mode, respectively due to detaching or exposed mats.

Benthic cyanobacteria coverage was low throughout the monitoring period, with only one survey exceeding 5% coverage (range from 0 to 9%). The benthic cyanobacteria found were a *Phormidium* sp. The 'Action' and 'Alert' levels were never exceeded for percentage cover or for detaching and exposed mats.

4.2.17 Lake Ratapiko

Bathing usage of the lake was not observed. Boating and fishing were each recorded on one occasion. However, the lake is commonly used for boating and fishing purposes, particularly at weekends and holidays. Ducks were present occasionally in low numbers. Minimal stock access to the lake margins was recorded, unlike on some past occasions (TRC, 2013). The lake was drawn down for maintenance purposes at the end of this season (early April 2017), and as a result sampling was unable to be performed on one occasion.

The data for this site are presented in Table 93 and illustrated in Figure 73 with a statistical summary provided in Table 94.

Table 93 Analytical results for Lake Ratapiko

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
01.11.16	1230	7.9	47	15	47	14.6	1.3
30.11.16	0810	7.7	4400	240	4400	15.0	2.4
05.12.16	1105	8.3	12	<4	12	19.0	1.4
12.01.17	1120	8.6	40	2	46	19.8	2.1
30.01.17	0810	8.3	4	32	4	18.5	1.4
01.02.17	0925	8.5	76	10	78	17.3	1.6
10.02.17	1120	8.7	16	2	16	18.4	1.5
16.02.17	1000	8.6	38	<2	40	19.0	1.4
27.02.17	0800	8.3	20	46	22	19.3	1.0
02.03.17	0930	8.3	70	18	72	19.9	1.1
17.03.17	0940	7.9	7	11	7	15.8	0.9
02.04.17	0950	7.6	40	8	42	18.0	1.0
11.04.17*	-	7-	-	-	-	-	-

* lake level lowered for HEP scheme maintenance

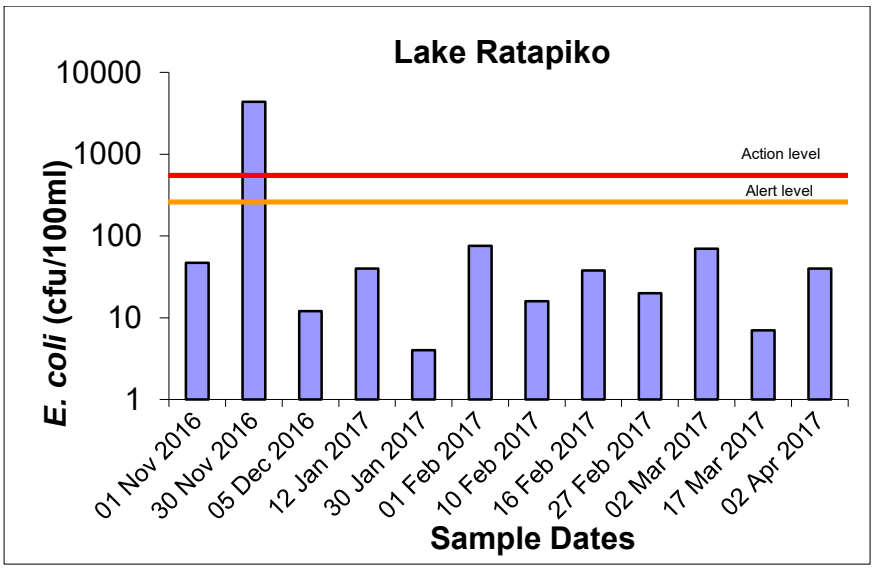


Figure 73 *E. coli* numbers for Lake Ratapiko during the survey season

Table 94 Statistical results summary for Lake Ratapiko

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	12	7.6	8.7	8.3
E. coli	cfu/100ml	12	4	4400	39
Enterococci	cfu/100ml	12	<2	240	10
Faecal coliforms	cfu/100ml	12	4	4400	41
Temperature	°C	12	14.6	19.9	17.9
Turbidity	NTU	12	0.9	2.4	1.4

The lake is replenished by diversion water flow from the mid reaches of the Manganui River via the Motukawa HEP scheme. Water quality was generally very good with minimal variation in clarity (median turbidity: 1.4 NTU; range of turbidity: 1.5 NTU) as a result of low suspended algae populations possibly due to short retention times in the lake. Water temperatures were moderate over a narrow

range of 4.5˚C for the period with a low maximum of 19.9˚C (mid-morning in early March 2017) although all of the measurements were recorded prior to 1235 hrs. Conductivity showed minimal variation (up to 1.1 mS/m) during the period.

Generally, bacteriological quality was good considering that the inflow to the lake is from the mid reaches of a river draining a developed farmland catchment. Only one count exceeded 78 *E. coli* per 100 ml, in late November 2016, when the highest count by a factor of ten over the entire programme since 1996 was recorded (4,400 per 100 ml). Follow-up sampling on 5 and 6 December 2016 returned low *E.* coli counts of 12 and 10 per 100ml, respectively. The reason for this single high count was not established.

4.2.17.1 Comparison with guidelines

Comparison with the 2003 guidelines for freshwater contact usage is summarised in Table 85.

Table 95 Bacterial guidelines performance at Lake Ratapiko [% of 12 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Single sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	0 [0]	1 [8]

(Designation: Freshwater contact recreational area)

One single sample exceedance of the 'Action' mode occurred and no sample was recorded within the 'Alert' mode during the review period.

Bacteriological water quality was good and within acceptable guidelines for contact recreational usage throughout the survey period, except for a single sampling.

4.2.17.2 Comparison with previous summers' surveys

A statistical comparison of all sites' summers' *E. coli* survey data is presented graphically in Appendix VI for all sites. Data from the eleven summer surveys for the Lake Ratapiko site are summarised in Table 96 and illustrated in Figure 74.

Table 96 Summary of *E.coli* bacteriological water quality data (cfu/100ml) for all summer surveys at Lake Ratapiko to date

Summer	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17
Minimum	1	1	5	4	13	1	3	<1	2	3	4
Maximum	86	120	220	91	140	150	240	240	120	420	4400
Median	21	16	35	16	25	35	10	10	12	12	39

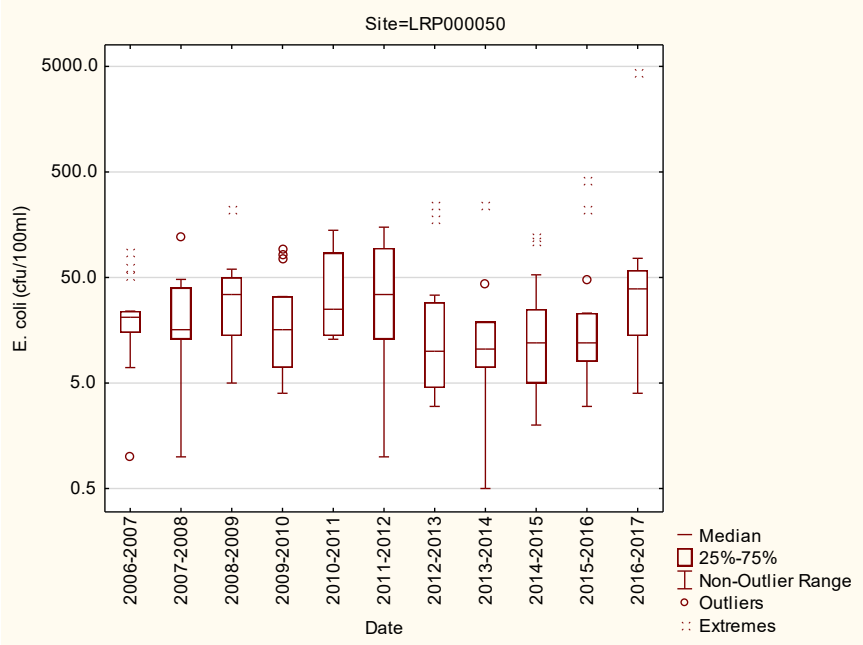
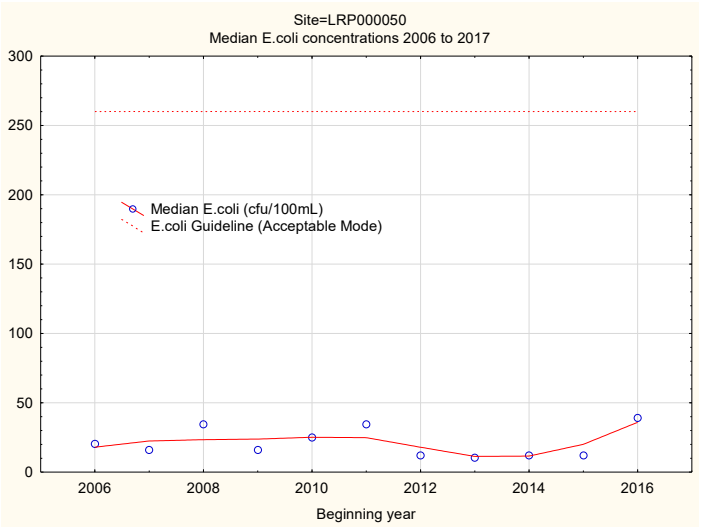


Figure 74 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers at Lake Ratapiko

A low median *E. coli* number was found by the latest season's survey and a moderate range of counts was recorded, with one outlier. All seasonal medians have been low, with this season's being marginally the highest of the eleven seasons' medians to date.

Trend analysis of these median *E.coli* numbers has been performed for the eleven seasons of data by first applying LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 75) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.



N = 11
Kendall Tau = -0.153
p level = 0.514 [>FDR, p = 0.571]
N/S at p < 0.05

Figure 75 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Lake Ratapiko site, for the 2006-2017 period

No statistically significant trends in median *E.coli* counts have been found over the eleven seasons of monitoring, which have indicated an unimportant decrease in *E.coli* numbers over this period. None of these medians exceeded the 'Alert' or 'Action' modes for freshwater contact recreational usage.

4.2.17.3 Cyanobacteria

Planktonic cyanobacteria were monitored on seven occasions throughout the season. The results of these analyses are presented in Table 97 and Figure 76.

Table 97 Cyanobacteria counts and biovolumes for Lake Ratapiko

Date	Cyanobacteria total cell count (cells/ml)	Biovolume (mm^3/L)	Principal species by biovolume	Mode
22/11/2016	0	0	No cyanobacteria	Low Risk
07/12/2016	0	0	No cyanobacteria	Low Risk
21/12/2016	0	0	No cyanobacteria	Low Risk
05/01/2017	0	0	No cyanobacteria	Low Risk
26/01/2017	0	0	No cyanobacteria	Low Risk
07/02/2017	0	0	No cyanobacteria	Low Risk
07/03/2017	0	0	No cyanobacteria	Low Risk

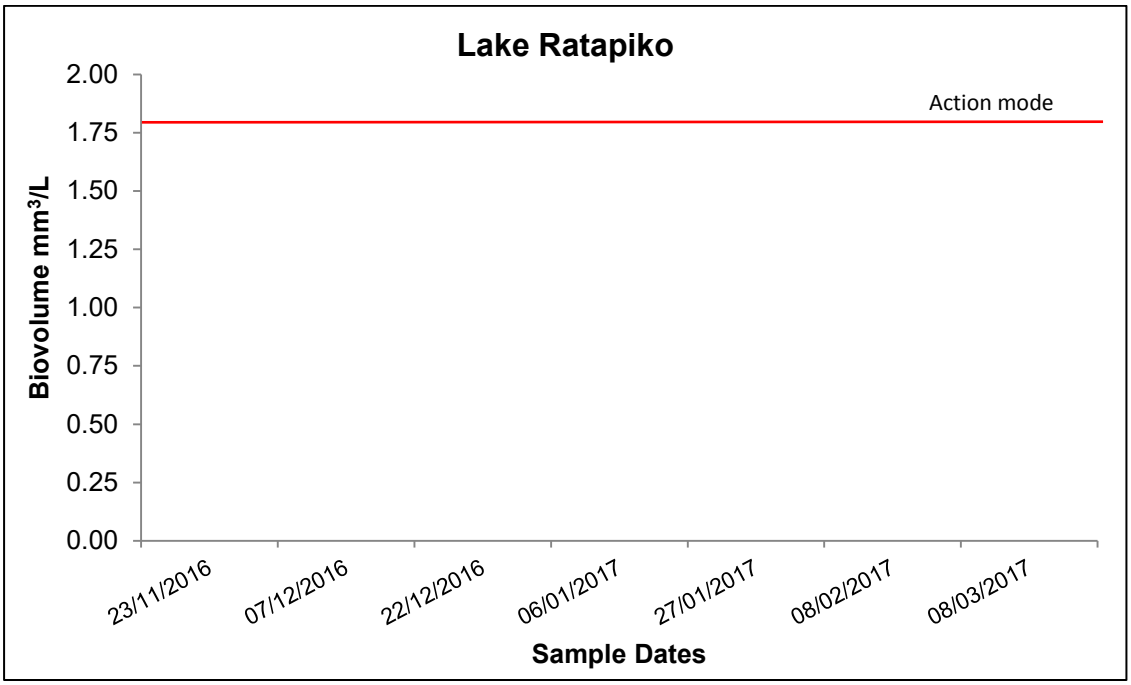


Figure 76 Cyanobacteria bio-volume at Lake Ratapiko

Planktonic cyanobacteria were not detected throughout the entire recreational monitoring year.

Previously, no cyanobacteria had been found in this lake during any of the monitoring periods from 2006 to 2013 with the exception of low numbers of *Anabaena* present in the latter part of the 2007-2008 season following a lengthy, extremely low flow period. Also, moderate numbers of *Anabaena* were found during late January, 2014 during a dry period, but these numbers reduced rapidly by late February, 2014 and none were found by the survey of mid-March 2014. A similar event, with a near

'high risk' bloom of *Picocyanobacteria* occurred briefly in February 2016. The relatively short lake water residence time (due to hydroelectric power generation usage) may be a factor in the control of these bacteria populations.

4.2.18 Lake Rotokare

Cyanobacteria monitoring of this lake was instigated in the 2007-2008 season in recognition of this small lake's recreational usage, particularly for boating activities. A reduced bacteriological monitoring programme was also included, as considered appropriate. The boating season is restricted to the period from 1 December to 1 May by the STDC in recognition of the status of the Rotokare Scenic Reserve.

Some bacteriological water quality monitoring was also undertaken in conjunction with the cyanobacteria monitoring during the 2016-2017 season, with the lake sampled on ten occasions between early November 2016 and mid April 2017. [Note: bacteriological monitoring is not a component of the SEM programme at this lake].

Usage of the lake included walkers (visitors) and camping, and kayaking early in the season. The boat ramp was locked from late November for the remainder of the monitoring period. Birdlife, a few ducks, scaup and shags were observed at the lake margin on the majority of monitoring occasions. The lake appeared turbid, green or green-brownish throughout most of the period with a clearer appearance at the beginning and end of the period.

The bacteriological water quality data for this site are presented in Table 98 with a statistical summary provided in Table 99.

Table 98 Analytical results for Lake Rotokare

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)
22.11.16	1225	12.2	92	52	92	17.6	6.5
07.12.16	0814	12.5	54	120	54	20.3	12
21.12.16	0830	12.5	7	3	7	19.6	9.4
05.01.17	0747	12.3	160	84	160	18.6	6.4
12.01.17	1045	12.6	31	15	31	21.3	14
26.01.17	0810	12.5	62	42	62	17.9	4.4
07.02.17	1145	12.0	94	48	96	22.4	5.0
23.02.17	1045	12.1	84	14	84	22.1	2.6
07.03.17	1300	12.1	62	18	62	21.5	1.7
20.03.17	1040	12.1	340	34	340	19.2	1.5

Table 99 Statistical results summary for Lake Rotokare

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	10	12.0	12.6	12.2
E. coli	cfu/100ml	10	7	340	73
Enterococci	cfu/100ml	10	3	120	38
Faecal coliforms	cfu/100ml	10	7	340	73
Temperature	°C	10	17.6	22.4	20.0
Turbidity	NTU	10	1.5	14	5.7

In general, bacteriological water quality was good, as might be expected for a small, bush clad lake with only small inflows and relatively low wildfowl numbers. Conductivity levels were very stable (range: 0.6 mS/m) through the period despite variations in inflow during the season. Water temperatures varied over a narrow range of 4.8˚C with a maximum of 22.4˚C recorded in early February 2017. Turbidity was relatively high (median: 5.7 NTU) with the range (12 NTU) reflecting the variability in abundances of suspended algae in the water column during the season. Highest turbidities (≥ 10 NTU) were coincidental with peaks in cyanobacteria concentrations in December 2015 and January 2016.

No bacterial counts from routine sampling entered the 'Action' level on any occasion during the season, and one count just reached 'Alert' level. However, an additional sample taken later in the day after the 21 December 2016 sampling returned a high *E. coli* count of 1,300 per 100 ml (time, 1310 NZST; temperature, 21.7°C; turbidity, 9.8 NTU; conductivity at 20°C, 13.2 mS/m). This was unexplained. It should be noted that in past seasons the overriding health warnings on both the Regional Council website and on the sites at the lake and road access have related to cyanobacteria level exceedances of guidelines (see below), and not to bacterial counts. It has been noted in the past, that as cyanobacteria numbers decreased later in some seasons, coincidentally *E.coli* bacterial numbers increased.

4.2.18.1 Cyanobacteria

There was a moderate level of planktonic cyanobacteria bio-volume recorded in early November 2016 with cyanobacteria levels increasing to high levels by mid-November. High cyanobacteria bio-volume levels continued to occur throughout summer before decreasing in autumn. The principal species found were *Anabaena sp*.

The installation of a blue-green algal hazard warning sign by the STDC upon advice from the Taranaki Area Health Board occurred once levels exceeded the health guideline (>1.8mm^3/L) from late November onwards. There was a requirement for STDC to erect signage at the lake and road access and the boat ramp remained closed all through summer. The Area Health Board did not require algal toxin testing during the period. Normally, Lakes Rotomanu, Ratapiko and Opunake are sampled on the same date and have the same number of sampling occasions (seven samples are scheduled) but due to public interest two additional samples were collected.

Planktonic cyanobacteria at Lake Rotokare were monitored on nine occasions throughout the season with results presented in Table 100 and illustrated in Figure 77.

Table 100 Cyanobacteria counts and biovolumes for Lake Rotokare

Date	Cyanobacteria total cell count (cells/ml)	Biovolume (mm³/L)	Principal species by biovolume	Mode
03/11/2016*	3634	0.6	*Anabaena*	Medium Risk
22/11/2016	34150	4.6	*Anabaena*	High Risk
07/12/2016	11962	2.5	*Anabaena*	High Risk
21/12/2016	75726	15.0	*Anabaena*	High Risk
05/01/2017	30159	6.3	*Anabaena*	High Risk
26/01/2017	9515	1.8	*Anabaena*	High Risk
07/02/2017	31684	4.1	*Anabaena*	High Risk
07/03/2017	0	0		Low Risk
20/03/2017*	3888	0.08	*Microcystis*	Low Risk

* Additional samples

[Note: Biovolume has been used as the trigger level instead of total cells/mL. This method was considered to be superior as cell size is thought to be correlated with the amount of toxins produced (Woods et al., 2008). Bio-volumes specific for Lake Rotokare have been produced to improve the accuracy of this variable (TRC, 2015)].

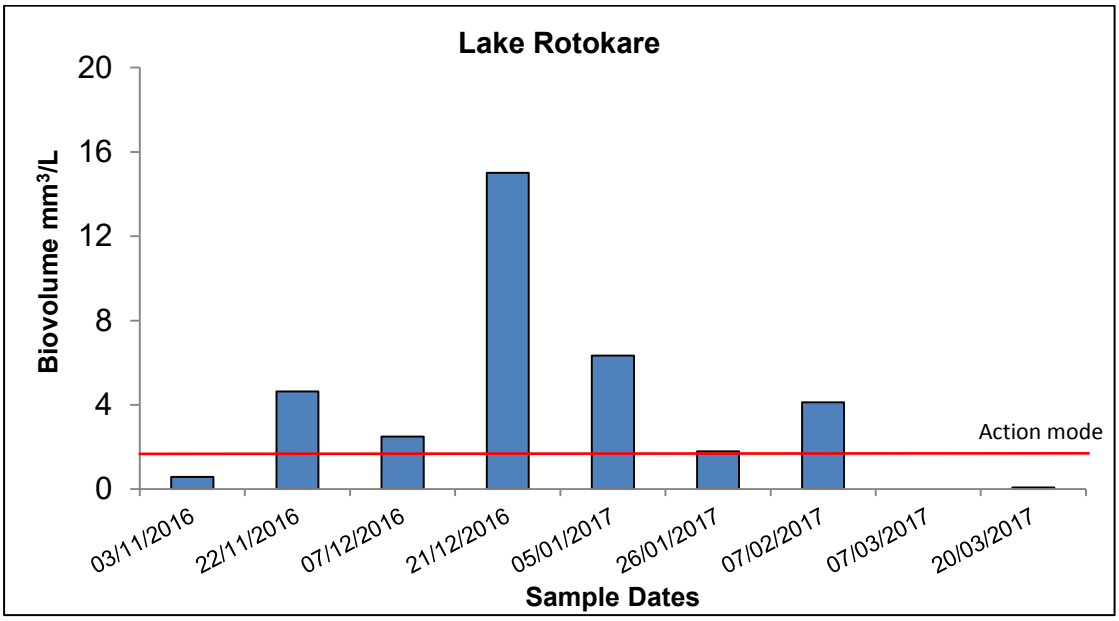


Figure 77 Cyanobacteria biovolume (mm³/L) at Lake Rotokare

The warning signage displayed adjacent to the boat ramp in past seasons was required for the period from late November until early March 2017. No primary contact recreational usage of the lake was recorded at the time of sampling surveys after the boat ramp remained locked from early in summer.

5. General data summary

A comparative summary of results of the twenty-first summer bacteriological quality freshwater survey involving seventeen contact recreational sites in the Taranaki region is provided in Table 101. Results are also illustrated in Figure 78 for each of the bacteriological species and a comparison of all sites' summer data is presented in Appendix VI in the form of statistical 'box and whisker' plots.

Table 101 Statistical summary of results for the sites sampled in the SEM freshwater contact recreational water quality survey, 2016-2017

Site		Temperature (°C)	Conductivity @ 20°C (mS/m)	Faecal coliforms (cfu/100 ml)	E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Turbidity (NTU)
Lake Rotomanu	Median	20.9	10.6	88	84	71	6.9
	Minimum	17.8	9.9	17	17	<3	3.1
	Maximum	24.4	11.3	2400	2200	1299	13
	No. of samples	13	13	13	13	13	13
Waiwhakaiho River at Merrilands Domain	Median	16.8	11.7	63	63	23	0.7
	Minimum	12.1	10.3	14	14	5	0.4
	Maximum	20.6	13.2	160	160	95	2.1
	No. of samples	13	13	13	13	13	13
Waiwhakaiho River adjacent to L. Rotomanu	Median	17.5	11.8	740	610	280	0.7
	Minimum	14.2	10.2	200	200	28	0.5
	Maximum	21.4	13.9	2500	1900	1700	2.4
	No. of samples	13	13	13	13	13	13
Te Henui Stream at mouth, East End	Median	17.0	54.1	1100	1100	640	0.7
	Minimum	12.5	9.1	520	520	53	0.4
	Maximum	28.2	1240	6000	5700	3100	1.5
	No. of samples	13	13	13	13	13	13
Patea River at King Edward Park, Stratford	Median	13.9	8.9	240	220	120	0.7
	Minimum	11.8	8.2	80	80	7	0.6
	Maximum	16.7	9.7	700	670	700	0.8
	No. of samples	13	13	13	13	13	13
Patea River at boatramp, Patea	Median	18.6	4590	28	25	6	17
	Minimum	15.3	22.4	1	1	1	6.0
	Maximum	20.2	4780	200	200	51	55
	No. of samples	13	13	13	13	13	13
Waingongoro River at Eltham camp	Median	15.1	11.1	340	340	120	1.3
	Minimum	12.6	10.3	100	100	8	1.1
	Maximum	17.9	11.8	1600	1600	500	3.4
	No. of samples	13	13	13	13	13	13
Waingongoro River at Ohawe Beach	Median	18.6	17.0	200	200	150	1.6
	Minimum	12.6	15.7	84	84	23	1.2
	Maximum	21.0	19.7	390	390	690	4.8
	No. of samples	13	13	13	13	13	13
Kaupokonui River at beach domain	Median	19.0	15.8	200	190	84	1.4
	Minimum	14.8	13.7	23	23	13	1.0
	Maximum	21.1	272	480	480	410	1.9
	No. of samples	13	13	13	13	13	13
Lake Opunake adjacent to boat ramp	Median	17.8	13.6	220	220	630	1.1
	Minimum	13.9	12.3	37	37	23	0.8
	Maximum	21.1	14.9	610	610	2400	1.6
	No. of samples	13	13	13	13	13	13
Timaru Stream at Weld Road (near mouth)	Median	17.3	41.6	330	330	190	0.6
	Minimum	14.3	8.6	34	34	9	0.2
	Maximum	19.6	600	550	550	540	1.5
	No. of samples	13	13	13	13	13	13
Waimoku Stream at Oakura beach	Median	15.6	14.6	1100	1100	1300	3.6
	Minimum	13.3	13.8	840	770	460	2.1
	Maximum	17.3	15.7	5800	5700	2600	6.4
	No. of samples	13	13	13	13	13	13
Oakura River d/s of SH45 bridge	Median	16.8	8.1	120	120	96	0.5
	Minimum	12.8	6.8	23	14	21	0.3
	Maximum	18.8	406	200 000	200 000	6400	1.3
	No. of samples	13	13	13	13	13	13
Waitara River at town wharf, Waitara	Median	18.3	557	250	250	63	11
	Minimum	14.5	179	92	84	9	4.8
	Maximum	21.2	868	2500	2500	330	120
	No. of samples	13	13	13	13	13	13
Urenui River at estuary	Median	19.4	4590	13	12	7	14
	Minimum	16.0	4300	1	1	<1	3.0
	Maximum	21.1	4740	60	59	34	36
	No. of samples	13	13	13	13	13	13
Manganui River d.s of Kurapete S. (Everett Park)	Median	16.0	10.3	230	220	97	1.0
	Minimum	13.6	9.7	96	96	8	0.7
	Maximum	18.4	10.6	510	500	510	1.3
	No. of samples	13	13	13	13	13	13
Lake Ratapiko at boat ramp	Median	17.9	8.3	41	39	10	1.4
	Minimum	14.6	7.6	4	4	<2	0.9
	Maximum	19.9	8.7	4400	4400	240	2.4
	No. of samples	12	12	12	12	12	12

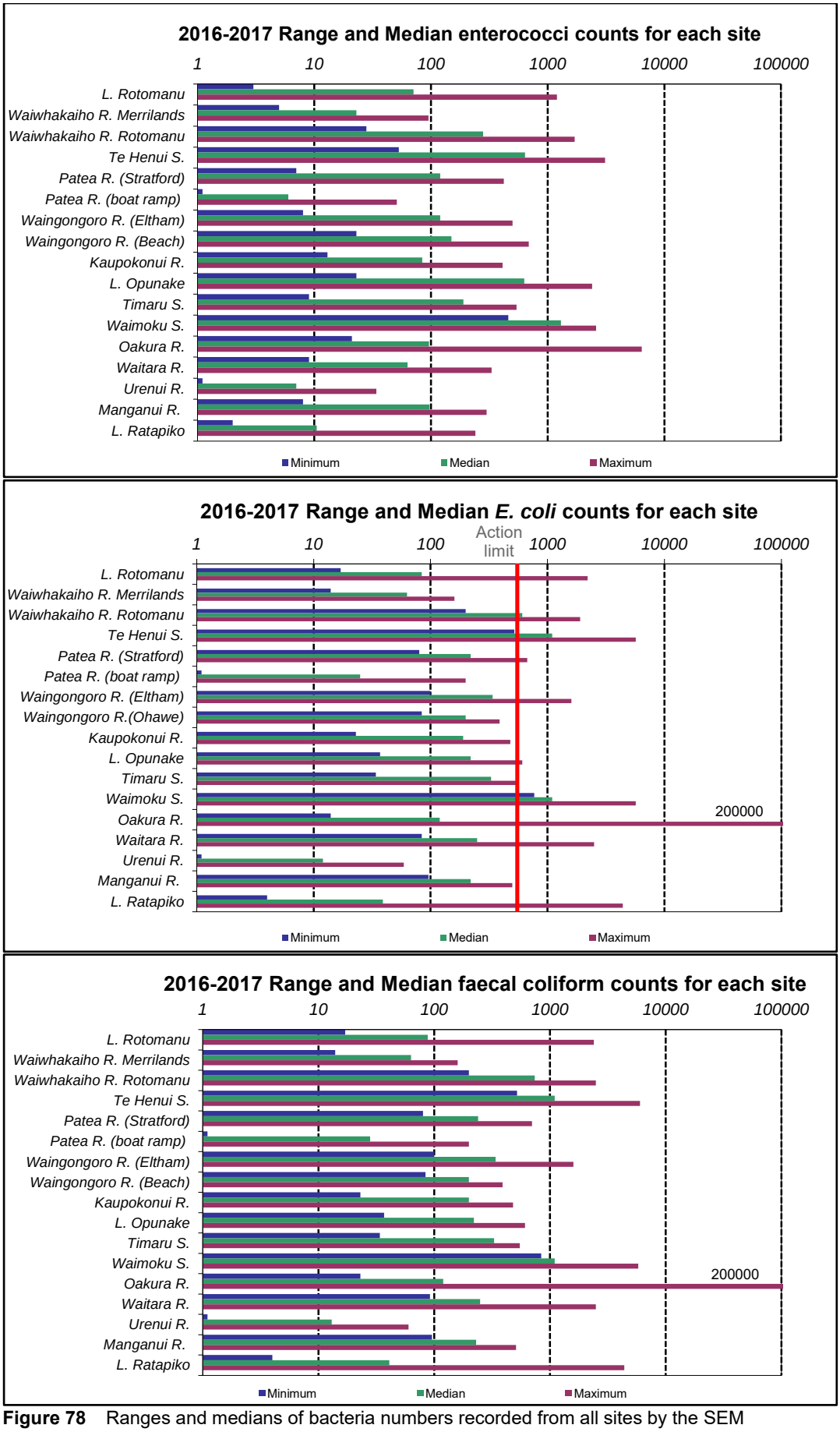


Figure 78 Ranges and medians of bacteria numbers recorded from all sites by the SEM programme over the 2016-2017 survey season

Non-exceedance of the 2003 guidelines has varied amongst the seventeen freshwater contact recreational sites sampled during the survey period (Figure 78 and Table 102), to the same degree as recorded in many of the previous seasons. In relation to the guidelines, three sites (Waiwhakaiho River at Lake Rotomanu, Te Henui Stream at East End beach and Waimoku Stream at Oakura beach), regularly failed to be below the *E. coli* 'Action' guideline suitable for contact recreation. In terms of median *E. coli* counts, these were also the only sites with the median count in the 'Action' (>550 *E. coli* per 100ml) mode. Two sites (Timaru Stream at mouth and Waingongoro River at Eltham camp) had median counts in the 'Alert' (>260 *E. coli* per 100 ml) mode. None of the other sites had a median count in the 'Action' or 'Alert' modes.

Table 102 Number of occasions single sample *E.coli* counts entered the 'Alert' and 'Action' modes and percentage [%] of samples which were below these modes

Site	' Surveillance' mode	'Alert' mode	'Action' mode
Lake Rotomanu at western beach	[62%]	3	2
Waiwhakaiho River at Merrilands Domain	[100%]	0	0
Waiwhakaiho River adjacent to L Rotomanu	[23%]	2	8
Te Henui Stream at mouth, East End	[0%]	1	12
Patea River at King Edward Park, Stratford	[54%]	5	1
Patea River at boatramp, Patea	[100%]	0	0
Waingongoro River at Eltham Camp	[23%]	9	1
Waingongoro River at Ohawe beach [2]	[77%]	3	0
Kaupokonui River at beach domain	[69%]	4	0
Lake Opunake at boat ramp	[69%]	3	1
Timaru Stream at Weld Road	[31%]	9	0
Waimoku Stream at Oakura beach [2]	[0%]	0	13
Oakura River at SH45	[77%]	1	2
Waitara River at town wharf, Waitara	[77%]	2	1
Urenui River at estuary*	[100%]	0	0
Manganui River at Everett Park	[62%]	5	0
Lake Ratapiko at boat ramp[1]	[92%]	0	1

[Notes: N = 13 samples; * = enterococci count;] [2] Not a regional bathing site

Three sites maintained counts below the 'Alert' mode at all times throughout the season (the same sites as in the 2015-2016 season), while an additional four sites maintained counts below the 'Action' mode (Table 102 and Table 104) at all times, so, of the 16 recognised bathing sites, 7 (43%) never had a non-compliance during the 2016-2017 season, and another 5 (31%, giving 74% altogether) had only 1 non-compliance. In, and including the Waimoku Stream site, terms of the overall monitoring season, forty-seven 'Alert' levels (21% of counts) and forty-two 'Action' levels (19% of counts) resulted over the period representing an overall 60% achievement of the 'Surveillance' contact recreational guideline (compared with 74%, 71%and 72% achievement in the 2013-2014, 2014-2015 and 2015-2016 seasons, respectively). These percentage figures included samples from the Waimoku in 2013-2014, but not in the two more recent seasons. Excluding the Waimoku Stream site, and reviewing only the 'Action' level samples (i.e. those which indicate swimming poses an unacceptable risk), 86 % of all samples met the bathing guideline in 2016-2017. Of the 14% of samples that were non-compliant, 10% were from just two urban sites – the lower Waiwhakaiho River and the Te Hēnui Stream. Both sites have high bird populations. Comparing levels of compliance for the same suite of sites over the past four years, the 86% compliance rate in 2016-2017 follows on from 84.1% in 2015-2016, 85.6% in 2014-2015, and 91.9% in 2013-2014. Thus, while bacteriological levels generally were higher in the latest period, this did not lead to a noticeable increase in conditions when swimming would have involved an unacceptable risk.

Of these 40% 'Surveillance' guideline exceedances in 2016-2017, 16% occurred at three sites, including the single site that is monitored triennially (Waimoku Stream).

In terms of guidelines attainment, the sites may be ranked in the following order for the 2016-2017 season:

1=	Waiwhakaiho River at Merrilands Domain
1=	Patea River at boat ramp, Patea
1=	Urenui River at estuary
4	Lake Ratapiko
5=	Waingongoro River at Ohawe Beach
5=	Oakura River d/s SH45 bridge
5=	Waitara River at town wharf
8=	Kaupokonui River at beach domain
8=	Lake Opunake at boat ramp
10=	Lake Rotomanu
10=	Manganui River at Everett Park
12	Patea River at King Edward Park
13	Timaru Stream at Weld Road (near mouth)
13	Waingongoro River at Eltham
14	Waitara River at town wharf
15	Waiwhakaiho River adjacent to Lake Rotomanu
16	Te Hēnui Stream at mouth, East End.
17	Waimoku Stream at Oakura beach

Overall, a wide range from poor to very good bacteriological water quality was measured at the seventeen sites. In terms of results to date, this represented no overall change, with measured water quality improving at some sites and reducing at others. In terms of median *E. coli* counts, by far the best bacteriological quality was again found in the lower (estuarine) reach of the Patea River, and at the most estuarine site (Urenui River) which was strongly influenced by seawater penetration during high tide conditions, where both sites' median count was 1 *E.coli* per 100 mL. The programme focused on high tide periods due to its design and integration with the coastal bathing water quality monitoring programme. While future programmes' designs could give consideration to extending sampling to include low tide timing of sampling (at tidal sites), if this becomes necessary, it is essential that the high-tide format is retained for future trend monitoring purposes.

Based upon median *E. coli* bacterial numbers for the survey period, the following ranking of sites (in descending water quality) may be used to summarise results:

1	Urenui River at estuary
2	Patea River at boatramp, Patea
3	Lake Ratapiko
4	Waiwhakaiho River at Merrilands Domain
5	Lake Rotomanu
6	Oakura River d/s of SH 45 bridge
7	Kaupokonui River at beach domain
8	Waingongoro River at Ohawe Beach
9=	Lake Opunake at boat ramp
9=	Patea River at King Edward Park, Stratford

9=	Manganui River at Everett Park (d/s of Kurapete Stream)
12	Waitara River at town wharf, Waitara
13	Timaru Stream at Weld Road (near mouth)
14	Waingongoro River at Eltham camp
15	Waiwhakaiho River adjacent to Lake Rotomanu
16	Te Henui Stream at mouth, East End
17	Waimoku Stream at Oakura beach

No significant improvements in ranking occurred, in comparison with the 2015-2016 season. The three highest rankings remained at the three sites which were highest ranked for the last several seasons. The three lowest rankings also remained at the same three sites. Lake Opunake at the boat ramp slipped down in the rankings (five places to ninth equal) in terms of seasonal median bacteriological water quality, where the median *E.coli* count between consecutive seasons increased from the lowest to the highest recorded (from 51 to 220 *E.coli*/100 mL). Similarly, the Waingongoro River at Eltham fell in ranking (by four places to fourteenth), where the highest seasonal median *E. coli* count to date was recorded (340 *E. coli*/100mL).

5.1 Comparison with twenty previous summers' surveys

A statistical comparison of each summer's survey *E. coli* data is presented graphically in Appendix VI for all sites. Shorter data periods exist for the Patea River (at King Edward Park, Stratford) and Waingongoro River (at Eltham camp) which were added in 2001-2002, two lakes' sites (Lakes Ratapiko and Opunake) which were added in 2006-2007, the site in the lower reaches of the Patea River which was added in the 2007-2008 season, the site in the lower Waitara River which was added in the 2009-2010 season, and the sites in the lower reaches of the Waiwhakaiho River and Te Henui Stream which were added in the 2011-2012 season.

In general terms, *E. coli* bacteriological water quality was within ranges generally similar to those recorded over most previous summer bathing seasons. There was marked deterioration at five sites and improvement at two sites in terms of median counts, in comparison with the previous summer's results (as determined on the basis of >20% change where the median value was ≥10 cfu/100 ml). Variability in quality between bathing seasons at each site may be related to a variety of reasons including hydrological conditions, stock access, wildlife presence, and dairy farm wastes disposal practices in particular.

All seasons' results have been summarised in terms of comparisons with the single sample modes of the MfE, 2003 guidelines for each site over the period since the state of the environment monitoring programme commenced (over the 1996-1997 season). This summary is presented in Table 104.

Noting that there is some variability in the numbers of sites included in each season's programme, conformity with the 'Surveillance' guidelines has occurred on 70% of sampling occasions over the combined twenty-one seasons to date with the worst season (2016-2017, by 1%) showing 60% guidelines conformity and the best seasons (1996-1997 and 1999-2000), 82% conformity with the guidelines. The previous season (2015-2016) was equal to the historical average and the latest season showed a 12% deterioration from the last season. (Note that in any comparison between seasons, variability in monitored sites should be taken into account).

A ranking of sites based upon the historical average conformity with the surveillance mode guideline for the period 1996 to date can be summarised as follows:

1= Urenui River at estuary
1= Patea River at boatramp, Patea
1= Lake Ratapiko
4 Waiwhakaiho River at Merrilands Domain
5= Oakura River at SH45
5= Waingongoro River at Ohawe Beach
5= Lake Rotomanu
8 Manganui River at Everett Park
9= Kaupokonui River at beach domain
9= Lake Opunake
11 Waingongoro River at Eltham Camp
12 Waitara River at town wharf, Waitara
13 Timaru Stream at Weld Road
14 Patea River at King Edward Park, Stratford
15 Waiwhakaiho River adjacent to Lake Rotomanu
16 Te Henui Stream at mouth, East End
17 Waimoku Stream at Oakura

The two estuarine sites (in the Patea and Urenui Rivers) have never reached the 'Alert' *E.coli* level of the guidelines over the 21 seasons to date. All sites ranked above twelfth have not exceeded guidelines on an average of at least 75% of seasonal sampling occasions. The poorest bacteriological water quality (less than 6% of seasonal sampling occasions within guidelines) has been recorded at the Te Henui and Waimoku Streams mouths where resident wildfowl population has been the principal contributor to elevated *E.coli* counts. This has also been the case for the Waiwhakaiho River adjacent to Lake Rotomanu, the third worst site.

Temporal trending of season's median *E.coli* counts at each of the sixteen sites with a minimum of ten years' data, was undertaken statistically for the period 1996 to 2017. Two of these sites have shown a statistically significant ($p < 0.01$ after FDR application) trend in median *E.coli*. counts:

- Waimoku Stream at Oakura beach had a very strong trend of increasing median *E. coli* numbers of the 21 year period (17 seasons) to date which was significant at $p<0.01$ after FDR application
- Waiwhakaiho River opposite Lake Rotomanu also had a very strong trend of increasing median *E.coli* numbers over the 21 year period (14 seasons) to date which was significant at $p < 0.01$ after FDR application

Another site showed a significant ($p<0.05$, but not after FDR) application trend in median *E. cli* counts.

- Te Henui Stream at the mouth had a strong trend of increasing median *E. coli* numbers over the 15 year period which however was significant at $p<0.5$ but not after FDR application

A ranking of the order of the significance of the temporal trends at those sites with a minimum of ten seasons' data (sixteen sites) is provided in Table 103.

Table 103 Ranking of sites in terms of significant temporal trends in median *E.coli* counts over the period 1996 to 2017

Site location	Valid N	p-level	FDR-corrected p value	Trend
Waimoku Stream at Oakura Beach	17	0.0004	0.0032	↑↑↑
Waiwhakaiho River at Lake Rotomanu	14	0.0004	0.0032	↑↑↑
Te Henui Stream mouth, East End	15	0.0382	0.2162	↑
Oakura River d/s SH45 bridge	21	0.0848	0.3114	↑
Waingongoro River at Eltham camp	15	0.0916	0.3114	↑
Lake Rotomanu western beach	21	0.1608	0.4555	↑
Manganui River at Everett Park	21	0.2397	0.5715	↑
Urenui River at estuary - enterococci	21	0.2910	0.5715	↓
Lake Opunake at boat ramp	11	0.3026	0.5715	↓
Timaru Stream at end of Weld Road	20	0.4609	0.7835	↑
Lake Ratapiko at boat ramp	11	0.513	0.7938	↓
Patea River at boat ramp, Patea	10	0.6473	0.8752	↑
Patea River at King Edward Park	16	0.7141	0.8752	↓
Waiwhakaiho River at Merrilands Domain	21	0.7616	0.8752	↑
Waingongoro River at Ohawe Beach	21	0.8035	0.6752	↓
Urenui River at estuary	21	0.8237	0.8752	↑
Kaupokonui River at Beach Domain	21	0.9010	0.9010	↑

[NB: * = enterococci: ↑ = deteriorating: ↓= improving]

In summary, two sites have shown statistically significant increasing temporal trends and no sites significant decreasing temporal trends in seasonal median *E. coli* counts. The other less significant trends indicate gradual improvement (five sites) or deterioration (nine sites) in seasonal median *E. coli* counts.

Table 104 Seasonal summaries of single sample *E.coli* counts in 'Surveillance'. 'Alert'. 'Action' modes for the period 1996 to date (13 samples per season)

Site / Season	1996-1997		1997-1998		1998-1999		1999-2000		2000-2001		2001-2002		2002-2003		2003-2004		2004-2005		2005-2006		2006-2007		2007-2008		2008-2009		2009-2010		2010-2011		2011-2012		2012-2013		2013-2014		2014-2015		2015-2016		2016-2017		Average per season		
Lake Rotomanu at western beach	0	1	0	1	0	0	0	0	0	0	1	2	1	1	0	3	0	0	2	0	2	1	4	1	3	3	1	3	0	0	0	5	1	0	0	0	0	0	2	2	3	2	11	1	1
Waiwhakaiho River at Merrilands Domain	0	1	0	1	1	0	0	0	1	0	2	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	12.5	<0.5	<0.5
Waiwhakaiho River adj. to L. Rotomanu	0	1	*		3	0	*		2	1	*		3	0	*		2	5	*		1	6	*		7	5	*		1	9	5	5	0	12	5	7	1	11	0	12	2	8	4.5	2.5	6
Te Henui Stream at mouth, East End	*		*		*		*		*		*		7	5	7	4	1	10	1	11	2	10	2	10	1	12	2	11	1	11	4	9	1	12	1	11	0	12	3	10	1	12	1	2	10
Patea River at King Edward Park, Stratford	*		*		*		*		*		5	1	2	2	3	1	5	3	5	3	3	1	3	4	3	1	4	2	0	1	4	0	4	0	3	0	8	1	2	1	5	1	8	3.5	1.5
Patea River at boatramp, Patea	*		*		*		*		*		*		*		*		*		*				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0
Waingongoro River at Eltham Camp	*		*		*		*		*		4	1	6	0	1	0	4	2	1	0	1	0	3	0	1	0	1	0	1	0	1	0	3	0	4	0	5	0	3	0	9	1	9.5	3	<0.5
Waingongoro River at Ohawe Beach	2	0	2	2	1	0	0	0	0	2	0	1	1	2	1	0	2	2	1	0	2	0	0	3	1	1	0	1	0	0	0	1	1	2	1	0	0	1	3	0	3	0	11	1	1
Kaupokonui River at beach domain	1	0	3	6	2	1	0	2	1	1	2	0	1	2	0	0	1	1	1	0	0	1	1	1	3	1	2	0	1	0	1	0	4	0	1	0	5	0	2	1	4	0	10	2	1
Lake Opunake at boat ramp	*		*		*		*		*		*		*		*		*		*		1	3	2	1	2	2	5	0	0	3	0	2	5	0	3	0	3	0	0	1	3	1	10	2	1
Timaru Stream at Weld Road	*		7	0	1	1	2	2	3	0	2	1	4	2	4	0	3	3	4	0	2	0	2	3	4	0	6	1	4	0	3	0	4	0	2	1	3	2	2	2	9	0	8.5	3.5	1
Waimoku Stream at Oakura Beach	2	9	2	11	3	10	8	3	5	5	3	9	1	12	1	12	2	11	0	13	2	11	0	13	0	13	0	13	0	13	*		*		2	11	*		*		0	13	0.5	2	10.5
Oakura River at SH45	0	0	2	2	0	0	2	0	2	0	1	1	1	0	0	1	3	2	3	0	4	0	1	1	1	0	4	1	1	0	2	0	1	0	0	0	2	1	1	3	1	2	11	1.5	0.5
Waitara River at town wharf, Waitara	*		*		*		*		*		*		*		*		*		*		*		*		*		2	3	1	1	2	0	3	1	3	0	2	1	5	1	2	1	9.5	2.5	1
Urenui River at estuary	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0
Manganui River at Everett Park	1	1	3	1	1	1	1	0	3	0	3	2	2	0	1	1	1	1	0	0	2	0	2	1	4	0	3	0	2	0	3	0	1	1	1	0	1	1	1	0	5	0	10.5	2	0.5
Lake Ratapiko at boat ramp	*		*		*		*		*		*		*		*		*		*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	13	<0.5	<0.5
Average per site	0.7	1.4	2.1	2.7	1.2	1.3	1.4	0.9	1.7	0.9	2.1	1.6	2.2	2.0	1.6	1.8	2.0	3.1	1.5	2.3	1.5	2.2	1.3	2.5	1.9	2.4	1.9	2.3	0.7	2.2	1.6	1.4	1.8	1.8	1.5	1.8	1.9	1.9	1.6	2.1	2.8	2.5			
% overall non-exceedance of 2003 guidelines	82		63		80		82		80		71		67		74		61		71		71		70		67		68		77		78		72		74		71		72		60		70		

5.2 General

The Taranaki Regional Council will continue to ensure that attention is given to the appropriate timing of dairy shed wastes disposal inspections and repeat inspections when necessary in specific catchments, to ensure that river and stream bacteriological water quality is not compromised by inappropriate wastes disposal practices. However, initiatives proposed by the revision of the Regional Freshwater Plan (particularly the provisions for riparian fencing and interception planting, and the diversion of dairy ponds treated wastewaters to land irrigation) should result in further improvements in bacteriological surface water quality. There is also a need to encourage farmers to refrain from allowing direct stock access to natural surface waters and/or fording stock through streams particularly under summer-autumn low flow conditions.

It is intended that the improved liaison initiated over the 2000-2001 season with territorial local authorities and the Health Protection Unit of Taranaki Healthcare, and maintained to date, will continue with particular regard to the frequency and immediacy of reporting bathing water quality and cyanobacteria results during the survey period and in particular by usage of the District and Regional Councils' websites. All sites' results were displayed on these websites throughout the 2016-2017 survey period and all instances of exceedance of guidelines were advised to the appropriate authorities. Use of **LAWA website. Changes in follow-up protocol.**

Few follow-up investigations were necessary over the 2016-2017 season and there were no obvious immediate issues with poor operation of dairy wastes disposal systems contributing to elevated counts in receiving waters. In most cases, occasionally at lakes and mainly in the lower reaches of three urban streams, wildfowl contamination was responsible for elevation in counts, particularly where public feeding of birds occurred at recreational sites. No isolated instances were related to localised rainfall during the regular, state of the environment monitoring surveys. On some occasions, particularly during lower flow periods, stock access problems, and/or cumulative impacts of consented wastewater discharges may have contributed.

In particular sub-catchments, appropriate publicity and timing of the annual round of dairy inspections has assisted with mitigation of these effects. Regular reviews of the sites' grading system will be performed and maintenance of the programme of increased sampling frequency (weekly from December to March) will continue at the four principal freshwater contact recreation usage sites. Planktonic cyanobacteria monitoring will also continue at lake sites (at a slightly lesser frequency to the bacteriological monitoring) and the benthic cyanobacteria periphyton monitoring will continue at the river/stream sites.

For planktonic cyanobacteria, of the four designated lake monitoring sites, two had bio-volumes exceeding contact recreational guidelines during the 2016-2017 season, requiring the erection of warning signs: Lake Rotokare for most of the summer and Lake Rotomanu in March 2017. Lake Opunake reached medium risk level on one occasion, and Lake Ratapiko had no or very low levels of cyanobacteria.

To date, the standard monitoring programme has consisted of seven sampling occasions spread over a five month period from October to March. Usually, due to

high cyanobacteria levels and interest from the public and other organisations extra sampling has been conducted on Lakes Rotokare and Rotomanu. Best practice guidelines suggest weekly to fortnightly sampling, multiple sampling sites within larger waterbodies, and sampling from spring to autumn (MfE and MoH, 2009). Therefore, it is recommended that an increase in sampling occasions is warranted and that ten sampling occasions over the five-month period representing approximately fortnightly sampling should be conducted for the next monitoring year (2017-2018).

Benthic cyanobacteria were found occasionally in most of the nine rivers and streams monitored. No site reached over the 50% coverage that would trigger the 'Action' level for that criterion (MfE and MoH, 2009), and one site on a total of three occasions had over 20% coverage, triggering the 'Alert' level that requires weekly monitoring. Exposed mats triggered the 'Action' or 'Alert' level at six sites on 17 occasions and detaching mats or detached mats accummulating on the rivers edge triggered the 'Action' or 'Alert' level at six sites on 15 occasions.

Monitoring before the 2014-2015 season was focussed on streambed percentage cover though information on exposed and detaching mats was collected. No sites had previously triggered the 'Action' or 'Alert' level before the 2014-15 sampling season based on the exposed or detaching mats criteria. Currently, the guidelines do not give any direction about how much exposed, detaching or detached mats is required to trigger the 'Action' level (MfE and MoH, 2009). The Council has adopted an approach based on best judgement practices to report minor and significant levels of exposed or detaching mats which trigger the 'Alert' and 'Action' level respectively as it better reflects the actual potential danger of benthic cyanobacteria. To date there have been no reported incidences of humans or animals in the Taranaki Region having been harmed by toxins produced by benthic cyanobacteria though there may have been unreported incidences.

Levels of cyanobacteria were lower than the 2015-2016 season, and did not reach public health warning levels. The improvement was probably caused by above-average rainfall causing a large number of freshes that scoured streambeds of periphyton.

The Suitability for Recreation Grading (SFRG) referenced earlier in this report (Section 2.2) may now be re-assessed to include the 2016-2017 microbiological data enabling a comparison of the five year 2011-2016 period (Table 1) with the latest SFRG for the 2012-2017 period (presented in Table 105).

Table 105 Suitability for recreation grade for freshwater sites for the period November 2012 to April 2017

Site	Sanitary Inspection Category	Microbiological assessment *E.coli* (cfu/100ml)			SFR Grade	% of all samples in compliance (ie: ≤550 *E.coli*)
		95 %ile	Number of samples	Category		
L Rotomanu: western beach	High	652	65	D	Very poor	93
Waiwhakaiho R: Merrilands domain	High	220	65	B	Poor	98
Waiwhakaiho R at L.Rotomanu	High	3075	65	D	Very poor	23
Te Henui S: mouth	High	4525	65	D	Very poor	12
Patea R: King Edward Park	High	572	65	D	Very Poor	95
Patea R. boat ramp, Patea	High	83	65	A	Poor	100
Waingongoro R: Eltham camp	High	472	65	C	Poor	98
Waingongoro R: Ohawe beach	High	518	65	C	Poor	95
Kaupokonui R: Beach domain	High	482	65	C	Poor	98
L Opunake: adjacent boat ramp	High	455	65	C	Poor	96
Timaru S: Lower Weld Road	High	690	65	D	Very poor	92
Waimoku S. at Oakura beach	High	3780	26	D	Very poor	7
Oakura R: d/s SH45	High	1675	65	D	Very poor	90
Waitara R: Town wharf	High	1000	65	D	Very poor	93
Urenui R: estuary	High	59	65	A	Poor	100
Manganui R: Everett Park	High	432	65	C	Poor	96
L Ratapiko: boat ramp	High	240	60	B	Poor	98
L Rotokare: adjacent boat ramp	Low	255	44	B	Very good	100

Few differences between the two five-year periods were apparent when comparing Table 1 and Table 105.

There were minimal changes in gradings at all sites, although in terms of the 95 percentile *E.coli* number: there was a moderate improvement at the Lake Rotomanu and Waimoku Stream sites and deterioration at the Oakura River and Waitara town wharf sites. There were slightly fewer samples in excess of the 'Action' level over the most recent five year period at three of the monitored sites (Lakes Rotomanu and Opunake, and Waingongoro River at Ohawe) while seven sites (Waiwhakaiho River adjacent to Lake Rotomanu, Te Henui Stream, Oakura River, Waingongoro River at Eltham, Waitara River at Town Wharf, Laqke Ratapiko and Patea River at King Edward Park) had more samples (4%, 4%, 3%, 2%, 2%, 2% and 1% more, respectively) in the 'Action' mode. The Patea River at King Edward Park site deteriorated in terms of the MAC assessment, which resulted in a change in SFR grading to 'very poor', while the Waingongoro River at Ohawe and Lake Opunake sites improved in MAC assessment, leading to a change in SFR grading to 'poor'. There were no other changes in MAC or SFR grades.

As outlined earlier in this report and also by the Ministry for the Environment, SFRG and MAC gradings do not represent actual water quality (and hence suitability for swimming) at any particular time. '*This indicator update* [of SFRG gradings] *cannot tell you whether it is safe to swim today at a particular spot and does not replace the site-specific information available on regional and district council websites which can help people understand the likely health risk when deciding whether to go swimming…. While beach grades provide information about the typical state of a beach, regional and district councils also use weekly monitoring to inform the public of more immediate health risks when measured bacteria concentration exceed 'action thresholds'. These action thresholds are based on levels of risk drawn from international guidelines confirmed by New Zealand studies.'*

('Recreational water quality in New Zealand indicator update' October 2012, INFO 653, Ministry for the Environment). [Suitability for recreation grading] '*reflects a precautionary approach to managing public health risks….it does not tell us whether a site is suitable for primary contact recreation on a particular day*'. ('Suitability for swimming update', August 2013, Ministry for the Environment website).

5.3 Water quality at bathing sites and the National Objectives Framework

The National Policy Statement for Freshwater Management 2014 (NPS-FW) requires that the Council, in giving effect to the NPS, is 'to safeguard…. (b) the health of people and communities, **at least as affected by secondary contact with fresh water**; in sustainably managing the use and development of land, and of discharges of contaminants' (Objective A1 for Water Quality, emphasis added). This is colloquially described as setting a 'wadeability' standard for all water bodies. The National Objectives Framework (NOF) provides the quantitative criteria by which compliance with the narrative objective of the NPS-FW can be established. The NOF provides criteria for 'wadeability', and it also provides a second set of criteria to be applied when a water body is to be used for primary recreation, ie, its 'swimmability'. The latter criteria are much more stringent. The table below illustrates the criteria prescribed in the NOF.

Table 106 NPS attribute table for *E. coli*

Attribute state	Numeric criterion	Statistic and usage
A	<260 E coli/100 ml	Grading for 'wading' suitability- use annual median of record
		Grading for 'swimming' suitability- 95% of results must be below 260 E coli/100 ml
B	260 E coli/100 ml – 540 E coli/100 ml	Grading for 'wading' suitability - use annual median of record
		Grading for 'swimming' suitability - 95% of results must be below 540 E coli/100 ml
C	540E coli/100 ml – 1000 E coli/100 ml	Grading for 'wading' suitability - use annual median of record
		Below the national 'bottom line' for swimming
D	>1000 E coli/100 ml	Below the national 'bottom line' for both swimming and wading

To clarify further: through the Council's bathing waters monitoring programme, each individual sample result is evaluated at the time of analysis according to the 2003 Microbiological Water Quality Guidelines as to whether the site is suitable for swimming **at the time of sampling**. However, the NOF expresses whether a site is formally judged as suitable for swimming **over the long term as a general rule**, based on the **worst** results obtained at any time. So, for example, a site could have just a single exceedance at some time throughout a bathing season; every other sample collected during the season could remain within the recreational guidelines, yet because of the one non-complying result according to the 2003 Guidelines, the site must be deemed 'unacceptable for bathing' according to the NOF.

The monitoring data from Taranaki's freshwater bathing sites for the past five seasons (Table 105) were analysed against the NOF criteria for 'swimmability'. Out of the 18 fresh water bathing sites that the Council routinely monitors each season, 5 fall into the 'A' NOF category for primary (swimming) usage, 5 into the 'B' category, and 8 would be deemed 'unacceptable for bathing'. Of these latter eight sites, 6 routinely meet the guidelines between 90-95% of the time, but because their 95th%ile results exceed the NOF criteria (that is, they do not have 95% or more of their results below 540 E coli/100 ml), they are to be regarded as 'unsuitable' according to the NOF even though their samples almost always meet the bathing guidelines. That is, 44% of the freshwater bathing sites in Taranaki would have to be categorised as unsuitable for swimming because of occasional poor results.

It can be noted that the equivalent bathing water criterion across Europe is that 90% of results must be less than 900 E coli/100 ml (which is comparable to having 95% of results less than 1300 E coli/100 ml), rather than less than 540 E coli/100 ml, for a site to be deemed 'swimmable'. Were this basis of grading applied to the sites in Taranaki, 47% of the freshwater bathing sites in Taranaki would be graded 'excellent' for swimming, another 41% would be graded 'good' for swimming, no sites would be graded 'sufficient', and only 4 sites (22%) be deemed 'unsuitable'.

5.4 Water quality at bathing sites and the 2017 MfE 'Clean Water' Swimmability Proposals

In February 2017 MfE released a suite of discussion documents which included proposals to further amend the National Objectives Framework (NOF). The NOF specifies compulsory national criteria for various parameters used to categorise water quality in terms of suitability for various uses and values. Included in the proposals were new criteria to be applied to water used for primary recreation (colloquially referred to as 'swimmability'). These proposals also included new protocols around sampling. The new criteria are presented in Table 107. The proposed NOF does not include a national bottom line (compulsory minimum standard), but the government has announced its intention that 90% of the nation's rivers should be in the yellow, green, or blue categories by 2040.

Table 107 *E. coli* swimming categories proposed in draft 'Clean Water' document, 2017

CATEGORY	PERCENTAGE OF EXCEEDANCES OVER 540: E. COLI PER 100 ML	MEDIAN: E. COLI PER 100ML	95TH PERCENTILE: E. COLI PER 100 ML	PERCENTAGE OF SAMPLES ABOVE 260: E. COLI PER 100 ML	NARRATIVE DESCRIPTION
Blue	< 5 per cent	≤ 130	≤ 540	< 20 per cent	Excellent for swimming
Green	5-10 per cent	≤ 130	≤ 1000	20-30 per cent	Good for swimming most of the time
Yellow	10-20 per cent	≤ 130	≤ 1200	20-34 per cent	Fair to swim in some of the time
Orange	20-30 per cent	>130	> 1200	> 34 per cent	Intermittently suitable to swim in
Red	> 30 per cent	>260	> 1200	> 50 per cent	Not safe to swim in.

The monitoring data from Taranaki's freshwater bathing sites for the past five seasons (Table 105) have been analysed against the proposed 2017 MfE criteria for 'swimmability'. Results are shown in Table 108.It should be noted that in some cases, a single criterion has been applied by MfE across several gradings. In this case, the categorisation in Table 108 has been based on the highest category in which a result applies.

What becomes apparent is that gradings denoting degrees of suitability for swimming vary immensely according to the particular criterion. For example, the quality of the Oakura River below SH45 can apparently be variously rated as 'excellent', 'good', or 'only intermittently suitable' for swimming. Likewise, the Patea River at King Edward Park, the Timaru Stream, and the Waingongoro River could be variously graded as 'excellent' or 'good' through to only 'intermittently safe', or even completely 'not safe for swimming', depending on the choice of criterion. This lack of rationalisation between criteria is not helpful for conveying 'swimmability' to the public.

Table 108 *E. coli* swimming categories for freshwater sites for the period November 2012 to April 2017, according to MfE 2017

CATEGORY/SITE	N 'SEM' samples/All samples	PERCENTAGE OF EXCEEDANCES OVER 540: E. COLI PER 100 ML		MEDIAN: E. COLI PER 100ML		95TH PERCENTILE: E. COLI PER 100 ML		PERCENTAGE OF SAMPLES ABOVE 260: E. COLI PER 100 ML	
L Rotomanu: western beach	65/105	6.2	7.6	77	84	652	738	15	16
Waiwhakaiho R: Merrilands domain	65/104	1.5	7.7	54	64	220	1700	3.1	14
Waiwhakaiho R at L.Rotomanu	65	77		870		3075		89	
Te Henui S: mouth	65	88		1200		4525		97	
Patea R: King Edward Park	65	6.2		240		572		38	
Patea R. boat ramp, Patea	65	0		7		83		0	
Waingongoro R: Eltham camp	65	1.5		240		472		38	
Waingongoro R: Ohawe beach	65/76	4.6	3.9	160	180	518		17	16
Kaupokonui R: Beach domain	65/76	1.5	1.3	120	140	482		26	28
L Opunake: adjacent boat ramp	65	3.1		110		455		25	
Timaru S: Lower Weld Road	65	12		230		690		38	
Waimoku S. at Oakura beach	26	92		1250		3780		100	
Oakura R: d/s SH45	65	9.2		110		1675		17	
Waitara R: Town wharf	65	6.2		180		1000		29	
Urenui R: estuary	65	0		7		59		0	
Manganui R: Everett Park	65	3.1		200		432		17	
L Ratapiko: boat ramp	60	1.7		13.5		240		3.3	
L Rotokare: adjacent boat ramp	44	0		32		255		6.8	

6. Recommendations

As a result of the 2016-2017 summer freshwater contact recreation bacteriological survey it is recommended:

1. THAT the 2017-2018 survey be performed at sixteen regular sites continuing with the existing sampling protocols during the season extending from 1 November to 31 March (and into April, if necessary).

2. THAT the 2017-2018 survey includes additional samples collected at the four principal usage sites (Lake Rotomanu, Waiwhakaiho River at the Merrilands Domain, Waingongoro River at Ohawe and Kaupokonui River at the mouth) in accordance with MfE, 2003 guidelines.

3. THAT the 2017-2018 summer survey includes cyanobacteria monitoring at the three lake sites and an additional lake (Rotokare) site and benthic cyanobacteria monitoring at nine of the river and stream sites fortnightly on at least ten occasions.

4. THAT follow-up sampling (after guideline exceedances) be performed when deemed necessary by TRC staff.

5. THAT appropriate timing of the annual dairy farms inspection round be incorporated into the programme for catchments where issues relating to exceedances of contact recreational standards have been identified and advice and publicity be provided in relation to the prevention of stock access to natural water.

6. THAT appropriate DNA faecal source tracking marker investigations are undertaken into the source of high baseline *E.coli* counts at the Waingongoro River site at Eltham Presbyterian camp.

7. THAT reporting of results be performed as appropriate during the season, and in an Annual Report upon completion of the season's programme.

8. THAT the appropriate statistical trend detection procedures be applied to the data and reported in the Annual Report.

Glossary of common terms and abbreviations

The following abbreviations and terms are used within this report:

'Action' mode	Two consecutive single samples greater than 280 enterococci cfu/100 ml.
'Alert' mode	Single sample greater than 140 enterococci cfu/100 ml.
Bathers	Those who enter the water, and either partially or fully immerse themselves.
Bathing season	Generally the bathing season extends between 1 November and 31 March.
Beach	The shore or any access point to the sea.
Catchment Assessment Checklist (CAC)	A checklist to identify potential catchment risk factors of faecal contamination for water recreational quality, used in establishing. the Sanitary Inspection Category of a monitoring site
cfu	Colony forming units. A measure of the concentration of bacteria usually expressed as per 100 ml sample.
Condy	Conductivity, an indication of the level of dissolved salts in a sample, usually measured at 20°C and expressed in mS/m.
Contact recreation	Recreation activities that bring people physically in contact with water, involving a risk of involuntary ingestion or inhalation of water.
E.coli	*Escherichia coli*, member of the Enterobacteriaceae, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 ml of sample.
Enterococci	Members of the Streptococcus group of bacteria characterised as faecal in origin. Enterococci provide an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 ml of sample.
Faecal coliform	An indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 ml of sample.
Faecal Indicator Bacteria (FIB)	Micro-organisms selected as indicators of faecal contamination.
False Discovery Rate (FDR)	The expected proportion of true hypothesis rejected out of the total number of rejections.
Follow-up sample	Second sample taken to confirm an initial high result; usually within 24-72 hours depending on accessibility/sample turnaround time, etc.
Median	Central value when values are arranged in order of magnitude.
Microbiological Assessment	A measurement of water quality over time as provided by historical (five years) microbiological results – A, B, C or D Category (MAC).
RMA	Resource Management Act 1991 and subsequent amendments.
Sanitary Inspection Category (SIC)	A measure of the susceptibility of a water body to faecal contamination – Very High, High, Moderate, Low or Very Low.
Suitability for Recreation Grade (SFRG)	A combination of Sanitary Inspection Category (SIC) and Microbiological Assessment Category (MAC), describes the general condition of a site at any given time, based on both risk and indicator bacteria counts.
Temp	Temperature, measured in °C (degrees Celsius).

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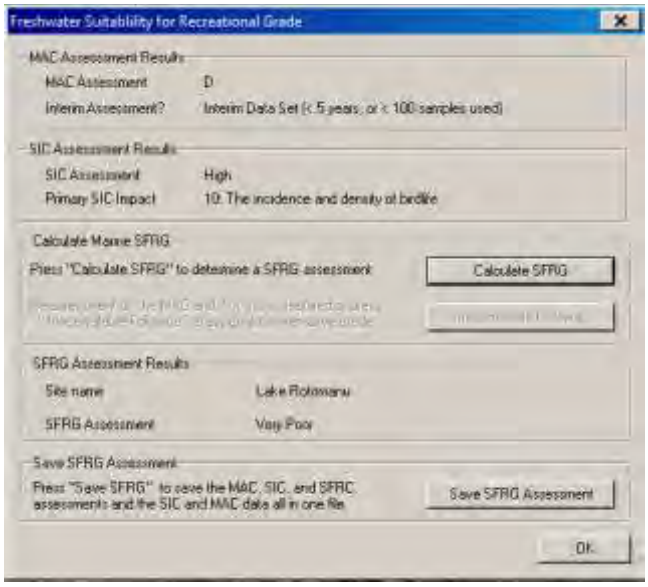
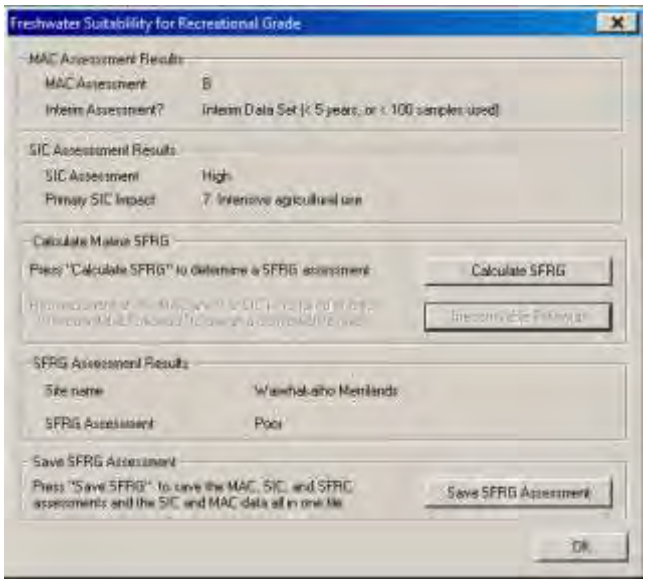
Appendix I

MAC assessments for all sites (for the 2012-2017 period)

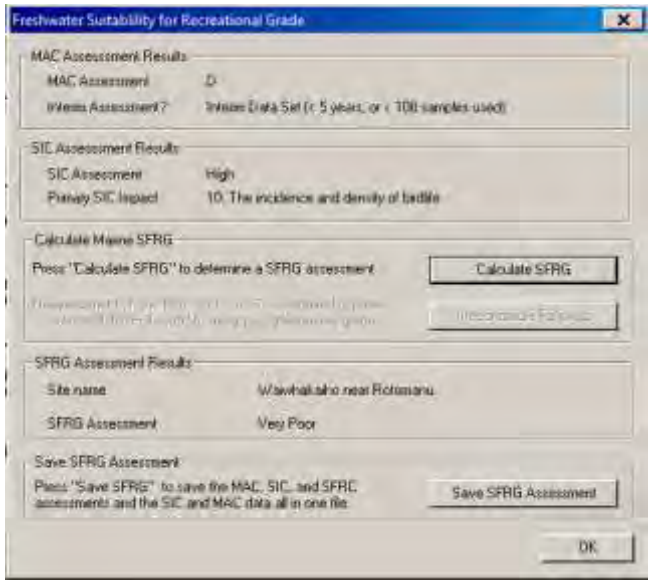
Lake Rotomanu



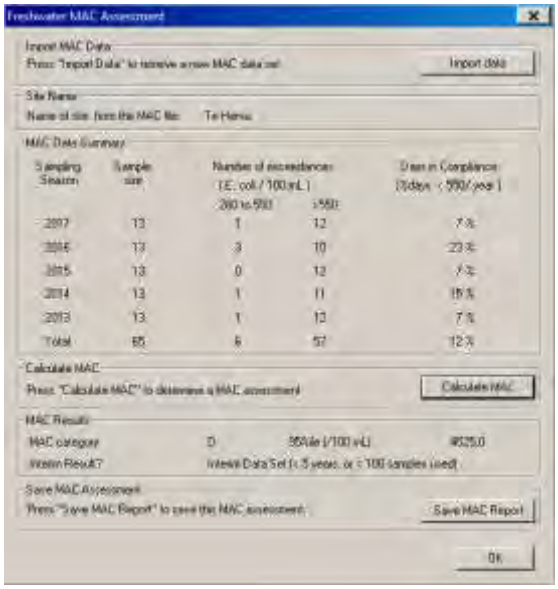
Waiwhakaiho River at Merrilands Domain

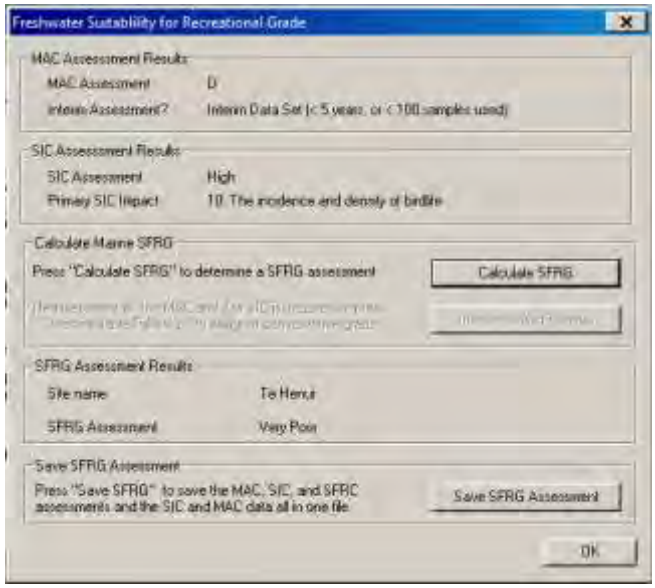


Waiwhakaiho near Lake Rotomanu

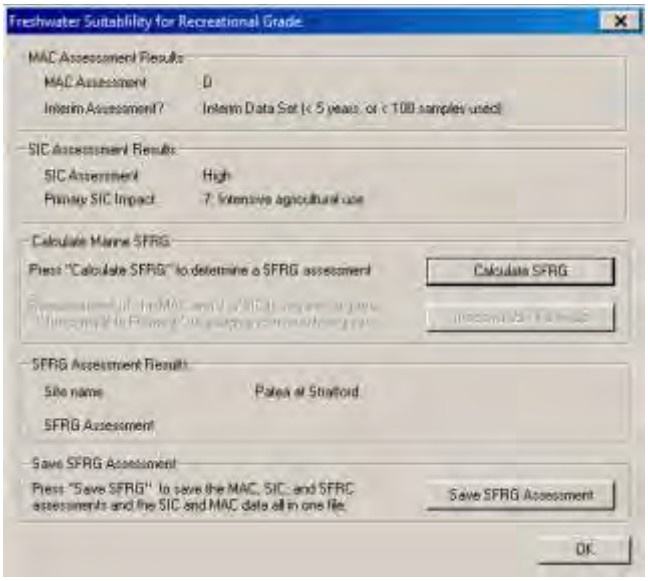


Te Henui Stream: mouth

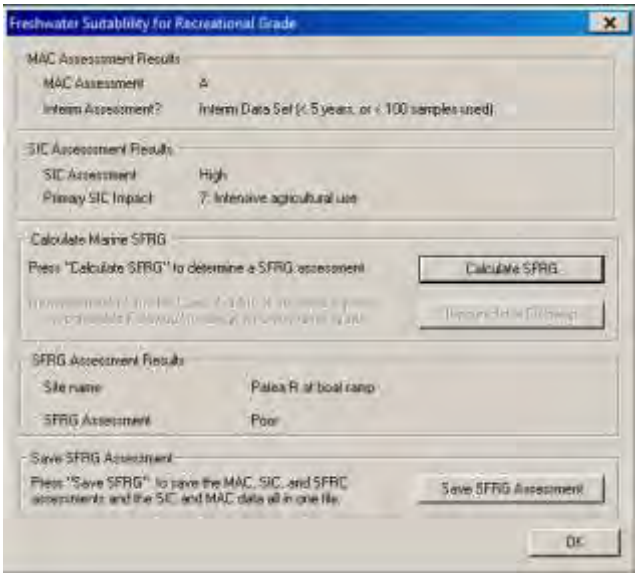




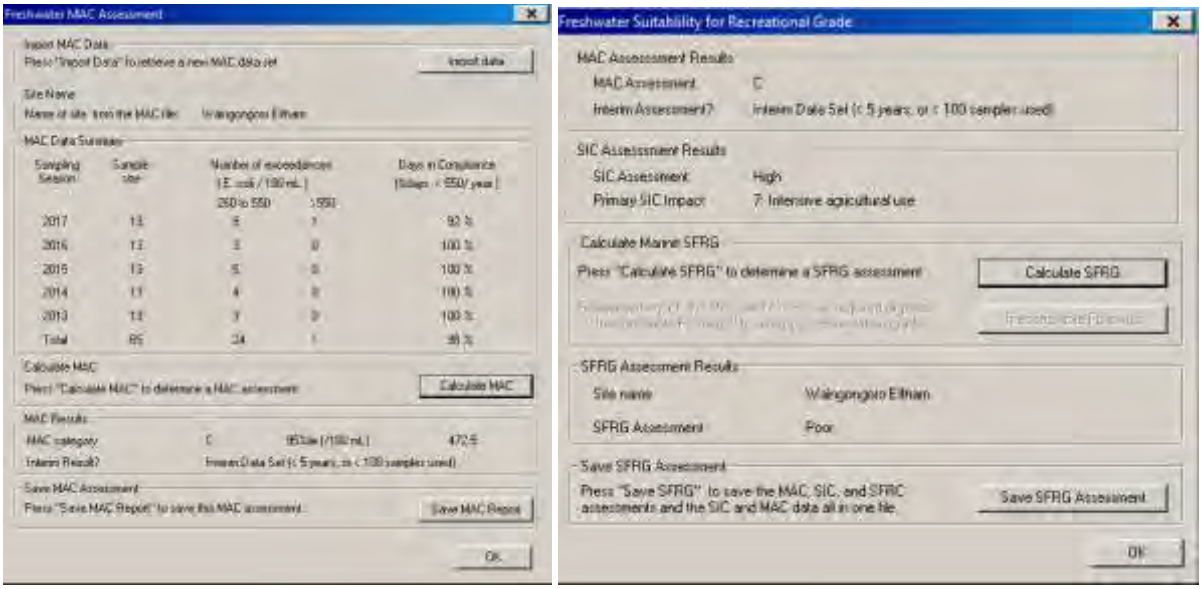
Patea River at Stratford



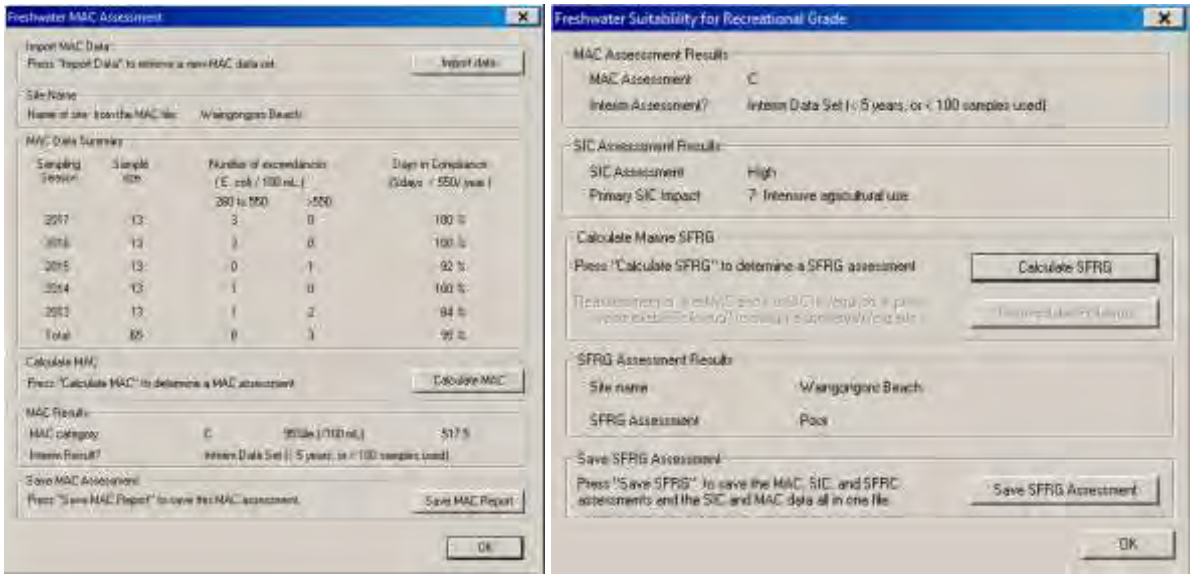
Patea River at boat ramp, Patea



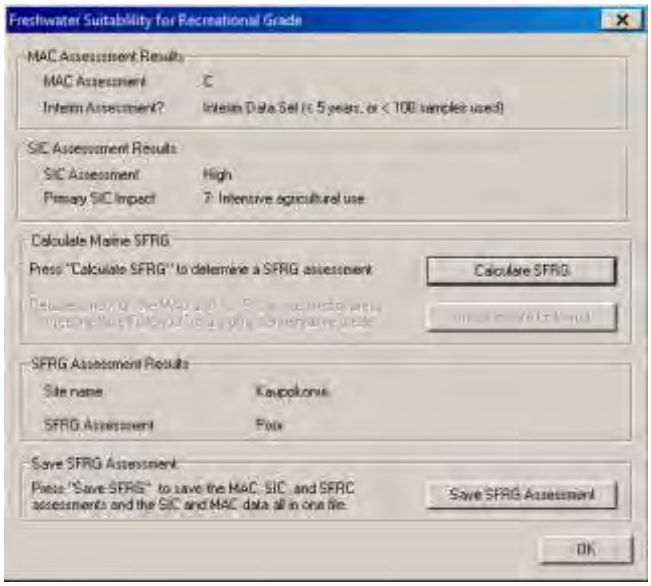
Waingongoro River at Eltham camp



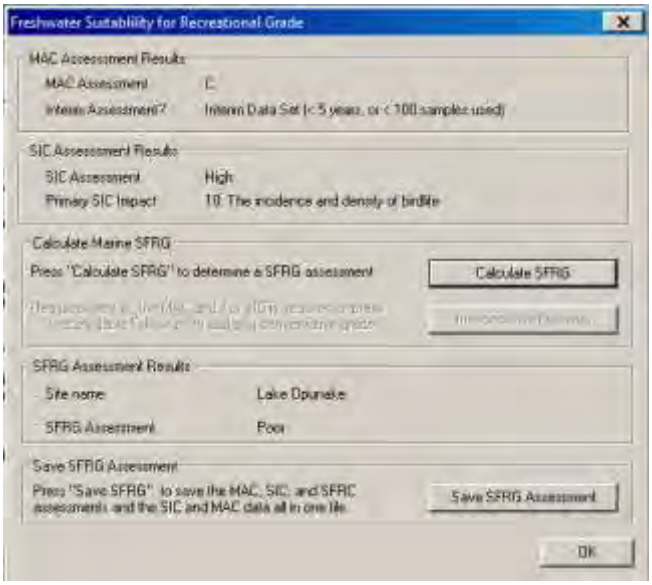
Waingongoro River at Ohawe beach



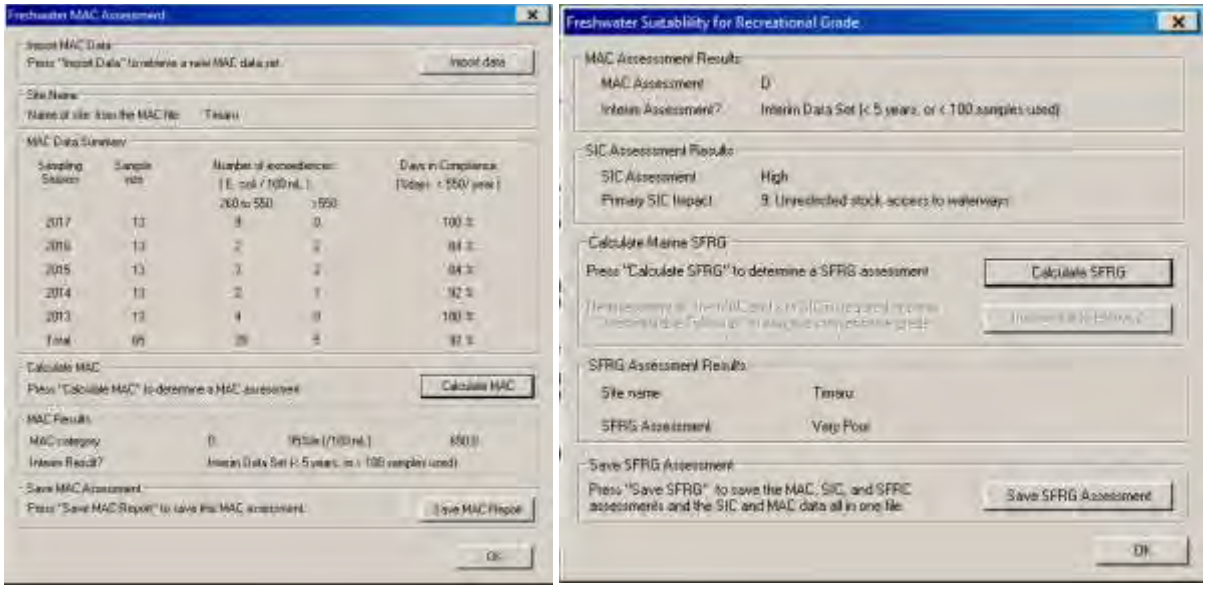
Kaupokonui River at beach domain



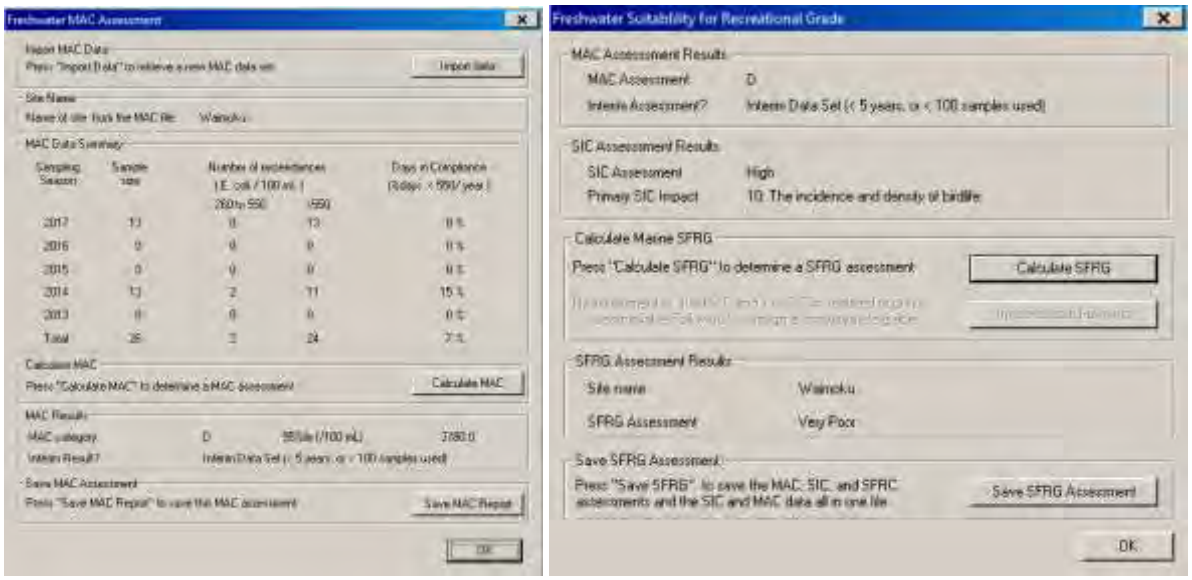
Lake Opunake



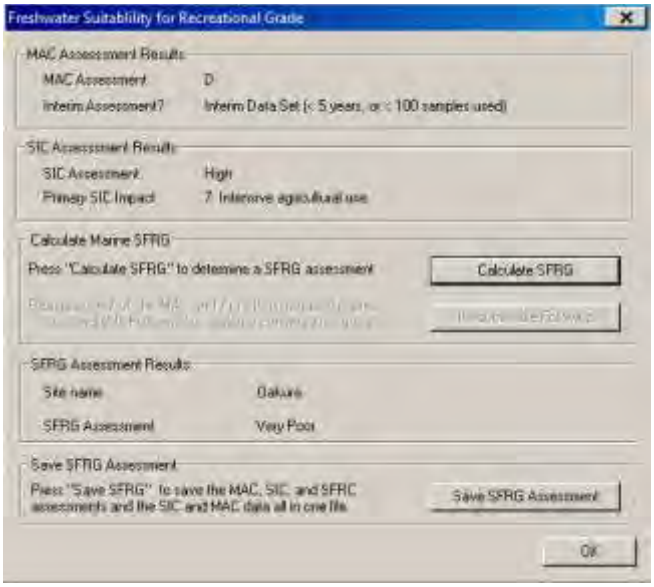
Timaru Stream at Weld Road



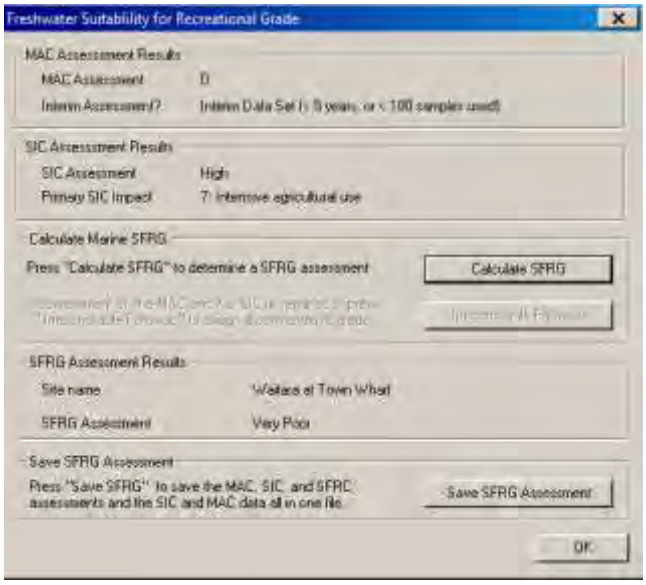
Waimoku Stream



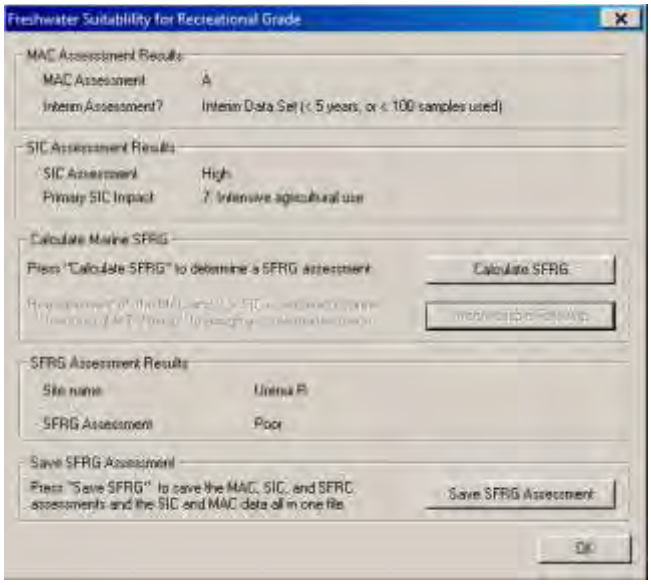
Oakura River d/s SH45



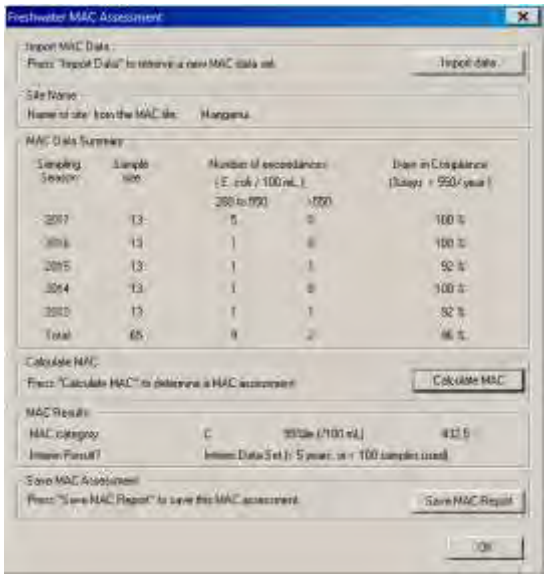
Waitara

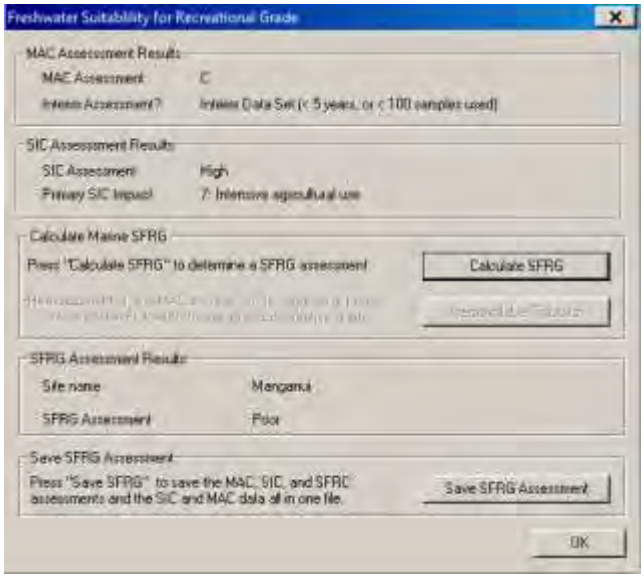


Urenui River at estuary

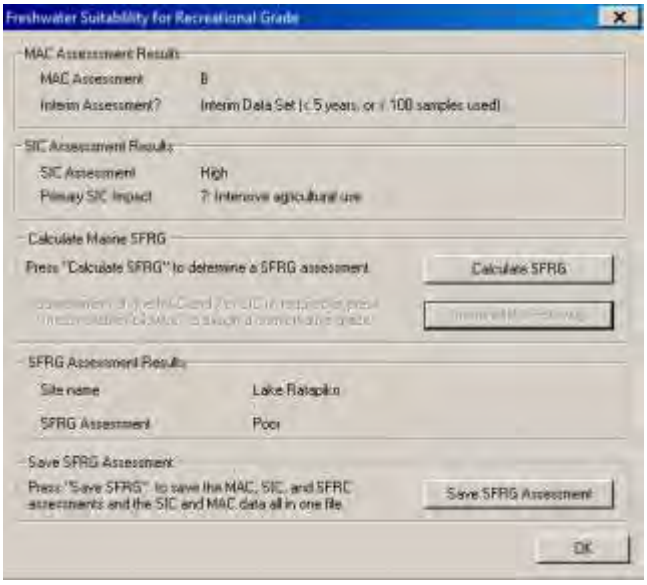


Manganui River at Everett Park

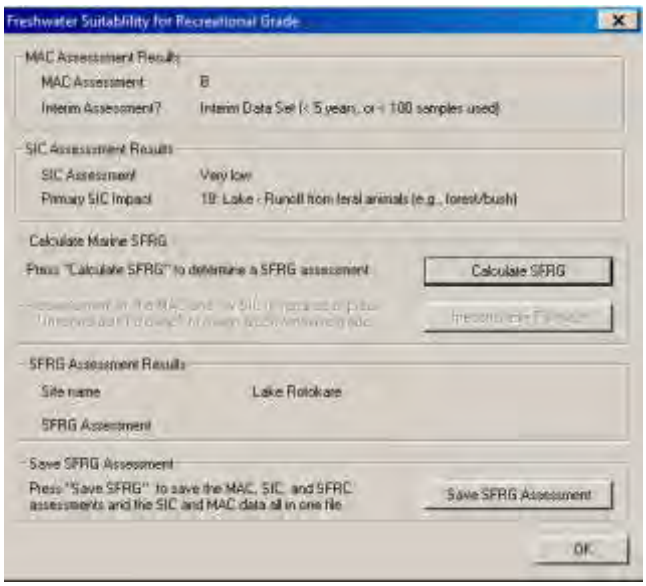




Lake Ratapiko



Lake Rotokare



Appendix II

High tide times

High tide times (NZST) at Port Taranaki, New Plymouth for 2016-2017 sampling dates

Date		High Tide (NZST)	Height (m)
Tuesday	1 November 2016	1029	3.4
Thursday	30 November 2016	1008	3.4
Tuesday	5 December 2016	1315	3.1
Thursday	12 January 2017	0929	3.6
Monday	30 January 2017	1116	3.5
Wednesday	1 February 2017	1236	3.5
Friday	10 February 2017	0917	3.5
Thursday	16 February 2017	1314	3.2
Monday	27 February 2017	1015	3.6
Thursday	2 March 2017	1216	3.6
Friday	17 March 2017	1238	3.2
Sunday	2 April 2017	1342	3.3
Tuesday	11 April 2017	0953	3.4

Appendix III

Sampling conditions and public usage recorded at each site by the SEM programme

Site Lake Rotomanu (Site Code: LRM000002)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	1/8	Nil	Sl. turbid, orange-brown	Flat	1/6 (1 kayaker; 5 on banks, 1 walking dog)	One duck on lake, 5 ducks on bank, signage present	0	0.5
30 November 2016	Fine, spitting	8/8	N/A	Turbid, brown	Flat	0/2+ (2 groups of boaties)	Ducks and gulls common, 2 eels, signage present	0.5	6.0
5 December 2016	Fine	3/8	Nil	Sl. turbid, brown	Flat	0/2 (banks)	Few ducks and gulls, signage present	1.0	1.0
12 January 2017	Fine	6/8	N/A	Turbid, brown	Rippled	10/10 (swimming/skiing, banks)	Gulls common on far bank, signage present	0	0.5
30 January 2017	Fine, overcast	8/8	N/A	Turbid, brown	Flat	1/0 (boaT and skier)	Ducks and gulls common on banks; signage present	0	0
1 February 2017	Fine, overcast	8/8	Nil	Turbid, brown	Flat	0/0	Ducks common, signage present	0.5	0.5
10 February 2017	Fine, overcast	8/8	Nil	Turbid, brown	Flat	0/1 (walker)	Ducks common; 2 harmful bacteria signage present	2.0	10.0
16 February 2017	Drizzling	8/8	Nil	Turbid, brown	Rippled	0/1 (walker)	Ducks common; harmful bacteria signage	0	1.5
27 February 2017	Fine	2/8	Nil	Turbid, brown/green	Flat	1/0 (jet-ski)	Few gulls on bank; new sign set to “no swimming”-	0	0
2 March 2017	Fine	1/8	N/A	Clear, brown	Flat	0/0	Ducks and gulls common; No siwimming sign	0	0
17 March 2017	Fine	2/8	N/A	Sl. turbid, brown	Rippled	0/0	Duck, 2 gulls; signage present	0	0.5
2 April 2017	Light rain	8/8	N/A	Turbid, light brown	Flat	2/0 (boats)	Few ducks, new sign gone	1.5	2.5
11 April 2017	Overcast	8/8	Nil	Clear, brown	Rippled	0/0	Few ducks, 2 gulls	0	0

Site Waiwhakaiho River at Merrilands (Site Code: WKH000800)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	1/8	70%, possible cyanobacteria	Clear, green	D/S	0/1 (walker)	Signage present, few ducks d/s, one dog	0	0
30 November 2016	Spitting	8/8	<10% on hard substrate	Clear, sl. yellow tinges	D/S	0/0	Signage present; no birdlife	1.5	9.0
5 December 2016	Fine	3/8	<10% on hard substrate	Clear, yellow-green	D/S	0/0	Signage present; no birdlife	2.0	2.0
12 January 2017	Drizzle	8/8	40%, exposed cyanobacteria mats	Clear, green	D/S	5/0 (swimming)	Signage present; no birdlife	0	2.0
30 January 2017	Drizzle	8/8	40%	Clear, light green	D/S	0/0	Signage present; no birdlife	0.5	0.5
1 February 2017	Fine, overcast	8/8	50%, cyanobacteria mats abundant	Clear, yellow-green	D/S	0/0	Signage present; no birdlife	0	3.0
10 February 2017	Fine, overcast	8/8	15%	Clear, green tinge	D/S	0/0	TRC and NPDC signage; no birdlife	0.5	12.5
16 February 2017	Fine, overcast	8/8	60%	Clear, green, foam present	D/S	0/0	TRC and NPDC signage; no birdlife,	0	4.0
27 February 2017	Fine	1/8	50% of hard substrate	Clear, yellow tinge, foam present	D/S	2/0 (swimming)	TRC and NPDC signage, no birdlife, 3 dogs	0	0
2 March 2017	Fine	3/8	70% of hard substrate	Clear, colourless, foam present	D/S	0/0	Signage present; no birdlife	0	0
17 March 2017	Fine	5/8	25% of hard substrate, cyanobacteria	Clear, green tinge	D/S	0/0	Signage present; no birdlife	0	0
2 April 2017	Drizzle	8/8	Widespread	Clear, green	D/S	0/0	Signage present; no birdlife	1.5	2.0
11 April 2017	Overcast	8/8	50% brown mat	Clear, grey	D/S	0/0	Signage present; no birdlife	0	0

Site Waiwhakaiho River adjacent to Lake Rotomanu (Site Code: WKH000950)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	1/8	Cyanobacteria 90% hard substr.	Clear, yellow	D/S	0/4 (whitebaiting)	Gulls and ducks very common u/s.	0	0.5
30 November 2016	Fine, overcast	8/8	75% hard, 60% total substrate	Clear, colourless	D/S	0/0	Gull colony u/s.	0.5	6.0
5 December 2016	Fine	4/8	60% hard substrate	Clear, colourless	D/S	0/1 (dogwalker)	Gull colony u/s. One dog.	1.0	1.0
12 January 2017	Fine	6/8	75% hard, 10% total substrate	Clear, colourless	D/S	0/0	Gulls u/s	0	0.5
30 January 2017	Fine, overcast	8/8	On hard substrate	Clear, colourless	D/S	0/0	Gulls common u/s	0	0
1 February 2017	Fine	7/8	Cyanobacteria 95% hard, 20% total substrate	Clear, colourless	D/S	0/0	Gulls very common u/s. Low flow.	0.5	0.5
10 February 2017	Drizzle	8/8	0%, sandy	Clear, sl. brown	D/S	0/0	Gulls very common u/s	2.0	10.0
16 February 2017	Fine, overcast	8/8	<10%	Clear, colourless	D/S	0/1 (dogwalker)	Gulls very common u/s; one dog. High flow.	0	1.5
27 February 2017	Fine	1/8	60% hard substrate	Clear, colourless	D/S	0/0	Gull colony u/s	0	0
2 March 2017	Fine	2/8	>80% hard substrate	Clear, colourless	D/S	0/0	Gull colony u/s	0	0
17 March 2017	Fine	2/8	50% hard substrate, mats	Clear, colourless	U/S	0/0	Gull colony u/s	0	0.5
2 April 2017	Light rain	8/8	Green mats widespread	Clear, colourless	D/S	0/0	Ducks common, 3 shags u/s	1.5	2.5
11 April 2017	Fine, overcast	8/8	0%	Clear, brown	D/S	0/0	Gulls very common, ducks common u/s	0	0

Site Te Henui Stream at mouth, East End (Site Code: THN000499)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	1/8	N/A	Clear, yellow	U/S	0/0	Ducks common on water u/s, gulls common d/s	0	0.5
30 November 2016	Fine, overcast	8/8	<5%	Clear, sl. green	D/S	0/0	Few ducks u/s, gulls common d/s	0.5	6.0
5 December 2016	Fine, overcast	8/8	<5%%	Clear, yellow	D/S	0/2 (banks)	Ducks common u/s, few gulls d/s; sewage spill signage	1.0	1.0
12 January 2017	Fine	2/8	N/A	Sl turbid, green	D/S	0/6 (5 on beach d/s, 1 on bank)	Ducks and gulls common d/s, one dog swimming	0	0.5
30 January 2017	Fine,overcast	8/8	0%, sand	Clear, colourless	D/S	0/0	Ducks common u/s, few gulls d/s	0	0
1 February 2017	Fine, overcast	8/8	0%	Clear, green	U/S	0/0	Few ducks u/s, gulls common d/s	0.5	0.5
10 February 2017	Fine, overcast	8/8	N/A	Sl. turbid, green	D/S	0/2 (bridge)	Ducks very common d/s, few gulls	2.0	10.0
16 February 2017	Fine, overcast	8/8	N/A	Clear, green tinge	D/S	0/1 (bank)	Ducks very common on water	0	1.5
27 February 2017	Fine,	2/8	N/A	Sl. turbid, green/brown	D/S, surging	0/0	Ducks common u/s, few gulls d/s; sewage overflow warning	0	0
2 March 2017	Fine	7/8	N/A	Sl. turbid, brown	D/S, surging	0/0	Ducks common u/s; and on far bank with gulls; sewage warning signage	0	0
17 March 2017	Fine	0/8	N/A	Clear, yellow-green	D/S	0/7 (bank/playground)	Ducks very common u/s, common on bank	0	0.5
2 April 2017	Fine, drizzle	8/8	N/A	Clear, light brown	D/S	0/0	Few gulls u/s	1.5	2.5
11 April 2017	Fine, overcast	8/8	70% brown mat	Clear, green	D/S	0/0	Ducks common; few gulls	0	0

Site Patea River, King Edward Park and Stratford (Site Code: PAT000297)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	5/8	30%	Clear, uncoloured	D/S	0/0	No birdlife	0	3.0
30 November 2016	Light rain	8/8	Patchy green mats	Clear, green	D/S	0/1 (dog walker)	No birdlife, one dog	0	2.0
5 December 2016	Fine	6/8	Patchy green mats	Clear, green	D/S	0/0	No birdlife	0	0
12 January 2017	Drizzle	8/8	40% brown mat	Clear, dark green	D/S	0/0	No birdlife	0	0
30 January 2017	Fine, overcast	8/8	50% brown mat	Clear, dark green/brown	D/S	0/0	No birdlife	0	0
1 February 2017	Spitting	8/8	Widespread green mats	Clear, dark green tinge	D/S	0/0	No birdlife	0	0
10 February 2017	Light rain	8/8	Widespread green/brown	Clear, uncoloured	D/S	0/0	No birdlife	0	0
16 February 2017	Fine, overcast	8/8	Widespread green/brown	Clear, uncoloured	D/S	0/30+ (school children study)	No birdlife	0	8.0
27 February 2017	Fine	3/8	Widespread green/brown	Clear, uncoloured	D/S	0/0	No birdlife	0	0
2 March 2017	Fine, overcast	8/8	Widespread green/brown	Clear, uncoloured	D/S	0/0	Few ducks	0	0
17 March 2017	Fine	1/8	Widespread green/brown	Clear, uncoloured	D/S	0/0	One duck	0	0
2 April 2017	Drizzle	8/8	Widespread green/brown	Clear, uncoloured	D/S	0/0	No birdlife	0	0
11 April 2017	Fine	7/8	Patchy green/brown	Clear, uncoloured	D/S	0/0	No birdlife, recent high flows	0	0.5

Site Patea River, boatramp, Patea (Site Code: PAT000995)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	1/8	N/A	Turbid, brown	D/S	0/0	One gull. Didymo sign	0	7.6
30 November 2016	Drizzle	8/8	N/A	Turbid, brown-green	D/S (steady)	0/0	No birdlife	1.6	5.4
5 December 2016	Fine	5/8	N/A	Turbid, light green	U/S	0/3 (launching boat)	No birdlife	12.2	13.2
12 January 2017	Fine	0/8	N/A	Clear, green-grey	-	0/0	No birdlife, choppy	0	0.2
30 January 2017	Fine, overcast	8/8	N/A	Turbid, light green	U/S	1/0	No birdlife	0	0
1 February 2017	Fine, overcast	8/8	N/A	Turbid, green-grey	D/S (slow)	0/0	No birdlife	0	0
10 February 2017	Fine	7/8	N/A	Turbid, light green	U/S (slow(	0/2 (launching boat)	No birdlife	0	9.4
16 February 2017	Fine, overcast	8/8	N/A	Turbid, light green	U/S (slow)	0/0	No birdlife	0	1.2
27 February 2017	Fine, overcast	8/8	N/A	Turbid, light brown-green	U/S (steady)	0/0	No birdlife	0	0
2 March 2017	Fine	0/8	N/A	Turbid, light green	D/S (slow)	0/0	Two gulls	0	0.2
17 March 2017	Fine	0/8	N/A	Turbid, brown-green	U/S (slow)	0/0	No birdlife	0	0
2 April 2017	Fine	7/8	N/A	Turbid, milky light green	D/S (slow)	0/4 (fishers)	No birdlife	0	0.8
11 April 2017	Fine, overcast	8/8	N/A	Turbid, brown	D/S (slow)	2/2 (boating. boat launching)	No birdlife. Debris.	0	0

Site Waingongoro River, Eltham Camp (Site Code: WGG000492)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	4/8	Extensive thin mats	Clear, uncoloured	D/S	0/0	One duck	0	3.0
30 November 2016	Light rain	8/8	Sparse brown & green mats	Clear, brown	D/S	0/0	No birdlife	0	2.0
5 December 2016	Fine	4/8	Green fils. & patchy brown	Clear, green	D/S	0/0	No birdlife	0	0
12 January 2017	Fine	6/8	90%	Clear, dark green	D/S	0/0	No birdlife; sheep in adjacent paddock open to river; foaming.	0	0
30 January 2017	Fine, overcast	8/8	80% brown mats	Clear, dark green	D/S	0/0	No birdlife; foaming	0	0
1 February 2017	Fine, overcast	8/8	Widespread brown, patchy green mats	Clear, green-brown	D/S	0/0	No birdlife, sheep in paddock	0	0
10 February 2017	Fine, overcast	8/8	Widespread brown, patchy green mats	Clear, uncoloured	D/S	0/0	No birdlife	0	0
16 February 2017	Fine, overcast	8/8	Widespread brown, patchy green mats	Clear, uncoloured	D/S	0/0	No birdlife; sheep in paddock	0	8.0
27 February 2017	Fine	2/8	Widespread brown, patchy green mats	Clear, green tinge	D/S	0/2 (cyanobacteria surveyors)	No birdlife; sheep in paddock	0	0
2 March 2017	Fine	4/8	Widespread brown, patchy green mats	Clear, brown tinge	D/S	0/0	No birdlife	0	0
17 March 2017	Fine	0/8	Patchy thin brown mats	Clear, green tinge	D/S	0/0	No birdlife	0	0
2 April 2017	Fine, overcast	8/8	Patchy brown & green mats	Clear, green tinge	D/S	0/0	No birdlife; sheep in paddock	0	0
11 April 2017	Fine, overcast	8/8	20% thin mats	Clear, uncoloured	D/S	0/0	No birdlife	0	0.5

Site Waingongoro River, near mouth (Site Code: WGG000995)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	4/8	25%	Sl. turbid, brown	D/S	0/8 (whitebaiting)	One dog, 3 dead whitebait	0.5	12.5
30 November 2016	Light rain	8/8	Sparse brown mats	Clear, dark green	D/S	0/5 (whitebaiting)	No birdlife	0	7.0
5 December 2016	Fine	6/8	Widespread brown fils.	Sl. turbid, brown	D/S	0/0	No birdlife	7.0	7.0
12 January 2017	Fine	2/8	60% brown mats	Clear, dark green	D/S	0/0	No birdlife	0	0
30 January 2017	Drizzle	8/8	30% brown mats	Clear, dark green	U/S	0/0	No birdlife ; foaming	3.0	3.0
1 February 2017	Fine, overcast	8/8	Widespread brown mats	Sl. turbid, brown	D/S (surging)	0/0	One black shag; tidal surging increasing turbidity	0	3.0
10 February 2017	Fine	5/8	Widespread brown mats	Clear, green	D/S	0/0	Two ducks on water	0	2.5
16 February 2017	Fine, overcast	8/8	Widespread brown mats	Clear, brown-green	D/S (surging)	0/0	No birdlife	0	0.5
27 February 2017	Fine	1/8	Widespread brown mats	Sl. turbid, brown	D/S (surging)	0/0	No birdlife	0	0
2 March 2017	Fine	3/8	Widespr. thin brown mats	Sl. turbid, brown	D/S (surging)	0/0	No birdlife	0	0
17 March 2017	Fine	0/8	Widespr. thin brown mats	Sl. turbid, brown-green	D/S	0/0	No birdlife	0	0
2 April 2017	Fine	3/8	Widespr. thick brown mats	Clear, brown	D/S (surging)	0/4 onshore with dogs	3 ducks on water, 2 dogs	0	2.0
11 April 2017	Fine, overcast	8/8	Patchy thin brown mats	Sl. turbid, brown-green	D/S	0/0	2 black shags in water	0	0

Site Kaupokonui River, beach domain (Site Code: KPK000995)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	5/8	25%	Clear, brown	D/S	0/26 (23 whitebaiting, 3 fishing)	1 gull, 3 ducks	0	8.0
30 November 2016	Drizzle	8/8	Nil	Clear, dark brown-green	D/S	0/0	No birdlife	2.5	12.0
5 December 2016	Fine	1/8	Nil	Clear, brown-green	D/S (surging)	0/0	2 gulls	0	0
12 January 2017	Fine	4/8	Sparse green clumps afloat	(Turbid), dark green	D/S (surging)	0/1 (banks)	No birdlife	0	0
30 January 2017	Fine, overcast	8/8	Nil	Clear, dark green	U/S (surging)	0/0	No birdlife, foaming	0	0
1 February 2017	Fine, overcast	8/8	Nil	Clear, dark green	D/S (surging)	0/2 (banks)	No birdlife.	0	0
10 February 2017	Fine, overcast	8/8	Nil	Clear, dark green	D/S (surging)	4/3 (paddling, fishing)	4 ducks on water	0	4.0
16 February 2017	Fine, overcast	8/8	Nil	Sl. turbid, brown	U/S (surging)	0/0	No birdlife.	0	1.5
27 February 2017	Fine	1/8	Nil	Sl. turbid, dark green-brown	U/S (surging)	0/0	No birdlife	0	0
2 March 2017	Fine	4/8	Nil	Sl. turbid, dark green	U/S (surging)	0/0	No birdlife	0	0
17 March 2017	Fine	0/8	Nil	Clear, light green	U/S (surging)	0/2 (banks)	No birdlife	0	0
2 April 2017	Fine	5/8	Nil	Sl. turbid, green	D/S (surging)	4/0 (swimming)	No birdlife	0	2.0
11 April 2017	Fine, overcast	8/8	Nil	Clear, bright green	D/S (surging)	0/0	2 gulls on banks	0	0

Site Lake Opunake (Site Code: LOP000001)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine, calm	2/8	Emergent macrophytes	Clear, brown-green	Rippled	0/5 (banks)	Ducks very common and a swan on lake, few ducks on bank	0	5.0
30 November 2016	Drizzle	8/8	N/R	Sl. turbid, dark green	Rippled	0/0	Few ducks on lake and bank	3.5	10.0
5 December 2016	Fine	1/8	Nil	Clear, dark green	Rippled	0/0	Few ducks on lake, common on bank	0	0
12 January 2017	Fine	7/8	N/R	Sl. turbid, dark green	Rippled	0/0	Ducks very common on lake, few on bank	0	0.5
30 January 2017	Fine, overcast	8/8	N/R	Sl. turbid, dark green	Rippled	0/0	Few ducks on lake, common on bank	1.6	1.5
1 February 2017	Fine, overcast	8/8	Nil	Clear, dark green	Rippled	0/0	Few ducks on lake, common on bank. Health warning sign.	0	1.5
10 February 2017	Fine, high cloud	8/8	Nil	Clear, dark green	Rippled	0/0	Ducks common on lake, very common on bank. Health warning sign.	0	4.0
16 February 2017	Fine, overcast	8/8	Nil	Clear, dark green	Rippled	0/0	Few ducks on water, very common on bank.	0	3.0
27 February 2017	Fine	1/8	Nil	Clear, dark green	Rippled	0/0	Few ducks on water, common on bank	0	0.5
2 March 2017	Fine	7/8	Nil	Clear, dark green	Rippled	0/0	No wildlife on lake, ducks common on bank and one pukeko.	0	0
17 March 2017	Fine	0/8	Nil	Clear, dark green	Rippled	0/2 (banks) with dog	Canadian geese very common on water. Lake level low.	0	0
2 April 2017	Fine, high cloud	6/8	Nil	Clear, green tinge	Rippled	0/0	No wildlife on lake, ducks very common on banks Level low.	0	5.0
11 April 2017	Spitting	8/8	Nil	Sl. turbid, dark green	Choppy	0/0	Ducks common, one shag. Lake level high.	0	0

Site Timaru Stream, near mouth (Site Code: TMR000497)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	1/8	Nil, sand	Clear, colourless	U/S	3/4 (swimmers/waders, beach)	No birdlife, two dogs in stream	0	1.0
30 November 2016	Fine, overcast	8/8	20% hard substrate	Clear, colourless	U/S	0/0	No birdlife	4.5	10.5
5 December 2016	Fine	0/8	Nil, sand	Clear, colourless	D/S	7/0 (surfers at mouth)	No birdlife	2.5	2.5
12 January 2017	Fine, overcast	8/8	Nil	Clear, sl. green	D/S	0/1 (banks)	Gulls common, two dogs	1.0	2.5
30 January 2017	Fine, overcast	8/8	Nil	Clear, colourless	Still	2/0 (surfing)	No birdlife	3.5	3.5
1 February 2017	Drizzle	8/8	Nil	Clear, brown	D/S	1/0 (swimmer)	Terns very common. 1080 sign	1.0	5.0
10 February 2017	Fine	2/8	Nil	Clear, colourless	U/S	0/0	Two swallows	0	9.5
16 February 2017	Fine, overcast	8/8	Nil	Clear, colourless	U/S	0/0	Few gulls	0	5.5
27 February 2017	Fine	1/8	80% hard substrate	Clear, colourless	U/S	0/0	No birdlife	0	0
2 March 2017	Fine	6/8	Too deep to assess	Clear, colourless	D/S	0/0	Few gulls d/s	0	0.5
17 March 2017	Fine	1/8	70% thin brown film	Clear, sl. yellow tinge	D/S	0/0	Few oystercatchers on opposite bank	0	0
2 April 2017	Drizzle	8/8	-	Clear, colourless	D/S	0/0	No birdlife	0.5	3.0
11 April 2017	Fine, overcast	8/8	Nil	Clear, grey	U/S	0/0	No birdlife	0	0

Site Waimoku Stream, Oakura (Site Code: WMK000298)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	5/8	40%	Clear, uncoloured	D/S	0/0	Permanent health warning sign	0	1.0
30 November 2016	Spitting	8/8	5% film	Clear, uncoloured	D/S	0/0		4.5	10.5
5 December 2016	Fine	4/8	<5%	Clear, uncoloured	D/S	0/0		2.5	2.5
12 January 2017	Fine	6/8	40%, mats and fils.	Clear, uncoloured	D/S	0/0		1.0	2.5
30 January 2017	Fine, overcast , calm	8/8	nil	Clear, uncoloured	D/S	0/0		3.5	3.5
1 February 2017	Drizzle	8/8	nil	Clear, brown	D/S	0/0	(	1.0	5.0
10 February 2017	Fine	6/8	<20%	Clear, uncoloured	D/S	0/0		0	9.5
16 February 2017	Fine, overcast	8/8	30%	Clear, uncoloured	D/S	0/0		0	5.5
27 February 2017	Fine	1/8	50%	Clear, uncoloured	D/S	0/10 (on beach)	No birdlife	0	0
2 March 2017	Fine	4/8	60% total	Clear, uncoloured	D/S	0/0	10 gulls at mouth	0	0.5
17 March 2017	Fine	0/8	75%	Clear, uncoloured	D/S	0/5 (on b each)		0	0
2 April 2017	Drizzle	8/8	brown mats & filaments	Clear, uncoloured	D/S	0/0		0.5	3.0
11 April 2017	Fine, overcast	8/8	100% mats	Clear, brown	D/S	0/1 (dog-walker)	1 dog	0	0

Site Oakura River, near mouth (Site Code: OKR000497)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	2/8	Nil, sandy	Clear, colourless	U/s	0/0	One shag	0	1.0
30 November 2016	Overcast, spitting	8/8	Nil	Clear, colourless	U/S	0/0	No birdlife	4.5	10.5
5 December 2016	Fine	0/8	Nil	Clear, green hue	D/S, surging	0/5 (bank)	One duck u/s. one dog	2.5	2.5
12 January 2017	Fine	6/8	Nil	Clear, colourless	D/S, surging	0/ 2 families entering water	No birdlife	1.0	2.5
30 January 2017	Fine, overcast	8/8	Nil	Clear, green hue	U/S	0/0	No birdlife	3.5	3.5
1 February 2017	Fine, overcast	8/8	Nil	Clear, brown	U/S	0/0	No birdlife.	1.0	5.0
10 February 2017	Fine	7/8	Nil	Clear, sl. green	D/S, surging	0/1 (opposite bank)	No birdlife	0	9.5
16 February 2017	Fine	7/8	Nil	Clear, yellowy-brown	D/S, surging	0/0	Two birds	0	5.5
27 February 2017	Fine	4/8	Nil	Clear, colourless	D/S, surging	0/0	30+ seagulls d/s	0	0
2 March 2017	Fine	4/8	Nil	Clear, yellow tinge	U/S, surging	0/0	One black shag	0	0.5
17 March 2017	*Fine*	0/8	Nil	Clear, green tinge	D/S, surging	0/3 (bank)	No birdlife	0	0
2 April 2017	Drizzle	8/8	N/A	Clear, colourless	D/S, slow	0/0	No birdlife	0.5	3.0
11 April 2017	Fine	0/8	5%	Clear, brown	D/S	0/0	No birdlife, terrestrial debris from recent storm	0	0

Site Waitara River at town wharf, Waitara (Site Code: WTR000922)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	S.G. level	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	3/8	2.1	Turbid, brown	D/S	6/0 (boats)	Signage, no birdlife	0	0
30 November 2016	Fine	7/8	2.0	Turbid, brown	U/S	0/0	No birdlife	0	4.0
5 December 2016	Fine	3/8	1.8	Sl. turbid,green-brown	U/S	0/0	Harmful bacteria signage no birdlife	0.5	0.5
12 January 2017	Fine	4/8	2.4	Sl. turbid, green	U/S	0/0	Signage, no birdlife	0	0.5
30 January 2017	Fine, overcast	8/8	2.0	Turbid, green	U/S	0/0	Signage, no birdlife	0.5	0.5
1 February 2017	Fine, overcast	8/8	2.1	Turbid, brown	D/S	0/0	Signage, no birdlife	0	2.0
10 February 2017	Fine	4/8	2.25	Turbid, green-brown	D/S	0/0	Signage, two ducks	0	3.5
16 February 2017	Fine	7/8	1.75	Turbid, brown-green	D/S	0/0	Signage, few ducks, gulls common	0	1.0
27 February 2017	Fine	0/8	2.3	Sl. turbid, green-brown	D/S	0/0	New health risk signage; 2 ducks	0	0
2 March 2017	Fine	1/8	2.2	Sl. turbid, brown	D/S	0/0	Signage; 8 ducks	0	0
17 March 2017	Fine	0/8	1.8	Sl. turbid, brown	Still	0/0	Signage; no birdlife	0	0
2 April 2017	Fine, o vercast	8/8	1.5	Turbid, green-brown	D/S	0/2 (fishing)	Signage; few ducks	1.0	1.5
11 April 2017	Fine	7/8	2.25	Turbid, brown	D/S	0/0	Signage, no birdlife	0	0

Site Urenui River at estuary (Site Code: URN000480)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	3/8	N/A	Turbid, green	U/S	0/0	No birdlife	0	0
30 November 2016	Fine, overcast	8/8	N/A	Turbid, turquoise green	U/S	0/0	No birdlife	0	4.0
5 December 2016	Fine	3/8	N/A	Clear, turquoise green	U/S	0/4 (fishing)	No birdlife	0.5	0.5
12 January 2017	Fine	6/8	N/A	Sl. turbid, turquoise green	U/S	0/5 (fishing)	One gull	0	0.5
30 January 2017	Drizzle	8/8	N/A	Sl. turbid, green	U/S	0/0	No birdlife	0.5	0.5
1 February 2017	Fine, overcast	8/8	N/A	Clear, green	U/S	0/0	No birdlife	0	2.0
10 February 2017	Fine	7/8	N/A	Turbid, turquoise green	U/S	0/0	No birdlife	0	3.5
16 February 2017	Fine	7/8	N/A	Turbid, turquoise green	U/S	0/0	Few gulls	0	1.0
27 February 2017	Fine	0/8	N/A	Sl. turbid, grey-brown	Still	0/0	No birdlife	0	0
2 March 2017	Fine	3/8	N/A	Clear, turquoise green	U/S	0/0	No birdlife	0	0
17 March 2017	Fine	0/8	N/A	Clear, green	U/S	0/0	No birdlife	0	0
2 April 2017	Fine, overcast	8/8	N/A	Clear, turquoise-green	U/S	0/0	No birdlife	1.0	1.5
11 April 2017	Fine	7/8	N/A	Sl, turbid, green-brown	-U/S	0/0	No birdlife	0	0

Site Manganui River d/s of Kurapete Stream (Site Code: MGN000435)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	4/8	Thin-medium	Sl. turbid,, brown-green	D/S	0/0	No birdlife	0.5	0.5
30 November 2016	Fine, overcast	8/8	30%	Clear, light brown	D/S	0/0	No birdlife	2.0	8.5
5 December 2016	Fine	5/8	50%	Clear, brown-green	D/S	0/0	No birdlife	1.0	1.0
12 January 2017	Fine	7/8	90%	Clear, green-brown	D/S	0/0	2 ducks	0	3.0
30 January 2017	Drizzle	8/8	40%	Clear, green-brown	D/S	0/0	No birdlife	0	0
1 February 2017	Fine, overcast	8/8	60%	Clear, light green	D/S	0/0	No birdlife	0.5	1.5
10 February 2017	Fine	7/8	100% thin brown mats	Clear, green-brown	D/S	0/0	No birdlife, some foam	0	10.0
16 February 2017	Fine	7/8	100%	Clear, green-brown	D/S	0/0	No birdlife	0.5	7.5
27 February 2017	Fine	0/8	60%	Clear, uncoloured	D/S	0/0	No birdlife	0	0
2 March 2017	Fine	4/8	60%	Clear, uncoloured	D/S	0/0	3 ducks	0	0
17 March 2017	Fine	2/8	60%	Clear, uncoloured	D/S	0/0	No birdlife	0	0
2 April 2017	Drizzle	8/8	Thin medium mats	Clear, brown-green	D/S	0/0	No birdlife	0	0
11 April 2017	Fine	7/8	Clear	Clear, uncoloured	D/S	0/0	No birdlife	0	0

Site Lake Ratapiko (Site Code: LRP000050)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algae	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
1 November 2016	Fine	3/8	N/A	Clear, uncoloured	Rippled	0/0	One duck, freshwater pest signage	0.5	0.5
30 November 2016	Fine, overcast	8/8	N/A	Clear, brown	Rippled	0/0	No birdlife	2.0	8.5
5 December 2016	Fine	5/8	N/A	Clear, slight brown	Ripple	0/0	No birdlife, harmful bacteria sign	1.0	1.0
12 January 2017	Fine, overcast	8/8	N/A	Sl. turbid, dark green-brown	Rippled	0/0	Few ducks	0	3.0
30 January 2017	Fine, overcast	8/8	N/A	Clear, dark brown	Flat	0/0	Several ducks	0	0
1 February 2017	Fine, overcast	8/8	N/A	Clear, light brown	Rippled	0/2 (fishing)	No birdlife	0.5	1.5
10 February 2017	Drizzle	8/8	N/A	Clear, green-brown	Rippled	0/0	No birdlife	0	10.0
16 February 2017	Fine	7/8	N/A	Clear, green brown	Rippled	0/2 (in boat)	No birdlife	0.5	7.5
27 February 2017	Fine	0/8	N/A	Clear, light brown	Flat	0/0	No birdlife	0	0
2 March 2017	Fine	4/8	N/A	Clear, uncoloured	Flat	0/0	No birdlife. Level being lowered.	0	0
17 March 2017	Fine	1/8	N/A	Clear, uncoloured	flat	0/0	One duck	0	0
2 April 2017	Fine, overcast	8/8	N/A	Sl. turbid, brown-green	Flat	0/0	No birdlife	0	0
11 April 2017			N/A	N/A	N/A	N/A	Lake level lowered for maintenance. (No sampling possible)		

Appendix IV

Sampling conditions and public usage recorded at four sites by the additional programme

Dates of additional sampling

Date	Preceding weather
Tuesday 22 November 2016	Dry over 72 hours. Bright.
Thursday 15 December 2016	Light rain over 48 hours
Wednesday 21 December 2016	Dry over 60 hours. Cloudy.
Wednesday 28 December 2016	Dry over 5 days. Long cloudy periods
Thursday 5 January 2017	Dry over 48 hours, heavy rain 72 hours before
Monday 9 January 2017	Dry for 6 days, except isolated heavy showers on mountain 48 hours before
Thursday 19 January 2017	Dry over 72 hours
Thursday 26 January 2017	Light rain over 24 hours, heavy rain 72 hours before
Tuesday 7 February 2017	Overcast/drizzle. Showers 24 hours before.
Tuesday 21 February 2017	Overcast. Light rain 72 hours before
Tuesday 7 March 2017	Overcast. Dry for 10 days

Site Lake Rotomanu (Site Code: LRM000002): additional monitoring (eleven samples)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
22 November 2016	Fine	0/8	N/A	Sl. turbid, brown	Flat	1/0 (boat)	Several ducks, signage present	0	0
15 December 2016	Drizzle	8/8	N/A	Sl. turbid, brown	Rippled	0/0	No wildlife, signage present	2.0	15.5
21 December 2016	Fine	3/8	N/A	Sl. turbid, brown	Rippled	0/0	No wildlife, signage present	0	6.5
28 December 2016	Fine	2/8	N/A	Sl. turbid, brown	Flat	1/2 (boat, camper vans)	No wildlife, signage present	0	0
5 January 2017	Fine	4/8	N/A	Sl. turbid, green-brown	Rippled	0/0	Few ducks; several gulls, signage present	0	22.0
9 January 2017	Fine	7/8	N/A	Turbid, brown	Rippled	0/0	No wildlife, signage present	0	0
18 January 2017	Fine, overcast	8/8	N/A	Turbid, brown	Flat	1/0 (jet-ski)	Few ducks, signage present	0	0.5
26 January 2017	Fine	2/8	N/A	Sl. turbid, brown	Rippled	0/0	Several ducks; signage present	1.5	2.5
7 February 2017	Fine, overcast	8/8	N/A	Sl. turbid, brown	Rippled	0/0	Ducks common, health warning sign	1.0	1.0
21 February 2017	Fine, overcast	8/8	N/A	Clear, green-brown	Flat	0/0	No wildlife, NPDC sign on yellow	1.0	2.0
7 March 2017	Fine	7/8	N/A	Sl. turbid, light brown	Flat	0/0	Few ducks on banks, signage present	0	0

Site Waiwhakaiho River at Merrilands (Site Code: WKH000800): additional monitoring (eleven samples)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
22 November 2016	Fine	0/8	10%	Clear, green	D/S	0/0	Signage present; no birdlife	0	1.0
15 December 2016	Drizzle, rainfall preceding	8/8	40%	Clear, brown-green	D/S	0/0	Signage present; no birdlife	5.0	24.5
21 December 2016	Fine	3/8	30%	Clear, green-brown	D/S	0/0	Signage preent; no birdlife	0	11.5
28 December 2016	Fine	2/8	30%	Clear, green-brown	D/S	0/1 (dogwalker)	Signage present; no birdlife; one dog	2.0	2.0
5 January 2017	Fine, rainfall preceding	5/8	20%	Clear, greeny-brown	D/S	0/0	Signage preent; no birdlife	0	31.0
9 January 2017	Fine	6/8	20%	Clear, green-brown	D/S	0/0	Harmful bacteria sign; no birdlife	0	0
18 January 2017	Fine, overcast	8/8	20%	Clear, green-brown	D/S	1/0 (with dog in water)	Signage present; no birdlife, one dog	0	1.5
26 January 2017	Fine	2/8	20%	Clear, green-brown	D/S	0/2 (dogwalkers)	Signage present, no birdlife, 2 dogs	7.0	10.5
7 February 2017	Fine, overcast	8/8	10%	Clear, breen-brown	D/S	0/0	Signage present; 1 duck	7.0	7.0
21 February 2017	Fine, overcast	8/8	20%	Clear, green-brown	D/S	0/0	Signage present, no birdlife	4.5	5.5
7 March 2017	Fine	7/8	Wide-spread	Clear, brown	D/S	0/0	Signage preent; no birdlife	0	0

Site Waingongoro River at Ohawe (Site Code: WGG000995): additional monitoring (eleven samples)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
22 November 2016	Fine	4/8	Sparse brown mat	Clear, brown-green	D/S	0/1 (whitebaiting)	No wildlife	0	0.5
15 December 2016	Fine, rainfall preceding	8/8	95% brown mat	Clear, green-brown	-	0/0	No wildlife, foamy brown scum	4.5	12.5
21 December 2016	Fine	5/8	90% brown green fils.	Clear	D/S	0/0	No wildlife, foaming	0	3.0
28 December 2016	Fine	5/8	40% brown mat	Clear, dark green	D/S	0/0	No wildlife, foaming	0	0
5 January 2017	Fine	1/8	90% brown mat	Clear, dark green	D/S	0/0	Few gullss, foaming	0	15.5
9 January 2017	Fine	7/8	90% brown mat	Clear, dark green	D/S	0/0	No wildlife, foaming	0	0
18 January 2017	Fine, overcast	8/8	40% brown mat	Clear, dark green	D/S	3/0 (swimming)	Gulls common, small fish common, foaming	0.5	0.5
26 January 2017	Fine, rainfall preceding	1/8	10% brown mat	Clear, dark green	D/S (surging)	0/0	Gulls common, sl. foaming	1.5	1.5
7 February 2017	Drizzle	8/8	Widespread brown mats	Sl. turbid, brown	D/S	0/0	Few ducks in water	1.5	1.5
21 February 2017	Fine	7/8	Widespread brown mats	Clear, brown	D/S	0/0	No wildlife, foaming	0.5	9.0
7 March 2017	Fine, overcast	8/8	Widespread brown mats	Clear, brown	D/S	0/1 (fishing)	No wildlife	0	9

Site Kaupokonui River at beach (Site Code: KPK000995): additional monitoring (eleven samples)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
22 November 2016	Fine	3/8	Sparse brown mats	Clear, green tinge	D/S	0/2 (banks)	No birdlife, foaming	0	0
15 December 2016	Fine, overcast	8/8	70% brown mat	Sl. turbid, brown	D/S	0/0	No birdlife	5.0	12.0
21 December 2016	Fine	4/8	30% brown mat	Clear, dark green	D/S	0/2 (banks)	No birdlife	0	5.5
28 December 2016	Fine	5/8	80% brown mat	Clear, dark green	D/S	0/9 (banks)	No birdlife	0	0
5 January 2017	Fine	2/8	40% brown	Clear, dark green	D/S	1/0 (swimming)	5 ducks, foaming, floating algal clumps	0	17.5
9 January 2017	Fine	7/8	80% brown mat	Clear, dark green	D/S	0/10 (banks)	No birdlife, foaming	0	0
18 January 2017	Drizzle	8/8	80% brown	Clear, dark green-brown	D/S	0/3 (banks)	3 ducks, foaming	0	0
26 January 2017	Fine	2/8	-	Sl. turbid, dark green-brown	U/S, (surging)	0/4 (banks)	No birdlife, foaming	5.5	5.5
7 February 2017	Fine, overcast	8/8	Widespread brown mats	Clear, brown	D/S	0/2 (banks)	No birdlife, foaming	2.5	2.5
21 February 2017	Fine	4/8	Widespread brown mats	Clear, brown	D/S	0/0	4 ducks on water, shoal of mullet	0	3.0
7 March 2017	Fine, overcast	8/8	Widespread brown mats	Clear, dark green-brown	D/S	0/0	No birdlife	0	0

Appendix V

Sampling conditions and public usage recorded at three sites during the cyanobacteria programme

Site Lake Opunake (Site Code: LOP000001)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
22 November 2016	Fine	5/8	Nil	Clear, green	Rippled	0/0	Ducks common, didymo signage	0	0.5
7 December 2016	Fine, overcast. Strong northerly	8/8	Nil	Sl. turbid, dark green	Rippled	0/0	Ducks common	0	0.5
21 December 2016	Fine	5/8	Nil	Clear, darkgreen	Rippled	0/0	Ducks common, 2 scaup	0	13.5
5 January 2017	Fine	3/8	Nil	Sl. turbid, dark green-brown	Rippled	0/3 (banks)	Ducks very common.	0	21.0
26 January 2017	Fine	4/8	Nil	Sl. turbid, dark green	Rippled	0/0	Ducks common	10.5	14.0
7 February 2017	Drizzle	8/8	Nil	Sl. turbid, dark green	Flat	0/0	Two ducks, level low.	6.5	6.5
7 March 2017	Fine, overcast	8/8	Nil	Clear, uncoloured	Flat	0/0	Ducks common; level low	0	0

Site Lake Ratapiko (Site Code: LRP000050)

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
22 November 2016	Fine	4/8	N/A	Clear, light brown	Rippled	0/0	Two ducks; didymo sign	0	0.5
7 December 2016									
21 December 2016	Fine	3/8	Nil	Clear, light brown	Rippled	0/0	Few ducks	0	19.0
5 January 2017	Fine	2/8	Some macrophytes	Clear,brown	Flat	0/0	Few ducks	0	37.5
26 January 2017	Fine	0/8	-	Clear, brown	Flat	0/0	Ducks common	17.0	21.5
7 February 2017	Drizzle	8/8	-	Clear, dark brown	Rippled	0/0	Few ducks	7.0	7.0
7 March 2017	Fine	478	-	Clear; light brown	Rippled	0/0	No birdlife	1.0	1.0

Site Lake Rotokare adjacent to boatramp (Site Code: LRK000003)

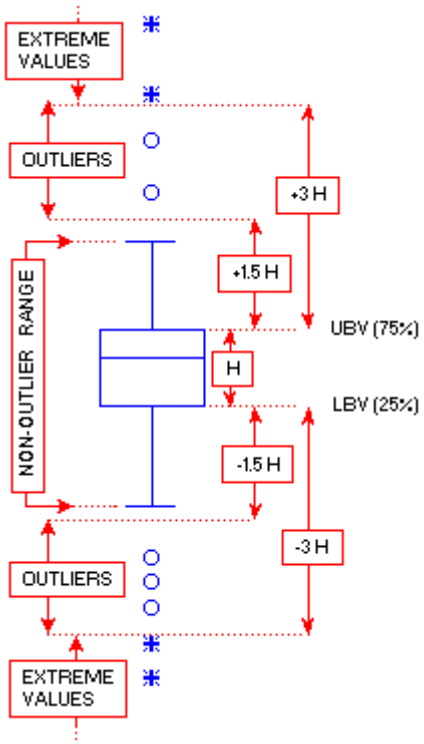
Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	Algal cover	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
3 November 2016	Fine	3/8	-	Clear, dark brown	Rippled	2/0 (kayakers)	Few ducks	3.5	49.5
22 November 2016	Fine	1/8	Colonies down column	Turbid, dark green	Rippled	0/0	Few scaup	0	0
7 December 2016	Fine	7/8	Colonies visible	Turbid, dark green	Rippled	0/5 (3 tents, 2 campers)	Several scaup	0	0
21 December 2016	Fine	5/8	Colonies visible	Turbid, green	Rippled	0/3 (banks)	Boat ramp closed, STDC warning signs, Few ducks and 2 shags	0	11.5
5 January 2017	Fine	1/8	Colonies visible	Turbid, green-brown	Rippled	0/6 (banks)	Boat ramp closed, warning signs, one duck	0	15.5
26 January 2017	Fine	4/8	Colonies down column	Sl. turbid, dark green	Rippled	0/8 (banks)	Boat ramp closed, warning signs, no bidlife	3.5	4.0
7 February 2017	Drizzle	8/8		Turbid, green	Flat	0/0	Boat ramp closed, warning signs, few ducks	0	0
7 March 2017	Fine, overcast	8/8	Brown mats on bed	Sl. turbid, brown	Rippled	0/2	Boat ramp closed, warning signs, two black shags	0	0
20 March 2017	Fine	4/8	-	Clear, tannin brown	Rippled	0/0	Didymo sign only. No birdlife.	0	0

Appendix VI

Comparative annual box and whisker plots of SEM data for *E. coli* for the period 1996 to 2017

Interpretation of Box and Whisker Plots (produced using STATISTICA)

Box and whisker plots are a useful method of summarising data in a graphical form that allows rapid comparisons of data groups. The data is represented as a box with a whisker from each end.



The median (middle value of the sorted data; half of the data is either side of the median) is represented by a single horizontal line (or ◊ point).

The top and bottom of the box represent the upper (UBV) and lower (LBV) hinges respectively. The median splits the ordered group of data in half and the hinges split the remaining halves in half again. This means that 50% of the data lies within the box.

Hspread, comparable to the interquartile (25% and 75%) range is the difference between the values of the two hinges, i.e., Upper hinge – Lower hinge = Hspread. The inner fences (within whiskers) are defined as follows:

Lower fence = lower hinge - (1.5 x Hspread)
Upper fence = upper hinge + (1.5 x Hspread)

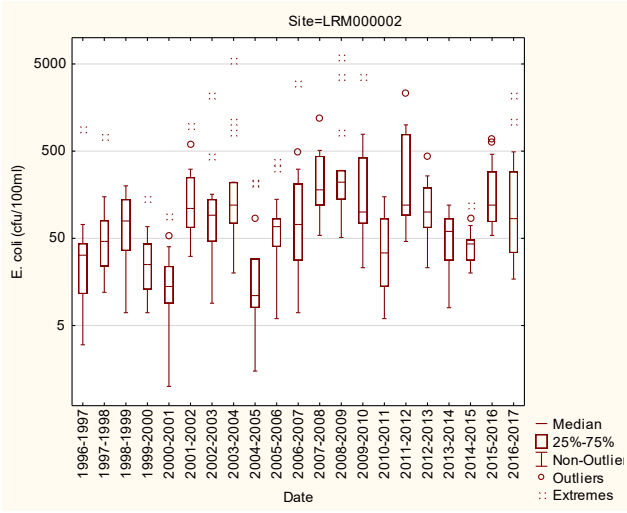
The outer fences (outside whiskers) are defined as follows:

Lower fence = lower hinge - (3 x Hspread)
Upper fence = upper hinge + (3 x Hspread)

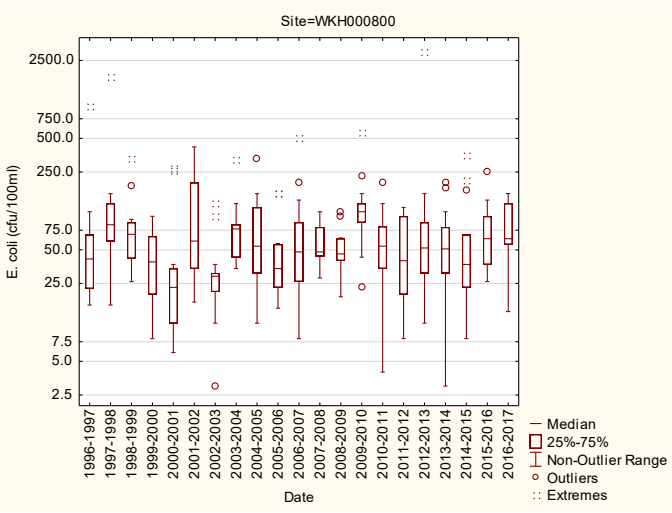
The whiskers show the range of values that lie within the inner fences. Values outside the inner fence are plotted as open circles (o). Values outside the outer fence are plotted as asterisks (*).

E. coli

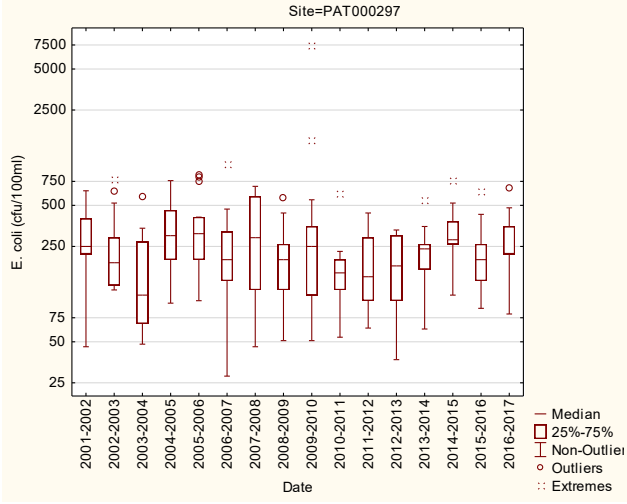
Lake Rotomanu



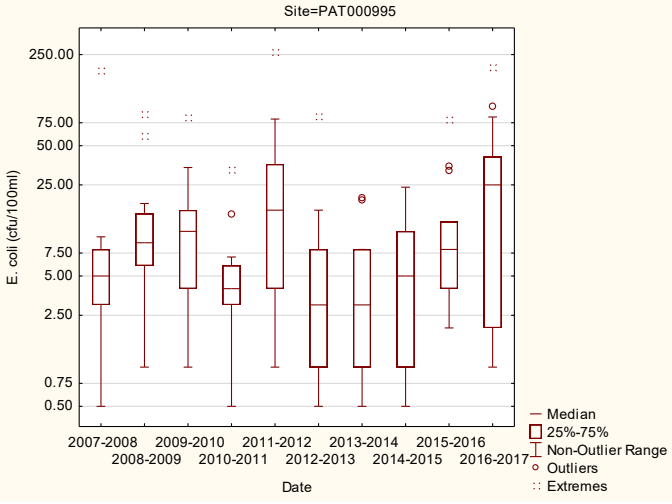
Waiwhakaiho River at Merrilands Domain



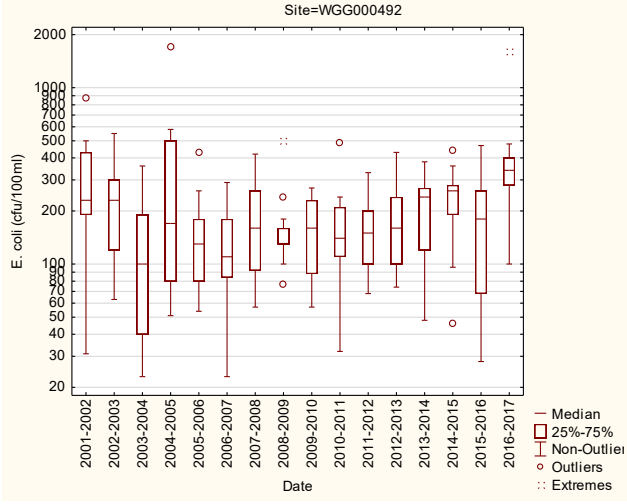
Patea River at Stratford



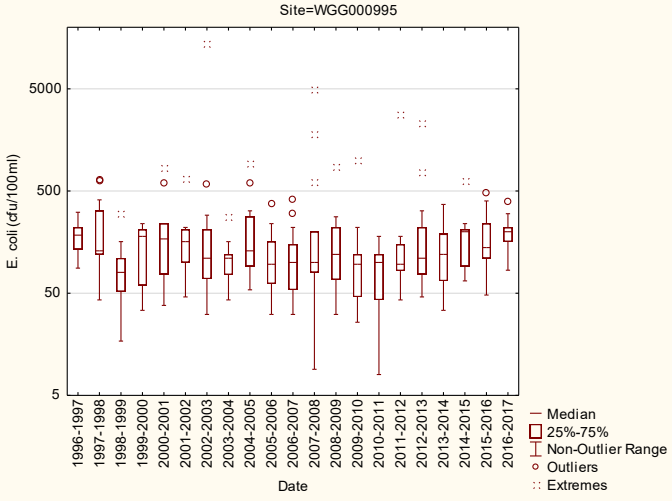
Patea River at Patea boat ramp



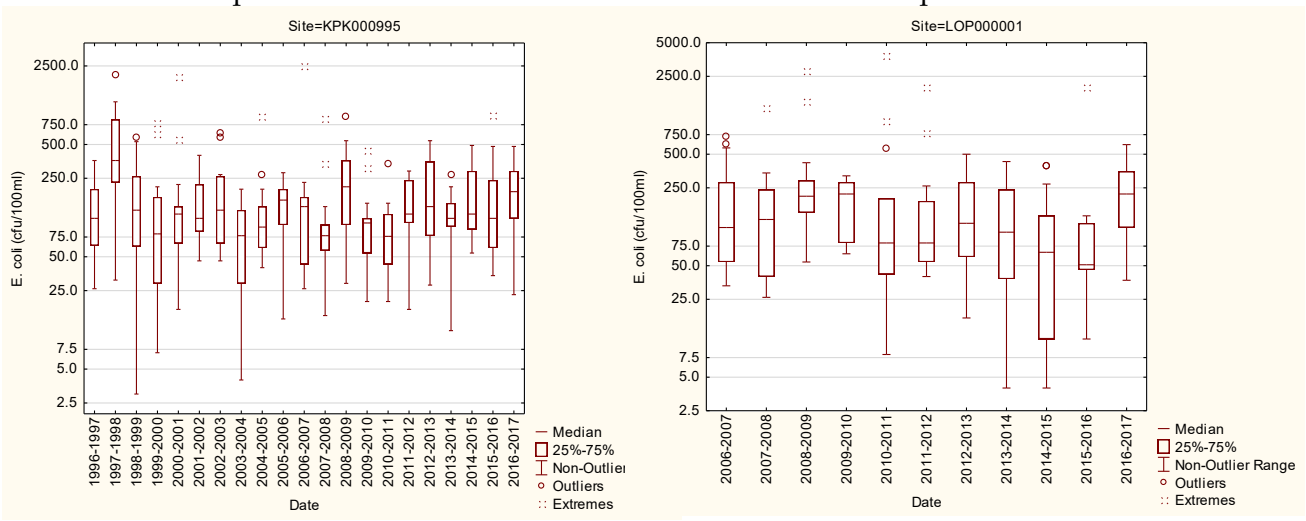
Waingongoro R at Eltham



Waingongoro R at Ohawe

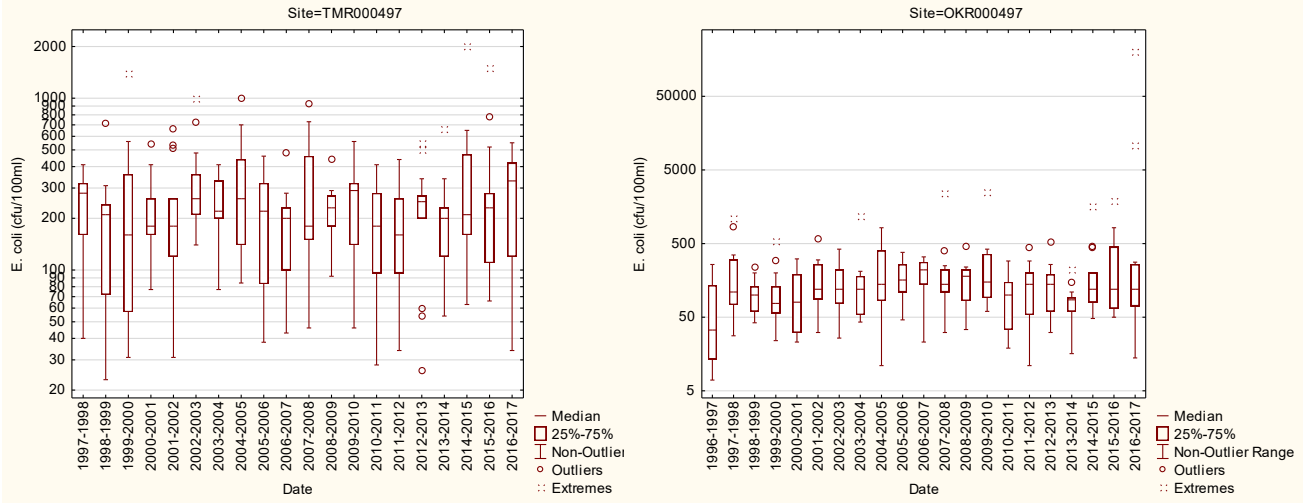


Kaupokonui River



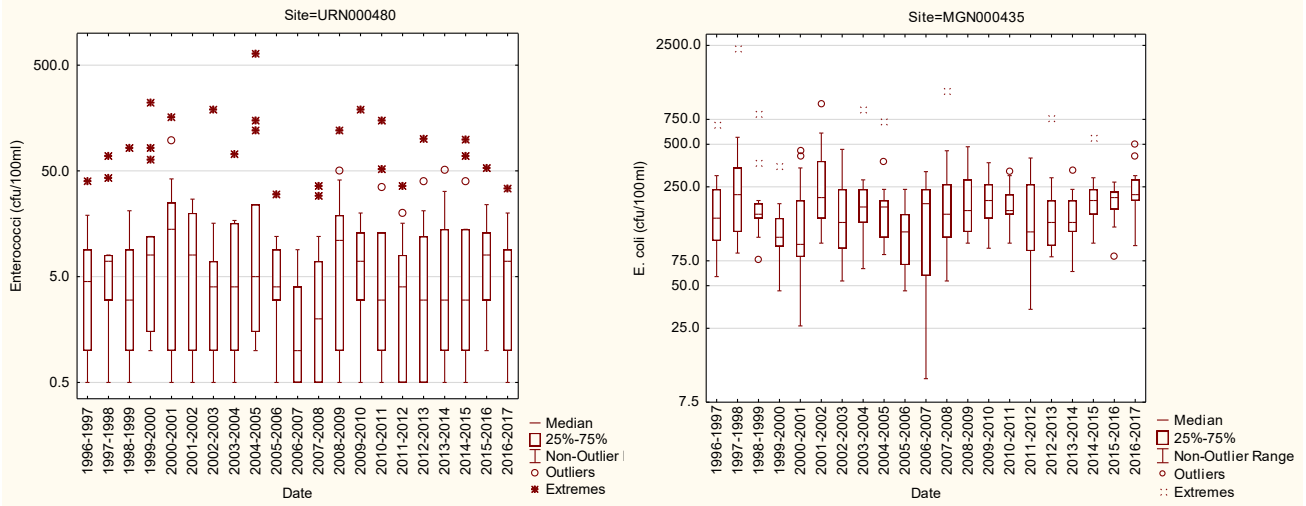
Lake Opunake

Timaru Stream



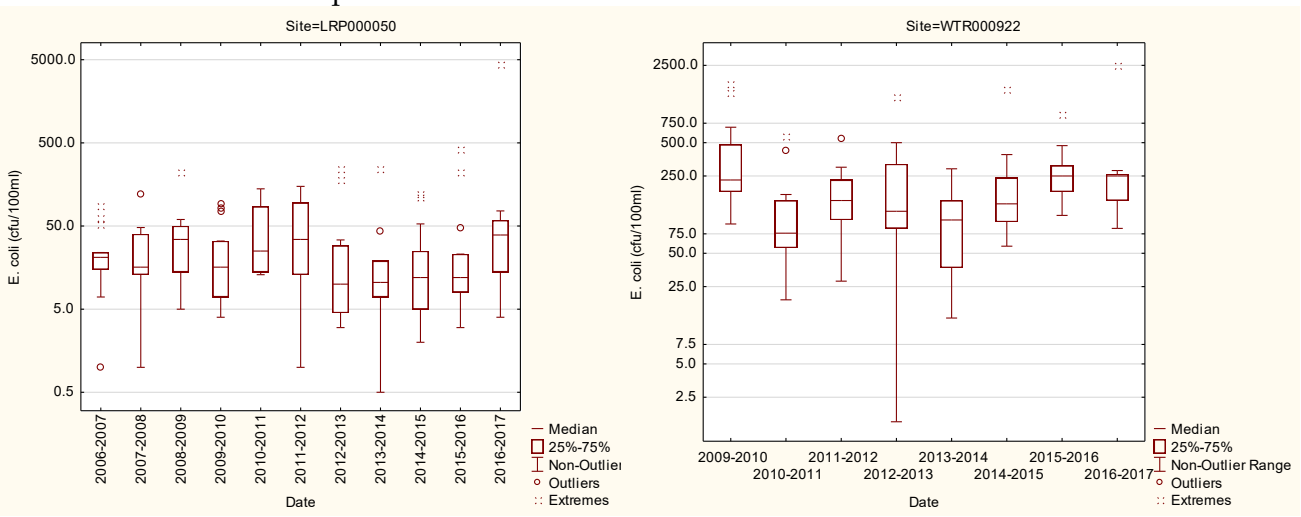
Oakura River

Urenui River



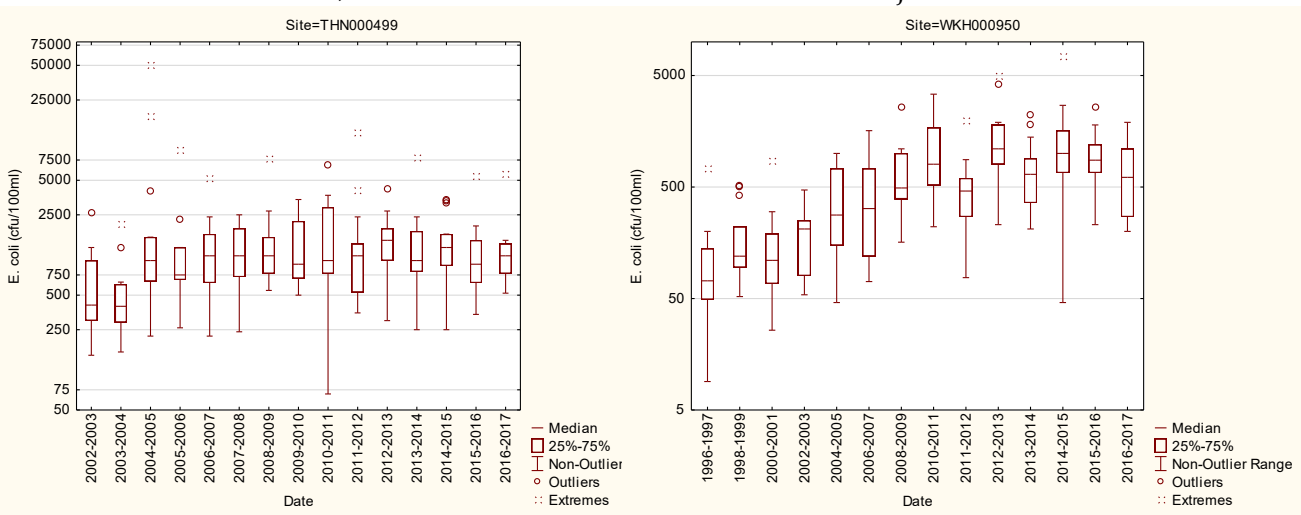
Manganui River

Lake Ratapiko



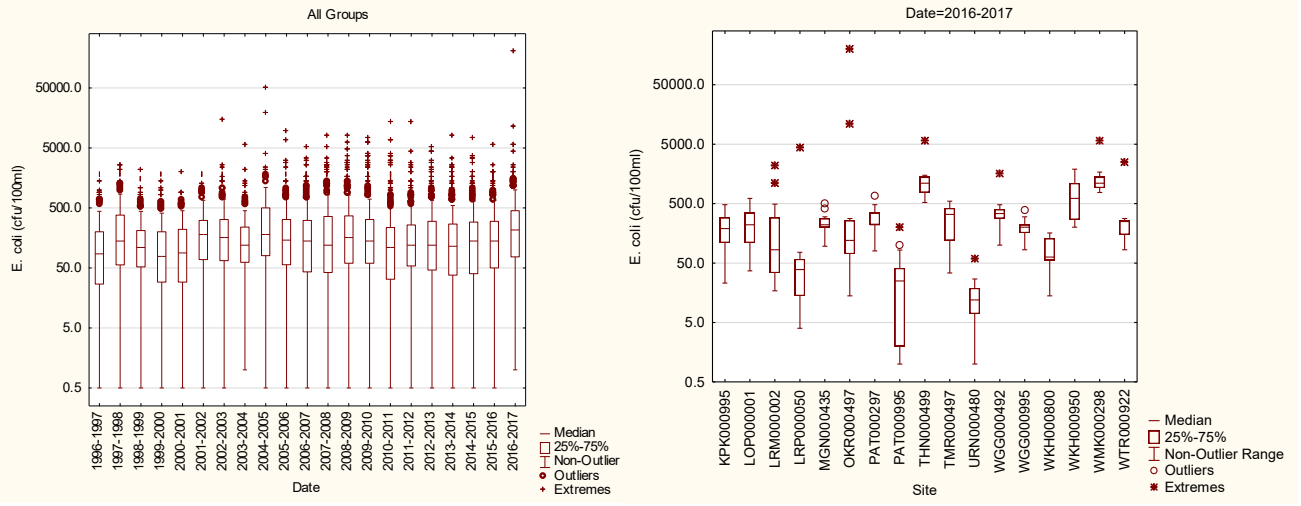
Waitara River at town wharf

Te Henui mouth, East End



Waiwhakaiho adjacent to L.Rotomanu

All sites combined, 1995 - 2017



All sites individually, 2016 – 2017

Appendix VII

Sporadic sampling at miscellaneous sites of public interest

Comments

Public enquiries into the water quality of other river/lakes sites have been received from time to time. During the 2016-2017 season, these specifically related to:

- the lagoon adjacent to the true right bank of the Waitara River, 300m upstream of SH3 bridge (site: WTR000911) (GPS ref: 1707707E 5681257); also known as Lake Ngagnana.
- Lake Rotorangi near the Hawera Water Ski Club, Tangahoe Valley (site: LRT00S300) and near the Patea HEP dam (site: LRT00S450).

Water quality sampling surveys were undertaken occasionally at each of these sites in conjuction with other monitoring work. The results are presented beneath.

Site	Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity	Usage
		(NZST)	(mS/m)	*E.coli* (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	(°C)	(NTU)	
WTR000911	30.1116	1030	15.4	8	11	11	18.4	1.3	Nil
	05.01.17	1005	15.0	20	40	20	21.8	2.3	Nil
LRT00S300	20.10.16	0847	9.8	34	<1	34	15.6	5.0	Nil
	20.02.17	0925	10.0	41	4	41	21.5	1.4	Nil
	22.03.17	0939	11.1	7	<1	7	19.7	1.2	Nil
LRT00S450	20.10.16	1103	9.2	2	6	2	16.4	2.1	Nil
	20.02.17	1047	11.5	9	62	8	21.7	0.8	Nil
	22.03.17	1115	9.8	1	5	1	20.4	0.9	Nil

The recreational water quality guidelines were met at the site on Lake Ngagnana and both sites at Lake Rotorangi on each monitoring occasion. The *E. coli* count was at 'Surveillance' level on each monitoring occasion.