Freshwater contact recreational water quality at selected Taranaki sites State of the Environment Monitoring Report 2009-2010 Technical Report 2010–11

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Executive summary

This survey of fifteen freshwater contact recreational sites in the Taranaki region was the fourteenth of an on-going programme designed to annually monitor the bacteriological quality of lakes, rivers and streams at popular contact recreational sites. 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 the 2009-2010 period for the fourth time, partly as a component of the recently instituted cyanobacteria programme (covering four lakes and one river site) instigated after consultation with Taranaki Healthcare. An additional site in the lower Waitara River was added in the latest period at the joint request of Taranaki Healthcare and NPDC. The fifteen sites have been graded for recreational suitability according to MfE, 2003 guidelines, based upon the immediately preceding five seasons of monitoring data (where such data existed). A sixteenth site (Lake Rotokare) has been monitored, principally for cyanobacteria, in the 2009-2010 period.

The results of this 2009-2010 survey have continued to illustrate variability in bacteriological water quality, with the highest water 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 Waingongoro River (at Ohawe Beach). However, impacts on bacteriological water quality at some sites, particularly the Waimoku Stream and Lakes Rotomanu and Opunake were due principally to resident wild fowl populations in the vicinity of recreational usage sites.

In terms of *E. coli*, bacteriological water quality showed some general improvement in the latest survey period in comparison with historical surveys.

One site (Waimoku Stream at Oakura beach) continued to record all of its single samples in the 'Action' mode of the MfE, 2003 guidelines and further investigative work in the catchment, together with DNA marker tracking, confirmed the principal contribution to be the wildfowl populations. Twelve other sites exhibited occasional single sample entries into the 'Alert' or 'Action' modes of the 2003 guidelines at some time during the season. However, eight sites' counts entered the 'Action' mode, a small increase in the frequency of exceedances in comparison with previous survey 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. Birdlife contributed to exceedances from time to time particularly at sites where recreationalists were feeding the birds. Follow-up sampling was performed when deemed necessary following exceedances of the 'Action' limit and in most cases bacteriological quality was found to have returned to typical levels within a short period. Health warning signage was erected at two sites by the New Plymouth District Council (on the direction of Taranaki District Health Board) during the season following exceedances of 'Alert' levels but other single sample 'Alert' level exceedances were not signposted.

Temporal trends over the 1996-2010 period have been evaluated for the eight sites with ten years or more data (and will continue to be assessed annually). Two sites (Oakura River and Waimoku Stream) have shown a statistically significant trend (increase) in median *E. coli counts* with median counts consistently in the 'Action' level for the Waimoku Stream but no median counts reaching 'Alert' or 'Action' levels in the Oakura River. No other sites have shown significant trends (positive or negative) in seasonal median *E. coli* counts. Elevated enterococci to faecal coliform ratios typified ponded sites near the stream/river mouths 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) at two principal usage sites (Lake Rotomanu and Waiwhakaiho River) coincided on few occasions with wet weather conditions and resulted in slight increases in the median bacteriological number at one site and no change at the other. Few additional exceedances of limits occurred at the river site and more at the lake site where poorer bacteriological quality followed wet weather events and wildfowl influences in the case of the lake site.

A cyanobacteria bloom was recorded again at Lake Rotokare from near mid-season with numbers peaking in late summer, necessitating a warning notice to avoid contact recreation on these waters through the latter part of the season but levels had fallen below recreational guidelines by the end of the survey period. Unlike the situation in the 2008-2009 season, cyanobacteria levels did not reach warning levels at Lake Rotomanu during the season. This lake was mechanically weeded during the season for maintenance purposes.

Timely reporting of the results of bacteriological water quality and cyanobacteria presence/absence was undertaken by use of the Taranaki Regional Council website (www.trc.govt.nz) as well as liaison with territorial local authorities and the Health Protection Unit of Taranaki District Health Board (who also utilised its newly created website) throughout the survey season of 2009-2010.

It is recommended that bacteriological monitoring of selected freshwater sites be continued on an annual basis (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. Cyanobacteria monitoring at up to five selected sites (including the four lakes) 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 have been located.

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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 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 one river and three lake sites since the 2006-2007 summer and an additional lake site in 2007-2008.

The SEM bacteriological bathing water quality programme has three objectives:

- to characterise the bacteriological 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 water quality over time. Therefore the detection of trends is an important component in programme design; and
- to assess compliance with 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.]*

2. Contact recreation water quality standards and guidelines

Prior to 2003, the Council has 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). Since 2003 new guidelines are now relevant to this programme. This guideline is 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). Components of these 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. Changes to the *E. coli* freshwater recreational guideline values have been made for the purpose of regularly assessing single sample compliance with suitability for recreation. The new 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 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*/100mls)	≤260	261-550	>550
Marine (enterococci/100mls)	≤140	141-280	>280 (2 consecutive samples)

2.2 Suitability for recreation grading (SFRG) of sites

The 2003 Microbiological Water Quality Guidelines (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. The SFRG therefore describes the general condition of a site based on both risk and indicator bacteria water quality. 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 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 considered that

they will rarely pass the guidelines. The risk of illness from bathing at these sites is deemed 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. The public will be informed when guideline values are exceeded and swimming is not recommended (MfE, 2003).

All of the eleven freshwater sites originally 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 2003 to April 2008 period (i.e. the five years immediately preceding the current season as required by the Guidelines). The two new sites added to the programme in 2006-2007, the two sites added in 2007-2008, and the single site added in 2009-2010 have minimal historical bacteriological data and only a maximum of three year's data have been collected in the recent five year period. The relevant information is provided in Appendix 1 is summarised in Table 1.

Table 1 Suitability for recreation grade for freshwater sites for the period November 2004 to April 2009

Site	Sanitary Inspection Category	Microbiological assessment *E.coli* (nos/100ml)			SFR Grade	% of all samples in compliance (ie: <550 *E.coli*)
		95 %ile	Number of samples	Category		
L Rotomanu: western beach	High	1650	65	D	Very poor	92
Waiwhakaiho R: Merrilands domain	High	170	65	B	Poor	100
Patea R: King Edward Park	High	773	65	D	Very poor	81
Patea R. boatramp, Patea	High	144	39	B	Poor	100
Waingongoro R: Eltham camp	High	508	65	C	Poor	96
Waingongoro R: Ohawe beach	High	888	65	D	Very poor	90
Kaupokonui R: Beach domain	High	858	65	D	Very poor	93
L Opunake: adjacent boatramp	High	1410	39	D	Very poor	84
Timaru S: Lower Weld Road	High	708	65	D	Very poor	90
Waimoku S: Oakura	High	4525	65	D	Very poor	6
Oakura R: d/s SH45	High	500	65	C	Poor	95
Waitara R: Town wharf	High	-	-	-	-	-
Urenui R: estuary	High	85	65	A	Poor	100
Manganui R: Everett Park	High	457	65	C	Poor	96
L Ratapiko: boatramp	High	106	38	A	Poor	100
L Rotokare: adjacent boatramp	High	-	19	-	-	100

Although most of the sites' SFRGs indicate possible high risks associated with contact recreational usage, the gradings have been strongly influenced by the agricultural nature of all catchments. The 5-year microbiological data however, indicate that all but one site (Waimoku Stream) would not have entered the 'Action' guideline (ie would have been out of compliance) on more than 19% of all sampling occasions, with twelve sites achieving compliance on 90% or more of occasions. The Merrilands Domain site in the lower reaches of the Waiwhakaiho 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 SEM programme, although the Merrilands Domain Site has exceeded this sporadically since November 2004 under wet weather conditions (as detected by the MfE extended sampling protocols). In general, these data indicate shortcomings in the grading system for these sites based upon landuse/perceived impacts, rather than actual monitoring data measured throughout the bathing seasons. Council's contact recreational water quality programmes confirm that 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 in terms of the reporting of actual contact recreational water quality.

2.3 Programme design

2.3.1 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 assessment of compliance with contact recreational guidelines.

The locations of the sixteen sites sampled in the 2009-2010 programme are shown in Figures 1 and 2 and summarised in Table 2.

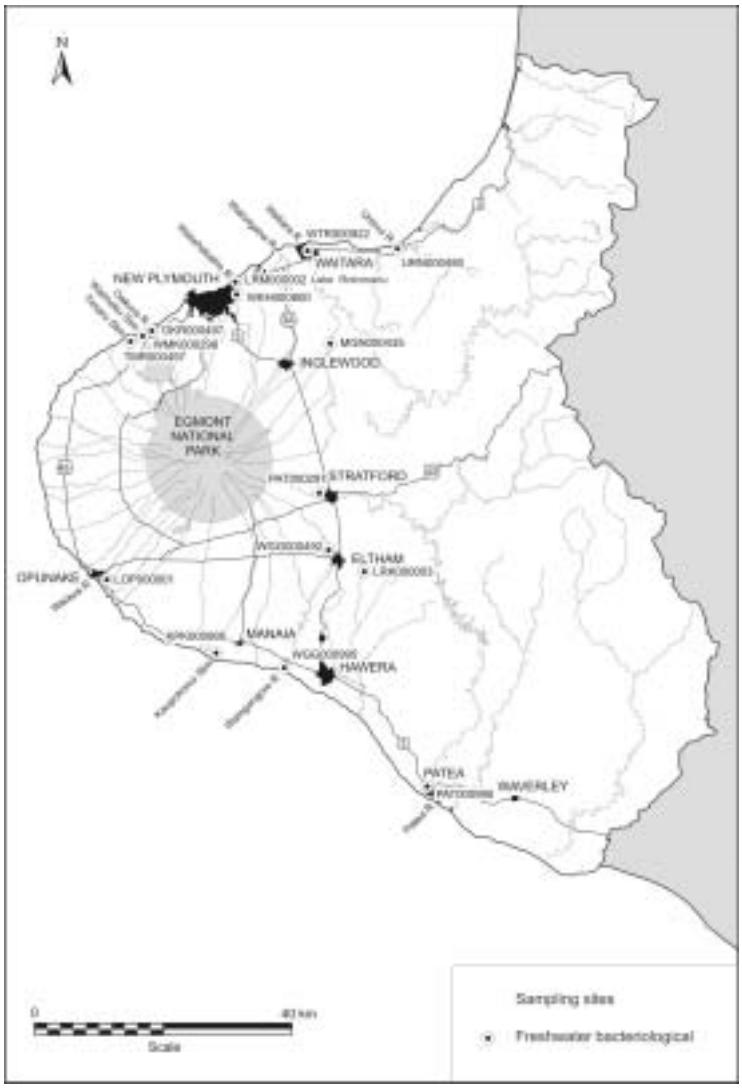


Figure 1 Freshwater contact recreation survey sites

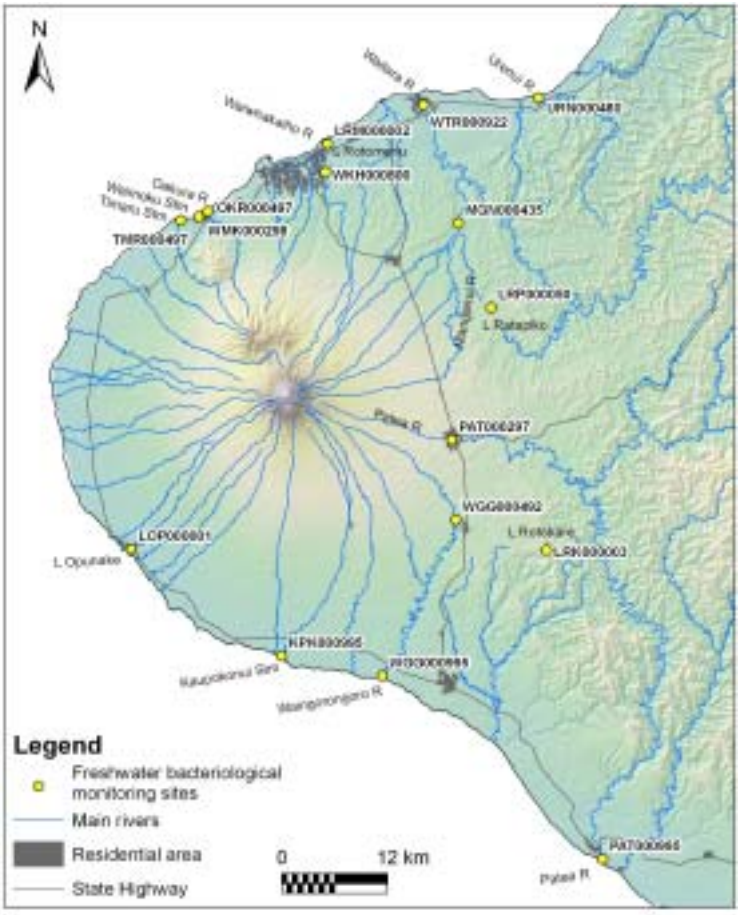


Figure 2 Location of freshwater contact recreation survey sites

Table 2 Location of bathing water bacteriological sampling sites

Site	Location	GPS Location		Site code
Lake Rotomanu	Western beach	E 1696309	N 5678128	LRM000002
Waiwhakaiho River	Merrilands Domain	E 1696059	N 5674931	WKH000800
Patea River	King Edward Park, Stratford	E 1710433	N 5644464	PAT000297
Patea River	Boatramp, Patea	E 1727517	N 5596784	PAT000995
Waingongoro River	Eltham Presbyterian Camp	E 1710861	N 5635349	WGG000492
Waingongoro River	Ohawe Beach	E1702531	N 5617624	WGG000995
Kaupokonui River	Beach domain	E 1691110	N 5619893	KPK000995
Lake Opunake	adjacent to boatramp	E 1674029	N 5632022	LOP000001
Timaru Stream	end of Weld Road	E 1697622	N 5669438	TMR000497
Waimoku Stream	Oakura Beach	E 1681725	N 5669851	WMK000298
Oakura River	d/s SH45 bridge	E1682721	N 5670440	OKR000497
Waitara River	Town wharf	E 1707203	N 5682572	WTR000922
Urenui River	Urenui estuary	E 1720245	N 5683370	URN000480
Manganui River	Everett Park (d/s Kurapete S)	E1711149	N 5669127	MGN000435
Lake Ratapiko	Boatramp	E1714913	N 5659488	LRP000050
Lake Rotokare*	Adjacent to boatramp	E 1721182	N5631898	LRK000003

For sampling convenience these sites were included with the (three) coastal bathing beaches runs undertaken over the same five month period from early November 2009 to late March 2010. Eight sites, relatively close to stream mouths, were potentially affected by tidal influences (see conductivity data later in this report).

Sample collection, field measurements, transport 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). However, spring wet weather affected the frequency of sample collection earlier in the period. Sampling commenced in early November 2009 with three of the sampling surveys performed prior to January 2010. The majority of the surveys were performed over the latter half of the summer period. Bathing water samples were normally taken between the hours of 0900 and 1800 hours (NZDST) with none collected within a three day period following significant river 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 each site during the season.

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, percentage estimation of algal cover on the streambed, and number of bathers and other users. All sites' locations (map references and GPS) and descriptions are stored in the Council Taradise and laboratory (Labsys) computer database and all analytical results were stored in Labsys following standard sample registration procedures.

After consultation with Taranaki District Healthboard, cyanobacteria monitoring commenced at each of the three lake sites and the lower Waiwhakaiho River site for the 2006-2007 bathing season and continued in 2009-2010 and included an additional lake site. Cyanobacteria can produce toxicity in recreational waters which pose risks to humans and animals by contact or consumption during recreational activities. Visual checks for surface scums were made on each sampling occasion and samples were collected for microscopic analysis which was performed in the TRC biological laboratory.

Results were posted on the Taranaki Regional Council website (www.trc.govt.nz) for public and local health authority notification in particular, as soon as checking had been completed. Mapping of the results was also included on the newly established Taranaki District Health Board website (www.tdhb.org.nz) in the 2009-2010 season (see Appendix VI). Where results fell in the 'Action' mode, further investigations (eg sampling and inspections) were performed when considered necessary ie: where historical databases and staff expertise indicated this was warranted. Cyanobacteria information was included on the websites where appropriate.

2.3.2 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. Following consultation with the three territorial local authorities and Taranaki District Health Board, TRC undertook to add seven sampling occasions to the SEM protocol 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) 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 appropriately signposted and the additional data were included on the TRC website [Note: These data will not be used for future trend detection purposes as they do not comply with the format of the originally established SEM programme].

3. Results

3.1 Introduction

Sampling times in relation to tidal conditions (particularly for estuarine sites, see Appendix II), weather conditions and sites' usage information are contained in Appendix III and IV. Timing of sampling in relation to river flows is illustrated by Figures 7, 13, 18, 20 and 25. Those illustrate that the majority of the sampling occasions coincided with steady to low river recession flow conditions. Occasionally sampling was affected by localised rainfall and/or a prior increase in river flows. However, where possible no sampling was undertaken within three days following significant river freshes. A total of 13 samples were collected at each site during the period from early November 2009 to late March 2010.

Sampling was confined to weekdays during the period with no public holidays 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 the current period) is used for boating and bathing purposes, more so recently with the construction of a new wharf in the town.

3.2 Presentation of results and discussion

All results are presented and discussed on a site-by-site basis for the sampling period, which extended from 2 November 2009 to 31 March 2010 and totalled thirteen sampling occasions at each site. The results for the sites with additional (seven) sampling occasions are also presented within the discussion for the two appropriate sites.

3.2.1 Lake Rotomanu

3.2.1.1 SEM programme

Bathing usage of the lake was minimal, although boating, water and jet-skiing and/or picnicking activities were recorded at the time of a number of the sampling surveys when there was no signage warning of health risks associated with lake water quality. Ducks (and occasionally, gulls) were present on the lake or in the vicinity of the lake edge throughout the period and were often attracted to the immediate vicinity of the sampling site by public feeding of the ducks. Mechanical weed harvesting was undertaken in the lake (Appendix VI), in addition to biological (grass carp) control, and completed by mid December 2009. In addition, a wetland

was created at Peringa Park to improve the quality of stormwater runoff entering the lake.

The data for this site are presented in Table 3 and illustrated in Figure 3, with a statistical summary provided in Table 4.

Table 3 Analytical results for Lake Rotomanu

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	0935	13.8	74	20	74	17.0	2.2
17.12.09	1000	12.5	46	6	46	20.9	2.3
22.12.09	1300	12.5	60	14	60	21.3	3.4
6.01.10	1105	13.5	150	60	150	21.9	5.6
14.01.10	1055	13.5	23	17	23	22.3	5.0
18.01.10	1125	13.6	80	96	80	22.9	4.6
4.02.10	1250	13.7	3600	1500	3600	26.5	3.5
16.02.10	1045	14.0	92	54	92	22.5	1.9
1.03.10	1030	12.8	420	85	420	25.0	1.5
15.03.10	1000	13.2	780	670	790	19.9	2.5
19.03.10	1120	13.0	770	1100	770	18.7	3.3
22.03.10	1100	13.2	150	4400	150	20.6	2.1
31.03.10	1010	13.9	100	15	110	20.0	3.0

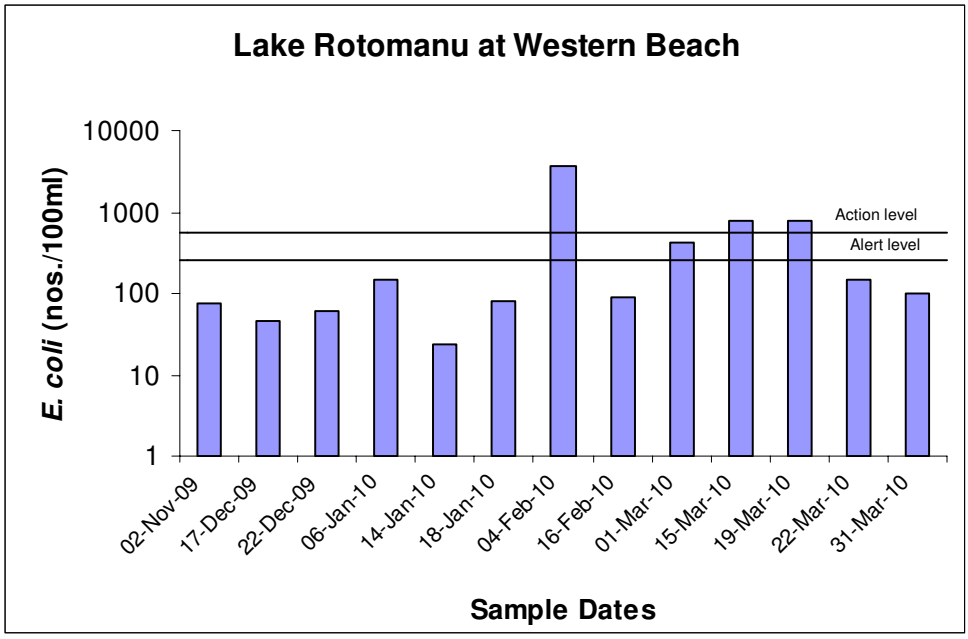


Figure 3 *E. coli* numbers for Lake Rotomanu during the regular season
(Note: Action limit >550/100 ml [single sample [:Alert limit => 260 nos/100ml [single sample])

Table 4 Statistical results summary for Lake Rotomanu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	12.5	14.0	13.5
E. coli	nos/100ml	13	23	3600	100
Enterococci	nos/100ml	13	6	1500	60
Faecal coliforms	nos/100ml	13	23	3600	110
Temperature	°C	13	17.0	26.5	21.3
Turbidity	NTU	13	1.5	5.6	3.0

The lake, which is close to the coast, is replenished from time to time by inflow from the nearby Waiwhakaiho River. Water quality was moderate with small variations in clarity (median turbidity: 3.0; and range of 4.1 NTU) possibly as a result of some sediment disturbance shortly after weed harvesting and /or fluctuating concentrations of suspended algae, particularly as cyanobacteria densities increased near mid season elevating turbidity. Water temperatures were relatively high (above 20°C) almost throughout the period with a high maximum of 26.5°C (in early February 2010) and a range of 9.5°C. Conductivity had a relatively narrow range through the season.

Generally bacteriological quality was average considering that the inflow to the lake is from the lower reaches of a river draining a developed catchment. Elevated numbers of *E. coli* (in or near the 'Action' mode) were found in early February and mid March 2010 while follow-up samples found a higher count of 4500 *E. coli* per 100 mls on one occasion and small decrease (420 *E. coli* per 100mls) in mid March 2010, each attributable to the wildfowl population. The cause of the elevated numbers was the high number of ducks attracted to the main public recreational area. NPDC signage discouraging lake usage was erected at the lake as had been the case in the previous season. Thereafter, bacterial counts remained below 'Alert' levels.

3.2.1.1.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 5.

Table 5 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	1 [8]	3 [23]

(Designation: freshwater contact recreational area)

Three single samples exceeded the 'Action' mode during the period, and another single sample was recorded within the 'Alert' mode. Three consecutive samples were within these modes on one occasion.

3.2.1.1.2 Comparison with previous summers' surveys

A statistical comparison of each of the thirteen seasons' *E. coli* surveys data is presented graphically in Appendix V for all sites. These summer data for the Lake Rotomanu site are summarised in Table 6 and illustrated in Figure 4.

Table 6 Summary of *E. coli* bacteriological water quality data (nos/100ml) for all summer surveys at Lake Rotomanu to date

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Minimum	3	12	7	7	1	31	9	20	<3	6	7	54	51	23
Maximum	899	740	200	140	90	980	2200	5500	220	380	3000	1200	6000	3600
Median	32	46	79	25	14	110	92	120	11	68	72	180	220	100

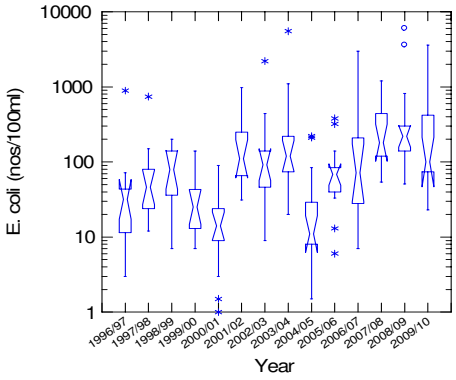
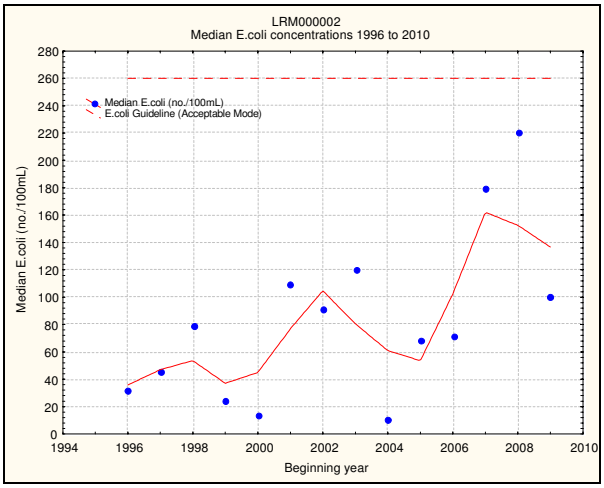


Figure 4 Box and whisker plots for all summer SEM surveys of *E coli* bacteria numbers at Lake Rotomanu

The recent trend of higher median *E. coli* numbers in five of the eight most recent years was continued over the summer of 2009-2010 with a wide range of counts recorded by this survey and a moderate median value, the fifth highest to date. However, this 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 fourteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 5) 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 = 14
Kendall tau = +0.385
p level = 0.055 [>FDR, p = 0.138]
N/S at p < 0.05

Figure 5 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Lake Rotomanu for the 1996-2010 period

A positive, but not statistically significant increase in median *E. coli* numbers has been found over the fourteen seasons of monitoring. None of these seasonal medians exceeded the 'Alert' or 'Action' modes.

3.2.1.2 MfE guidelines additional sampling

Seven additional samples were collected randomly under varying weather conditions during the survey season. Limited bathing was noted on these occasions, but boating, jet-skiing, kayaking, and picnicking were recorded more frequently. Ducks were present in moderate numbers on the lake on all occasions. One survey occurred by chance soon after a significant rainfall event.

The data from these additional surveys are presented in Table 7, illustrated and statistically summarised (with the 13 SEM samples' data) in Figure 6 and Table 8 respectively.

Table 7 Lake Rotomanu additional seven water quality samples' results

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
26.11.09	1015	13.7	270	120	360	18.8	4.6
10.12.09	0955	13.2	170	14	170	21.7	4.3
12.01.10	0955	13.6	660	100	660	22.2	6.3
26.01.10	0950	13.3	17	6	17	22.8	2.9
9.02.10	1000	13.8	11	11	11	24.8	3.4
23.02.10	1100	12.4	1700	180	1800	23.3	1.4
9.03.10	1025	13.1	730	920	770	21.3	8.7

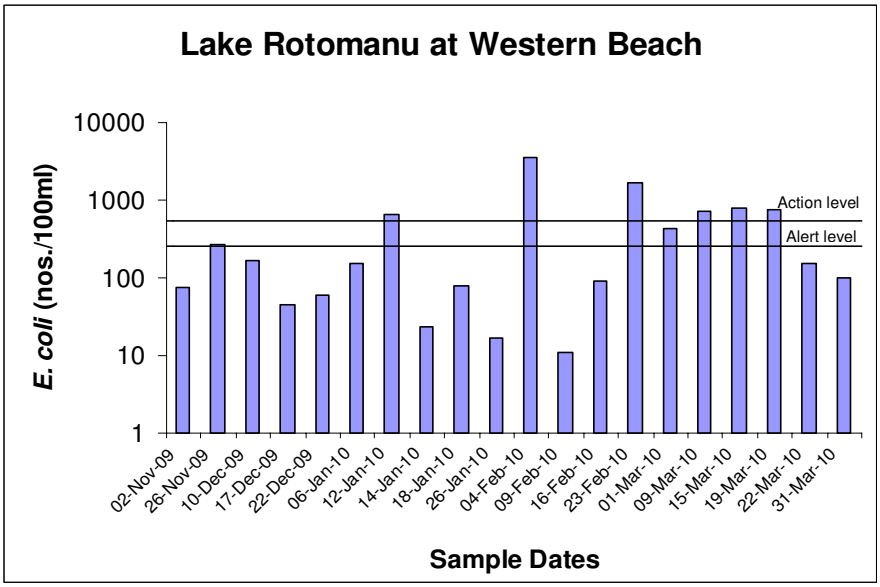


Figure 6 *E. coli* numbers for Lake Rotomanu for the 20 sample extended survey

Table 8 Summary statistics for SEM and additional samples at Lake Rotomanu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	12.4	14.0	13.5
E. coli	nos/100ml	20	11	3600	125
Enterococci	nos/100ml	20	6	1500	67
Faecal coliforms	nos/100ml	20	11	3600	130
Temperature	°C	20	17.0	26.5	21.8
Turbidity	NTU	20	1.4	8.7	3.4

The additional sampling resulted in a small difference to the overall seasonal median bacteria numbers with an increase of 25 *E.coli* (per 100mls). These additional surveys' bacteria counts had a moderately wide range (11 to 1700 *E. coli* per 100mls) due to the proximity of wet weather to one of the sampling survey occasions.

3.2.1.2.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 9.

Table 9 Bacterial guidelines performance at Lake Rotomanu [% of 20 samples]

Parameter	Number of exceedances of *E. coli* guidelines	
	ALERT Simgle sample 261-550/100ml	ACTION Single sample >550/100ml
E. coli	2[10]	6 [30]

The number of exceedances of the single sample 'Alert' and 'Action' modes increased with the additional monitoring, as three additional exceedances of the 'Action' level and one of the 'Alert' level occurred, one following wet weather conditions and elevated river flows and the remainder related to the presence of high bird numbers.

3.2.1.3 Cyanobacteria

No visual surface algal blooms were recorded during the season but more turbid lake water quality, partly due to suspended algae, was noted in the latter half of the season. Microscopic scans of samples found cyanobacteria present in four of the nine samples analysed. The results of this sampling are presented in Table 10 and Figure 7.

Table 10 Cyanobacteria counts (cells/ml) for Lake Rotomanu [Health warning: >15,000 cells/ml]

Date	Cyanobacteria total cell count (cells/ml)	Principal species
19.11.09	nil	-
27.11.09	nil	-
10.12.09	889	*Anabaena*
12.01.10	3270	*Anabaena*
26.01.10	7600	*Anabaena*
09.02.10	6100	*Anabaena*
23.02.10	nil	-
09.03.10	nil	-
26.03.10	nil	-

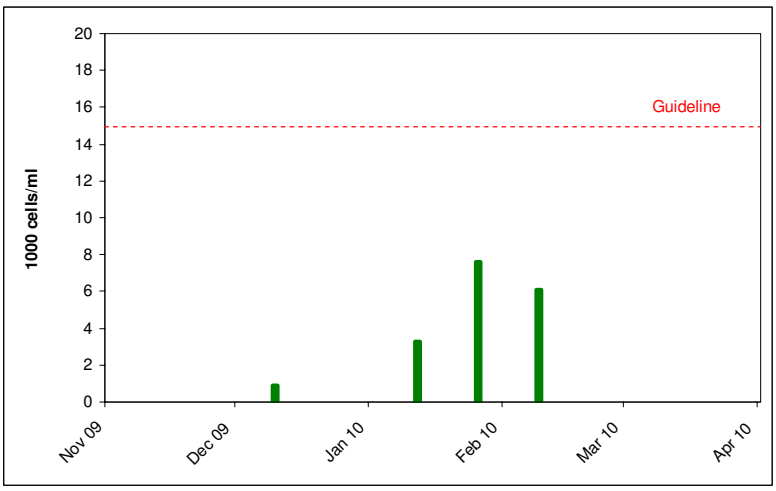


Figure 7 Cyanobacteria counts for Lake Rotomanu [Health warning: >15,000cells/ml]

Elevated counts in early January to early February 2010 were found to comprise entirely *Anabaena*. No health warning signage was required at the lake as the cyanobacteria density remained well below the health warning high alert level of 15,000 cells/ml (TDHB, 2006) unlike during the 2008-2009 season when *Microcystis* dominated the lake (TRC, 2009). No toxin testing of the lake waters (by the Cawthron laboratory) was therefore requested by the Taranaki Health Board.

3.2.2 Waiwhakaiho River at Merrilands Domain

3.2.2.1 SEM programme

Very limited usage of this site was recorded at the time of the sampling surveys, with no bathing, and occasional walking or picnicking on the banks of the river noted.

The data for this site are presented in Table 11 and illustrated in Figure 9, with a statistical summary provided in Table 12. River flow information is illustrated in Figure 8.

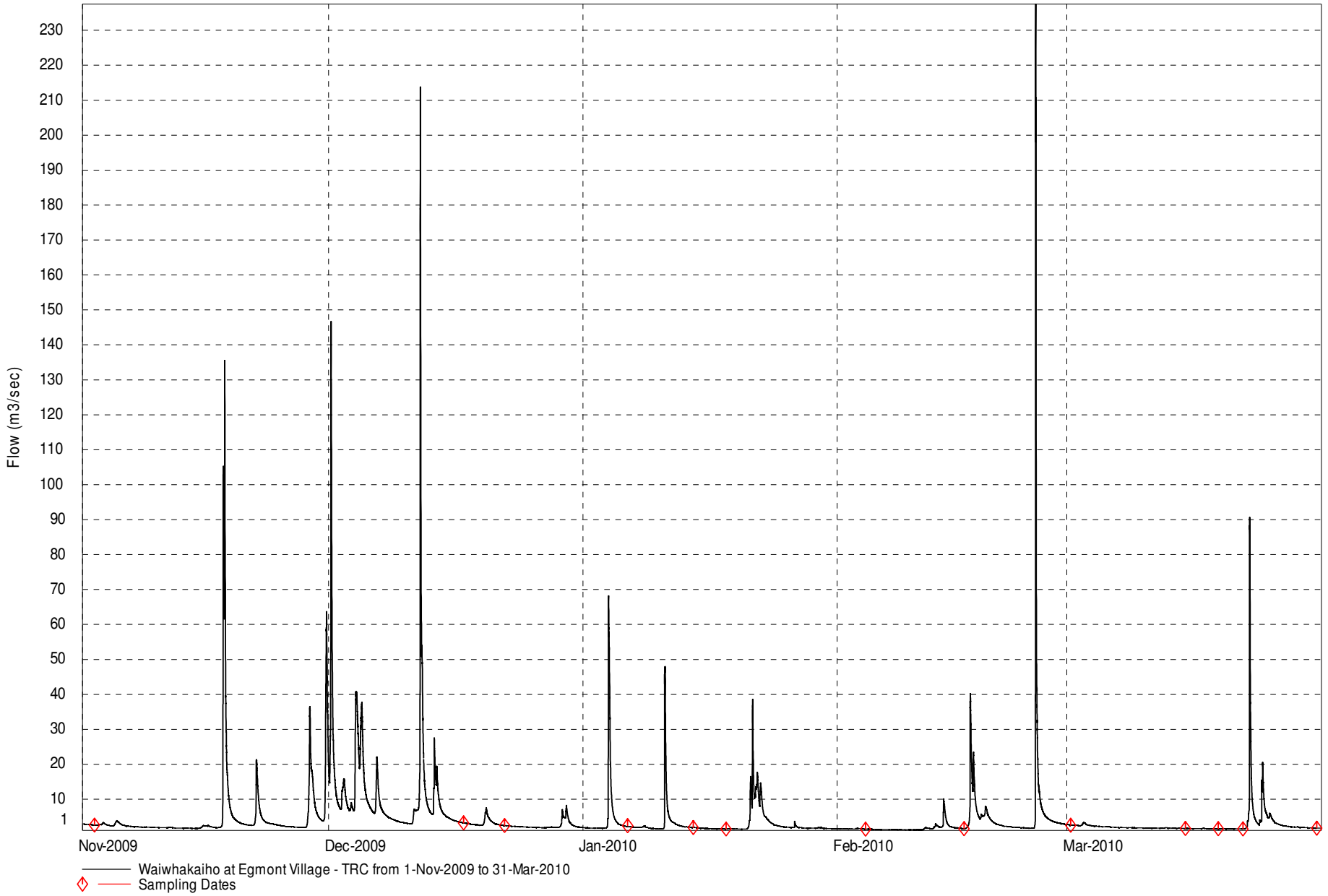


Figure 8 River flow in the Waiwhakaiho River during the survey period (NOTE: Waiwhakaiho at Egmont Village Flow is unaudited data)

Table 11 Analytical results for the Waiwhakaiho River at Merrilands Domain

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	1000	11.8	98	5	100	13.9	0.6
17.12.09	1020	10.0	88	9	88	15.5	0.8
22.12.09	1320	11.0	23	3	23	16.0	0.7
6.01.10	1045	10.6	130	14	130	17.0	1.1
14.01.10	1140	11.2	230	41	230	18.0	1.2
18.01.10	1140	13.4	570	140	620	20.5	1.1
4.02.10	1305	13.9	110	43	120	22.2	1.2
16.02.10	1055	11.7	110	80	120	18.2	0.8
1.03.10	1050	11.3	160	110	160	18.3	0.8
15.03.10	1015	13.3	120	71	120	16.7	0.6
19.03.10	1150	13.4	60	28	66	15.0	0.7
22.03.10	1045	14.1	96	26	96	18.8	0.5
31.03.10	1030	13.1	43	54	43	15.2	0.5

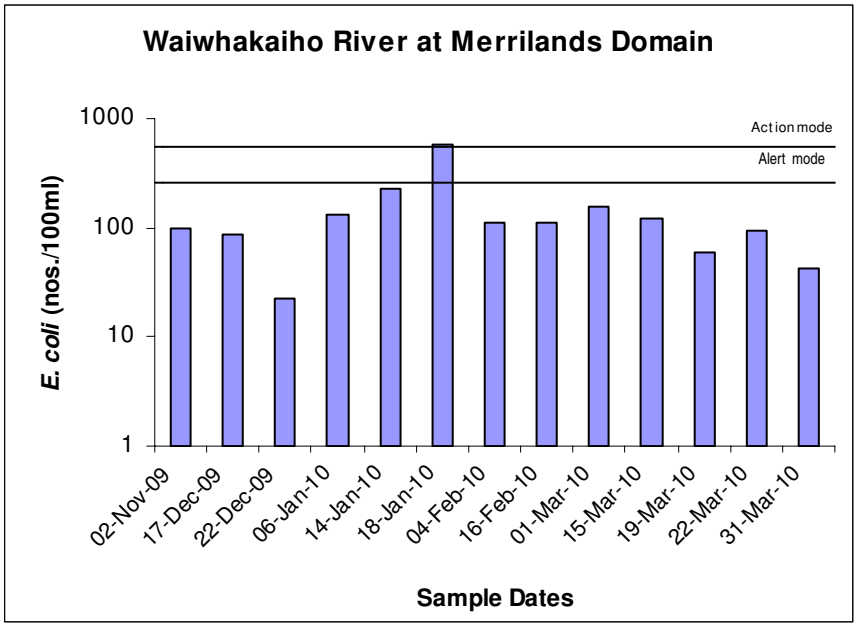


Figure 9 *E. coli* numbers for the Waiwhakaiho River at Merrilands Domain during the regular survey season

Table 12 Statistical results summary for the Waiwhakaiho River at Merrilands Domain

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	10.0	14.1	11.8
E. coli	nos/100ml	13	23	570	110
Enterococci	nos/100ml	13	3	140	41
Faecal coliforms	nos/100ml	13	23	620	120
Temperature	°C	13	13.9	22.2	17.0
Turbidity	NTU	13	0.5	1.2	0.8

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 8.3°C between early November and late March, with a maximum of 22.2°C in early February 2010. Conductivity and turbidity results were indicative of very clean, clear, relatively high water quality but percentage algal cover was high (80% or higher) throughout most of the period.

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 on all but one occasion through the season. One high count was recorded under dry weather conditions but the number had returned to normal levels within a week of this event. A good standard of compliance with on-site dairy wastes disposal practices was recorded by the season's annual inspection round in this catchment.

3.2.2.1.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 13.

Table 13 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]	1 [8]

(Designation: freshwater contact recreational area)

One single sample was recorded within the 'Action' mode and none in the 'Alert' mode during the season. Bacteriological water quality measured at this site was therefore within the acceptable standard for contact recreational usage for the majority of the survey period.

3.2.2.1.2 Comparison with previous summers' surveys

A statistical comparison of each of the fourteen summer's surveys data is presented graphically in Appendix V for all sites. These data for the Waiwhakaiho River site are summarised in Table 14 and illustrated in Figure 10.

Table 14 Summary of *E. coli* bacteriological water quality data (nos/100 ml) for all summer surveys in the Waiwhakaiho River at Merrilands domain to date

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Minimum	16	16	26	8	6	17	3	34	11	15	8	28	19	23
Maximum	970	1800	330	100	270	420	130	320	330	160	510	110	110	570
Median	42	84	69	39	23	60	29	77	54	34	48	48	46	110

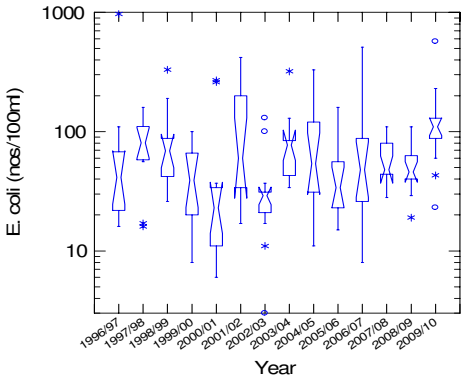
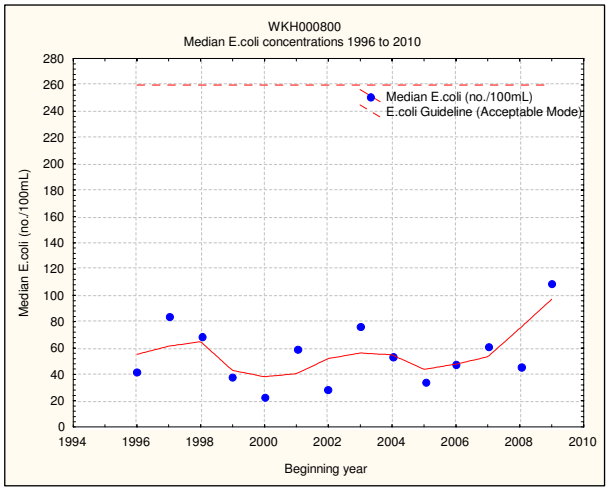


Figure 10 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers in the Waiwhakaiho River at Merrilands Domain

The median *E. coli* number in the 2009-2010 period was the highest recorded to date and 26 per 100 mls above the maximum of the range of historical medians (Table 14 and Figure 10), all of which have been well below the 'Alert' level of the 2003 MfE guidelines.

Trend analysis these median *E.coli* numbers has been performed for the fourteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 11) and testing the significance of any trend using the Mann-Kendall test at the 5% level followed by Benjamini-Hochbery False Discovery Rate (FDR) analysis.



N = 14
Kendall tau = +0.077
p level = 0.702 [>FDR, p = 0.780]
N/S at p <0.05

Figure 11 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Waiwhakaiho River, Merrilands Domain for the 1996 to 2010 period.

An insignificant temporal trend of slightly increasing median *E.coli* numbers was found over the fourteen seasons of monitoring. None of these seasonal medians exceeded the 'Alert' or 'Action' modes.

3.2.2.2 MfE guidelines additional sampling

Seven additional samples were collected randomly at irregular intervals and under varying weather conditions (one of which by chance was a wet weather event) during the survey season. Recreational activities included bathing and walking (sometimes with dogs present on these occasions).

The data from these additional surveys are presented in Table 15, illustrated in Figure 12, and statistically summarised (together with the 13 SEM samples' data) in Table 16.

Table 15 Waiwhakaiho River at Merrilands Domain additional seven water quality samples' results

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
26.11.09	0945	11.8	180	17	180	15.4	1.0
10.12.09	0935	11.0	160	20	160	16.5	0.7
12.01.10	0935	9.0	470	37	470	15.2	1.2
26.01.10	0930	11.1	46	54	46	19.0	1.2
9.02.10	0940	14.0	14	8	14	21.7	0.6
23.02.10	1030	11.3	200	260	200	18.4	0.6
9.03.10	1330	13.7	20	8	20	18.7	0.6

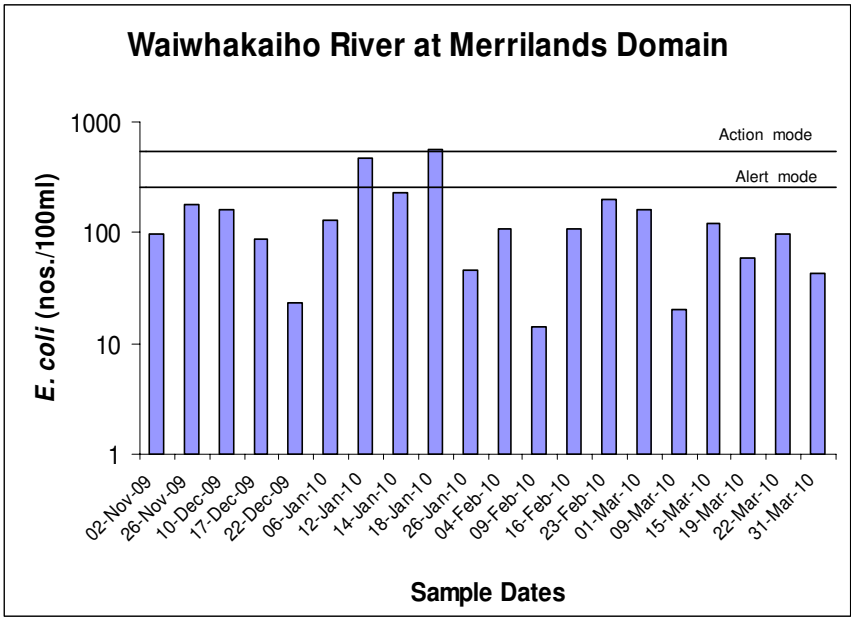


Figure 12 *E. coli* numbers for the Waiwhakaiho River at Merrilands Domain for the 20 sample extended survey

Table 16 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	20	9.0	14.1	11.8
E. coli	nos/100ml	20	14	570	110
Enterococci	nos/100ml	20	3	260	33
Faecal coliforms	nos/100ml	20	14	620	120
Temperature	°C	20	13.9	22.2	17.5
Turbidity	NTU	20	0.5	1.2	0.8

These seven additional samples resulted in a very small increase in the seasonal median enterococci bacterial number and no changes in median *E. coli* and faecal coliform bacterial numbers in comparison with the regular SEM programme results (Table 12). The ranges for all three bacteria species remained identical however, despite elevated counts recorded in mid January 2010 under higher river flow conditions following a significant rainfall event, as also indicated by a marked decrease in conductivity level (Table 15).

3.2.2.2.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 17.

Table 17 Bacterial guidelines performance in the Waiwhakaiho River at Merrilands Domain [% of 20 samples]

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

(Designation: freshwater contact recreational area)

One exceedance of the single sample 'Alert' mode occurred but no sample counts exceeded 550 *E. coli* per 100 mls ('Action' mode). No follow-up sampling was deemed necessary as the elevated count was considered to have been due to the proximity of a river fresh and rainfall to the day of sampling, as confirmed by the sampling surveys which followed these events (Figure 12).

3.2.2.3 Cyanobacteria

No visual surface or river margin algal blooms were noted during the season. Microscopic scans of nine samples found no cyanobacteria species present in any of these samples in the period. The results of the sampling are presented in Table 18.

Table 18 Cyanobacteria counts (cells/ml) for the Waiwhakaiho River at Merrilands Domain [Health warning :>15,000 cells/ml]

Date	Cyanobacteria total cell count (cells/ml)
19.11.09	nil
27.11.09	nil
10.12.09	nil
12.01.10	nil
26.01.10	nil
08.02.10	nil
23.02.10	nil
09.03.10	nil
26.03.10	nil

Therefore no health warning signage was required to be displayed at this site during the period.

3.2.3 Patea River at King Edward Park, Stratford

Minimal bathing usage of this river site was recorded at the time of sampling surveys, most of which were in the morning or early afternoon. Picnickers and fishermen were noted on some occasions at this site, and following the release of trout into the river for the 'Take a Kid Fishing' promotion in mid January 2010.

Data from the site are presented in Table 19 and illustrated in Figure 13, with a statistical summary provided in Table 20. River flow records are illustrated in Figure 14.

Table 19 Analytical results for the Patea River at Kind Edward Park, Stratford

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	1215	8.4	88	6	88	12.2	0.9
17.12.09	1310	8.6	130	26	130	14.4	0.8
22.12.09	0950	9.1	1500	34	1500	12.2	0.8
6.01.10	1615	9.0	240	130	240	16.2	1.1
14.01.10	1250	9.2	51	54	51	17.0	1.0
18.01.10	1440	9.5	7400	2000	7400	16.2	2.0
4.02.10	0940	8.9	300	240	300	16.4	1.2
16.02.10	1335	9.5	550	430	550	15.6	1.2
1.03.10	1330	8.4	280	410	280	15.0	0.8
15.03.10	1300	9.1	88	350	88	15.4	0.7
19.03.10	1435	9.2	110	280	120	13.4	0.8
22.03.10	1015	9.7	350	550	350	15.6	0.9
31.03.10	1335	9.0	250	180	260	13.3	1.0

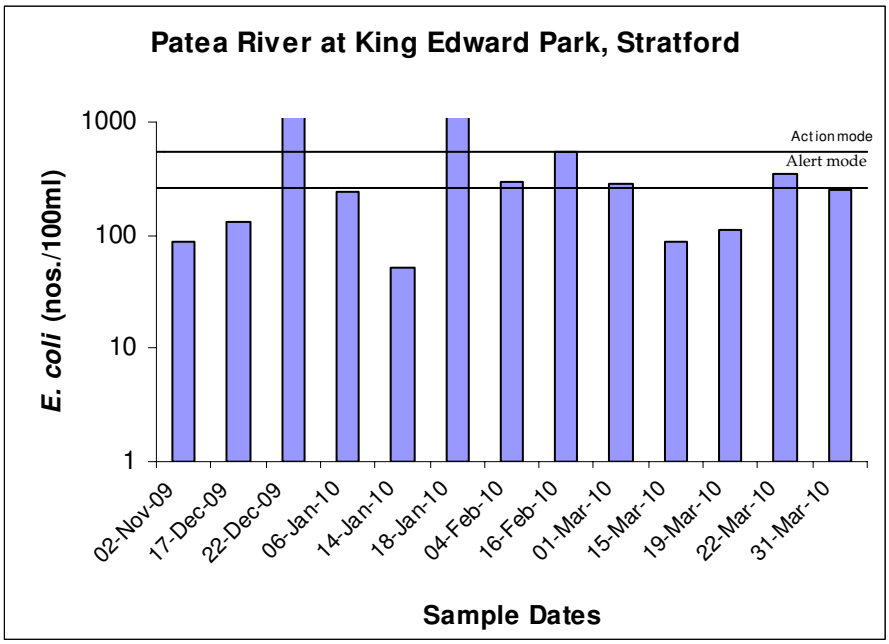


Figure 13 *E. coli* numbers for the Patea River at King Edward Park, Stratford during the survey season

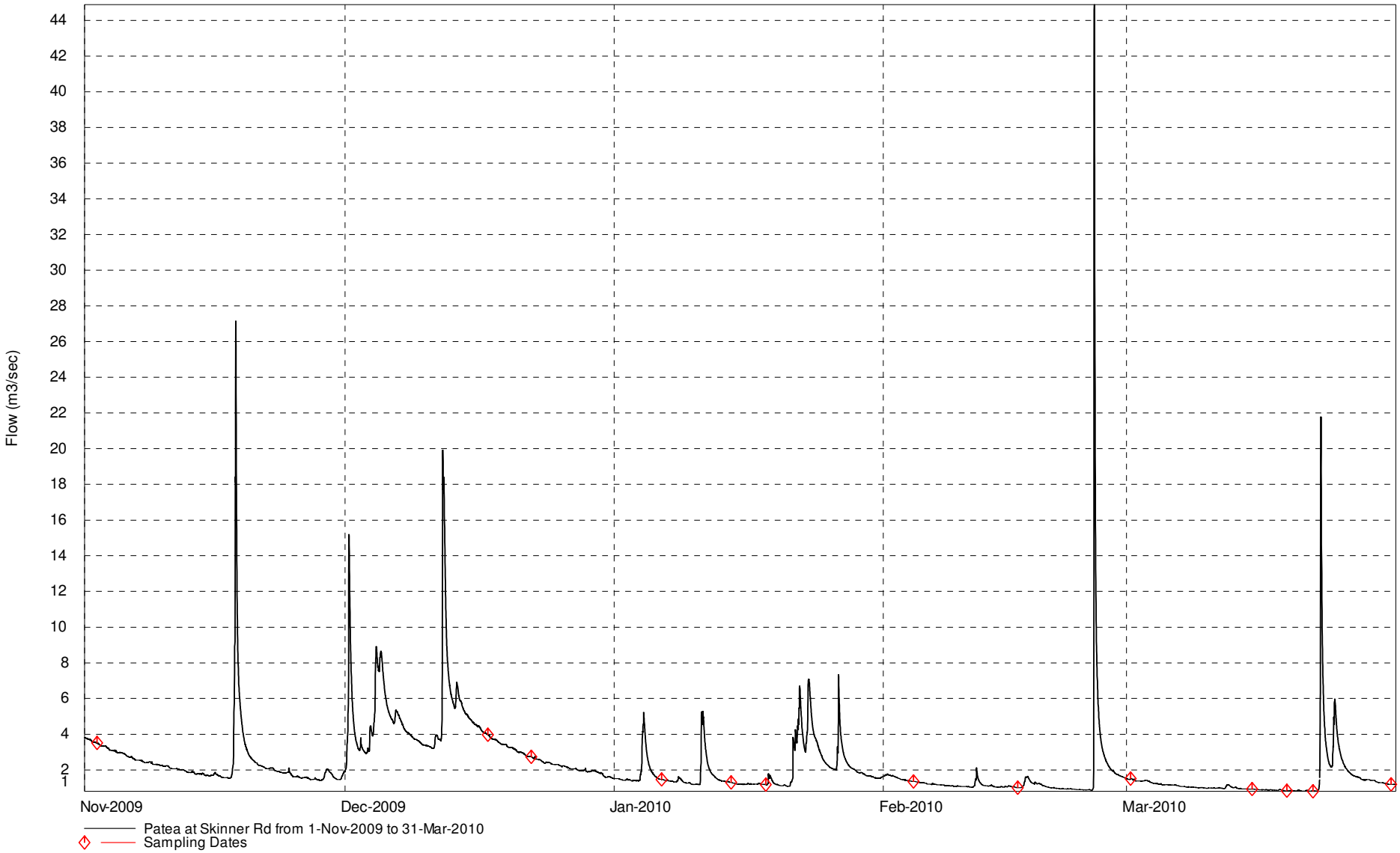


Figure 14 Flow in the Patea River during the survey period

Table 20 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	8.4	9.7	9.1
E. coli	nos/100ml	13	51	7400	250
Enterococci	nos/100ml	13	6	2000	240
Faecal coliforms	nos/100ml	13	51	7400	260
Temperature	°C	13	12.2	17.0	15.4
Turbidity	NTU	13	0.7	2.0	0.9

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 consistently clear and generally colourless with relatively low conductivity levels.

Water temperatures had a relatively narrow range of 4.8°C for this site (at an elevation of 300 m asl, with a maximum of 17.0°C recorded at 1250hrs in mid January 2010. All but one of the samples were collected before 1445 hours and therefore maximum river temperatures (which tend to occur later in the afternoon) were not recorded.

Bacteriological water quality was moderate for the mid reaches of this Taranaki ring plain river draining a predominantly agricultural catchment. Relatively high counts were recorded on two occasions during the survey period, one of which (18 January 2010) necessitated further investigations. Follow-up sampling over the next two days found lower counts (2900 and 160 *E.coli* per 100 mls respectively). This was a considerable improvement over most previous seasons' surveys when it had 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 requirements. Two counts exceeded the 'Action' level (in late December 2009 and mid January 2010) but these incidents were not considered to warrant the placement of appropriate signage at the site by the Stratford District Council.

Future annual dairy farms inspections in this area of the upper Patea catchment should continue to be timed to ensure compliance with consent conditions prior to the start at the contact recreation period.

3.2.3.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 21.

Table 21 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	4 [31]	2 [15]

(Designation: freshwater contact recreational area)

Four single samples fell within the 'Alert' mode, and two samples fell in the 'Action' mode. The latter counts occurred in late December 2009 and mid January 2010, the latter requiring immediate follow-up sampling (see above). In terms of the guidelines for contact recreational usage, bacteriological water quality at this site was compliant with the acceptable level for more than half of the period, with occasional short duration incursions into the 'Alert' level.

3.2.3.2 Comparison with previous summers' surveys

A statistical comparison of each of the fourteen summers' survey data is presented graphically in Appendix V for all sites. A shorter data period (nine years) exists for the Patea River (at King Edward Park, Stratford) site which was added in 2001-2002. These summer data for the Patea River at King Edward Park, Stratford site are summarised in Table 22 and illustrated in Figure 15.

Table 22 Summary *E. coli* bacteriological water quality data (nos/100 ml) all summer surveys in the Patea River at King Edward Park, Stratford

Summer	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Minimum	46	120	48	96	100	28	46	51	51
Maximum	640	780	580	760	840	1000	690	570	7400
Median	250	190	110	300	310	200	290	200	250

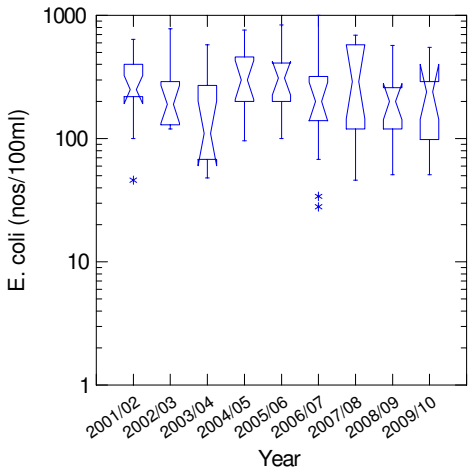


Figure 15 Box & whisker plots for all summer surveys of *E.* coli bacterial numbers for the Patea River at King Edward Park, Stratford

No improvement was indicated as the median *E. coli* bacterial count recorded for the 2009-2010 season was typical of historical median counts over the monitoring seasons. The 2009-2010 season recorded a wider range of counts for this site compared over the nine monitoring seasons to date.

Trend analysis of median *E.coli* numbers has not been performed as the sampling period has not yet encompassed ten seasons (nine years duration to date).

3.2.4 Patea River at the boatramp, Patea

No bathing usage of this river site was recorded at the time of sampling surveys, the majority of which were in the morning. Boating, fishing, and walking were noted occasionally at this site with boating as the main activity as this was a popular launching site for fishermen, judging by the number of boat trailers often in the parking area and the recent provision of a boat jetty.

Data from the site are presented in Table 23 and illustrated in Figure 16, with a statistical summary provided in Table 24.

Table 23 Analytical results for the Patea River at the boatramp, 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)
2.11.09	0900	4500	34	26	37	14.9	23
17.12.09	0925	4570	12	<1	12	18.2	11
22.12.09	1215	820	82	23	84	20.7	8.8
6.01.10	1250	4720	1	1	1	19.2	18
14.01.10	0855	4740	16	5	19	17.8	31
18.01.10	1030	4570	8	5	8	17.9	20
4.02.10	1220	4690	11	1	11	19.5	32
16.02.10	0955	4650	3	4	3	19.6	19
1.03.10	0950	4680	16	5	16	20.5	21
15.03.10	0915	4610	9	11	15	18.0	21
19.03.10	1035	4740	4	7	4	16.6	22
22.03.10	1240	4440	24	9	24	18.4	13
31.03.10	0955	4650	1	4	1	17.2	13

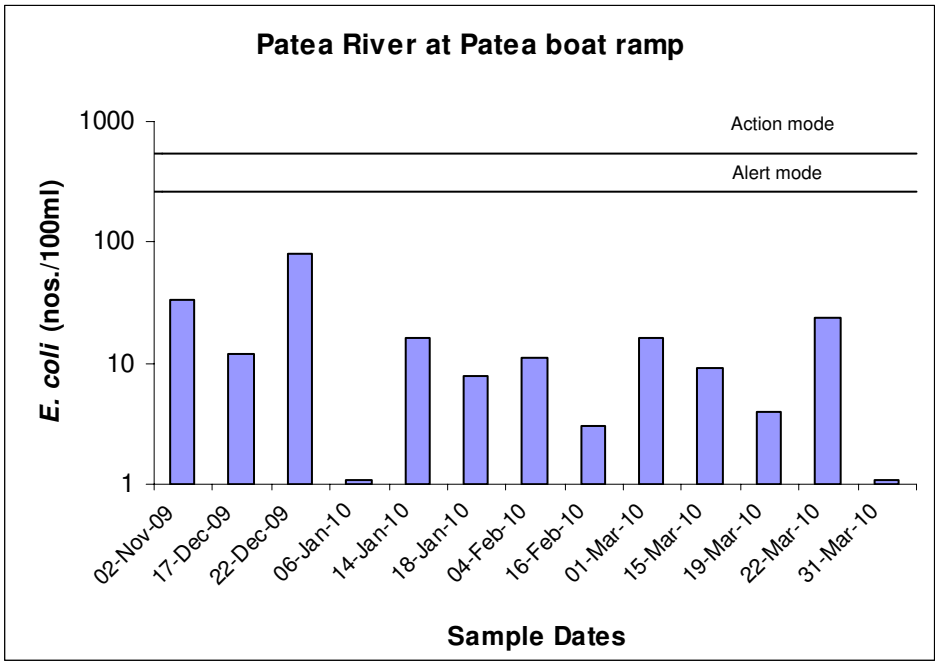


Figure 16 *E. coli* numbers for the Patea River at the boatramp, Patea during the survey season

Table 24 Statistical results summary for the Patea River at the boatramp, Patea

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	820	4740	4650
E. coli	nos/100ml	13	1	82	11
Enterococci	nos/100ml	13	<1	26	5
Faecal coliforms	nos/100ml	13	1	84	12
Temperature	°C	13	14.9	20.7	18.2
Turbidity	NTU	13	8.8	32	20

This ring plain river drains an extensively developed agricultural catchment. The survey site is situated some 45km downstream of the Patea HEP dam, 300 metres upstream of the river mouth. There are consented dairy ponds' treated wastes discharges in the catchment upstream of the site and the consented upgraded Patea Wastewater Treatment Plant discharge 0.7km upstream of the boatramp. River water was usually slightly turbid in appearance with high conductivity levels typical of seawater ingress at high tide.

Water temperatures had a moderate range of 5.8˚C, a narrower than expected range as a result of the coastal seawater influence, with a maximum of 20.7˚C recorded at midday in late December 2009 when the river was in normal flow. All of the samples were collected before 1255 hours and therefore maximum river temperatures (which tend to occur later in the afternoon) were not sampled.

Bacteriological water quality was very good for the lower reaches of this Taranaki ring plain river draining a predominantly agricultural catchment principally as a result of the coastal seawater influence under high tide conditions (median: 11 *E.coli* per 100mls and 5 enterococci per 100mls). 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 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 when a median *E. coli* bacterial number of 87 per 100mls (with counts ranging from 72 to 200 per 100mls) was found with numbers tending to be higher when seawater intrusion was less apparent.

3.2.4.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 25.

Table 25 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)

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

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 consistent with data for the nearby Patea Beach coastal site monitored in the current season [median *E.coli*: 4 per 100 mls (TRC, 2010)].

3.2.4.2 Comparison with previous summers' surveys

Two previous SEM sampling seasons have been surveyed at this site. Otherwise prior sampling has been confined to consent monitoring surveys (TRC 2009b). A statistical comparison of each of the three summers' survey data is presented graphically in Appendix V for all sites. A much shorter data period exists for the Patea River (at Patea boat ramp) site which was added in 2007-2008. These data are summarised in Table 26 and illustrated in Figure 17.

Table 26 Summary *E. coli* bacteriological water quality data (nos/100ml) all summer surveys in the Patea River at the boat ramp, Patea

Summer	07/08	08/09	09/10
Minimum	1	1	1
Maximum	190	87	82
Median	5	9	11

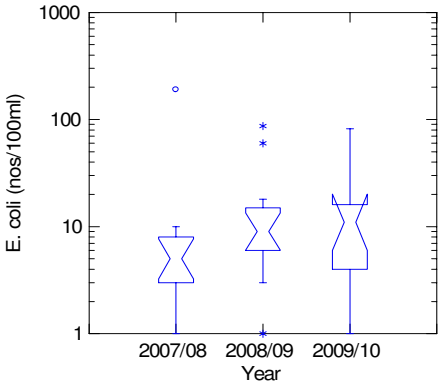


Figure 17 Box & whisker plots for all summer surveys of *E. coli* bacterial numbers for the Patea River at the boat ramp, Patea

Relatively similar (very low) median *E. coli* numbers have been found by these three seasons' surveys with a narrower range of counts found in the more recent season. 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.

3.2.5 Waingongoro River at Eltham camp

No bathing usage of this river site was recorded at the time of sampling surveys but camp activities were recorded occasionally 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 occasions.

Data from the site are presented in Table 27 and illustrated in Figure 18 with a statistical summary provided in Table 28. River flow records are illustrated in Figure 19

Table 27 Analytical results for the Waingongoro River at Eltham camp

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	1200	11.6	57	3	60	13.3	1.4
17.12.09	1255	10.8	60	23	60	17.4	1.6
22.12.09	1005	11.5	160	11	160	13.7	1.4
6.01.10	1035	11.4	210	110	210	15.2	1.5
14.01.10	1230	11.8	130	21	130	18.6	1.4
18.01.10	1425	11.5	88	23	96	20.8	1.6
4.02.10	1000	10.7	260	190	260	18.5	1.5
16.02.10	1315	11.5	230	290	250	17.8	1.2
1.03.10	1305	11.9	190	150	190	18.1	1.2
15.03.10	1230	11.5	92	140	92	17.4	1.5
19.03.10	1400	11.3	80	150	80	16.1	1.3
22.03.10	1030	11.8	260	240	260	17.2	1.2
31.03.10	1300	11.1	270	280	270	15.0	1.3

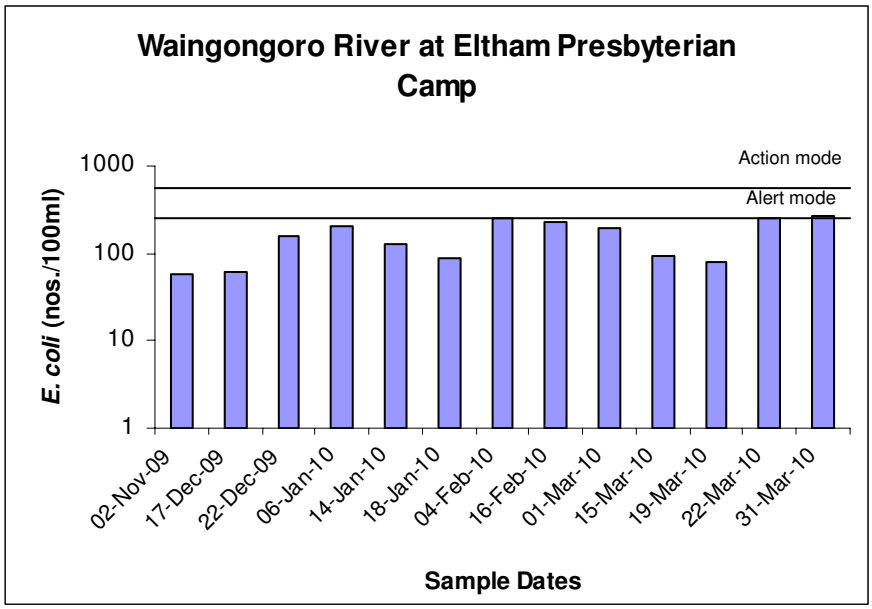


Figure 18 *E. coli* numbers for the Waingongoro River at Eltham Camp during the survey season

Table 28 Statistical results summary for the Waingongoro River at Eltham camp

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	10.7	11.9	11.5
E. coli	nos/100ml	13	57	270	160
Enterococci	nos/100ml	13	3	290	140
Faecal coliforms	nos/100ml	13	60	270	160
Temperature	°C	13	13.3	20.8	17.4
Turbidity	NTU	13	1.2	1.6	1.4

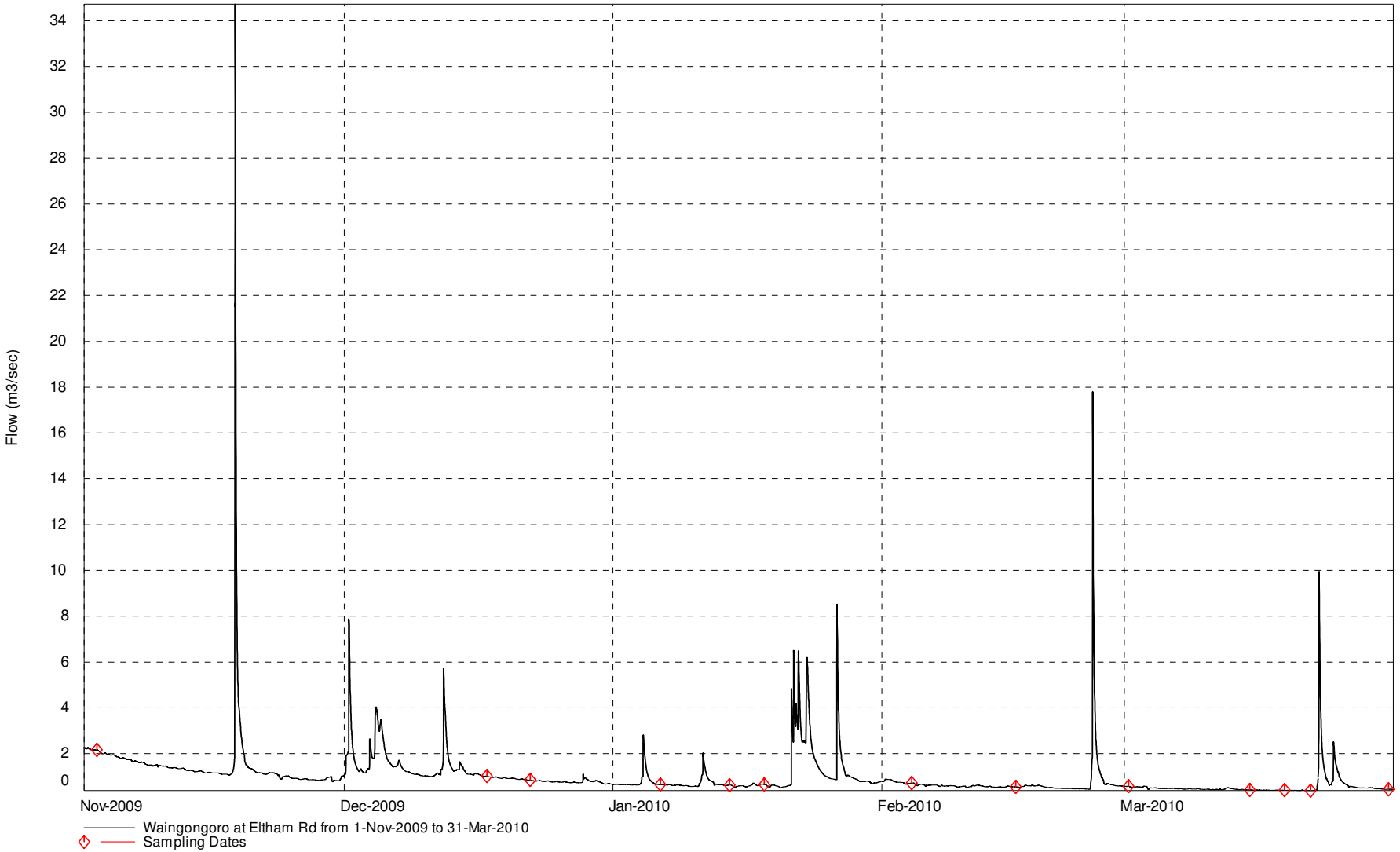


Figure 19 Waingongoro at Eltham Rd from 01 November 2007 to 15 April 2008 (NOTE: Waingongoro at Eltham Rd flow data from 8th Jan 2010 onwards is unaudited data)

This ring plain river drains an extensively developed agricultural catchment, with the survey site situated in Eltham some 21km below the National park boundary. River water was consistently clear in appearance with moderate conductivity levels. Water temperatures were within a moderate range of 7.5 ˚C but with a relatively high maximum of 20.8 ˚C recorded at 1425 hours in mid January 2010. All samples were collected before 1430 hours and therefore higher river temperatures (which tend to occur later in the afternoon) were not recorded.

Bacteriological water quality was in the range typical of the mid reaches of the 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 100mls) has been recorded by monthly sampling since 1995. The highest counts in the current survey tended to occur later in the period under lower flow conditions (Figures 18 and 19). A relatively good standard of compliance with dairy wastes disposal practices was found by the annual inspection round, with two non-compliance issues recorded.

3.2.5.1 Compliance with guidelines

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

Table 29 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	1 [8]	0 [0]

(Designation: freshwater contact recreational area)

Only one single sample fell within the 'Alert' mode and no samples reached the 'Action' mode. The highest sample count (in the 'Alert' mode) occurred at the very end of the season in March 2010 during a low flow period. In general these results were a small improvement on typical bacteriological counts obtained at the site just downstream at Eltham Road (by the longer term physicochemical SEM programme), although the latter programme samples more random river flows and variable climatological conditions.

In terms of contact recreational usage guidelines, bacteriological water quality at this site was within the acceptable level for almost the entire period and no warning signage was required during the period.

3.2.5.2 Comparison with previous summers' surveys

A statistical comparison of each of the fourteen summer's survey data is presented graphically in Appendix V for all sites. A shorter data period exists for the Waingongoro River (at Eltham camp) site which was added to the programme in 2001-2002. These data for the Waingongoro River site at Eltham camp are summarised in Table 30 and illustrated in Figure 20.

Table 30 Summary of *E. coli* bacteriological water quality data (nos/100 ml) for all summer surveys in the Waingongoro River at Eltham camp to date

Summer	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Minimum	31	63	23	51	54	23	57	77	57
Maximum	870	550	360	1700	430	290	420	500	270
Median	230	230	100	170	130	110	160	130	160

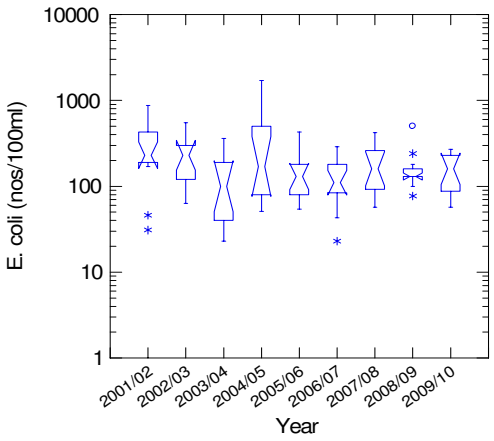


Figure 20 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers of the Waingongoro River at Eltham Camp

Similar *E.coli* bacterial water quality was indicated by a median count within the mid range of those recorded by the eight preceding seasons (Figure 20). There was a relatively narrow range of counts over the 2009-2010 season in comparison with the eight other seasons monitored previously. Trend analysis of median *E.coli* numbers has not been performed as the sampling period has not yet encompassed ten seasons (nine years duration to date).

3.2.6 Waingongoro River at Ohawe Beach

Some bathing usage of this site was recorded with the site used more frequently for whitebaiting (in season) and picnicking. Stock occasionally were present in the paddock upstream of the site, and stock were noted at the river's edge and in the river toward the end of the season (Photo 1). This necessitated remedial action initiated by the Council in conjunction with the occupier on two occasions. The data for this site are presented in Table 31 and illustrated in Figure 22, with a statistical summary provided in Table 32. River flow records are illustrated in Figure 21.

Photo 1 Stock access to streams: one of the major influences on contact recreational bacteriological water quality under low flow conditions [Waingongoro River immediately upstream of Ohawe Beach site]

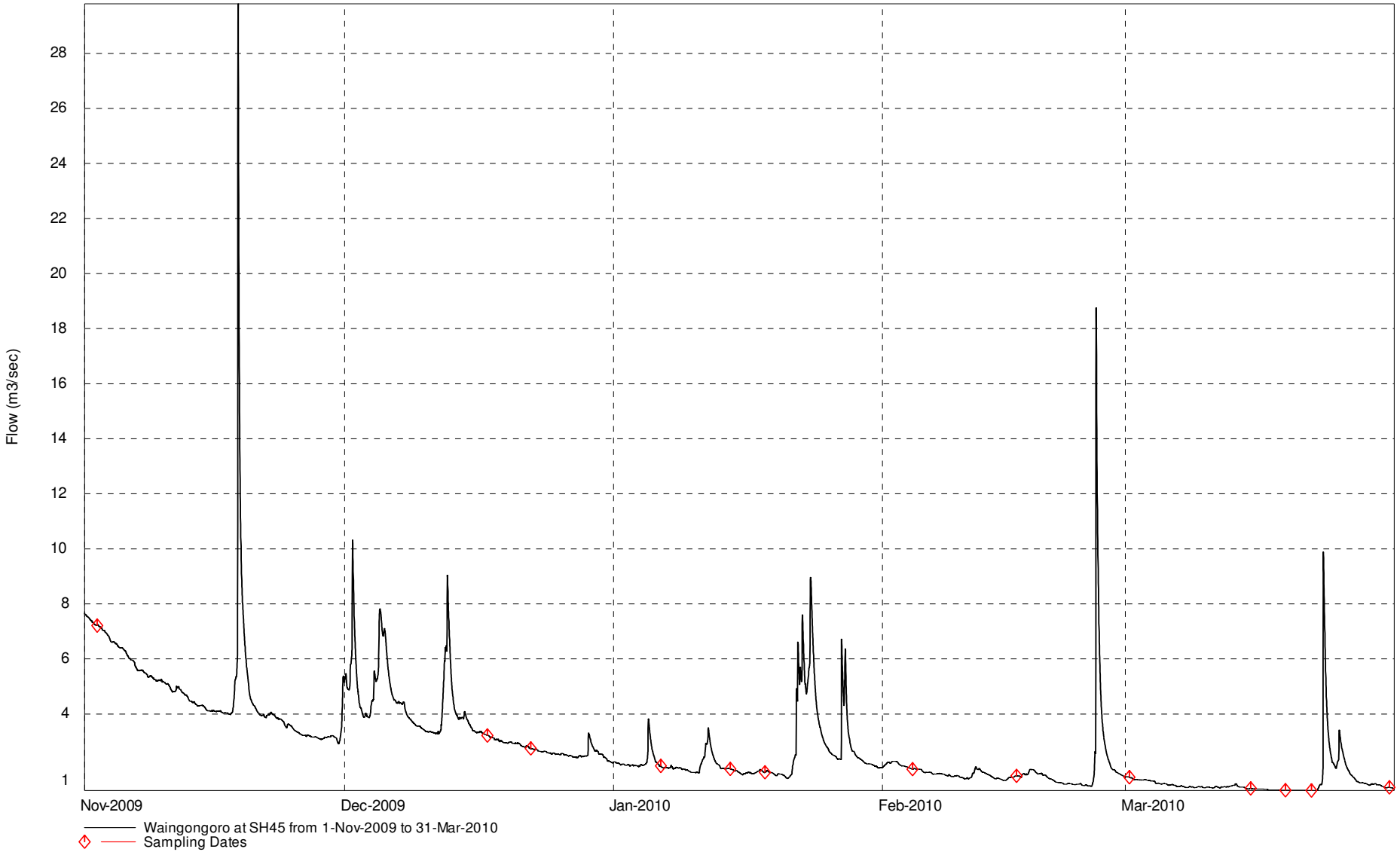


Figure 21 River flow in the Waingongoro River at SH45 during the survey period

Table 31 Analytical results for the Waingongoro River at Ohawe Beach

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	1010	18.0	110	23	120	14.1	4.2
17.12.09	1225	19.2	63	28	63	19.2	3.1
22.12.09	1125	18.7	57	46	60	19.6	2.4
6.01.10	1410	19.2	46	28	46	20.8	3.1
14.01.10	1000	21.0	31	28	31	18.8	2.6
18.01.10	1135	20.7	26	28	26	20.4	2.4
4.02.10	1330	18.7	120	700	120	22.4	2.8
16.02.10	1105	22.7	180	390	200	19.8	3.3
1.03.10	1055	283	1000	1800	1000	21.0	3.0
15.03.10	1030	19.4	220	240	220	17.8	1.6
19.03.10	1145	18.4	31	120	31	16.5	1.9
22.03.10	1355	19.4	120	210	120	19.9	1.6
31.03.10	1100	18.1	96	180	100	16.1	2.5

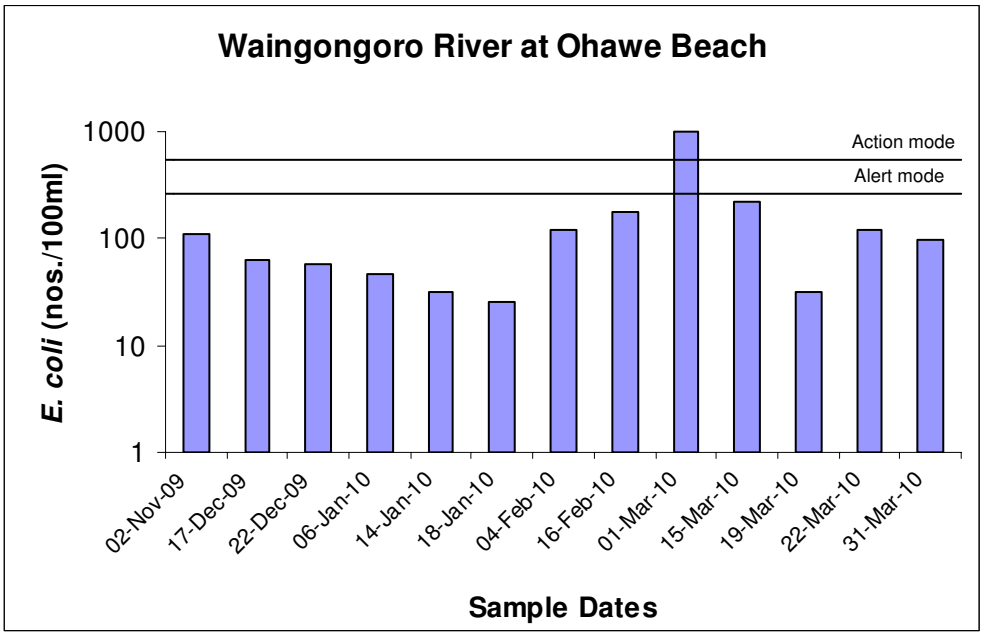


Figure 22 *E. coli* numbers for the Waingongoro River at Ohawe Beach during the survey season

Table 32 Statistical results summary for the Waingongoro River at Ohawe Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	18.0	283	19.2
E. coli	nos/100ml	13	26	1000	96
Enterococci	nos/100ml	13	23	1800	120
Faecal coliforms	nos/100ml	13	26	1000	100
Temperature	°C	13	14.1	22.4	19.6
Turbidity	NTU	13	1.6	4.2	2.6

This river drains an extensively farmed catchment and receives point source industrial/municipal wastes (in its mid-reaches) and dairy pond wastes (more than 110 treatment systems) discharges. 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 higher tidal conditions during late summer. These conditions were less prevalent during the 2009-2010 season.

The range of water temperatures was moderate (8.3°C) with a maximum of 22.4°C recorded in early afternoon in early February 2010. However, as sampling was not performed after 1410hrs at this site, this maximum could 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 some salt water influence only on one occasion despite sampling low flow conditions coincident with higher tides. Turbidity values were indicative of relatively clean water on most occasions and were 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 21) was relatively good for 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 has recorded a median *E. coli* count of 220 per 100 mls. On-site monitoring of dairy farm wastes disposal systems indicated a generally good standard of compliance in the catchment during the survey period. However, uncontrolled stock access to the river remained a problem on occasions, particularly during low flow periods.

3.2.6.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 33.

Table 33 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	0 [0]	1 [8]

(Designation: freshwater contact recreational area)

No single sample was recorded in the 'Alert' category, but one sample was recorded in the 'Action' mode following the first instance of cattle access to the river immediately upstream of the site. Follow-up sampling two and eight days following this exceedance of the guidelines found lower counts (300 and 190 *E.coli* per 100 mls respectively) although the first of these counts was in the 'Alert' level. No signage was installed by the South Taranaki District Council after the only incident of 'Action' level exceedance. The high count was recorded at the start of March 2010

following a low, recession flow period, but counts were relatively low for the remainder of the period.

Bacteriological water quality at this site was within the acceptable guidelines for contact recreational usage for the majority of the survey period consistent with on-site monitoring of dairy wastes disposal systems having a relatively good compliance standard for this large catchment at the time of the summer contact recreation survey period.

3.2.6.2 Comparison with previous summers' surveys

A statistical comparison of each of the fourteen summer's survey data is presented graphically in Appendix V for all sites. These summer data for the Waingongoro River site at Ohawe Beach are summarised in Table 34 and illustrated in Figure 23.

Table 34 Summary of *E. coli* bacteriological water quality data (nos/100 ml) for all summer surveys in the Waingongoro River at Ohawe Beach to date

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Minimum	88	43	17	34	38	46	31	43	54	31	31	9	31	26
Maximum	310	650	300	240	850	660	14000	280	940	380	410	5000	870	1000
Median	185	130	80	180	170	160	110	110	130	96	100	100	120	96

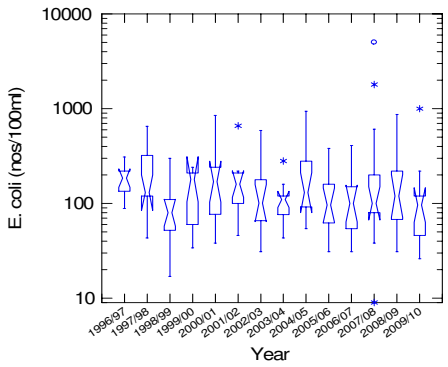
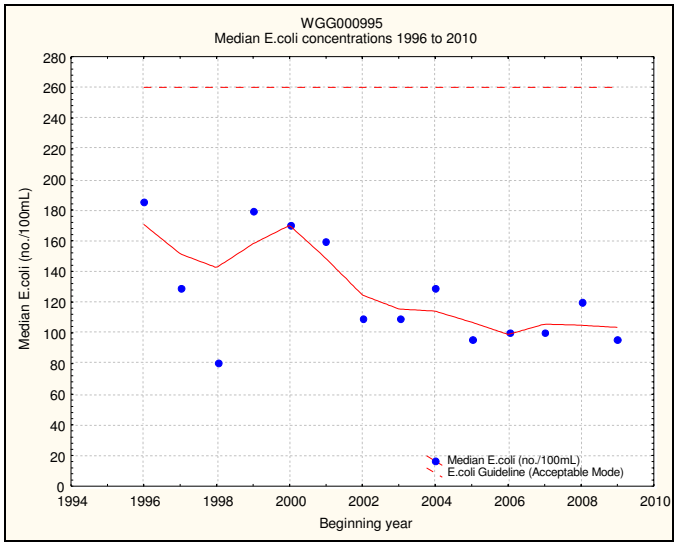


Figure 23 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Waingongoro River at Ohawe Beach

Median *E. coli* bacteria number for the 2009-2010 period was slightly lower than those found in the previous three seasons, maintaining the general trend of improvement in bacterial water quality recorded over the last eight seasons (Figure 23). A moderate range of *E. coli* numbers was recorded in the recent 2009-2010 period in comparison with the past seasons' ranges to date.

Trend analysis of these median *E.coli* numbers has been performed for the fourteen seasons of data by first applying a 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 Discover Rate (FDR) analysis.



N = 14
Kendall tau = - 0.461
p level = 0.022 [>FDR, p = 0.072]
Significant at p< 0.05,
not significant after FDR.

Figure 24 LOWESS trend plot of median *E.coli* numbers (per 100ml) for the 1996 to 2010 period at the Waingongoro River Ohawe beach site

A strongly decreasing trend in median *E.coli* number was found over the fourteen seasons of monitoring. Although the trend was statistically significant at the p <0.05 level, it was not significant after FDR application. None of these seasonal medians exceeded the 'Alert' or 'Action' modes.

3.2.7 Kaupokonui River at Beach Domain

Some usage at this site by bathers was recorded at the time of the sampling surveys while other recreational usage (mainly fishing (whitebaiting was common in early season) and picnicking) was occurring on a majority of survey occasions at this popular site. The site was characterised by the tidal ponded nature of this reach of the river, particularly under very 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. Data from this site are presented in Table 35 and illustrated in Figure 26, with a statistical summary provided in Table 36. River flow records are provided in Figure 26.

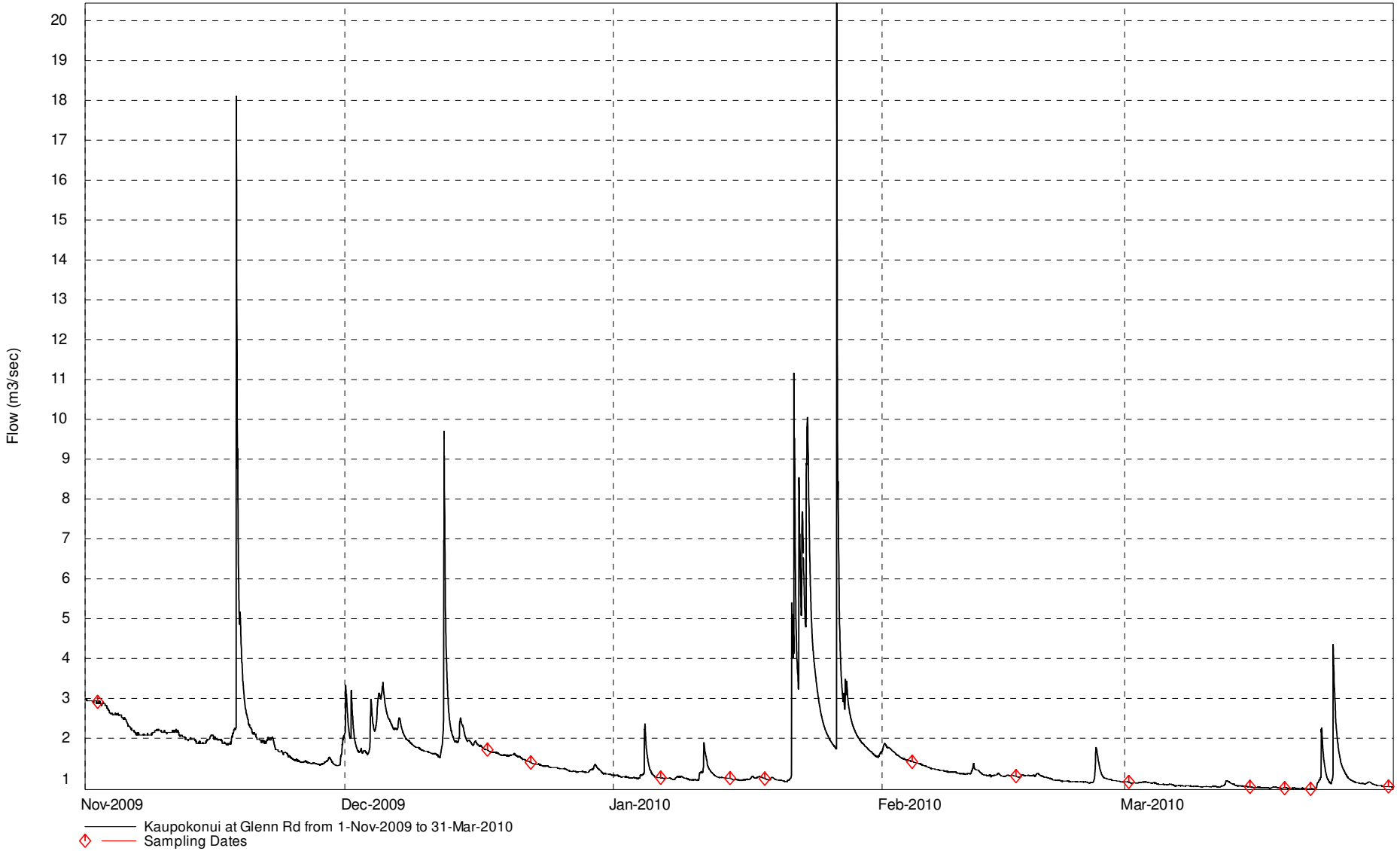


Figure 25 River flow in the Kaupokonui River during the survey period

Table 35 Analytical results for the Kaupokonui River at the beach domain

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	1035	17.2	440	96	440	14.4	2.4
17.12.09	1050	16.1	100	31	110	19.4	2.5
22.12.09	1355	16.6	40	34	40	20.5	2.0
6.01.10	1440	17.5	54	46	54	22.6	3.5
14.01.10	1135	18.0	63	50	63	21.5	2.4
18.01.10	1205	17.7	20	66	20	20.9	2.0
4.02.10	1355	14.5	80	71	84	22.9	2.4
16.02.10	1135	16.0	110	200	120	19.9	2.2
1.03.10	1220	202	310	1000	310	21.9	7.4
15.03.10	1100	15.8	110	370	110	19.1	1.6
19.03.10	1215	15.5	28	80	28	18.2	1.4
22.03.10	1415	16.6	100	350	100	20.3	1.4
31.03.10	1130	24.8	150	230	160	17.6	2.2

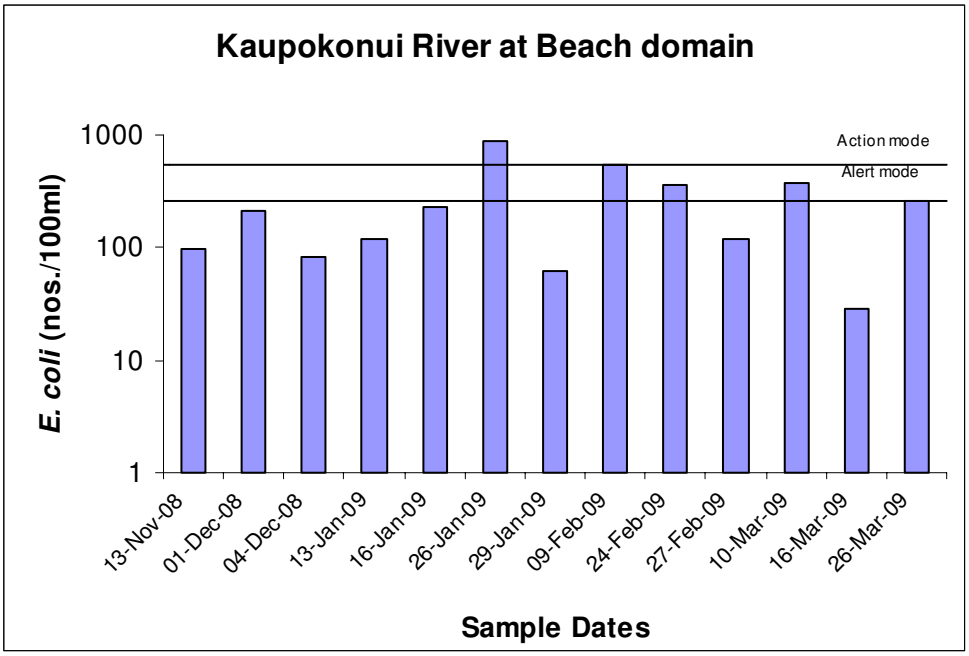


Figure 26 *E. coli* numbers for the Kaupokonui River at the beach domain during the survey season

Table 36 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	14.5	202	16.6
E. coli	nos/100ml	13	20	440	100
Enterococci	nos/100ml	13	31	1000	80
Faecal coliforms	nos/100ml	13	20	440	100
Temperature	°C	13	14.4	22.9	20.3
Turbidity	NTU	13	1.4	7.4	2.2

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 upgraded Kaponga township municipal wastewater treatment system.

The site is located in the lower reach of the river near the mouth and on ten occasions was noted as tidal (incoming surges or ponded) in terms of flow conditions. However, elevated conductivity levels indicating some seawater influence were recorded only on one occasion in early March 2010 at high tide and under very low flow conditions (Figure 25). Otherwise these levels were relatively stable (14.5 to 24.8 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 in many previous survey periods. 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 8.5°C with a maximum of 22.9°C recorded in early February 2010 and the majority greater than 19˚C. This temperature was recorded in early afternoon and would be expected to have been exceeded later in the day, particularly as no surveys were performed after 1440hrs at this site.

Bacteriological water quality was moderate and very similar to that recorded in the lower reaches of the nearby Waingongoro River (see section 3.2.6), and typical of the lower reaches of a Taranaki ring plain river draining a predominantly agricultural catchment. On-site monitoring of dairy farm wastes disposal systems indicated a generally good standard of compliance during the summer bathing period.

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 in response to 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. It has also been noted 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 again was apparent between mid February and late March 2010 (Table 35) when enterococci numbers exceeded *E. coli* numbers.

Two 'Alert' levels were recorded, one at the start of the season and the other in mid February 2010. Previously many flocks of ducks were recorded upstream of this site. Much lower counts were recorded by the following surveys two weeks later.

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 2009-2010 season.

3.2.7.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 37.

Table 37 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	2 [15]	0 [0]

(Designation: freshwater contact recreational area)

Two individual samples were recorded in the 'Alert' mode during the season. Minimal rainfall preceded these counts with numbers returning to typical levels by the time of scheduled surveys following these two rises in counts.

In summary, bacteriological water quality at this ponded lower river site was within guidelines for contact recreational usage for the majority of the survey period consistent with the generally good compliance standards found by on-site monitoring of dairy wastes disposal systems in the mid and lower reaches of this catchment although the numerous ducks previously recorded in the lower reaches of the river may have contributed to elevated counts from time to time.

3.2.7.2 Comparison with previous summers' surveys

A statistical comparison of each of the fourteen summer's survey data is presented graphically in Appendix V for all sites. These summer data for the Kaupokonui River site at the Beach Domain are summarised in Table 38 and illustrated in Figure 27.

Table 38 Summary of *E. coli* bacteriological water quality data (nos/100ml) for all summer surveys in the Kaupokonui River at the Beach Domain

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Minimum	26	31	3	7	17	46	46	<8	40	14	26	15	29	20
Maximum	360	2100	580	780	2000	400	630	200	880	280	2500	850	890	440
Median	110	360	130	80	120	110	130	77	92	160	140	77	210	100

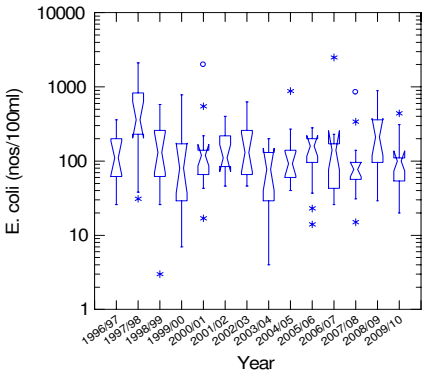
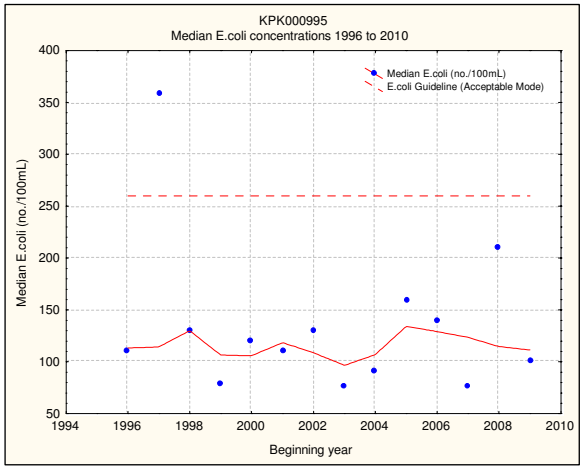


Figure 27 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Kaupokonui River at the Beach Domain

An improved *E. coli* bacterial water quality in terms of median number, and typical of the range found by most of the previous thirteen survey seasons, was recorded over the 2009-2010 season (Figure 27). The median *E. coli* count was lower than all but four of all other season's medians, and well below that of the previous season (Table 38).

Trend analysis of these median *E. coli* numbers has been performed for the fourteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 27) 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 = 14
Kendall tau = -0.045
p level = 0.824 [>FDR p = 0.824]
N/S at p < 0.05

Figure 28 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Kapokonui River beach domain site for the 1996 to 2010 period

A slightly, but not statistically significant, decreasing trend in median *E. coli* counts was found over the fourteen seasons of monitoring. One of these seasonal medians (1997-1998 season) exceeded the 'Alert' mode, but none have exceeded the 'Action' mode.

3.2.8 Lake Opunake

Bathing usage of the lake was noted on only occasion, but picnicking, kayaking and jet-skiing activities were recorded at the time of some sampling surveys. Ducks were also noted regularly on the lake (together with a few swan) or in the vicinity of the lake edge and numbers were high on most occasions. These wildfowl were present

frequently on the picnic area grass verge adjacent to the lake edge, attracted from time to time by food provided by picnickers.

Data from this site are presented in Table 39 and illustrated in Figure 29, with a statistical summary provided in Table 40.

Table 39 Analytical results for Lake Opunake

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	1125	14.4	64	52	68	13.4	1.1
17.12.09	1145	14.3	310	80	310	17.3	1.9
22.12.09	1450	13.2	96	15	96	20.0	1.4
6.01.10	1535	13.8	220	43	220	19.9	1.8
14.01.10	1110	13.6	68	24	68	19.5	1.7
18.01.10	1355	13.5	220	58	220	20.8	1.4
4.02.10	1450	13.4	140	40	140	23.8	1.2
16.02.10	1200	13.2	300	250	300	19.3	1.4
1.03.10	1150	12.9	280	86	280	21.1	0.9
15.03.10	1200	13.7	320	670	320	17.6	1.5
19.03.10	1245	13.5	80	200	80	17.9	1.2
22.03.10	1510	13.6	280	240	280	19.8	1.0
31.03.10	1200	13.1	77	220	77	16.8	0.9

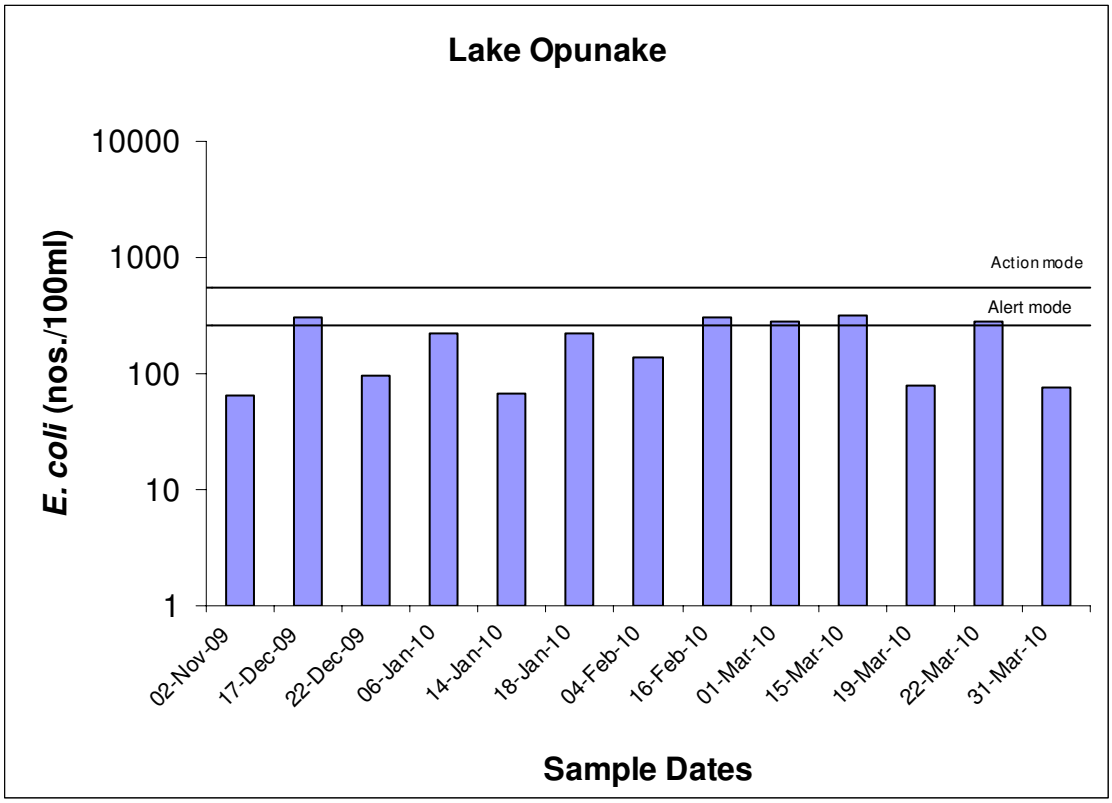


Figure 29 *E. coli* numbers for Lake Opunake during the survey season

Table 40 Statistical results summary for Lake Opunake

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	12.9	14.4	13.5
E. coli	nos/100ml	13	64	320	220
Enterococci	nos/100ml	13	15	670	80
Faecal coliforms	nos/100ml	13	68	320	220
Temperature	°C	13	13.4	23.8	19.5
Turbidity	NTU	13	0.9	1.9	1.4

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 quality was generally relatively good with consistently good water clarity (median turbidity: 1.4 NTU; range of turbidity: 1 NTU) as a result of minimal sediment disturbance or suspended algae in the water column. This was due, in part, to the lake's short residence time, with regular replenishment due to local hydroelectric power scheme usage. Water temperatures were moderately high (above 17˚C) for the majority of the period with a maximum of 23.8˚C (in early February 2010) and a relatively wide range of 10.4˚C. Conductivity varied over a narrow range (1.5 mS/m @ 20˚C) reflecting river flow conditions.

Generally bacteriological quality was moderate, influenced in part by the inflow to the lake originating from the lower reaches of a river draining a developed catchment. Elevated numbers, above 200 *E. coli* per 100 mls, were found in the latter half of the season co-incidental with higher duck numbers in the immediate vicinity of the site. Marked fluctuations in counts were most likely associated with this bird population, particularly in instances where ducks were attracted to the immediate vicinity of the monitoring site by picnickers feeding the birds.

3.2.8.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 41.

Table 41 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	5 [38]]	0 [0]

(Designation: freshwater contact recreational area)

No single sample exceedances of the 'Action' mode occurred during the period but five single samples were recorded within the 'Alert' mode. Sampling subsequent to 'Alert' levels in mid February showed similar *E. coli* numbers within one week of these exceedances. These counts remained in the 'Alert' mode for about one month. Installation of 'health warning' signage by STDC was not required (see Appendix VI).

3.2.8.2 Comparison with previous summers' surveys

A statistical comparison of each of the summers' *E. coli* survey data is presented graphically in Appendix V for all sites. The four summers of data collection for the Lake Opunake site are summarised in Table 42 and illustrated in Figure 30.

Table 42 Summary of *E. coli* bacteriological water quality data to date (nos/100 ml) for all summer surveys at Lake Opunake to date

Summer	06/07	07/08	08/09	09/10
Minimum	33	26	54	64
Maximum	720	1300	2800	320
Median	110	130	210	220

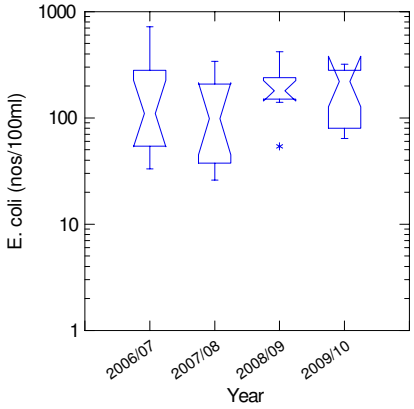


Figure 30 Box and whisker plots for the summer SEM survey of *E. coli* bacteria numbers at Lake Opunake

A slightly higher median *E. coli* number was found in the latest season in comparison with those found by the three previous seasons' surveys but the narrowest range of counts was found during the latest season (Figure 30).

Trend analysis of median *E. coli* numbers will not be performed for this site until ten seasons' data are available.

3.2.8.3 Cyanobacteria

Microscopic scans of eight samples were performed for the presence and enumeration of cyanobacteria during the season. The results of these analyses are presented in Table 43.

Table 43 Cyanobacteria counts (cells/ml) for Lake Opunake [Health warning:>15,000 cells/ml]

Date	Cyanobacteria total cell count (cells/ml)
26.11.09	nil
10.12.09	nil
12.01.10	nil
26.01.10	nil
09.02.10	nil
23.02.10	nil
09.03.10	nil
26.03.10	nil

No cyanobacteria were detected in any of these samples. No cyanobacteria had been found in this lake during the 2006-2007 or 2008-2009 seasons, but their presence (in low numbers) on three occasions in the latter part of the 2007-2008 season followed a lengthy, extremely low flow period. However numbers did not reach levels requiring the issue of 'health warnings' during that season. The relatively short lake water residence time (due to hydroelectric power generation usage) may be a controlling factor in these bacterial populations.

3.2.9 Timaru Stream at Weld Road (near mouth)

Some bathing usage was noted at this site on two sampling occasions during the period. Minimal picnicking and whitebaiting usage was recorded at the times of sampling surveys during the season. The site had been a popular camping area (until the camp was closed by NPDC during early 2005) and access point to the sea coast. The site, to a certain extent tidal, showed varying degrees of saltwater penetration, particularly in the latter half of the period under low flow recession conditions.

Data from this site are presented in Table 44 and illustrated in Figure 31, with a statistical summary provided in Table 45.

Table 44 Analytical results for the Timaru Stream at Weld Road

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	0800	9.8	300	57	310	12.8	0.5
17.12.09	0800	8.7	320	63	320	13.6	0.7
22.12.09	1105	9.0	46	11	46	16.1	0.5
6.01.10	1200	23.5	140	210	140	17.6	0.5
14.01.10	0805	10.9	300	230	320	15.9	0.5
18.01.10	0915	41.1	130	200	130	19.7	0.6
4.02.10	1110	82.3	140	190	150	20.4	1.0
16.02.10	0845	28.6	460	350	470	17.4	0.5
1.03.10	0815	14.3	400	510	420	17.1	0.7
15.03.10	0800	18.9	240	480	240	15.9	0.4
19.03.10	0930	29.0	210	290	210	14.6	0.5
22.03.10	1150	29.2	560	220	560	18.8	0.6
31.03.10	0810	96.3	290	310	330	14.6	1.0

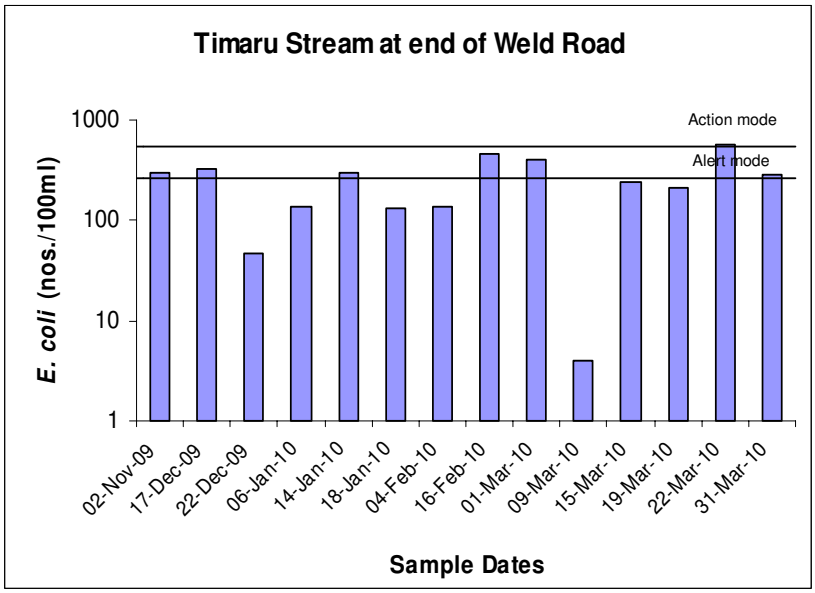


Figure 31 *E. coli* numbers for the Timaru Stream at Weld Road during the survey season

Table 45 Statistical results summary for the Timaru Stream at Weld Road

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	8.7	96.3	23.5
E. coli	nos/100ml	13	46	560	290
Enterococci	nos/100ml	13	11	510	220
Faecal coliforms	nos/100ml	13	46	560	310
Temperature	°C	13	12.8	20.4	16.1
Turbidity	NTU	13	0.4	1.0	0.5

This river drains a moderately farmed catchment (five consented dairy farm discharges) receiving point and non-point source discharges from these 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 several occasions during the season and particularly in mid to late summer-autumn under low stream flow conditions. Turbidity levels generally were very low consistent with the clear appearance of the river. No 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 7.6°C with a maximum water temperature of 20.4°C recorded in late morning in early February 2010. This maximum could have been expected to have been exceeded later in the day during summer as all of the sampling was undertaken during morning hours.

Bacteriological water quality at this site was average and typical of the lower reaches of a smaller Taranaki ring plain stream draining an agricultural catchment. Elevated counts occurred sporadically, more particularly under low flow conditions in the latter part of the sampling period. There was no installation of 'health warning' signage at the site by NPDC although there was one short term exceedance of the 'Action' level. No problems with wastes disposal practices were recorded by the annual dairy farms inspection round. 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 in the 2009-2010 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. It has also been noted at these tidal 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.

3.2.9.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 46.

Table 46 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 >550/100 ml
E. coli	6 [46]	1 [8]

(Designation: freshwater contact recreational area)

Six single samples were recorded in the 'Alert' mode, and one was recorded in the 'Action' mode during the period. Poorer bacteriological water quality coincided with the localised rainfall events some two to three days prior to some surveys coincident with low stream flow and an absence of higher quality seawater intrusion at the site. A follow-up survey on one of these occasions, in early March 2010, found very low numbers (<8 *E.coli* per 100mls) coincident with some seawater intrusion. No health warning signage was erected following the 'Action' level recorded in late March 2010 and the count dropped below this mode by the end of March, although it remained within the 'Alert' mode.

In terms of the new contact recreation guidelines, the bacteriological water quality at the site was moderate and partly affected by the ponding caused by the site's proximity to the sea coast although good compliance with dairy sheds' wastes disposal practices was monitored in this catchment during the season.

3.2.9.2 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 Timaru Stream site at the end of Weld Road (which has been monitored for eleven summers) are summarised in Table 47 and illustrated in Figure 32.

Table 47 Summary of *E. coli* bacteriological water quality data to date (nos/100ml) for all summer surveys in the Timaru Stream at lower Weld Road

Summer	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Minimum	40	23	31	77	31	140	77	84	38	43	46	92	46
Maximum	410	710	1400	540	660	1000	410	1000	460	480	930	440	560
Median	280	210	160	180	180	260	220	260	220	200	180	230	290

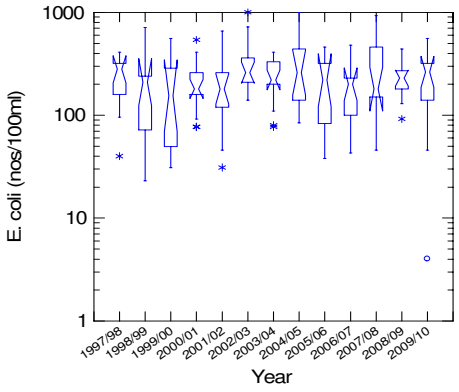
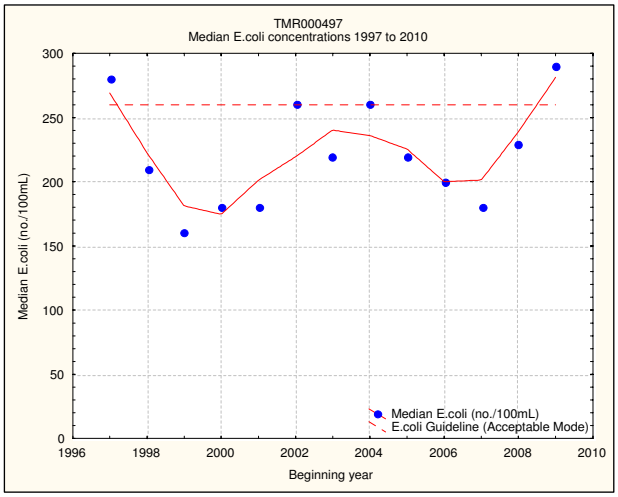


Figure 32 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Timaru Stream at lower Weld Road

The median *E. coli* count for the 2009-2010 season indicated a further small deterioration in bacterial water quality (Table 47) in comparison with all of the previous seasons. However, counts over the 2009-2010 season had a moderate range (Figure 32), with one count reaching the 'Action' mode.

Trend analysis of these median *E. coli* numbers has been performed for the thirteen 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-Hockberg False Discovery Rate (FDR) analysis.



N = 13
Kendall tau = +0.172
p level = 0.412 [>FDR, p = 0.667]
N/S at p < 0.05

Figure 33 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Timaru Stream, lower Weld Road site for the 1997 to 2010 period

A small increasing trend in median *E. coli* numbers has been found over the thirteen seasons of monitoring. However, this trend was not statistically significant. None of these seasonal medians exceeded the 'Action' mode, although the median for the

initial and latest seasons entered the 'Alert' mode and two others have been very close to the 'Alert' mode.

3.2.10 Waimoku Stream at Oakura beach

The easy access to this small 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 (see Appendix VI). More appropriate, permanent health warning signage was erected by NPDC in consultation with the Area Health Board early in the 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 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 recent completion of a newly 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.

Limited contact recreation (paddling) was observed at this very shallow stream site at the time of sampling visits and although few people were present on the beach in the immediate vicinity of the stream mouth on any sampling occasions, this site is known to be popular with children and families during favourable weather conditions at holiday periods and weekends (see Appendix VI, TRC 2009a and TRC, 2010).

Data from the site are presented in Table 48 and illustrated in Figure 34, with a statistical summary provided in Table 49.

Table 48 Analytical results for the Waimoku Stream at Oakura beach

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	0815	15.3	1700	140	1700	12.8	3.3
17.12.09	0810	15.1	1700	320	1700	13.5	4.2
22.12.09	1125	15.2	1600	460	1600	14.7	5.1
6.01.10	1240	15.3	3700	2700	3900	15.7	6.8
14.01.10	0830	15.4	2300	1600	2300	14.7	3.2
18.01.10	0935	15.4	4000	3600	4200	16.5	5.1
4.02.10	1135	16.0	6200	3400	6900	18.4	4.3
16.02.10	0910	15.1	4000	4200	4100	16.2	5.6
1.03.10	0835	14.3	1400	1900	1400	15.4	2.5
15.03.10	0815	14.0	2500	3100	2700	15.1	3.4
19.03.10	0940	13.9	3600	8700	3600	14.2	3.8
22.03.10	1200	14.1	6000	3400	6300	17.1	2.7
31.03.10	0820	14.1	2800	2300	3200	13.4	3.2

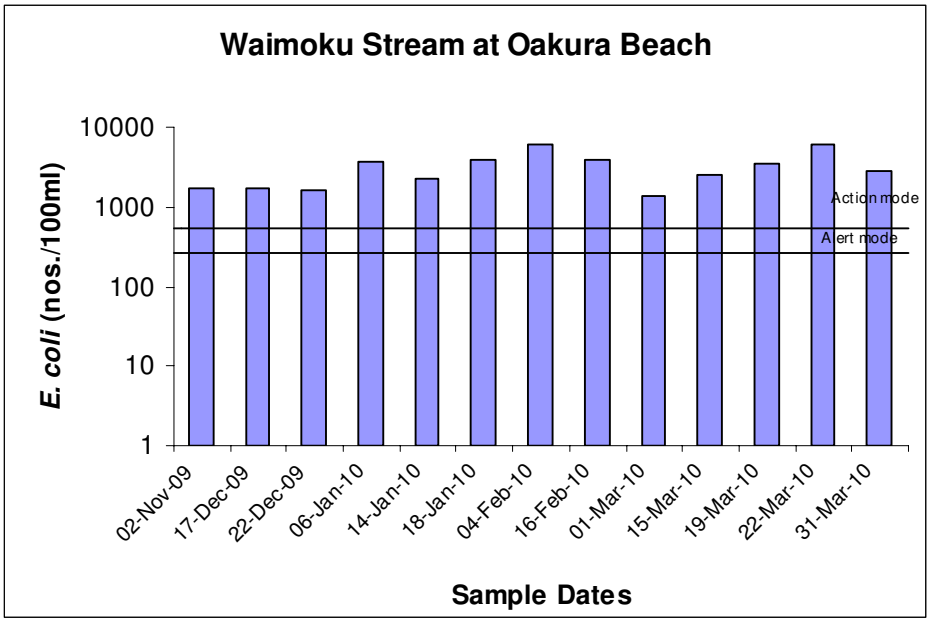


Figure 34 *E. coli* numbers for the Waimoku Stream at Oakura beach during the survey season

Table 49 Statistical results summary for the Waimoku Stream at Oakura beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	13.9	16.0	15.1
E. coli	nos/100ml	13	1400	6200	2800
Enterococci	nos/100ml	13	140	8700	2700
Faecal coliforms	nos/100ml	13	1400	6900	3200
Temperature	°C	13	12.8	18.4	15.1
Turbidity	NTU	13	2.5	6.8	3.8

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 and flows for a short distance through Oakura township where sewage disposal was via septic tank or similar systems to ground soakage although a pumped reticulation system (transferring sewage to the New Plymouth Wastewater Treatment Plant) has now been completed by NPDC although not all domestic wastes have been connected to this system. Wildfowl (ducks and pukekos 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).

Conductivity levels were relatively stable throughout the survey period with no salt water intrusion recorded. The stream was slightly turbid in appearance but the streambed had a cover (up to 90%) of periphyton growths (although not by thick mats). Water temperatures varied over a moderate range of 5.6°C with a maximum water temperature of 18.4°C recorded in late morning in early February 2010. Water temperatures later in the day could be anticipated to exceed the maximum recorded as all sampling at this site was performed prior to 1245 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 were also 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 pukekos)) and 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).

3.2.10.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 50.

Table 50 Bacterial guidelines performance at the Waimoku Stream, Oakura 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	0 [0]	13 [100]

(Designation: freshwater contact recreational area)

No single samples were recorded in the 'Alert' mode with every one of the 13 single samples within 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. However, the coastal bathing waters monitored adjacent to the stream mouth (main Oakura beach) met the enterococci guidelines on 17 of 22 sampling occasions (median: 45 per 100ml) with five individual samples

entering the 'Alert' mode but no occurrence (of two consecutive samples) entering the 'Alert' 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 (46 per 100 mls) for the SEM season (TRC, 2010).

3.2.10.2 Comparison with previous summers' surveys

A statistical comparison of each of the summers' survey data is presented graphically in Appendix V for all sites. Shorter data periods exist for the Waimoku Stream at Oakura beach which was included in the programme in 1999-2000 for the first time. These summer data for the Waimoku Stream site at Oakura beach are summarised in Table 51 and Figure 35.

Table 51 Summary of *E. coli* bacteriological water quality data (nos/100ml) for all summer surveys in the Waimoku Stream at Oakura beach to date

Summer	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Minimum	200	85	250	300	450	440	560	390	730	700	1400
Maximum	1700	900	1800	1700	1700	2200	6300	3200	8100	4600	6200
Median	480	400	730	770	710	900	830	930	2100	1600	2800

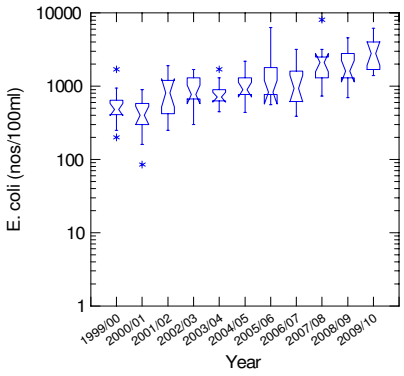
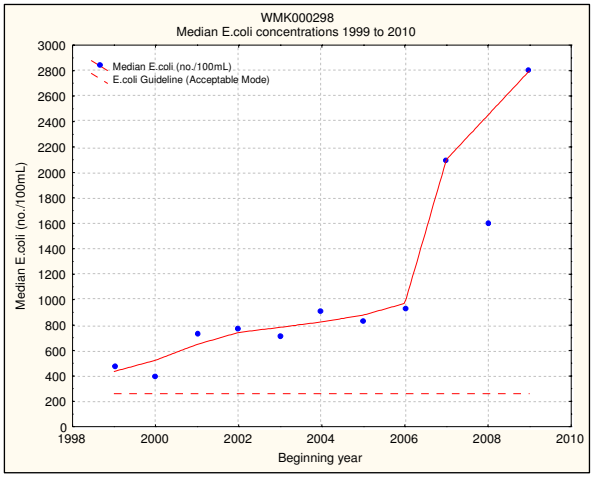


Figure 35 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Waimoku Stream at Oakura beach

The very high median *E. coli* count for the 2009-2010 season continued the more recent seasons' high median bacterial levels with the highest median of the eleven seasons' surveys and one of the widest ranges of counts to date. The trend of relatively high minimum counts was also maintained with the highest seasonal minimum count to date, indicative of poor bacterial water quality, long associated with this, small predominantly agricultural catchment stream with high wildfowl numbers.

Trend analysis of median *E.coli* numbers has been performed for the eleven seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 35) 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 = 11
Kendall tau = +0.818
p level = 0.0005 [>FDR, p = 0.0023]
Significant at p<0.05 and after FDR

Figure 36 LOWESS trend plot of median *E. coli* numbers (per 100ml) at Waimoku Stream, Oakura Beach site for the 1999 to 2010 period

A steady increase in median *E. coli* numbers has been found over the eleven seasons of monitoring. This trend was statistically very significant. All of these seasonal medians exceeded the 'Alert' mode and the latest nine seasonal medians have all exceeded the 'Action' mode.

3.2.11 Oakura River below SH45

Some bathing usage, kayaking and whitebaiting (in season), were recorded at this site and occasionally people were present on the riverbank at this very accessible tidal site where ponding and upstream surging frequently occurred under high tide conditions.

Data from the site are presented in Table 52 and illustrated in Figure 37, with a statistical summary provided in Table 53.

Table 52 Analytical results for the Oakura River below SH45

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	0830	8.4	140	14	150	12.9	0.6
17.12.09	0840	7.7	88	17	88	13.9	0.7
22.12.09	1050	7.6	60	8	60	15.5	0.6
6.01.10	1150	7.6	68	63	74	17.0	0.5
14.01.10	0900	7.8	120	42	120	15.8	0.5
18.01.10	1000	8.8	360	76	360	20.8	0.5
4.02.10	1155	27.5	240	240	240	22.0	0.6
16.02.10	0930	7.8	2500	310	2500	17.7	0.4
1.03.10	0900	44.6	370	240	370	16.9	0.5
15.03.10	0845	9.4	420	240	430	15.9	0.5
19.03.10	1005	11.4	150	280	150	14.6	0.5
22.03.10	1230	9.8	92	140	110	18.9	0.6
31.03.10	0845	62.3	320	200	360	14.3	0.6

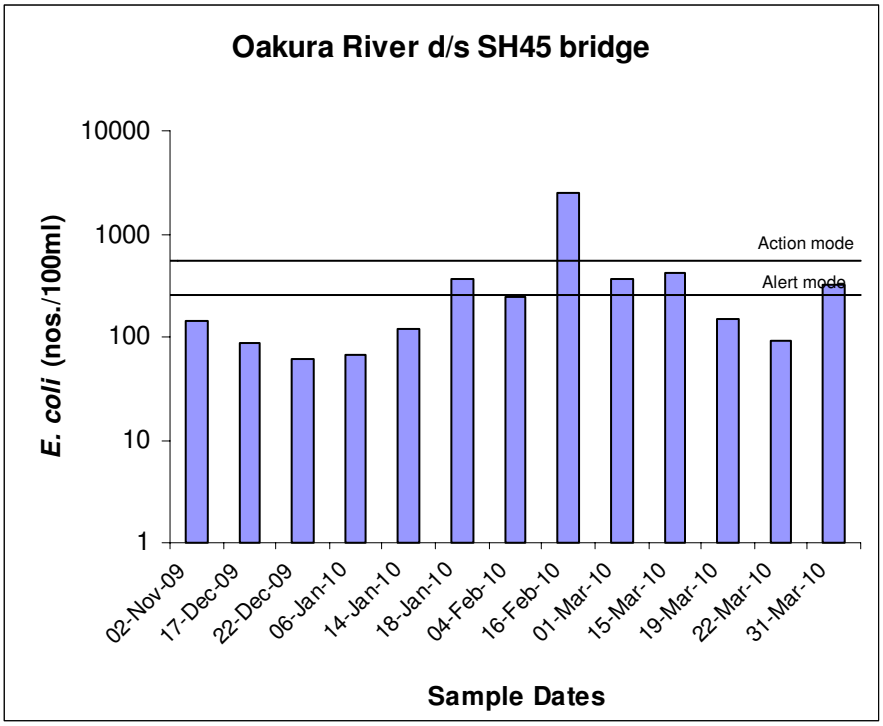


Figure 37 *E. coli* numbers for the Oakura River below SH45 during the survey season

Table 53 Statistical results summary for the Oakura River below SH45

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	7.6	62.3	8.8
E. coli	nos/100ml	13	60	2500	150
Enterococci	nos/100ml	13	8	310	140
Faecal coliforms	nos/100ml	13	60	2500	150
Temperature	°C	13	12.9	22.0	15.9
Turbidity	NTU	13	0.4	0.7	0.5

This river drains a mainly agricultural catchment (five consented dairy farm discharges) with the survey site established in the short tidal reach between SH45 and the mouth of the river. The river was noted as tidal with ponding or inflowing surges obvious on eight sampling occasions. Conductivity levels indicated an influence of saltwater intrusion on at least three sampling occasions during the season, all of which were during low flow conditions in the latter part of this season. On all occasions the river was clear in appearance with no algal substrate cover due to the sandy nature of much of the substrate. Water temperatures varied over a moderate range (9.1°C) during the period reaching a maximum of 22.0°C near midday in early February 2010, below the maximum water temperature which might be anticipated later in the day as all sampling at this site occurred before 1235 hrs.

Bacteriological water quality was average, with the majority of *E. coli* counts below 250 per 100 mls. 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 occasionally 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 river mouth reach. A markedly elevated count in mid February 2010 was coincident with some localised rainfall over the previous three days and no saltwater intrusion under low flow conditions. Follow-up sampling two and seven days after this high count, found decreasing *E.coli* counts (560 and 60 per 100mls respectively) when again there was no saltwater intrusion. A further elevation in count, in early March, 2010 was followed by a very low *E. coli* count (62 per 100mls) eight days later. A good standard of compliance with on-site dairy waste disposal practices was recorded during the season.

3.2.11.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 54.

Table 54 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 >550/100 ml
E. coli	4 [31]	1 [8]

(Designation: freshwater contact recreational area)

Four single samples fell within the 'Alert' mode and one sample entered the 'Action' mode. This latter occurrence coincided with low flow conditions but some localised rainfall over the preceding three days and subsequent samples showed a return to lower than normal levels, below the 'Alert' mode, within seven days of the occurrence. No health warning signage was displayed at this site by NPDC following the 'Action' level exceedance.

However, generally bacteriological water quality was average for the lower reaches of a Taranaki ringplain river, and within the acceptable single sample guidelines for contact recreational usage for the majority of the sampling occasions.

3.2.11.2 Comparison with previous summers' surveys

A statistical comparison of each of the fourteen summers' survey data is presented graphically in Appendix V for all sites. These summer data for the Oakura River site below the SH45 bridge are summarised in Table 55 and illustrated in Figure 38.

Table 55 Summary of *E. coli* bacteriological water quality data (nos/100ml) for all summer surveys in the Oakura River downstream of SH45

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Minimum	7	28	42	24	23	31	26	43	11	46	23	31	34	60
Maximum	260	1100	240	540	310	580	420	1200	820	380	330	2400	450	2500
Median	34	110	100	77	80	120	120	120	140	160	220	140	180	150

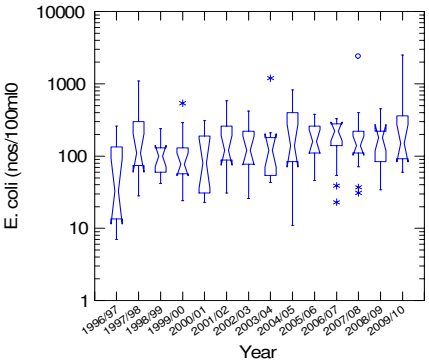
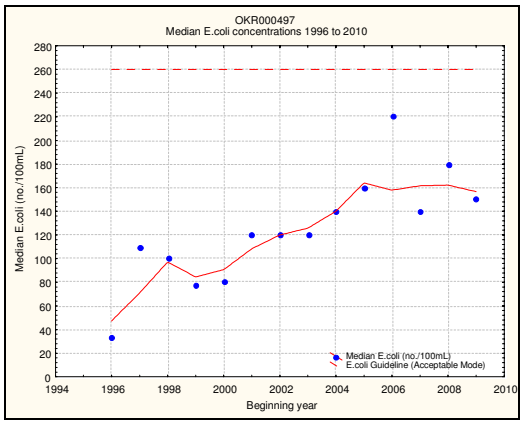


Figure 38 Box and whisker plots for all summer Oakura River downstream of SH45

The slightly elevated median *E. coli* counts since the 2003-2004 season continued with a moderate median count for the 2009-2010 season (Figure 38). A wider range of *E. coli* counts was recorded, due to one very high count. No median *E. coli* counts have exceeded the new guidelines for contact recreational usage over the fourteen seasons of monitoring.

Trend analysis of these median *E. coli* numbers has been performed for the fourteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 38) 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 = 14
Kendall tau = + 0.731
p level = 0.0003 [>FDR, p = 0.002]
Significant at p < 0.05 and after FDR

Figure 39 LOWESS trend plot of median *E.coli* numbers (per 100ml) at the Oakura River, SH 45 site for the 1996 to 2010 period

A statistically significant increase in median *E. coli* counts has been found over the fourteen 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.

3.2.12 Waitara River at the town wharf, Waitara

Minimal bathing usage of this river site at the new town wharf was recorded at the time of sampling surveys, the majority of which were in the morning. Whitebaiting and fishing were noted from time-to-time at this site with boating and picnicking as the main activities.

Data from the site are presented in Table 56 and illustrated in Figure 40 with a statistical summary provided in Table 57. River flow information is illustrated in Figure 41.

Table 56 Analytical results for the Waitara River at the town wharf, Waitara

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	0900	521	260	14	270	14.6	9.5
17.12.09	1030	564	690	43	700	16.8	34
22.12.09	1235	394	92	20	92	18.8	4.2
7.01.10	1020	319	1700	640	1700	18.1	130
14.01.10	0835	687	1400	220	1400	17.6	130
18.01.10	1045	782	220	120	220	20.3	9.9
4.02.10	1210	518	230	60	240	20.3	9.8
16.02.10	1000	1170	180	54	180	20.3	4.8
1.03.10	0835	884	480	300	480	19.6	40
15.03.10	0855	540	220	120	220	17.3	7.2
19.03.10	1115	960	120	26	120	17.0	5.3
22.03.10	1240	743	270	92	280	19.6	3.9
31.03.10	1025	550	160	71	170	17.9	5.0

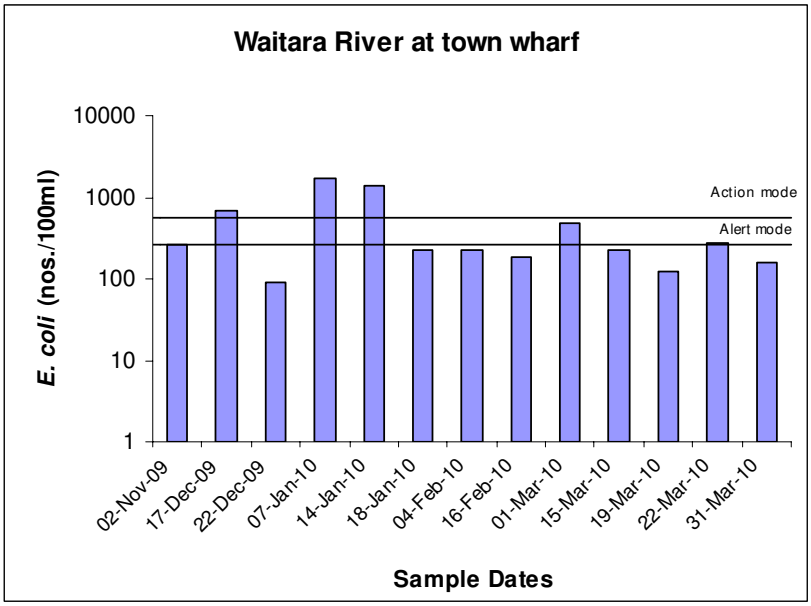


Figure 40 *E. coli* numbers for the Waitara River at the town wharf, Waitara during the survey season

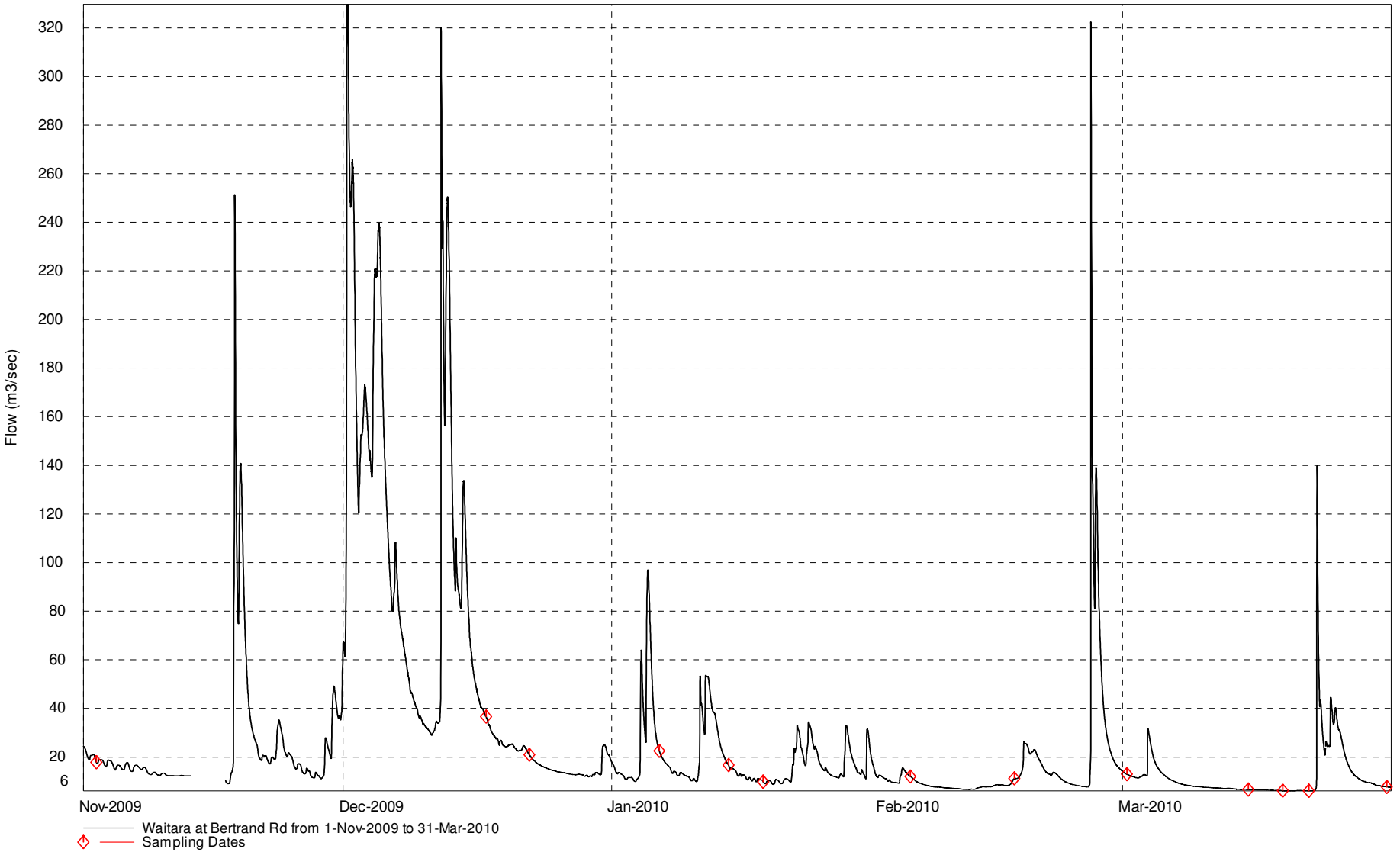


Figure 41 Flow in the Waitara River at Bertrand Road during the survey period

Table 57 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	319	1170	564
E. coli	nos/100ml	13	92	1700	230
Enterococci	nos/100ml	13	14	640	71
Faecal coliforms	nos/100ml	13	92	1700	240
Temperature	°C	13	14.6	20.3	18.1
Turbidity	NTU	13	3.9	130	9.5

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 2km upstream of the river mouth. There are consented dairy pond's treated wastes discharges in the catchment upstream of the site particularly in the Manganui River sub catchment (see 3.2.14). River water was consistently slightly turbid and occasionally dirty in appearance with elevated conductivity levels typical of seawater ingress near high tide on all sampling occasions.

Water temperatures had a moderate range of 5.7˚C due to the coastal seawater influence, with a maximum of 20.3˚C recorded on three occasions prior to midday from mid January to mid February 2010. All of the samples were collected before 1215 hours and therefore maximum river temperatures (which tend to occur later in the afternoon) were not sampled.

Bacteriological water quality was moderate for the lower reaches of this large Taranaki eastern hill country and ring plain river draining a predominantly agricultural catchment despite some coastal seawater influence under high tide conditions (median 230 *E. coli* per 100mls and 71 enterococci per 100mls). 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 same recreational period found a median *E. coli* bacterial number of 94 per 100mls but a wider range of *E. coli* numbers (31 to 5000 per 100mls).

3.2.12.1 Compliance with guidelines

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

Table 58 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 >550/100 ml
E. coli	2 [15]	3 [23]

(Designation: freshwater contact recreational area)

Two single samples fell within the 'Alert' mode and three within the 'Action' mode during the monitoring period. Most of these exceedances occurred about five to seven days following river freshes (Figure 41), coincident with turbid river appearance indicative of the lag effects of rainfall run-off within this large catchment. The three-day post rainfall sampling protocols followed by the SEM programme for the other (ringplain) catchment sites are therefore not necessarily appropriate for this site near the mouth of this large predominantly eastern hill country catchment river. These issues were discussed with the Area Health Board and NPDC staff and appropriately worded health warning signage was permanently installed at the town wharf following 'Action' mode exceedance. Sampling following two moderate river freshes in January 2010 indicated that *E. coli* numbers did not fall below the 'Alert' level until about 6 days after a fresh. After a larger fresh in late February 2010, numbers fell below 'Alert' levels about five to seven days later.

Although background *E. coli* numbers were moderate (i.e. > 120 per 100mls) for the majority of the sampling period, no exceedances of the guidelines were recorded during dry weather conditions (6 days or more after a river fresh).

3.2.12.2 Comparison with previous summers' surveys

No previous SEM sampling has been undertaken at this site. Therefore no statistical comparison can be made with previous data. The data for the Waitara River at the town wharf, Waitara site are summarised in Table 59 and illustrated in Figure 42 for this, the first season of monitoring.

Table 59 Summary *E. coli* bacteriological water quality data (nos/100ml) for summer surveys in the Waitara River at the town wharf, Waitara

Summer	09/10
Minimum	92
Maximum	1700
Median	230

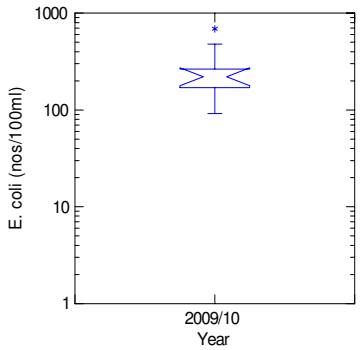


Figure 42 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers for the Waitara River at the town wharf, Waitara

A moderate median *E. coli* number was found by this first season's survey with a relatively wide range of counts found during the season due, in several cases, to the delayed effects of preceding freshes in this large, predominantly hill country catchment. 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.

3.2.13 Urenui River at the estuary

Bathing usage of this site was moderate (on four of the sampling surveys) with some usage apparent for other activities (eg boating, fishing, and picnicking) at this tidal site. This is a very popular site during weekends and holiday periods (see TRC, 1999 and TRC, 2008a).

Data from the site are presented in Table 60 and enterococci counts (as the site is predominantly seawater) illustrated in Figure 43, with a statistical summary provided in Table 61.

Table 60 Analytical results for the Urenui River at the estuary

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	1015	4680	<1	1	<1	16.4	6.7
17.12.09	0920	4570	4	<1	4	18.1	6.2
22.12.09	1115	4660	4	1	4	22.1	14
6.01.10	1215	4640	15	4	15	18.9	11
14.01.10	0945	4730	4	3	4	18.8	9.6
18.01.10	0940	4680	4	3	4	18.5	12
4.02.10	1110	4640	20	9	23	20.8	8.4
16.02.10	1105	4620	7	20	7	21.0	9.2
1.03.10	0940	4680	200	190	200	21.2	23
15.03.10	1020	4670	3	13	3	18.4	24
19.03.10	1000	4740	<1	13	<1	16.7	16
22.03.10	1140	4690	4	7	7	17.9	6.6
31.03.10	0920	4690	4	7	4	18.9	12

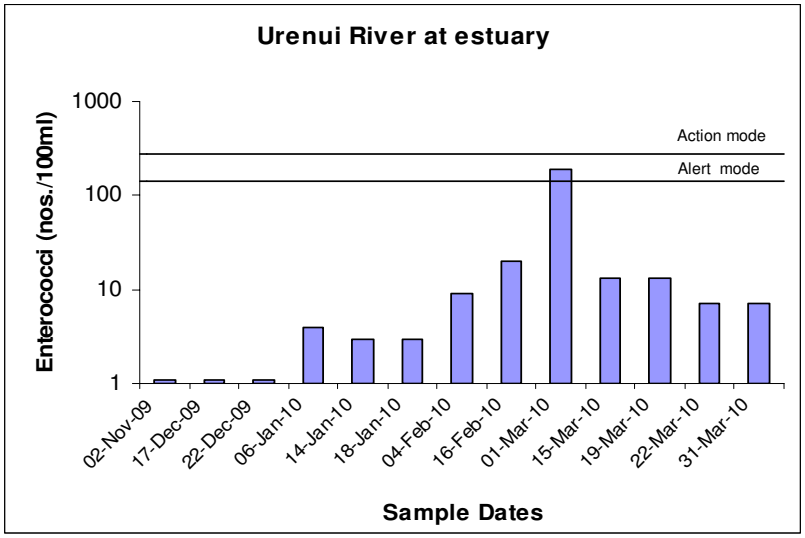


Figure 43 Enterococci numbers for the Urenui River at the estuary during the survey season

Table 61 Statistical results summary for the Urenui River at the estuary

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4470	4740	4680
E. coli	nos/100ml	13	<1	200	4
Enterococci	nos/100ml	13	<1	190	7
Faecal coliforms	nos/100ml	13	<1	200	4
Temperature	°C	13	16.4	22.1	18.8
Turbidity	NTU	13	6.2	24	11

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 caused marked aesthetic improvements within the estuary. Under high tide sampling conditions, the minimum (6.2 NTU) and median turbidity (11 NTU) levels were indicative of slightly to 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 greenish in appearance and relatively clear to slightly turbid. Conductivity levels were characteristic of coastal saltwater on all occasions. Relatively high water temperatures (median of 18.8°C), more typical of coastal seawater temperatures, varied over a relatively narrow range of 5.7°C during the sampling period with a maximum of 22.1°C recorded in late morning in late December 2009. All sampling however, was undertaken prior to 1220 hrs when water temperatures could have been expected to have been cooler than later in the day, dependent 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* [320 per 100 ml] and enterococci [150 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. One high enterococci count was recorded during the monitoring period.

No problems with dairy sheds' waste disposal practices were found during the season's annual inspection round.

3.2.13.1 Compliance with guidelines

Compliance with the 2003 guidelines for contact usage is summarised in Table 62 using the marine guidelines, which are considered to be more appropriate for this estuarine site.

Table 62 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
E. coli	1 [8]	0 [0]

(Designation: coastal contact recreational area)

One single sample fell within the 'Alert' mode but none within the 'Action' mode at any time during the monitoring period.

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 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: 5 per 100mls) monitored over six seasons to date.

3.2.13.2 Comparison with previous summers' surveys

A statistical comparison of each of the fourteen summers' survey data is presented graphically in Appendix V for all sites. These summer enterococci data for the Urenui River site at the estuary are summarised in Table 63 and illustrated in Figure 44.

Table 63 Summary of enterococci bacteriological water quality data (nos/100ml) for all summer surveys in the Urenui River estuary to date

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05-06	06/07	07/08	08/09	09/10
Minimum	<1	<1	<1	1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
Maximum	40	69	82	220	160	27	19	72	640	30	9	36	120	190
Median	5	7	3	8	14	8	4	4	5	4	1	2	11	7

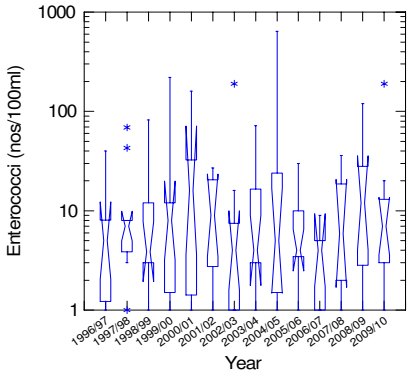
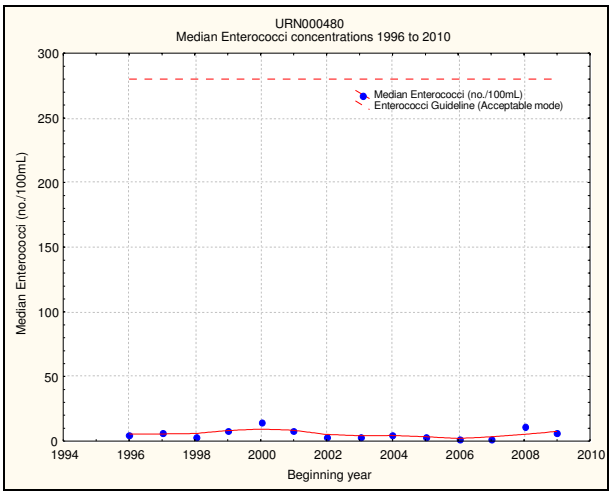


Figure 44 Box and whisker plots for all summer surveys of enterococci bacterial numbers in the Urenui River at the estuary

The high bacteriological water quality of the Urenui River estuary, during high tide conditions, was maintained during the 2009-2010 season (Figure 44) as emphasised by all seasonal median enterococci counts being less than 15 enterococci (per 100 mls). The range was moderate for enterococci during the 2009-2010 season as a result of one elevated single sample count during the period.

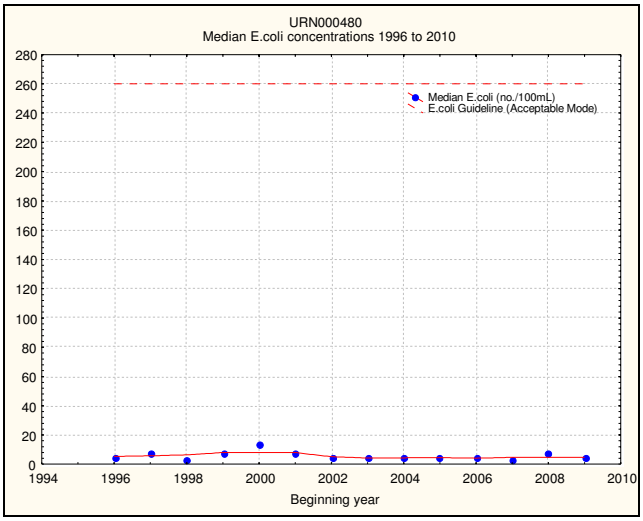
The high bacteriological quality of the coastal sea water intrusion was the major influence on the bacteriological water quality of the lower quality river water at this estuarine site during preferred recreational usage (ie, higher tide) conditions.

Trend analysis of median enterococci and *E. coli* numbers has been performed for the fourteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figures 44 and 45) 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 = 14
Kendall tau = - 0.125
p level = 0.533 [>FDR, p = 0.667]
N/S at p < 0.05

Figure 45 LOWESS trend plot of median enterococci (per 100ml) at the Urenui River, estuary site for the 1996 to 2010 period



N = 14
Kendall tau = - 0.201
p level = 0.318 [>FDR, p = 0.636]
N/S at p < 0.05

Figure 46 LOWESS trend plot of median *E. coli* (per 100ml) at the Urenui River, estuary site for the 1996 to 2010 period

No statistically significant trend in median enterococci or *E. coli* counts has been found over the fourteen seasons of monitoring. None of these medians exceeded the 'Alert' or 'Action' modes.

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

Minimal bathing (one occasion) and relatively limited 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.

Data from the site are presented in Table 64 and illustrated in Figure 47, with a statistical summary provided in Table 65. River flow records are illustrated in Figure 48.

Table 64 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* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	1100	9.8	150	14	150	14.2	1.0
17.12.09	0830	9.4	340	34	350	13.4	1.8
22.12.09	1030	9.9	180	31	190	15.9	1.0
6.01.10	1130	8.5	370	180	370	16.7	1.2
14.01.10	1040	9.2	150	28	150	16.6	0.9
18.01.10	0840	10.1	200	33	210	17.8	0.8
4.02.10	1015	9.5	210	130	240	20.4	1.0
16.02.10	1150	9.4	330	200	330	18.2	1.3
1.03.10	1110	9.2	260	300	270	19.2	0.7
15.03.10	1125	9.4	120	120	130	16.0	0.8
19.03.10	1230	9.4	92	63	92	15.1	0.8
22.03.10	1045	9.4	260	220	260	18.1	0.7
31.03.10	0820	9.2	96	140	100	13.8	1.5

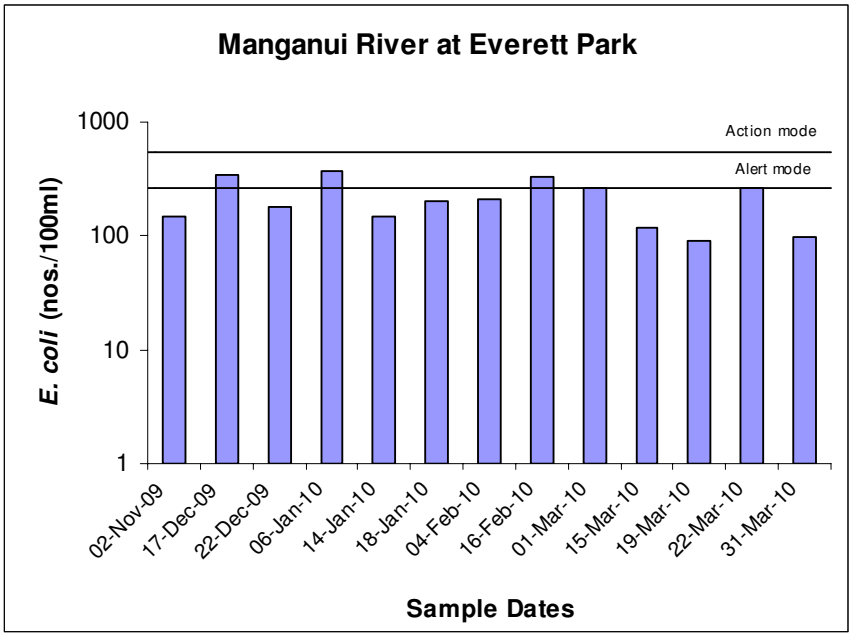


Figure 47 *E. coli* numbers for the Manganui River at Everett Park (downstream of the Kurapete Stream) during the survey season

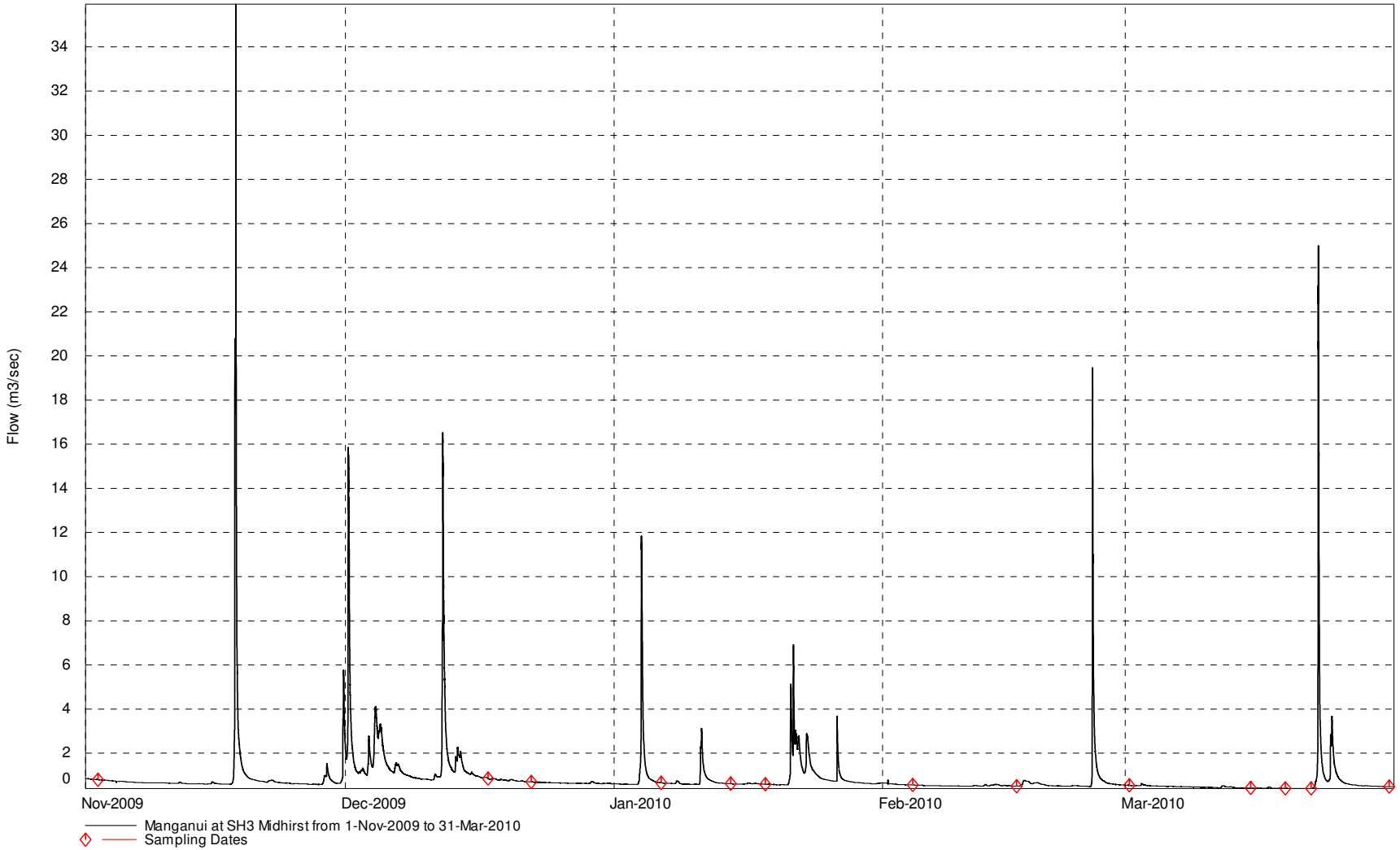


Figure 48 Flow in the Manganui River during the survey period (NOTE: This is all unaudited data from NIWA recorder site)

Table 65 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	8.5	10.1	9.4
E. coli	nos/100ml	13	92	370	200
Enterococci	nos/100ml	13	14	300	120
Faecal coliforms	nos/100ml	13	92	370	210
Temperature	°C	13	13.4	20.4	16.6
Turbidity	NTU	13	0.7	1.8	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 (approximately 8 km upstream of the survey site) have been diverted out of the Kurapete Stream to the New Plymouth wastewater treatment plant.

The river was clear and greenish at the time of all of the sampling surveys, with relatively low conductivity levels. Water temperatures varied over a moderate range of 7.0°C with the maximum temperature (20.4°C) recorded in mid morning in early February 2010. Higher temperatures could be expected later in the day as no sampling surveys were performed after 1230 hrs.

Bacteriological water quality was moderate for this site during the 2009-2010 survey period with all but two of the counts recorded during the period in excess of 100 *E. coli* per 100 mls (Figure 47). The elevated counts in December 2009, January and February 2010, which entered the 'Alert' level, followed localised rainfall some three days earlier. Levels decreased below the 'Alert' level gradually during the low flow conditions following each of these exceedances.

On-site dairy wastes disposal methods were generally satisfactory in the catchment above the site, although there were some concerns about occasional stock access to streams in the upstream catchment.

3.2.14.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 66.

Table 66 Bacterial guidelines performance at the Manganui River at Everett Park (upstream of Kurapete Stream) [% 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 fell in the 'Alert' mode but none reached the 'Action' mode during the season. All of these elevated counts were coincident with relatively recent localised rainfall prior to surveys.

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 (ie, significant abstraction of higher quality upper catchment water for hydroelectric power production purposes).

3.2.14.2 Comparison with previous summers' surveys

A statistical comparison of each of the fourteen summers' survey data is presented graphically in Appendix V for all sites. These summer data for the Manganui River site at Everett Park are summarised in Table 67 and illustrated in Figure 49.

Table 67 Summary of *E. coli* bacteriological water quality summary data (nos/100ml) for all summer surveys in the Manganui River at Everett Park to date

Summer	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Minimum	58	85	76	46	26	100	54	66	83	46	11	54	100	92
Maximum	690	2400	830	350	450	970	460	880	730	240	320	1200	480	370
Median	150	220	160	110	98	210	140	180	180	120	190	160	170	200

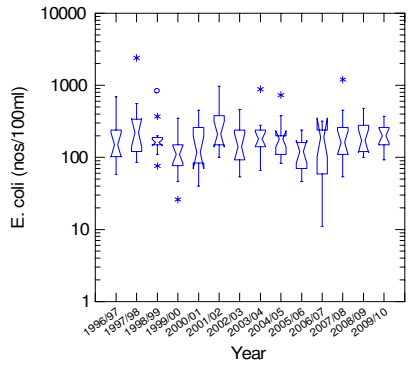
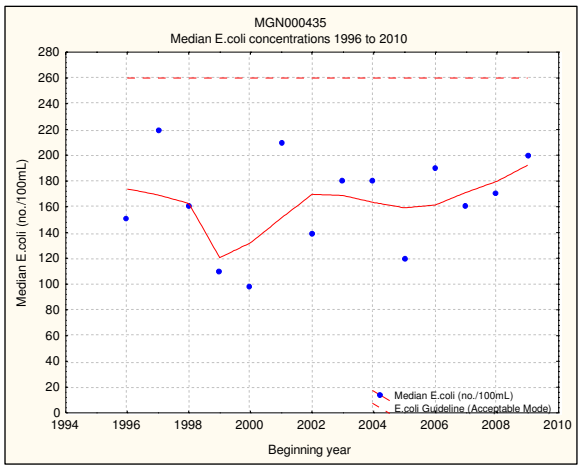


Figure 49 Box and whisker plots for all summer surveys of *E. coli* bacterial numbers in the Manganui River at Everett Park

The median *E. coli* count for the 2009-2010 season was within the range of the previous seasons' medians but the third highest of the range of median counts recorded within the fourteen seasons since the inception of the programme in 1996-97 (Figure 50). However the range of *E. coli* numbers was one of the narrowest recorded to date due to a moderate maximum count of 370 per 100 mls.

Trend analysis of these median *E. coli* numbers has been performed for the fourteen seasons of data by first applying a LOWESS fit (tension 0.4) to a time scatterplot of the median numbers (Figure 50) 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 = 14
Kendall tau = + 0.144
p level = 0.472 [>FDR, p= 0.667]
N/S at p< 0.05

Figure 50 LOWESS trend plot of median *E. coli* numbers (per 100ml) at the Manganui River, Everett Road site for the 1996 to 2010 period

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

3.2.15 Lake Ratapiko

Bathing usage of the lake was noted on only one occasion, although boating, waterskiing, kayaking, fishing, and picnicking activities were recorded at the time of other sampling surveys. The lake is commonly used for boating and fishing purposes, particularly at weekends and holidays. Ducks were present in moderate numbers on the lake as occasionally were shags.

The data for this site are presented in Table 68 and illustrated in Figure 51 with a statistical summary provided in Table 69.

Table 68 Analytical results for Lake Ratapiko

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
2.11.09	1120	7.7	19	1	19	15.2	1.3
17.12.09	0800	8.1	82	<1	82	17.6	1.8
22.12.09	1010	8.4	7	<1	7	18.6	1.5
6.01.10	1105	7.6	91	8	95	19.7	2.3
14.01.10	1215	7.4	19	9	19	21.3	1.5
18.01.10	0815	7.4	8	1	8	18.8	1.5
4.02.10	0945	7.1	16	16	16	22.2	1.6
16.02.10	1210	7.7	4	7	5	20.8	1.9
1.03.10	1140	8.0	7	140	7	22.8	1.8
15.03.10	1145	8.2	33	290	33	20.3	3.3
19.03.10	1300	8.6	8	290	9	19.1	2.9
22.03.10	1030	8.5	75	960	75	18.6	3.2
31.03.10	0805	8.3	4	260	4	17.9	1.9

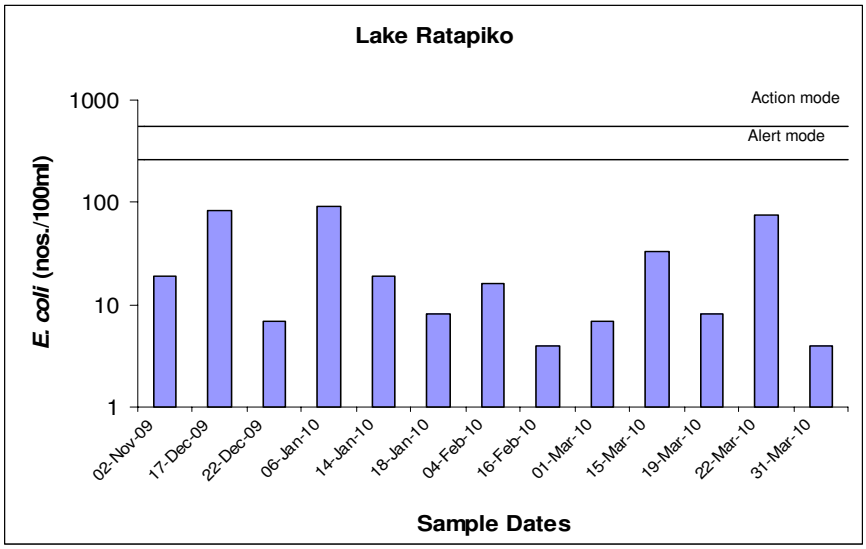


Figure 51 *E. coli* numbers for Lake Ratapiko during the survey season

Table 69 Statistical results summary for Lake Ratapiko

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	7.1	8.6	8.0
E. coli	nos/100ml	13	4	91	16
Enterococci	nos/100ml	13	1	960	9
Faecal coliforms	nos/100ml	13	4	95	16
Temperature	°C	13	15.2	22.8	19.1
Turbidity	NTU	13	1.3	3.3	1.8

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 variations in clarity (median turbidity: 1.8 NTU; range of turbidity: 2 NTU) as a result of low suspended algae populations possibly due to short retention times. Water temperatures were moderate ranging over 7.6˚C for the period with a moderately high maximum of 22.8˚C (near midday in early March 2010) although all measurements were recorded prior to 1305 hrs. Conductivity showed minimal variation during the period.

Generally bacteriological quality was very good considering that the inflow to the lake is from the mid reaches of a river draining a developed farmland catchment. No counts exceeded 95 *E. coli* per 100 mls despite the low summer-autumn flow conditions. However, a marked increase in enterococci numbers was recorded in the lake later in the season coincident with a shut-down of the HEP scheme i.e. increasing the residence time of the lake.

3.2.15.1 Compliance with guidelines

Compliance with the 2003 guidelines for freshwater contact usage is summarised in Table 70.

Table 70 Bacterial guidelines performance at Lake Ratapiko [% 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 sample exceedances of the 'Action' mode occurred and no samples were recorded within the 'Alert' mode during the entire period.

3.2.15.2 Comparison with previous summers' surveys

A statistical comparison of all sites' summers' *E. coli* survey data is presented graphically in Appendix V for all sites. Data from the four summer surveys for the Lake Ratapiko site are summarised in Table 71 and illustrated in Figure 52.

Table 71 Summary of *E.coli* bacteriological water quality data (nos/100ml) for all summer surveys at Lake Ratapiko to date

Summer	06/07	07/08	08/09	09/10
Minimum	1	1	5	4
Maximum	86	120	220	91
Median	21	16	35	16

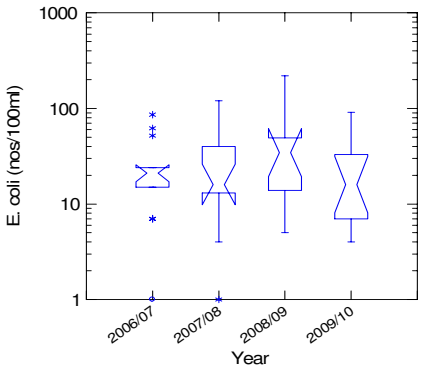


Figure 52 Box and whisker plots for all summer SEM surveys of *E.coli* bacteria numbers at Lake Ratapiko

A low median *E. coli* number was found by the latest season's survey and a relatively narrow range of counts was recorded. All seasonal medians have been low, however. Trend analysis of median *E. coli* numbers will not be performed for this site until ten seasons' data are available.

3.2.15.3 Cyanobacteria

There was no visual evidence of any nuisance algal blooms during the survey period. Microscopic scans of samples collected on eight sampling occasions were performed and found no cyanobacteria species present at any time of the season. Results of these analyses are presented in Table 72.

Table 72 Cyanobacteria counts (cells /ml) for Lake Ratapiko [Health warning: >15,000 cells /ml]

Date	Cyanobacteria total cell count (cells/ml)
26.11.09	nil
10.12.09	nil
12.01.10	nil
26.01.10	nil
09.02.10	nil
23.02.10	nil
09.03.10	nil
26.03.10	nil

No cyanobacteria were detected in any of the samples. None had been found in this lake during the 2006-2007 or 2008-2009 seasons, but low numbers of *Anabaena* had been present in the latter part of the 2007-2008 season following a lengthy, extremely low flow period. The relatively short lake water residence time (due to hydroelectric power generation usage) may be a factor in the control of these bacteria populations.

3.2.16 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. 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 2009-2010 season, with the lake visited on 10 occasions between mid November 2009 and late March 2010. [Note: Bacteriological monitoring is not a component of the SEM programme at this lake].

Usage of the lake included walkers (visitors) and picnicking throughout the season and boating and jet-skiing prior to closure of the lake for boating (and water-based recreation) due to high cyanobacteria levels (see beneath) in late January 2010. Ducks were noted from time to time on the lake which appeared murky to quite turbid, greenish-brown throughout most of the period before improving toward relatively clear, greenish at the end of March 2010.

The bacteriological water quality data for this site are presented in Table 73 with a statistical summary provided in Table 74.

Table 73 Analytical results for Lake Rotokare

Date	Time	Conductivity @ 20°C	Bacteria			Temperature	Turbidity
	(NZST)	(mS/m)	*E. coli* (nos/100ml)	Enterococci (nos/100ml)	Faecal coliforms (nos/100ml)	(°C)	(NTU)
19.11.09	1350	12.1	13	4	13	15.9	2.5
10.12.09	1315	11.9	12	4	12	20.7	1.8
21.12.09	1030	11.8	3	3	4	19.4	1.7
12.01.10	1300	-	-	-	-	20.9	-
19.01.10	0830	12.4	<1	<1	<1	21.6	26
26.01.10	1320	12.9	11	180	11	20.9	28
8.02.10	1010	11.2	<1	1	<1	22.7	21
23.02.10	0830	11.3	<1	4	<1	21.6	8.0
09.03.10	0845	11.6	7	5	7	19.7	10
26.03.10	0800	11.2	<1	7	<1	-	3.2

Table 74 Statistical results summary for Lake Rotokare

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	9	11.2	12.9	11.8
E. coli	nos/100ml	9	1	13	3
Enterococci	nos/100ml	9	1	180	4
Faecal coliforms	nos/100ml	9	1	13	4
Temperature	°C	9	15.9	22.7	20.9
Turbidity	NTU	9	1.7	28	8.0

In general, bacteriological water quality was very good, as might be expected for a small, bush clad lake with only small inflows and relatively low wild fowl numbers. Conductivity levels were very stable (1.7 mS/m range) through the period emphasising minimal variation in inflow during the season, while water temperatures varied over a moderate range of 6.8˚C with a maximum of 22.7˚C recorded in early February 2010. Turbidity was moderately high (median: 8.0 NTU) with the range (26 NTU) reflecting the variability in abundances of suspended algae in the water column during the season. Maximum turbidity (28 NTU) was coincidental with the peak in cyanobacteria concentration in late January 20101.

No bacterial counts approached or entered the 'Alert' or 'Action' levels on any occasion during the season although it should be noted that the overriding health warnings on both the Regional Council and Area Health Board's websites and on site at the lake related to cyanobacteria level exceedances of guidelines (see below).

3.2.16.1 Cyanobacteria

Microscopic scans of 11 samples during the recreational monitoring period found a low cyanobacteria population in November 2009 but high concentrations present throughout the period from late December 2009 to mid March 2010. The results of these analyses are presented in Table 75 and illustrated in Figure 53.

Table 75 Cyanobacteria counts (cells/ml) for Lake Rotokare [Health warning: > 15,000 cells /ml]

Date	Cyanobacteria total cell count (cells/ml)	Principal species
9.07.09	2350	*Anabaena*
19.11.09	650	*Anabaena*
27.11.09	nil	-
10.12.09	7150	*Anabaena*
21.12.09	12,550	*Anabaena*
12.01.10	66,700	*Anabaena*
19.01.10	105,900	*Anabaena*
26.01.10	202,250	*Anabaena*
8.02.10	210,650	*Anabaena*
23.02.10	45,900	*Anabaena*
09.03.10	63,550	*Anabaena*
26.03.10	8,650	*Anabaena*
10.05.10	7,050	*Anabaena*

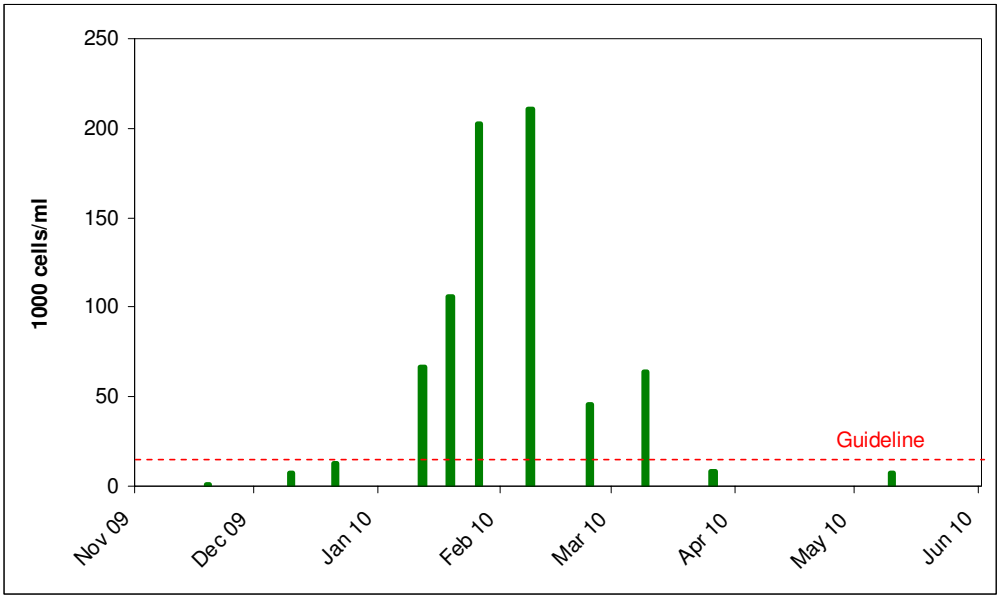


Figure 53 Cyanobacteria counts (cells/ml) at Lake Rotokare [Health warning: >15,000 cells/ml]

Low counts of *Anabaena* found in the lake in November 2009 did not necessitate installation of a blue-green algal hazard warning sign by the STDC upon advice from the Taranaki Area Health Board. Increasing counts exceeded the health guideline [15,000 cells/ml] by mid-January 2010 at which time STDC erected signage at the lake but did not padlock the boatramp. *Anabaena* concentrations increased through later summer reaching a peak of about 211,000 cells/ ml in early February 2010 before decreasing gradually through February-March 2010 with no occurrence of the *Microcystis* bloom which had been found toward the end of the 2007-2008 season.

Warning signage was displayed adjacent to the boatramp from mid January 2010 and then throughout the remainder of the season but, although no primary contact recreational usage of the lake was recorded at the time of late sampling surveys, recreational use of the lake was possible as the boat ramp remained open. Potential water-based users were re-directed to Lake Rotorangi, some 10 km further to the east of Lake Rotokare.

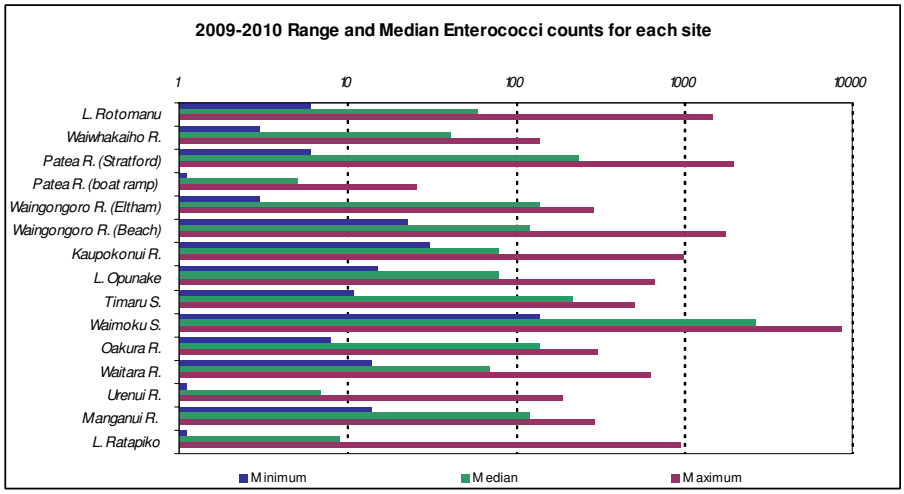
A post season survey in mid May 2010 found a small decrease in counts to approximately 7,000 cells/ml all of which were *Anabaena.*

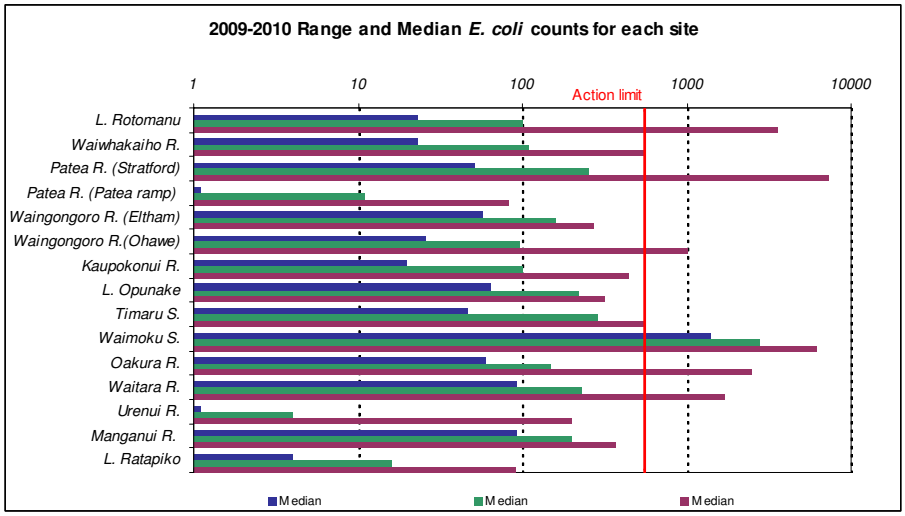
4. General data summary

A comparative summary of results of the fourteenth summer bacteriological quality freshwater survey involving fifteen contact recreational sites in the Taranaki region is provided in Table 76. Results are also illustrated in Figure 54 for each of the bacteriological species and a comparison of all sites' summer data is presented in Appendix V in the form of statistical 'box and whisker' plots.

Table 76 Statistical summary of results for the sites sampled in the SEM freshwater contact recreational water quality survey, 2009-2010

Site		Temperature (°C)	Conductivity @ 20°C (mS/m)	Faecal coliforms (nos/100 ml)	E. coli (nos/100 ml)	Enterococci (nos/100 ml)	Turbidity (NTU)
Lake Rotomanu	Median	21.3	13.5	110	100	60	3.0
	Minimum	17.0	12.5	23	23	6	1.5
	Maximum	26.5	14.0	36	3600	1500	5.6
	No. of samples	13	13	13	13	13	13
Waiwhakaiho River at Merrilands Domain	Median	17.0	11.8	120	110	41	0.8
	Minimum	13.9	10.0	23	23	3	0.5
	Maximum	22.2	14.1	620	570	142	1.2
	No. of samples	13	13	13	13	13	13
Patea River at King Edward Park, Stratford	Median	15.4	9.1	260	250	240	0.9
	Minimum	12.2	8.4	51	51	6	0.7
	Maximum	17.0	9.7	7400	7400	2000	2.0
	No. of samples	13	13	13	13	13	13
Patea River at boatramp, Patea	Median	18.2	4650	12	11	5	20
	Minimum	14.9	820	1	1	<1	8.8
	Maximum	20.7	4740	84	82	26	32
	No. of samples	13	13	13	13	13	13
Waingongoro River at Eltham camp	Median	17.4	11.5	160	160	140	1.4
	Minimum	13.3	10.7	60	57	3	1.2
	Maximum	20.8	11.9	270	270	290	1.6
	No. of samples	13	13	13	13	13	13
Waingongoro River at Ohawe Beach	Median	19.6	19.2	100	96	120	2.6
	Minimum	14.1	18.0	26	26	23	1.6
	Maximum	22.4	283	1000	1000	1800	4.2
	No. of samples	13	13	13	13	13	13
Kaupokonui River at beach domain	Median	20.3	16.6	100	100	80	2.2
	Minimum	14.4	14.5	20	20	31	1.4
	Maximum	22.9	202	440	440	1000	7.4
	No. of samples	13	13	13	13	13	13
Lake Opunake adjacent to boat ramp	Median	19.5	13.5	220	220	80	1.4
	Minimum	13.4	12.9	68	64	15	0.9
	Maximum	23.8	14.4	320	320	670	1.9
	No. of samples	13	13	13	13	13	13
Timaru Stream at Weld Road (near mouth)	Median	15.1	23.5	310	290	220	0.5
	Minimum	12.8	8.7	46	46	11	0.4
	Maximum	20.4	96.3	560	560	510	1.0
	No. of samples	13	13	13	13	13	13
Waimoku Stream at Oakura Beach	Median	15.1	15.1	3200	2800	2700	3.8
	Minimum	12.8	13.9	1400	1400	140	2.5
	Maximum	18.4	16.0	6900	6200	8700	6.8
	No. of samples	13	13	13	13	13	13
Oakura River d/s of SH45 bridge	Median	15.9	8.8	150	150	140	0.5
	Minimum	12.9	7.6	60	60	8	0.4
	Maximum	22.0	62.3	2500	2500	310	0.7
	No. of samples	13	13	13	13	13	13
Waitara River at town wharf,Waitara	Median	18.1	564	240	230	71	9.5
	Minimum	14.6	319	92	92	14	3.9
	Maximum	20.3	1170	1700	1700	640	130
	No. of samples	13	13	13	13	13	13
Urenui River at estuary	Median	18.8	4680	4	4	7	11
	Minimum	16.4	4470	<1	<1	<1	6.2
	Maximum	22.1	4740	200	200	190	24
	No. of samples	13	13	13	13	13	13
Manganui River d/s of Kurapete S. (Everett Park)	Median	16.6	9.4	210	200	120	1.0
	Minimum	13.4	8.5	92	92	14	0.7
	Maximum	20.4	10.1	370	370	300	1.8
	No. of samples	13	13	13	13	13	13
Lake Ratapiko at boat ramp	Median	19.1	8.0	16	16	9	1.8
	Minimum	15.2	7.1	4	4	1	1.3
	Maximum	22.8	8.6	95	91	960	3.3
	No. of samples	13	13	13	13	13	13





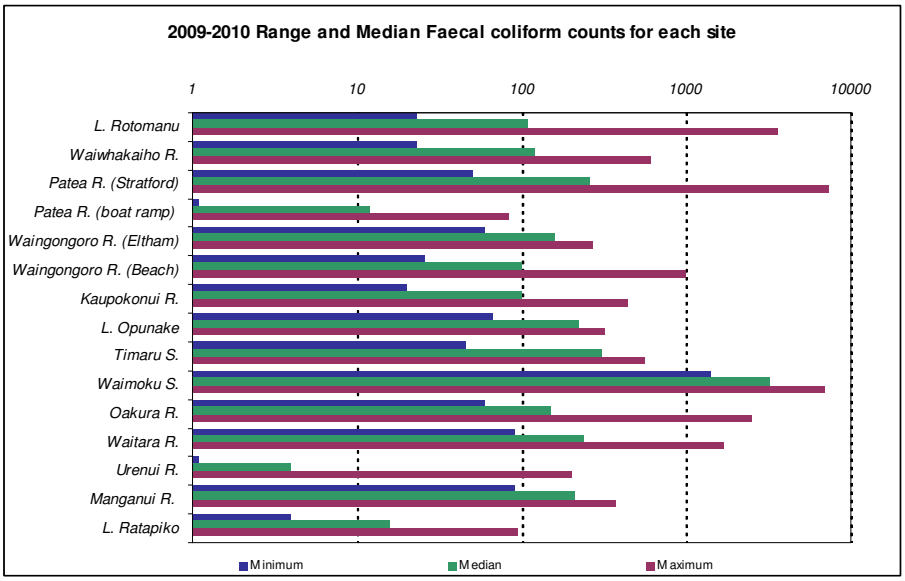


Figure 54 Ranges and medians of bacteria numbers recorded from all sites by the SEM programme over the 2009-2010 survey season

Compliance with the 2003 guidelines has varied at the fifteen freshwater contact recreational sites sampled during the survey period (Figure 54 and Table 77). In relation to the guidelines, only one site (Waimoku Stream at Oakura beach) regularly failed to meet the *E. coli* 'Action' guideline suitable for contact recreation. In terms of median *E. coli* counts, this was also the only site with the median count in the 'Action' (>550 *E. coli* per 100mls) mode, whereas no other sites had median counts in the 'Action' or 'Alert' modes.

Table 77 Number of occasions single sample *E.coli* counts entered the 'Alert' and 'Action' modes

Site	'Alert' mode	'Action' mode
Lake Rotomanu at western beach	1	3
Waiwhakaiho River at Merrilands Domain	0	1
Patea River at King Edward Park, Stratford	4	2
Patea River at boatramp, Patea	0	0
Waingongoro River at Eltham Camp	1	0
Waingongoro River at Ohawe Beach	0	1
Kaupokonui River at beach domain	2	0
Lake Opunake at boat ramp	5	0
Timaru Stream at Weld Road	6	1
Waimoku Stream at Oakura Beach	0	13
Oakura River at SH45	4	1
Waitara River at town wharf, Waitara	2	3
Urenui River at estuary*	1	0
Manganui River at Everett Park	3	0
Lake Ratapiko at boat ramp	0	0

[Notes: N = 13 samples; * = enterococci count]

Only two sites maintained counts below the 'Alert' mode at all times throughout the season, while five other sites maintained counts below the 'Action' mode (Table 77) at all times. In terms of the overall monitoring season, twenty-nine 'Alert' levels (15% of counts) and twenty-five 'Action' levels resulted over the period representing an overall 72% compliance with contact recreational guidelines.

Overall a range from poor to good bacteriological water quality was measured at the fifteen sites influenced to some extent during a relatively dry late summer-autumn period. Similar results have been recorded elsewhere for sites in the middle and lower reaches of other streams and rivers in New Zealand (Deely et al, 1997 and MfE, 2008). 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, Lake Ratapiko, and at the most estuarine site (Urenui River) which was strongly influenced by seawater penetration during high tide conditions. 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. Waingongaro River at Ohawe Beach
5= Kaupokonui River at beach domain
5= Lake Rotomanu
7. Waiwhakaiho River at Merrilands Domain
8. Oakura River d/s of SH 45 bridge
9. Waingongoro River at Eltham camp
10. Manganui River at Everett park (d/s of Kurapete Stream)
11. Lake Opunake at boat ramp
12. Waitara River at town wharf, Waitara
13. Patea River at King Edward Park, Stratford
14. Timaru Stream at Weld Road (near mouth)
15. Waimoku Stream at Oakura beach

The largest improvement in ranking, in comparison with the 2008-2009 season, occurred at the Kaupokonuio River (at beach) and Lake Rotomanu sites while the two lowest rankings remained the same. However, the Patea River at Stratford slipped furthest down in the rankings where it was ranked third lowest in terms of seasonal median bacteriological water quality and the newly established Waitara River (at Waitara township) was ranked fourth to lowest.

4.1 Comparison with thirteen previous summers' surveys

A statistical comparison of each summer's survey *E. coli* data is presented graphically in Appendix V for all sites. Shorter data periods exist for the Waimoku Stream at Oakura beach which was included in the programme in 1999-2000 for the first time, 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, and the site in the lower Waitara River which was added in the current season.

In general terms, *E. coli* bacteriological water quality remained within ranges similar to, or narrower than, those recorded over previous summer bathing seasons, with some deterioration at four sites and improvement at two sites in terms of median counts, in comparison with the previous summers' results. Variability in quality between bathing seasons at each site relates to a variety of reasons including hydrological conditions, stock access, wildlife presence and dairy farm wastes disposal practices in particular.

Trending of season's median *E.coli* counts at each site, with a minimum of ten years' data, was undertaken statistically for the period 1996 to 2010. Only three sites showed statistically significant ($p < 0.05$) trends in median *E.coli* counts and the two of these sites which were significant after FDR were:

- Oakura River below the SH45 bridge had a strong trend of increasing median *E.coli* numbers over the fourteen year period to date which was significant at $p < 0.01$ after FDR application.

- Waimoku Stream at Oakura beach had a strong trend of increasing median *E. coli* numbers over the eleven year period to date which was significant at p<0.01 after FDR application.

The Oakura River site's seasonal median *E.coli* counts did not approach contact recreational 'Alert' (or 'Action') guidelines whereas all seasonal median counts at the Waimoku Stream site were in the 'Action' mode. A ranking of the order of the significance of the temporal trends at those sites with a minimum of ten seasons' data (eight sites) is provided in Table 78.

Table 78 Ranking of sites in terms of significant temporal trends in median *E.coli* counts over the period 1996 to 2010 [significant at p< 0.05 and p<0.01]

Site	Location	Valid N	p-level	FDR-corrected p value	Trend
Oakura River	d/s SH45 bridge	14	<0.0003	0.0023	↑↑↑
Waimoku Stream	Oakura Beach	11	0.0005	0.0023	↑↑↑
Waingongoro River	Ohawe Beach	14	0.022	0.072	↓↓
Lake Rotomanu	Western beach	14	0.055	0.138	↑↑
Urenui River	Urenui estuary	14	0.318	0.636	↓
Manganui River	Everett Park	14	0.472	0.667	↑
Timaru Stream	End of Weld Road	13	0.412	0.667	↑
Waiwhakaiho River	Merrilands Domain	14	0.702	0.780	↑
Kaupokonui River	Beach Domain	14	0.824	0.824	↓

In summary, two sites have shown a significant (increasing) temporal trend in seasonal median *E. coli* counts. The other insignificant trends indicate gradual improvement (three sites) or deterioration (four sites) in seasonal median *E. coli* counts. None of these seasonal median counts at the sites with insignificant temporal trends have reached 'Alert' or 'Action' modes at any time.

4.2 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. 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 Regional Council's website. All sites' results were displayed on this website throughout the 2009-2010 survey period and every instance of exceedance of standards was advised to the appropriate authorities. Follow-up investigations indicated that few issues with dairy wastes disposal systems contributed to the elevated counts in receiving waters. In most cases, mainly at lakes, wildfowl contamination was responsible, particularly where public feeding

of ducks and geese encouraged large numbers of birds at recreational sites. Some isolated instances were related to localised rainfall and on a few occasions, particularly during lengthy low flow periods, stock access problems were apparent (Photo 2), although cumulative impacts of consented wastewater discharges may have contributed.

Photo 2 An issue for recreational water quality: stock access to waterways particularly during late summer low flow periods

In particular sub-catchments, appropriate publicity and timing of the annual round of dairy inspections could assist with mitigation of these effects. Regular reviews of the sites' grading system will be performed and maintenance of the programme of increased sampling frequency (20 samples per season) will continue at the two principal freshwater contact recreation usage sites. Cyanobacteria monitoring will also continue at designated sites (at a slightly lesser frequency to the bacteriological monitoring)..

5. Recommendations

As a result of the 2009-2010 summer freshwater contact recreation bacteriological survey it is recommended that:

1. THAT the 2010-2011 survey be performed at fifteen 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 2010-2011 survey includes an additional seven samples collected at the two principal usage sites (Lake Rotomanu and Waiwhakaiho River at the Merrilands Domain) in accordance with MfE, 2003 guidelines.
3. THAT the 2010-2011 summer survey includes cyanobacteria monitoring at the three lake sites, Lake Rotokare, and an additional principal river usage site (Waiwhakaiho River at Merrilands Domain).
4. THAT follow-up sampling be performed as 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 reporting of results be performed as appropriate during the season, and in an Annual Report upon completion of the season's programme.
7. THAT the appropriate statistical trend detection procedures be applied to the data and reported in the Annual Report

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Taranaki Regional Council, 2009b: South Taranaki District Council Waverley, Kaponga, Manaia and Patea Municipal Oxidation Ponds Systems Monitoring Programmes Annual Report 2008-2009. Technical Report 2009-44.

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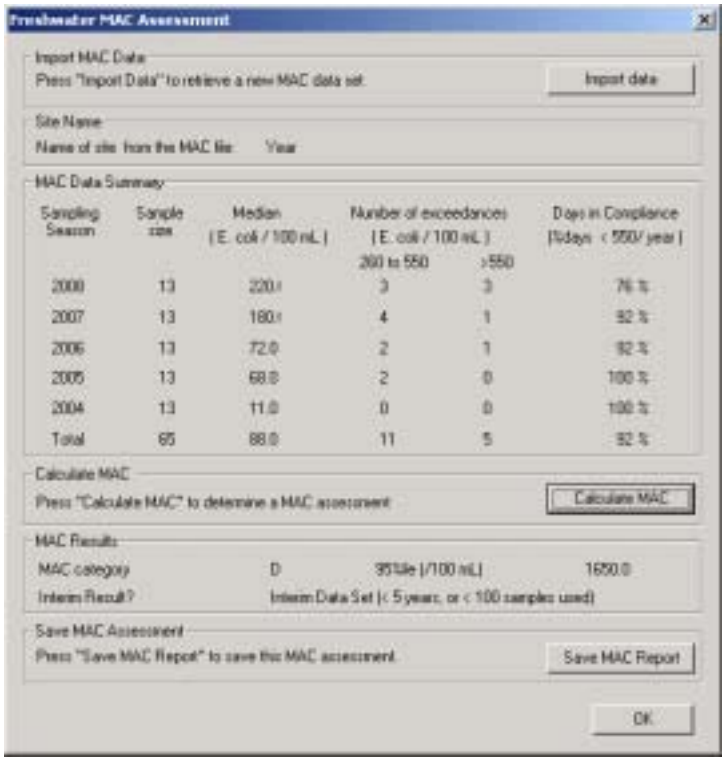
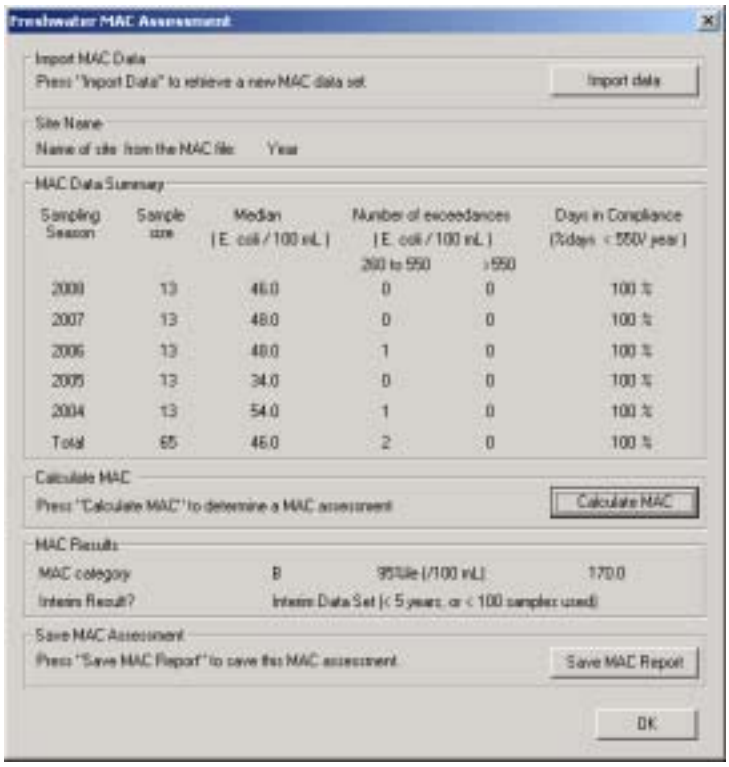
Appendix I

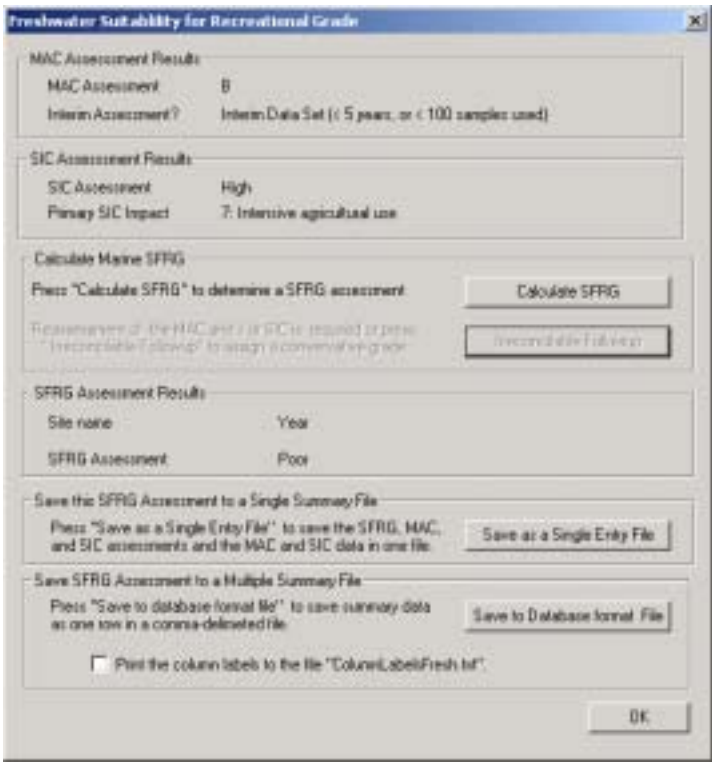
MAC assessments for all sites

Lake Rotomanu

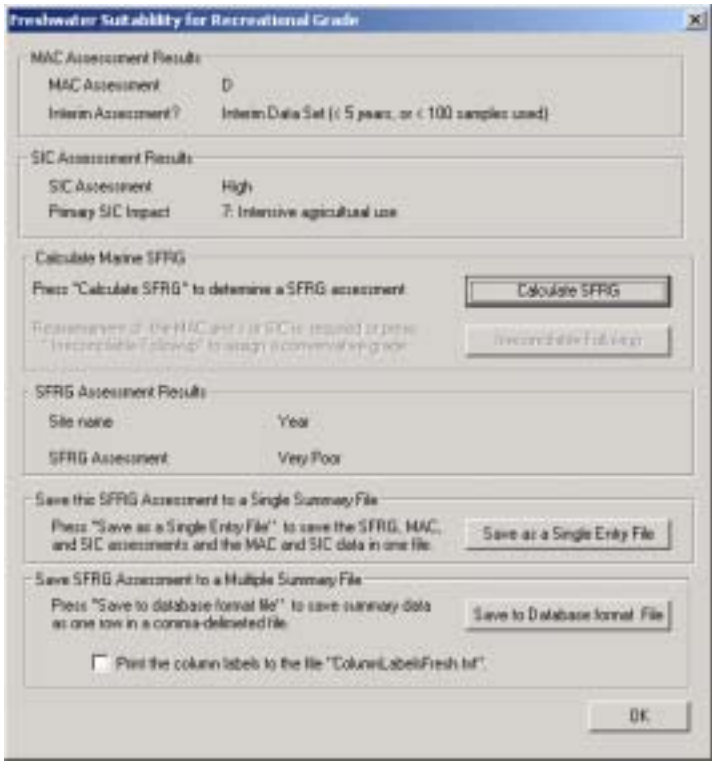


Waiwhakaiho River at Merrilands Domain

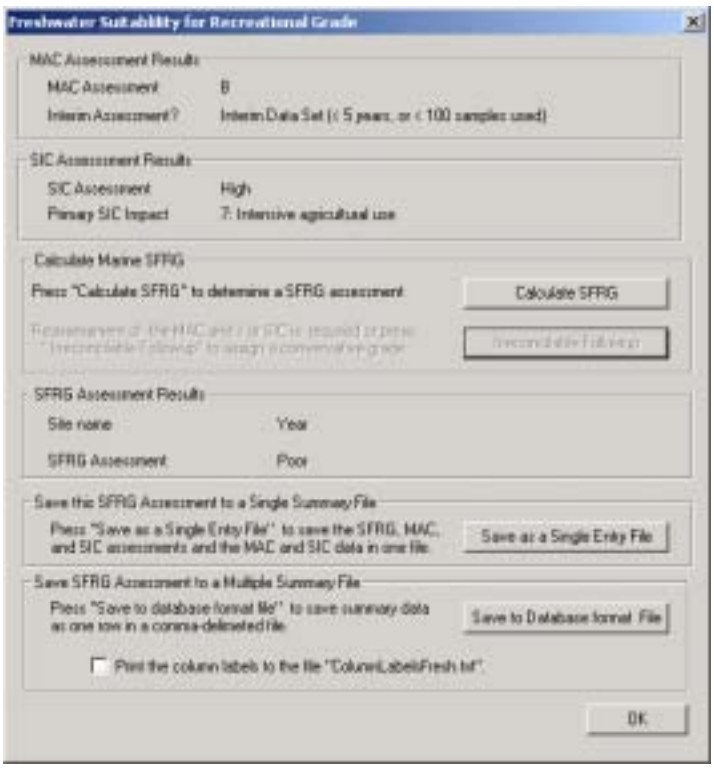


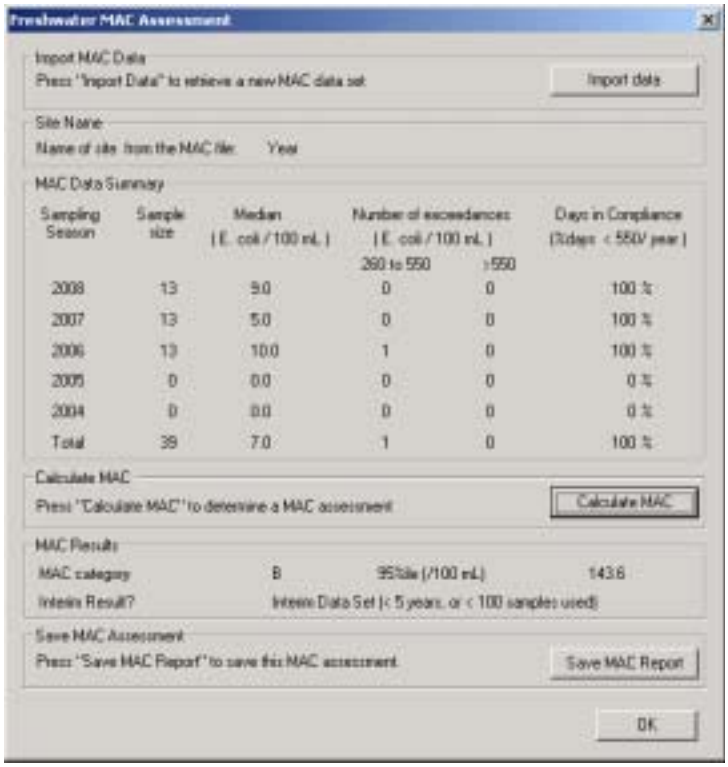


Patea River at Stratford

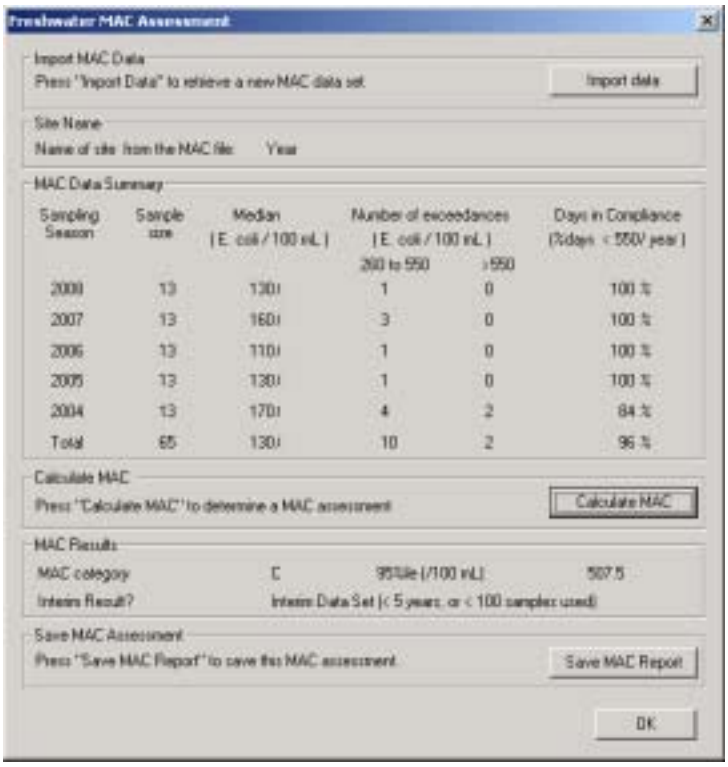


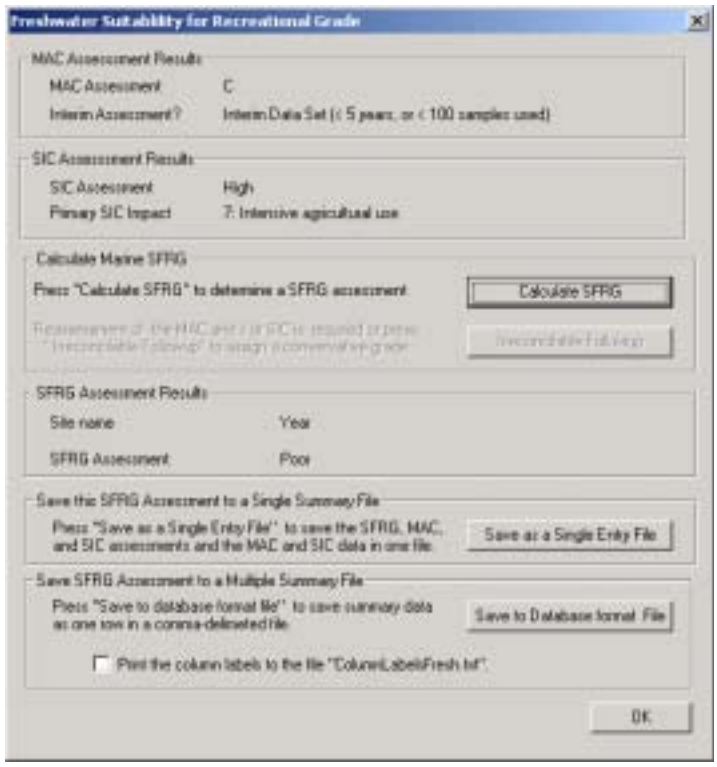
Patea at boat ramp, Patea





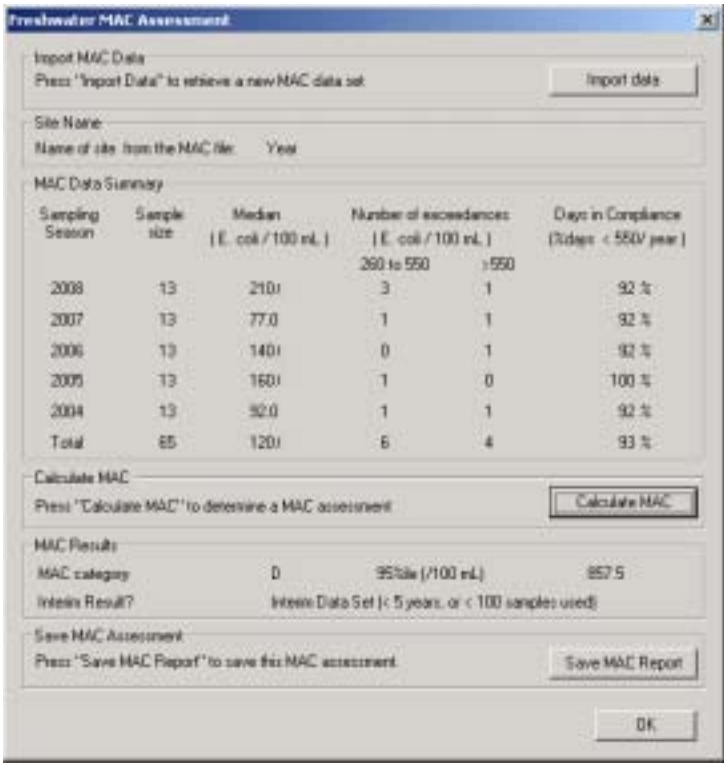
Waingongoro River at Eltham camp



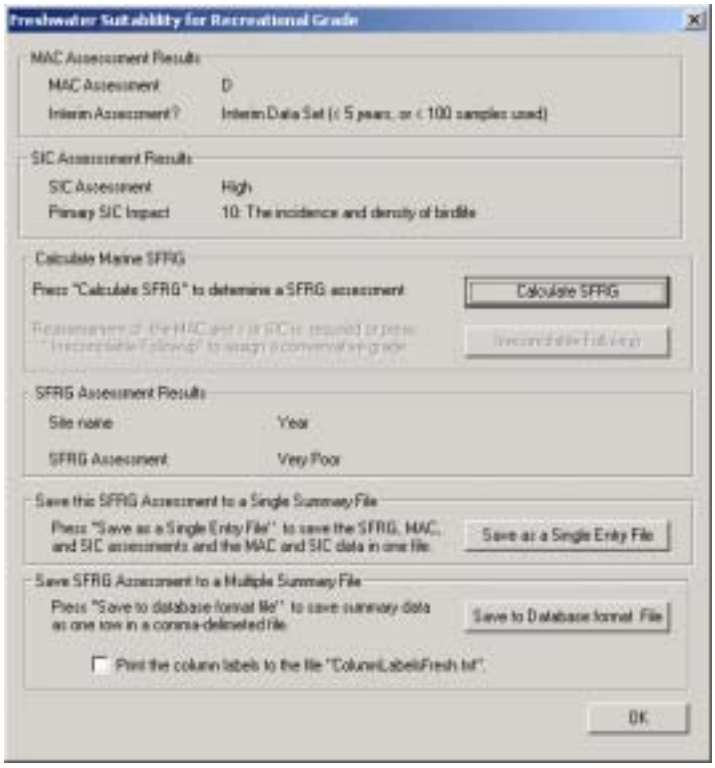


Waingongoro River at Ohawe beach

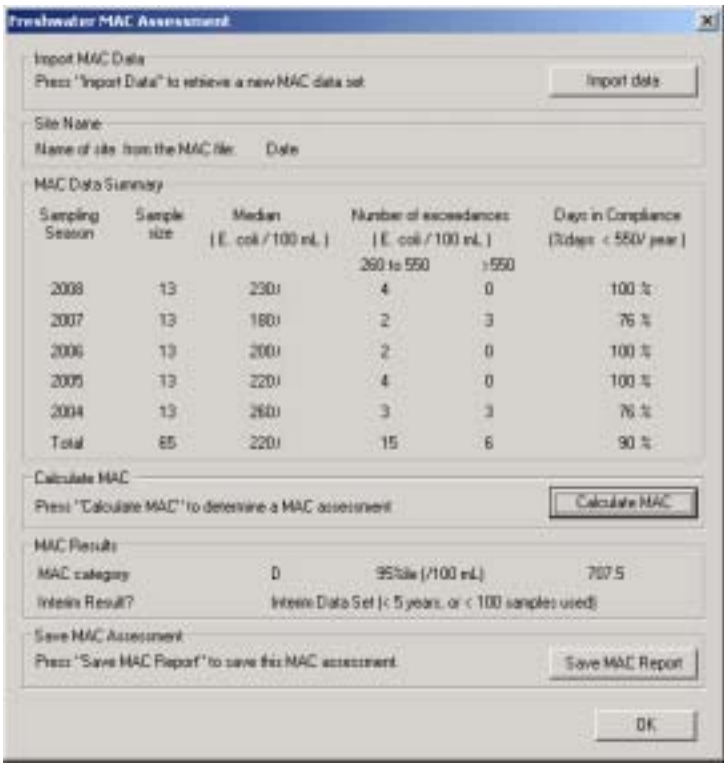
Kaupokonui River at beach domain



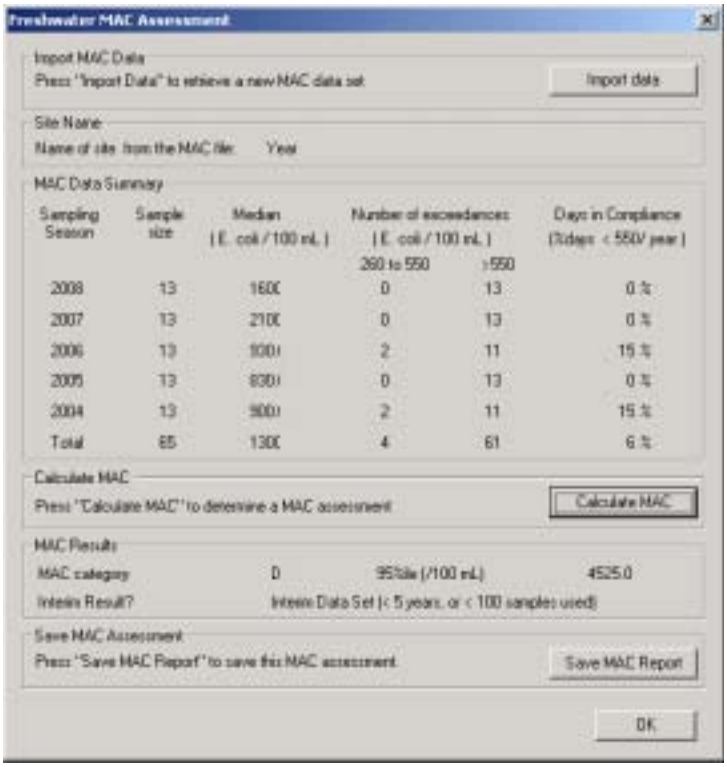
Lake Opunake



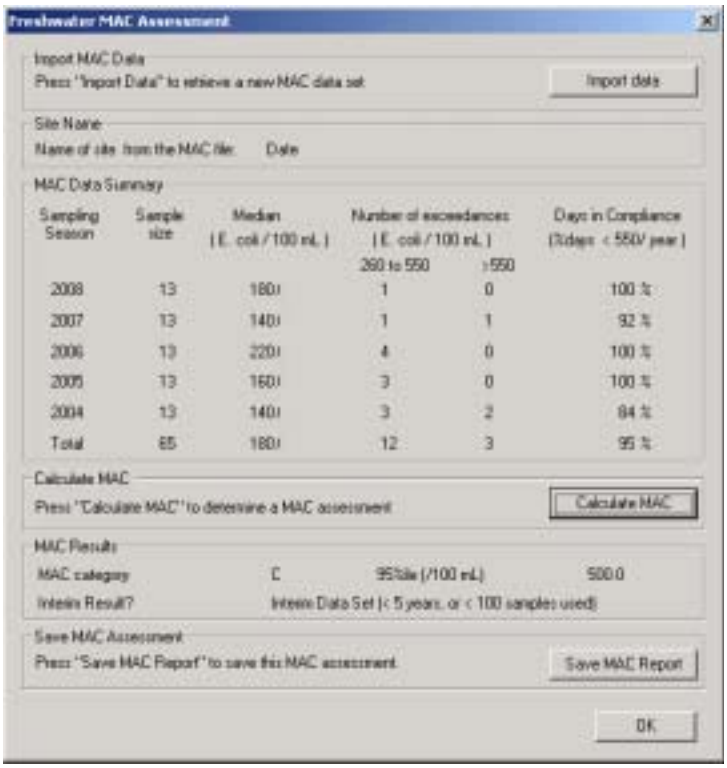
Timaru Stream at Weld Road

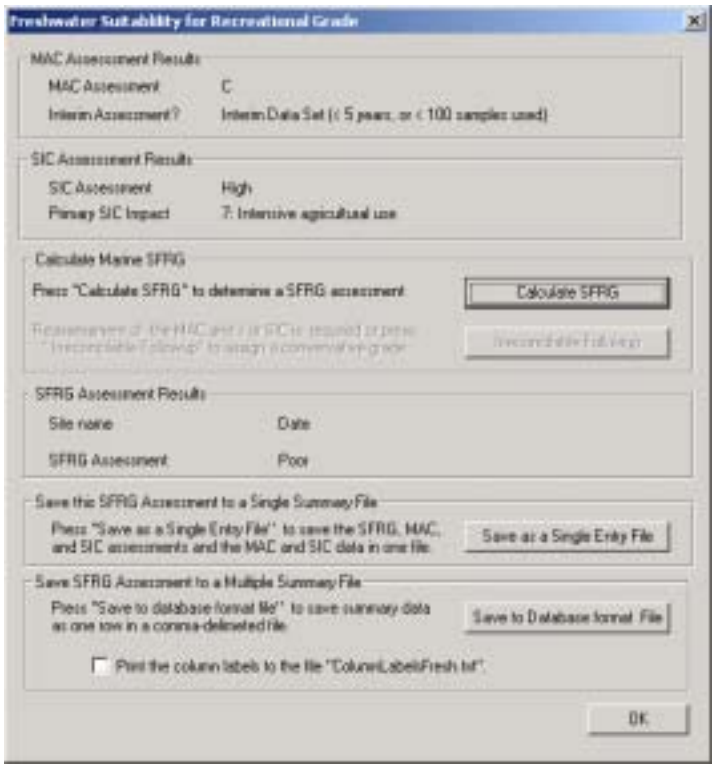


Waimoku Stream at Oakura beach

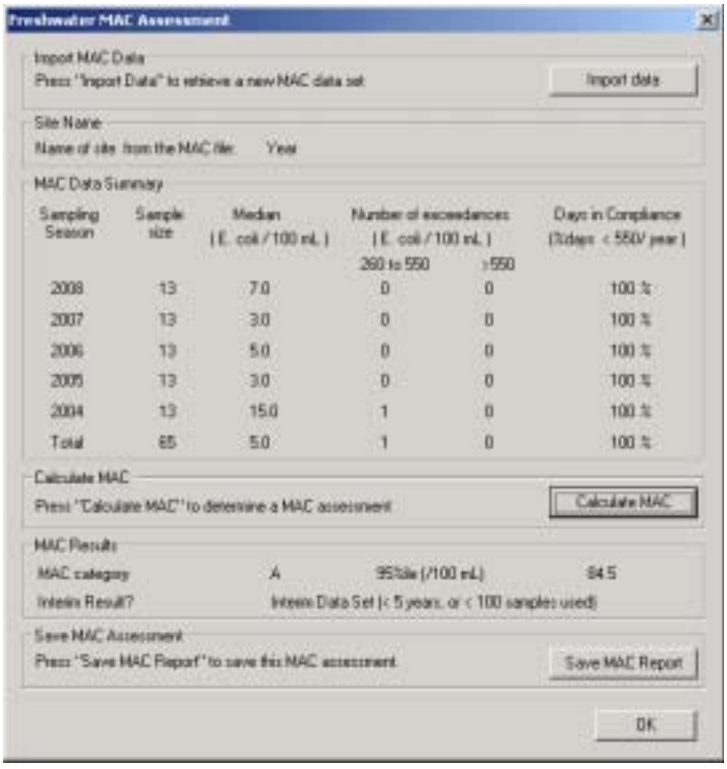


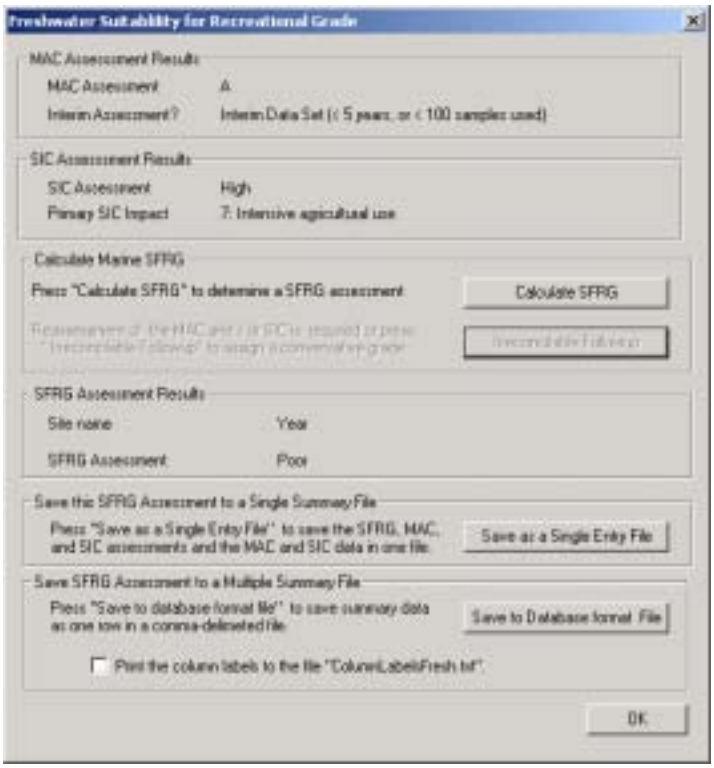
Oakura River d/s SH 45





Urenui River at estuary





Manganui River at Everett Park

Lake Ratapiko

Appendix II

High tide times

High tide times (NZST) at New Plymouth for 2009-2010 sampling dates

Date		Time of HT
Monday	22 November 2009	0902
Thursday	17 December 2009	1007
Tuesday	22 December 2009	1311
Wednesday	6 January 2010	1358
Thursday	14 January 2010	0916
Monday	18 January 2010	1132
Thursday	4 February 2010	1330
Tuesday	16 February 2010	1105
Monday	1 March 2010	1006
Monday	15 March 2010	0933
Friday	19 March 2010	1137
Monday	22 March 2010	1347
Wednesday	31 March 2010	1027

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	Algal cover	Appearance	Surface	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
2 November 2009	Fine, overcast	8/8	None	Clear	N/R	0/0	Few ducks	0	0
17 December 2009	Fine	0/8	None	Clear	N/R	0/0	Few ducks	1	2
22 December 2009	Fine	0/8	(suspended)	Slightly turbid	N/R	0/5 (boating/bank)	-	0	4.5
6 January 2010	Fine, overcast	8/8	(suspended)	Turbid	N/R	0/12 (boating)	-	0	14.5
14 January 2010	Fine	0/8	N/R	Slightly turbid	N/R	3/2 (jet-skiing)	Very few ducks	0	0.5
18 January 2010	Fine	2/8	(suspended)	Slightly turbid	N/R	0/9 (boating/banks)	-	0	0
4 February 2010	Fine	6/8	(some suspended)	Slightly turbid	N/R	0/1 (jet-skiing)	Few ducks	0	10.5
16 February 2010	Fine, overcast	8/8	(suspended)	Slightly turbid, brown	N/R	0/2 (banks)	Dog in lake; few ducks and gulls	0	5.5
1 March 2010	Fine	5/8	None	Rel. clear	N/R	0/0	Ducks common (lake and bank)	0	0
15 March 2010	Fine	1/8	None	Rel. clear	N/R	0/0	Ducks common (lake and bank)	0	0
19 March 2010	Fine, overcast	8/8	None	Slightly turbid, pale brown	N/R	0/0	Ducks common	0	6
22 March 2010	Fine, overcast	8/8	None	Rel. clear	N/R	0/0	Ducks common	0	0.5
31 March 2010	Fine	0/8	None	Rel. clear	N/R	0/0	Few ducks	0	3.5

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
2 November 2009	Overcast, very light rain	8/8	90%	Clear, pale-brown	D/S	0/0		0	0
17 December 2009	Fine	0/8	80%	Clear	D/S	0/0		1	2
22 December 2009	Fine	0/8	90%	Clear	D/S	0/3 (tubing)		0	4.5
6 January 2010	Fine, overcast	8/8	N/R	Very slightly turbid	D/S	0/5 (bank)	Two dogs in river	0	14.5
14 January 2010	Fine	0/8	40%	Clear	D/S	0/4 (bank)	Two dogs on bank	0	0.5
18 January 2010	Fine	1/8	90%	Very slightly turbid	D/S	0/10 (bank)	Dog in river	0	0
4 February 2010	Fine	3/8	90%	Clear	D/S	0/0		0	10.5
16 February 2010	Fine, overcast	8/8	100%	Very slightly turbid	D/S	0/0		0	5.5
1 March 2010	Fine	2/8	60%	Very slightly turbid	D/S	0/0		0	0
15 March 2010	Fine	1/8	N/R	Very slightly turbid	D/S	0/0		0	0
19 March 2010	Fine, overcast	8/8	100%	Clear, uncoloured	D/S	0/0		0	6
22 March 2010	Fine, overcast	8/8	N/R	Clear, uncoloured	D/S	0/0		0	0.5
31 March 2010	Fine	0/8	N/R	Clear, uncoloured	D/S	0/0		0	3.5

Site Patea River, King Edward Park, 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
2 November 2009	Fine	3/8	N/R	Clear	D/S	0/0		0	0
17 December 2009	Fine	1/8	Some	Clear, yellow-brown	D/S	0/10 (banks)		1	3.5
22 December 2009	Fine	0/8	Some	Clear, pale-brown	D/S	0/0		0	0.5
6 January 2010	Fine	4/8	N/R	Clear	D/S	3/1 (banks)	No health warning sign present	0	11.5
14 January 2010	Fine	1/8	Some	Clear, brown	D/S	0/0		0	0
18 January 2010	Heavy localised rain, overcast	8/8	Some	Clear, green-brown	D/S	0/0		0	0
4 February 2010	Overcast	8/8	Thin, widespread	Clear, pale brown	D/S	0/0	No health warning sign present	0	0
16 February 2010	Light rain, overcast	8/8	Wide-spread	Relatively clear,brown	D/S	0/1 (fishing)		0	3.5
1 March 2010	Fine	0/8	Wide-spread	Clear, uncoloured	D/S	0/0		0	0
15 March 2010	Fine	0/8	Wide-spread	Clear, uncoloured	D/S	0/0		0	0
19 March 2010	Fine, overcast	7/8	100%	Rel. clear, colourless	D/S	0/1 (bank)	Few ducks	0	0.5
22 March 2010	Fine, overcast	7/8	N/R	Relatively clear, colourless	D/S	0/0		0	0
31 March 2010	Fine	0/8	100%	Clear, colourless	D/S	0/0		0	0

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
2 November 2009	Fine, overcast	7/8	N/A	Turbid, grey	D/S (slow)	0/0		0	0
17 December 2009	Fine	1/8	N/A	Relatively clear, green	U/S	0/0		7	7.5
22 December 2009	Fine	0/8	N/A	Yellow-brown	U/S (slow)	0/19 (boating/banks)		0	0
6 January 2010	Fine	1/8	N/A	Blue-green	D/S	0/4 (bank)	Dog on bank	0	3.5
14 January 2010	Fine	4/8	N/A	Relatively clear, green	U/S (slow)	0/6 (fishing/boating)		0	0
18 January 2010	Fine	0/8	N/A	Relatively clear, blue-green	U/S	0/4 (kayakers)		0	0
4 February 2010	Fine	6/8	N/A	Slightly turbid, green-brown	U/S (slow)	0/0		0	0
16 February 2010	Fine, overcast	7/8	N/A	Clear, green-brown	U/S (slow)	0/1 (on jetty)		0.5	1
1 March 2010	Fine	1/8	N/A	Clear, green-brown	D/S (slow)	0/0		0	0
15 March 2010	Fine	5/8	N/A	Relatively clear, pale green	Still	0/0		0	1.5
19 March 2010	Fine, overcast	8/8	N/A	Turbid, milky, pale green	U/S (v. slow)	0/1 (bank)		0	3
22 March 2010	Fine, overcast	7/8	N/A	Slightly turbid	D/S (slow)	0/0		0	0
31 March 2010	Fine	0/8	N/A	Relatively clear	D/S (slow)	0/0		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
2 November 2009	Fine	5/8	Some	Clear, green-blue	D/S	0/0		0	0
17 December 2009	Fine	1/8	Some	Clear brown	D/S	0/0		1	3.5
22 December 2009	Fine	0/8	Some	Slightly turbid, green	D/S	0/0		0	0.5
6 January 2010	Fine, overcast	8/8	Wide-spread	Clear, pale brown-green	D/S	0/0		0	11.5
14 January 2010	Fine	1/8	Wide-spread	Clear, brown-green	D/S	0/0		0	0
18 January 2010	Fine	5/8	Some	Clear, brown-green	D/S	0/0		0	0
4 February 2010	Fine, overcast	8/8	Wide-spread	Clear, pale grey-green	D/S	0/0		0	0
16 February 2010	Fine, overcast	8/8	N/R	Clear, brown	D/S	0/0		0	3.5
1 March 2010	Fine	1/8	Some	Clear, brown	D/S	0/0		0	0
15 March 2010	Fine	1/8	N/R	Clear, pale brown	D/S	0/0		0	0
19 March 2010	Fine	3/8	90%	Clear, colourless	D/S	0/0		0	0.5
22 March 2010	Fine	6/8	Wide-spread	Clear, colourless	D/S	0/0		0	0
31 March 2010	Fine	0/8	100%	Clear, colourless	D/S	0/50 (banks)		0	0

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
2 November 2009	Fine, overcast	8/8	N/R	Pale green-brown	D/S (slow)	0/20 (whitebaiting)		0	0
17 December 2009	Fine	1/8	Wide-spread	Relatively clear, brown	D/S	2/4 (bank)		0	1.5
22 December 2009	Fine	0/8	Some	Slightly turbid, green	D/S	1/4 (bank)	Dog in water	0	2.5
6 January 2010	Fine	2/8	N/R	Clear, brown	Surging	3/3 (bank)		0	7
14 January 2010	Fine	3/8	Wide-spread	Clear, brown-green	D/S	4/3 (bank)		0	0
18 January 2010	Fine	3/8	Some	Green-brown	D/S	2/2 (bank)		0	0
4 February 2010	Fine	2/8	Thin	Clear, brown-green	D/S	0/1 (bank)	Dog on bank	0	0
16 February 2010	Fine, overcast	7/8	N/R	Clear, green-brown	D/S (slow)	0/0		0.5	1.5
1 March 2010	Fine	0/8	Some	Clear,brown-green	D/S (slow)	0/0	Calltle access u/s	0	0
15 March 2010	Fine	2/8	N/R	Clear, pale green	D/S (slow)	0/0		0	0
19 March 2010	Fine	2/8	90%	Clear, green-brown	Ponded	0/0	Many cattle on banks and in river u/s; few ducks	0	0
22 March 2010	Fine	3/8	N/R	Clear, uncoloured	D/S	0/0	No cattle u/s	0	0
31 March 2010	Fine	0/8	Wide-spread	Slightly turbid, pale brown	D/S	0/0	No cattle u/s	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
2 November 2009	Fine, overcast	8/8	N/R	Clear, pale green	D/S (slow)	0/12 (whitebaiting/fishing)		0	0
17 December 2009	Fine	1/8	N/R	Clear, colourless	U/S (slow)	0/4 (fishing/banks)		0	1.5
22 December 2009	Fine	0/8	N/R	Clear, pale green	U/S (slow)	1/1 (banks)		0	2.5
6 January 2010	Fine	3/8	N/R	Clear, green-brown	Surging	6/23 (banks/fishing)		0	7
14 January 2010	Fine	1/8	N/R	Clear, brown	U/S (slow)	3/1 (kayaking)		0	0
18 January 2010	Fine	2/8	N/R	Clear, green-brown	U/S (slow)	3/8 (banks)		0	0
4 February 2010	Fine	1/8	N/R	Slightly turbid, brown-green	U/S (slow)	0/0		0	0
16 February 2010	Fine, overcast	8/8	N/R	Clear, green-brown	U/S (slow)	0/0		0	1.5
1 March 2010	Fine	0/8	(Suspen-ded common)	Clear brown-green	Surging	0/0		0	0
15 March 2010	Fine	1/8	N/R	Clear, pale green	Still	0/0		0	0
19 March 2010	Fine	2/8	N/R	Clear,colourless	U/S (slow)	0/4 (fishing/banks)		0	0
22 March 2010	Fine	2/8	N/R	Rel. clear, brown	D/S (slow)	0/0		0	0
31 March 2010	Fine	0/0	N/R	Slightly turbid	U/S (slow)	0/0	1 blue heron	0	0

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
2 November 2009	Fine	5/8	N/A	Clear, green-brown	Ripple	0/0	Ducks common	0	0
17 December 2009	Fine	1/8	N/A	Clear, brown	Ripple	0/0	Ducks common	8.5	11
22 December 2009	Fine	0/8	N/A	Brown-yellow	Ripple	0/2 (bank)	Ducks common	0	10
6 January 2010	Fine	3/8	N/A	Clear, green-brown	Flat	0/0	Ducks common	0	12.5
14 January 2010	Fine	2/8	N/A	Relatively clear, brown-green	Ripple	4/11 (kayaking/jetskiing)		0	0.5
18 January 2010	Fine	1/8	N/A	Clear, brown-green	Ripple	0/0	Ducks common	0	1
4 February 2010	Fine	1/8	N/A	Clear, brown-green	Ripple	0/4 (kayaking/banks)	Ducks common	0	0
16 February 2010	Fine, overcast	8/8	N/A	Clear, brown	Flat	0/0	Ducks common	0	4.5
1 March 2010	Fine	0/8	N/A	Clear, green-brown	Ripple	0/0	Ducks very common	0	0
15 March 2010	Fine	2/8	N/A	Relatively clear, pale brown	Ripple	0/0	Ducks very common	0	1
19 March 2010	Fine	6/8	N/A	Clear, colourless	Ripple	0/0	Ducks very common; few swan	0	0
22 March 2010	Fine	2/8	N/A	Relatively clear	Ripple	0/0	Ducks very common	0	1
31 March 2010	Fine	0/8	N/A	Relatively clear, brown	Flat	0/0	Ducks very common	0	0.5

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
2 November 2009	Fine, overcast	8/8	Nil (Sandy)	Clear	Surging	0/2 (whitebaiters)		0.5	0.5
17 December 2009	Fine	1/8	Nil	Clear	D/S	0/0		3	7.5
22 December 2009	Fine	0/8	Nil	Clear	D/S	2/0		0	12
6 January 2010	Fine, overcast	8/8	Nil	Clear	D/S	4/6 (bank)		0	12
14 January 2010	Fine	2/8	Nil	Clear	D/S	0/0		0	1
18 January 2010	Fine	6/8	Nil	Clear	D/S	0/0		0	0
4 February 2010	Fine, overcast	7/8	Nil	Clear, greenish	D/S	0/0		0	1
16 February 2010	Fine, overcast	8/8	Nil	Clear	D/S	0/0		0	12.5
1 March 2010	Fine, overcast	7/8	Nil	Clear	Surging	0/0		0	0
15 March 2010	Fine	3/8	Nil	Clear, uncoloured	D/S	0/0		0	1.5
19 March 2010	Fine, overcast	8/8	Nil	Clear, uncoloured	D/S	0/0		0	5.5
22 March 2010	Fine, overcast	8/8	Nil	Clear, uncoloured	D/S	0/0		1	1.5
31 March 2010	Fine	0/8	Nil	Clear, uncoloured	D/S	0/0		0	0.5

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
2 November 2009	Fine, overcast	8/8	60%	Slightly turbid	D/S	0/0		0.5	0.5
17 December 2009	Fine	1/8	90%	Slightly turbid	D/S	0/0		3	7.5
22 December 2009	Fine	0/8	100%	Slightly turbid	D/S	0/2 (banks)		0	12
6 January 2010	Fine, overcast	8/8	N/R	Turbid	D/S	8/0		0	12
14 January 2010	Fine	2/8	60%	Slightly turbid	D/S	2/0		0	1
18 January 2010	Fine	6/8	90%	Slightly turbid	D/S	8/0	Few ducks	0	0
4 February 2010	Fine	4/8	90%	Slightly turbid	D/S	0/0	Few seagulls	0	1
16 February 2010	Fine, overcast	8/8	80%	Turbid, pale brown	D/S	0/0		0	12.5
1 March 2010	Fine	6/8	N/R	Slightly turbid	D/S	0/0		0	0
15 March 2010	Fine	2/8	N/R	Slightly turbid, brown	D/S	080		0	1.5
19 March 2010	Fine	6/8	N/R	Slightly turbid, brown	D/S	0/0		0	5.5
22 March 2010	Fine, overcast	8/8	N/R	Slightly turbid, pale brown	D/S	0/0		1	1.5
31 March 2010	Fine	0/8	N/R	Slightly turbid	D/S	0/0		0	0.5

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
2 November 2009	Fine	8/8	N/A	Clear	Surging	0/2 (whitebaiting)		0.5	0.5
17 December 2009	Fine	1/8	N/A	Clear	Surging	0/1 (bank)	Dog in river	3	7.5
22 December 2009	Fine	0/8	N/A	Clear	D/S	6/7 (bank)		0	12
6 January 2010	Fine, overcast	8/8	N/A	Clear	D/S	6/0		0	12
14 January 2010	Fine	2/8	N/A	Clear	Surging	0/0		0	1
18 January 2010	Fine	3/8	N/A	Clear	Surging	2/4 (banks)		0	0
4 February 2010	Fine	5/8	N/A	Clear	D/S	5/1 (kayaking)		0	1
16 February 2010	Fine, overcast	8/8	N/A	Clear	D/S	0/0	Dog in river	0	12.5
1 March 2010	Fine	1/8	N/A	Clear	Surging (strong)	0/0		0	0
15 March 2010	Fine	1/8	N/A	Clear	Surging	0/0	Three horses d/s	0	1.5
19 March 2010	Fine	6/8	N/A	Clear	D/S	0/0		0	5
22 March 2010	Fine, overcast	8/8	N/A	Clear	Surging	0/0		1	1.5
31 March 2010	Fine	0/8	N/A	Clear	Surging	0/1 (bank)	Dog d/s	0	0.5

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

Sampling Date	Weather		Conditions			Site usage		Rainfall (mm)	
	General	Cloud Cover	S.G	Appearance	Direction of Flow	Bathers / Users	Miscellaneous	Previous 24 hrs	Previous 72 hrs
2 November 2009	Fine, overcast	8/8	1.95	Green-grey	Still	0/2 (whitebaiters)		0	0
17 December 2009	Fine	0/8	1.75	Slightly turbid, brown	Still	0/2 (wharf)		4	5
22 December 2009	Fine	0/8	1.60	Clear, brown-green	Still	5/5 (bank)		0	7.5
7 January 2010	Light rain, overcast	8/8	1.4	Turbid, brown	D/S (slow)	0/16 (canoeing/bank)		0	0
14 January 2010	Fine	1/8	1.5	Turbid, brown	Still	0/4 (rowing)	Few ducks	0	1
18 January 2010	Fine	2/8	2.0	Clear, green-brown	Still	0/1 (fishing)	Few ducks	0	0
4 February 2010	Fine	5/8	1.75	Clear, blue-brown	Still	0/0		0	18
16 February 2010	Fine,overcast	8/8	1.80	Clear, green	Still	0/0		1	6
1 March 2010	Fine	6/8	2.10	Slightly turbid, brown	D/S (slow)	0/6 (banks)		0	0
15 March 2010	Fine	1/8	1.75	Slightly turbid, green	D/S (slow)	0/0	Few ducks	0	0
19 March 2010	Fine	5/8	1.75	Clear, green	D/S (slow)	0/2 (banks)		0	2.5
22 March 2010	Fine, overcast	8/8	1.5	Clear,green-grey	Still	0/0		0	0.5
31 March 2010	Fine	0/8	2.25	Clear, green-brown	Still	0/0		0	1

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
2 November 2009	Fine	6/8	N/A	Green	Still	0/0		0	0
17 December 2009	Fine, overcast	0/8	N/A	Clear, green	U/S (slow)	0/4 (fishing/bank)		4	5
22 December 2009	Fine	0/8	N/A	Clear, green	U/S	1/7 (kayaker/bank)		0	7.5
6 January 2010	Fine	0/8	N/A	Clear, green	U/S (slow)	25/54 (banks/fishing)		0	13.5
14 January 2010	Fine	4/8	N/A	Green	Still	5/30 (fishing/banks)		0	1
18 January 2010	Fine	4/8	N/A	Clear, green	U/S (slow)	0/14 (fishing/banks)		8	8
4 February 2010	Fine	2/8	N/A	Clear, green	U/S	0/0		0	18
16 February 2010	Light-rain, overcast	8/8	N/A	Clear, grey-green	U/S	3/2 (banks)		1	6
1 March 2010	Fine	3/8	N/A	Slightly turbid, green	U/S (swift)	0/0		0	0
15 March 2010	Fine	4/8	N/A	Slightly turbid, green	U/S	0/50 (banks)		0	0.5
19 March 2010	Fine	7/8	N/A	Clear, pale green	U/S (surging)	0/0		0	2.5
22 March 2010	Fine	4/8	N/A	Clear, green	U/S	0/0		0	0.5
31 March 2010	Fine	0/8	N/A	Clear, green	U/S	0/0		0	1

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
2 November 2009	Fine, overcast	8/8	Present	Clear, green-grey	D/S	0/0		0	0
17 December 2009	Fine	0/8	Present	Clear	D/S	0/0		0.5	3
22 December 2009	Fine	0/8	Present	Clear, brown-green	D/S	0/0		0	17
6 January 2010	Fine, overcast	8/8	Present	Clear, green	D/S	0/0		0	25
14 January 2010	Fine	2/8	Present	Clear, green-grown	D/S	0/0		0	0
18 January 2010	Fine	3/8	Present	Clear	D/S	0/0		0	0
4 February 2010	Fine, overcast	7/8	Present	Clear, green-brown	D/S	0/1 (bank)	Dog in river	0	6.5
16 February 2010	Light rain, overcast	8/8	Present	Clear	D/S	0/0		0	17
1 March 2010	Fine	4/8	Present	Clear, green	D/S	0/0		0	0
15 March 2010	Fine	3/8	95%	Slightly turbid, green-brown	D/S	0/0		0	1
19 March 2010	Fine	1/8	N/R	Rel. clear, green-brown	D/S	0/0		0	1
22 March 2010	Fine, overcast	8/8	Present	Clear, green-brown	D/S	4/12 (bank)		0	0.5
31 March 2010	Fine	0/8	Present	Clear, green	D/S	0/0		0	1

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
2 November 2009	Fine, overcast	7/8	N/A	Clear	Ripple	0/0		0	0
17 December 2009	Fine	0/8	N/A	Clear	Flat	0/0	Few ducks	0.5	3
22 December 2009	Fine	0/8	N/A	Clear	Flat	0/4 (banks/fishing)		0	17
6 January 2010	Fine, overcast	8/8	N/A	Clear	Ripple	0/11 (boating, waterskiing, banks)		0	25
14 January 2010	Fine	0/8	N/A	Clear, pale brown	Ripple	7/6 (boating/banks)		0	1
18 January 2010	Fine	2/8	N/A	Clear, blue-grey	Ripple	0/0	Few ducks	0	0
4 February 2010	Fine, overcast	8/8	N/A	Clear, brown-blue	Ripple	0/0	One shag	0	6.5
16 February 2010	Fine, overcast	8/8	N/A	N/R	N/R	0/0		0	17
1 March 2010	Fine	4/8	N/A	Clear, blue-brown	Ripple	0/1 (kayaking)		0	0
15 March 2010	Fine	2/8	N/A	Slightly turbid, brown	Ripple	0/0	Few ducks	0	1
19 March 2010	Fine	1/8	N/A	Clear, dark brown	Ripple	0/2 (banks)		0	1
22 March 2010	Fine, overcast	8/8	N/A	Relatively clear, pale brown	Chop	0/0	Few ducks	0	0.5
31 March 2010	Fine	0/8	N/A	Clear, blue	Ripple	0/0		0	1

Appendix IV

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

Dates of additional sampling

Date	Preceding weather
Thursday 26 November 2009	dry over 72 hours
Thursday 10 December 2009	dry over 72 hours
Tuesday 12 January 2010	wet over 72 hours
Tuesday 26 January 2010	dry over 72 hours
Tuesday 9 February 2010	dry over 72 hours
Tuesday 23 February 2010	dry over 72 hours
Tuesday 9 March 2010	dry over 72 hours

Site Lake Rotomanu (Site Code: LRM000002): additional monitoring (seven 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
26 November 2009	Fine, overcast	8/8	Minimal	Relatively clear, pale brown	Calm	0/0	Few ducks; weed dredge operating	0	1
10 December 2009	Fine, overcast	7/8	Some suspended	Relatively clear, pale brown	Ripple	0/14 (kayaking/banks)	Ducks common, weed dredge operating	0	0
12 January 2010	Fine	1/8	N/R	Slightly turbid, brown	Ripple	0/6 (boating, jetskiing)		0	29
26 January 2010	Fine	6/8	N/R	Clear, brown	Calm	2/1 (jetskiing)		2	2
9 February 2010	Fine	1/8	N/R	Clear, brown-green	Ripple	0/0	Ducks common	0	0
23 February 2010	Fine, overcast	8/8	Some	Clear, blue	N/R	0/0	Ducks common; and shag	0	0
9 March 2010	Fine	0/8	Minimal	Turbid, blue	N/R	0/2 (water & jetskiing)	Few ducks	0	0

Site Waiwhakaiho River at Merrilands (Site Code: WKH000800): additional monitoring (seven 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
26 November 2009	Fine, overcast	7/8	Wide-spread	Clear	D/S	0/0		0	1
10 December 2009	Fine, overcast	8/8	Some	Clear	D/S	2/0		0	0
12 January 2010	Fine	0/8	Some	Clear, pale brown	D/S	0/0		0	29
26 January 2010	Fine	6/8	Some	Clear, green-brown	D/S	0/3 (bank)		2	2
9 February 2010	Fine	0/8	Wide-spread	Clear, green-brown	D/S	0/2 (bank)	4 dogs on bank	0	0
23 February 2010	Fine, overcast	8/8	90%	Clear, colourless	D/S	0/0		0	0
9 March 2010	Fine	0/8	50%	Clear, green	D/S	4/0		0	0

Appendix IV

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
26 November 2009	Fine	3/8	N/A	Relatively clear, colourless	N/R	0/0	Ducks common	0	1.5
10 December 2009	Fine, overcast	8/8	N/A	Clear, pale brown	Flat	0/0	Ducks common	0	0
12 January 2010	Fine	1/8	N/A	Clear, brown-green	Ripple	0/0	Ducks common	0.5	30
26 January 2010	Fine	4/8	N/A	Slightly turbid, brown	Flat	0/0		0.5	1
9 February 2010	Fine	4/8	N/A	Clear, green-brown	Ripple	0/3 (bank)	Ducks very common; shag	0	0
23 February 2010	Fine	3/8	N/A	Clear, uncoloured	Flat	0/0	Ducks very common	0	0
9 March 2010	Fine	0/8	N/A	Relatively clear, green-brown	Ripple	0/0	Ducks very common	0	0
26 March 2010	Fine	6/8	N/A	Rel. clear uncoloured	Flat	0/0	Ducks very common; swan & geese	2	11

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
26 November 2009	Fine	4/8	N/R	Slightly turbid	N/R	0/0	Few ducks	0	1
10 December 2009	Fine, overcast	8/8	N/R	Clear, pale brown	Ripple	0/0		0.5	0.5
12 January 2010	Fine	0/8	N/R	Slightly turbid, brown	Ripple	0/0		0	31
26 January 2010	Fine, overcast	8/8	N/R	Clear, brown	Flat	0/5 (camping)		1	1.5
9 February 2010	Fine, overcast	8/8	N/R	Relatively clear, brown-grey	Ripple	0/0		0	0
23 February 2010	Fine, overcast	8/8	Some suspended	Slightly turbid, brown	N/R	0/0		0	0
9 March 2010	Fine	0/8	Some suspended	Slightly turbid, green	N/R	0/0	Few ducks & shags	0	0
26 March 2010	Fine	1/8	N/R	Clear, green-brown	Ripple	0/2 (boating)		0	15.5

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
19 November 2009	Fine, overcast	7/8	Some suspended	Slightly turbid, pale brown	Ripple	0/10 (walkers)	Boatramp locked	2	50
10 December 2009	Fine, overcast	8/8	Some suspended	Slightly turbid, brown	Flat	0/1 (walker)	Very few ducks	0	0
21 December 2009	Fine	5/8	Some suspended	Slightly turbid, brown	Ripple	0/1 (walker)	Few ducks & shags	0.5	0.5
12 January 2010	Fine	6/8	Some suspended	Slightly turbid, brown	Ripple	0/6 (jetskiing/banks)		0	26
19 January 2010	Fine	4/8	Some suspended	Turbid, bright green	Ripple	0/1 (bank)	Health warning signs present	10.5	10.5
26 January 2010	Fine	6/8	Abundant suspended	Turbid, green	Calm	0/2 (walkers)	Health warning signs present	0	2.5
8 February 2010	Fine	4/8	Some suspended	Turbid, green-brown	Calm	0/0	Health warning signs present	0	0
23 February 2010	Fine	4/8	Some suspended	Turbid, green-brown	Calm	0/0	Health warning signs present	0	0
9 March 2010	Fine	0/8	Some suspended	Turbid, brown	Ripple	0/0	Few ducks.Health warning signs present	0	0
6 March 2010	Fine, overcast	8/8	Some suspended	Relatively clear, pale green	Ripple	0/0	Few ducks. Health warning signs present	0	16.5

Appendix V

Comparative annual box and whisker plots of SEM data for *E. coli* for the period 1996 to 2010

Explanation of box and whisker plots

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. The notch, symmetrically spread around the median represents the 95% confidence interval of the median). It is a feature that allows rapid comparison between groups. If notches overlap, there is no significant difference between groups (at the 95 % confidence interval). If notches do not overlap, a statistical difference is expected.

The top and bottom of the box represent the upper and lower 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, ie, Upper hinge – Lower hinge = Hspread. The inner fences are defined as follows:

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

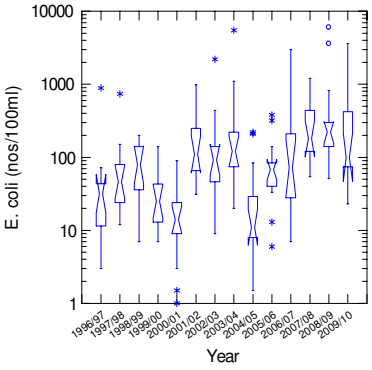
The outer fences are defined as follows:

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

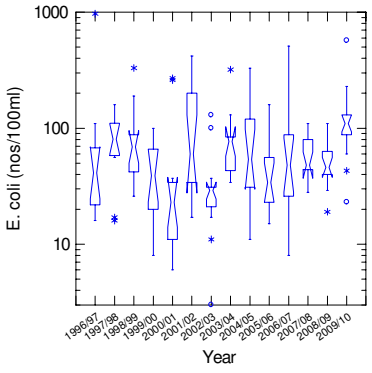
> The whiskers show the range of values that lie within the inner fences. Values outside the inner fence (outliers) are plotted as asterisks (*). Values outside the outer fence (extreme outliers) are plotted as ˚.

E. coli

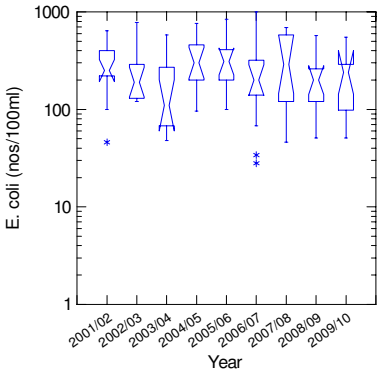
Lake Rotomanu



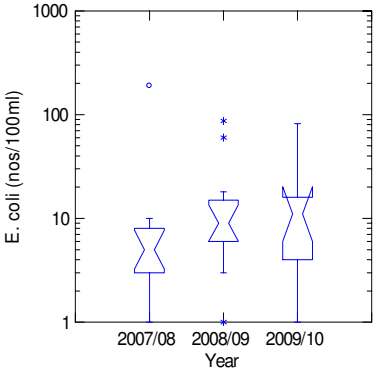
Waiwhakaiho River



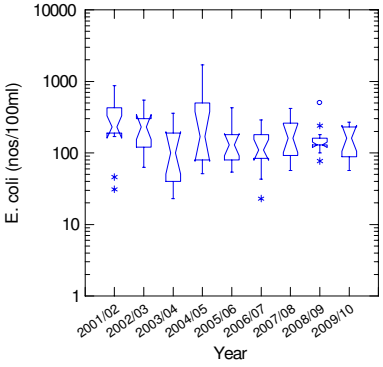
Patea River at Stratford



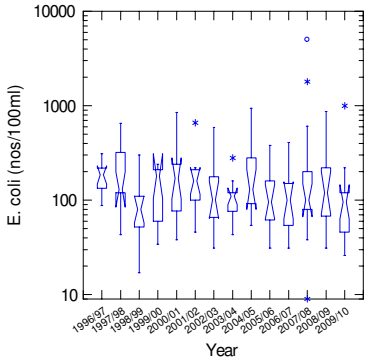
Patea River at Patea



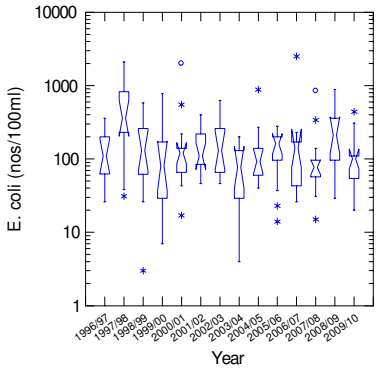
Waingongoro R at Eltham



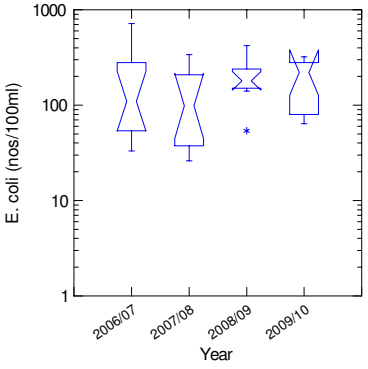
Waingongoro R at Ohawe



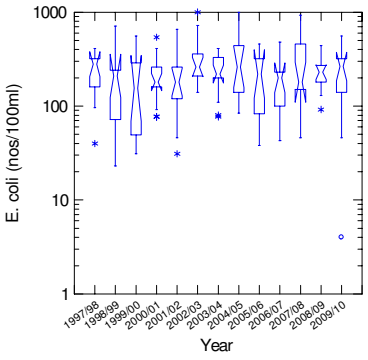
Kaupokonui River



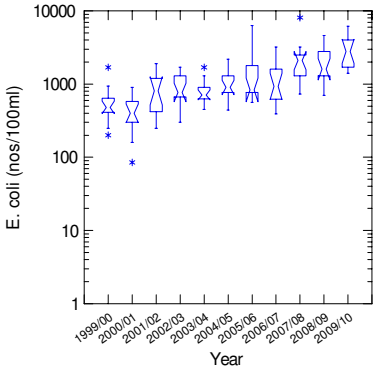
Lake Opunake



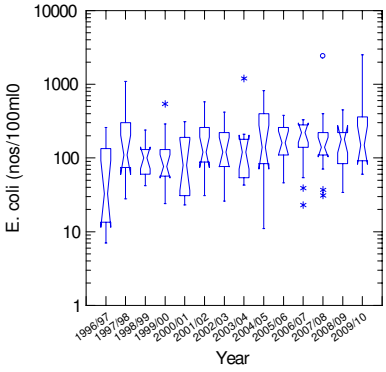
Timaru Stream



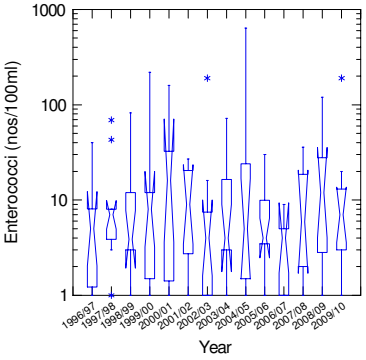
Waimoku Stream



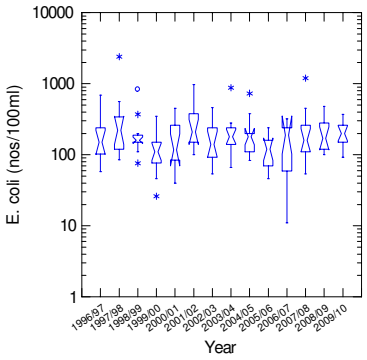
Oakura River



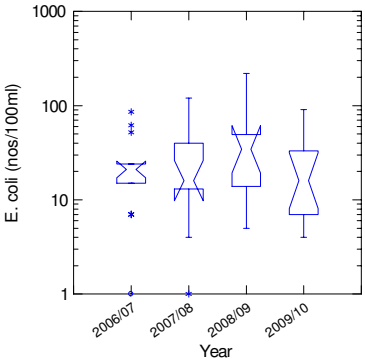
Urenui River



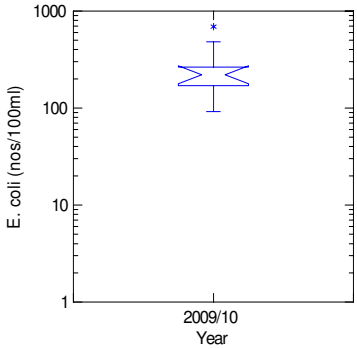
Manganui River



Lake Ratapiko



Waitara River at town wharf



Appendix VI

Publicity during the 2009-2010 season

Opunake Lake bacteria levels on the rise

By PETRA FINER
petra.finer@stl.co.nz

OPUNAKE is on the brink of yet another water crisis, with the latest bacteria figures for Opunake Lake showing worryingly high e-coli levels.

Figures from the Taranaki Regional Council website show two consecutive raised bacteria counts, meaning the lake needs close attention to prevent public bacteria poisoning.

There is a high chance usually harmless family bonding experiences are actually making the situation worse.

Regional council scientific officer Chris Fowles says feeding ducks and geese makes the bacteria count rise.

"At Opunake it's the wild fowl, the ducks and geese which is why we see problems," he says. "People recreating there feed the ducks."

Preferred E-coli levels are below 550 e-coli/100ml, but two consecutive counts of more than that level cause greater interest to be taken in the lake.

If levels rise to more than 550 e-coli/100ml, the lake will be considered unsafe for swimming or any water contact.

Throwing away sandwich crusts after lunching at the lake, taking children to feed the ducks and leaving food rubbish behind all encourage more wild fowl to reside in the area. The more fowl in the area, the higher the bacteria count.

Opunake Lake has returned three high counts this summer, with the two most recent taken consecutively this February and March at 500 and 580.

While the levels are not yet high enough to stop swimming or water contact, Chris says anyone showing symptoms of vomiting, diarrhoea and stomach cramps after swimming in the lake should contact the Taranaki District Health Board.

"Hawera Star", 18 March 2010

Beach keeps its flag despite dirty stream

Oakura retains environmental status

By [illegible]

OAKURA BEACH has had its Blue Flag status reconfirmed, despite the Waiwaka stream running into the sea being found the fifth-most polluted spot in New Zealand.

Both Oakura and Fitzroy East Bay beaches will be Blue Flag beaches for the third summer in a row.

Blue Flag New Zealand says it is confident issues with the Waiwaka Stream will be well managed but chairman Bob Acton has again warned that Blue Flag status could be taken away from Oakura if the stream becomes a problem.

"The water readings taken by the Taranaki Regional Council had been closely linked to," he said.

"From the history of the readings we believe any water entering the town will meet up to the World Health Organisation standards and if it doesn't they will step in into remedial action to rectify that. It's safe to say if anything happened that compromised the Blue Flag, the Blue Flag would come down if the public was at risk," he said.

High E.Coli bacteria counts in the popular paddling stream, which runs across the beachfront to the sea, prompted a health warning from the Taranaki District Health Board earlier this year.

And an Environment Ministry report found the stream was the fifth-most polluted spot in New Zealand.

In two years it never went noted below the 550 E.Coli per 100 millilitres of water test benchmark to be considered safe for swimming.

But Eastern Community Board chairman Doug Illsley insisted said by the time the stream reached the beach it was diluted enough to have no effect on the sea water readings.

"The plan we have for this summer is to mark the stream (at eight sites) for both to the sea, instead of recording using the beach for a week, so the stream water can be diluted as soon as possible," he said.

"We are also working closely with the health board and TRC on further investigations on how to mitigate the issues at Waiwaka Stream."

The two Taranaki beaches became the first Blue Flag accredited beaches in New Zealand in 2007 and have had their status reconfirmed every year since.

They are the only two beaches in New Zealand with Blue Flag status for Auckland's Northern Marina is also Blue Flag approved.

New Plymouth District Council assistant recreation services manager Kate Mamaradlt said the Blue Flag confirmation was good news for the region's beach users and for Taranaki's international profile.

She said extra signs would be put up at Oakura so the message is clear.

"We're having it tested quite frequently, very seriously although it's not something we're directly responsible for," she said.

"We're taking a serious pro-active approach to this. It's about the owners and they working together."

Blue beach: Oakura beach and the mouth of Waiwaka Stream [illegible] a new year contract.

NEWS

Filth finding puts Blue Flag at risk

Camp man: Don't blame the birds

Troubled water

■ (not Page 1)

Thirsty weed: A wetland has been made at Perrings Park to clean the water before it goes into Lake Roborough.

Photo: ROBERT CARTER

Plymouth District Council decided to drain the lake in an attempt to keep people out.

It was also ill timed as the council could flush water through the lake to freshen it up and dilute the E. coli and cyanobacteria, Mr Merrill says.

"Which did work briefly. E. coli and cyanobacteria, dependant on the conditions can multiply very quickly."

Whether or not the same problems with toxic algae will occur this summer still depends on the weather.

"There's not a lot we can do about that. It's either going to happen or it's not. We have to wait and see."

As well as removing geese and trying to discourage duck feeding, a wetlands has been made at Perrings Park, which will improve water quality going into the lake.

The water entering the lake is expected to be 30 to 50 per cent cleaner. Depending on the contamination, most of it came directly from the outlet pipe, the city council projects team manager Jeff Brady says.

"Beyond next year, you have to remember Roborough is fed mainly by the Waterlogged River rather than the wetlands itself. This is a small, incremental thing, overall. It's a positive thing, but in itself it's not going to solve the whole problem."

The $2m city wetlands project, which covers about 2 hectares, is ongoing, but most of it was finished last month, he says.

There have been three community plantings by volunteer groups, which have been undertaken in the riparian area around the wetland. And Mr John Brown fulfilled his adopted the wetlands as a guardian and is using it as a local education environmental project.

Signs warn of heartbreak and feeding have gone up, but there is a grass pollutant trap that still has to be installed by the council's Water and Waste department at the top of the hill, Mr Brady says.

"It is a big manhole-type device with a kind of a sieve inside it and it filters out things like plastic bottles and large waste debris.

"It's one of those things that is so visual and the litter is lifted out by a crane and taken away in the rig."

The litter is part of the Water and Waste department's ongoing Fitzroy stormwater programme and should be in place within 12 months, Mr Brady says.

The wetlands puts oxygen in the water and removes all the nutrients.

"It cleanses the water before it reaches Lake Roborough. So it carries two functions: one, it gets rid of stormwater out of the streets and secondly, it improves the water quality of the lake, which is becoming a bit of a problem."

A new development being studied in the wetland is a floating island.

"They've done a couple of those up north."

The island is a mat of floating synthetic matting, with holes drilled in it, he says. Plants are then planted through the holes.

"It just floats on the water like an artificial island, so that the roots reach down into the water. They're the ones that remove a lot of the nutrients from the water and turn it into oxygen by throwing out roots out of the water."

The plants don't sink, even when they've died – they just floating on top.

In time, the wetlands will also act a buffer, he says.

"So every storm hope that it's going to be an enhanced habitat. That's part of the deal, really."