Bathing Beach Recreational Water Quality State of the Environment Monitoring Report Summer 2015-2016

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Taranaki Regional Council
Private Bag 713
STRATFORD

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Executive summary

This report provides an assessment of microbial water quality at 14 bathing beach sites in the Taranaki region, based on routine summer monitoring of faecal indicator bacteria (enterococci, *E. coli* and faecal coliforms) conducted by the Council between 3 November 2015 and 30 March 2016. The report focusses on enterococci results, as this indicator is considered by health authorities to provide the closest correlation with risks of health effects in New Zealand coastal waters. Results have been assessed for compliance with microbiological water quality guidelines prepared by the Ministry for the Environment (MfE) and the Ministry of Health (MfE, 2003).

Thirteen samples were collected at every monitored beach under dry weather conditions for state of the environment monitoring (SEM) purposes. An extra 7 samples were collected regardless of weather conditions at 5 sites, to satisfy MfE grading purposes.

During the 2015-2016 summer season, microbiological water quality was generally good across bathing beaches in the Taranaki region. The highest median enterococci count was recorded at Ohawe (40 enterococci cfu/100 ml). Median enterococci counts at all other beaches were equal to or less than 9 cfu/100 ml. Out of the 217 samples collected for both SEM and for additional monitoring purposes, 95% were below the Alert level. Of the few samples which entered the Alert and Action guideline category (5%), the vast majority (9 out of 11) had been influenced by rainfall and/or freshwater.

The guideline MfE Action mode is reached when enterococci counts in two consecutive samples exceed 280 enterococci cfu/100 ml. Two site reached Action mode during the 2015-2016 season (Ohawe and Waitara West).

Mann-Kendall tests were performed in order to assess long term trends in microbiological water quality. Two sites show a significant decrease in median enterococci counts over the 14-21 years monitored (Fitzroy and Ngamotu), indicating an overall improvement in microbiological water quality. No site showed a significant increase in enterococci medians over the time period monitored i.e. deterioration in water quality.

During the 2015-2016 season, the median enterococci count at Oakura Surf Club was the lowest recorded at that site in the 21 years of the programme to date. At Mana, Waverley and Wai-inu the median enterococci counts obtained for the 2015-2016 summer season were the highest to date at these sites. However, the results were still representative of good water quality, with a low maximum counts.

Microbiological water quality results were regularly reported on the Taranaki Regional Council website (www.trc.govt.nz) and there was timely liaison with territorial local authorities and the Health Protection Unit of the Taranaki District Health Board throughout the summer bathing season of 2015-2016.

Through the Council's LTP, the Council's target in respect of the microbiological state of coastal bathing sites is that there is *maintenance or increase in the number of sites from 2003 compliant with 2003 Ministry of Health contact recreational guidelines*. In 2003, 10 of 11 coastal bathing sites were compliant with the guidelines (Action levels). In the season under review, 12 of 14 beaches were compliant with the guidelines. The LTP target was therefore not met in that the number of sites entering the 'Action' level did increase, but there was also an increase in the number of sites compliant with the 2003 guidelines.

Continuation of the bathing beach SEM programme is recommended in the 2016-2017 year.

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1. Introduction

The coastal waters of New Zealand are used for a broad range of recreational activities, including bathing, surfing, diving, sailing, kayaking, and shellfish gathering. Maintaining the quality of this recreational water is therefore an important resource management and environmental health issue.

1.1 State of the environment monitoring (SEM)

Regional councils have responsibilities under the Resource Management Act (1991) to monitor the state of the environment. The purpose of state of the environment monitoring (SEM) is to collect sufficient data to produce information on the general health of the environment. This information can then be used to measure how well management practices, policies and laws are working, and whether environmental outcomes are being achieved. As part of SEM, environmental performance indicators (EPI's) are used to measure human activities and their effects on the environment. Included amongst these EPI's, faecal indicator bacteria (enterococci, *E. coli* and faecal coliforms) can be monitored to assess the contamination of water by human or animal excreta. Levels of these faecal indicators are of particular interest in coastal waters used for recreational activities due to the potential health risks associated.

The Taranaki Regional Council has monitored faecal indicator bacteria at bathing beaches along the Taranaki coast since 1979, with systematic surveys undertaken from 1987. A more comprehensive annual bathing beach monitoring programme was implemented during the 1995-1996 summer as an on-going component of the SEM programme for the Taranaki region.

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;
- 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 other high-contact water sports e.g. jet-skiing, surfing, kayaking]*

2. Contact recreation water quality standards and guidelines

2.1 Microbiological water quality guidelines for marine recreational areas (2003)

Guidelines for microbiological water quality of marine recreational areas have been prepared by the Ministry for the Environment in conjunction with the Ministry of Health (MfE, 2003). The guidelines use a combination of a qualitative risk grading of the catchment, together with direct measurements of appropriate faecal indicators to assess the suitability of a site for recreation (see 2.2).

In addition, 'Alert' and 'Action' guideline levels are used for surveillance throughout the bathing season. These guideline levels are summarized in Table 1 and are based on keeping illness risk associated with recreational water use to less than approximately 2%. Levels are based on enterococci counts as these bacteria are the preferred indicators for marine waters. Research has shown that enterococci are the indicator most closely correlated with health effects in New Zealand marine waters, in common with general findings overseas (New Zealand Marine Bathing Study). In coastal waters, faecal coliforms and *E. coli* are not as well correlated with health risks, but can be used as indicators, in addition to enterococci, where enterococci levels alone may be misleading.

Table 1 Surveillance, Alert and Action levels for marine waters (2003)

	Mode		
	Surveillance	**Alert**	**Action**
Enterococci (cfu/100 ml)	No single sample >140	Single sample >140	Two consecutive single samples >280
Procedure	• Continue routine monitoring	• Increase sample to daily • Undertake sanitary survey • Identify sources of contamination • Consult CAC to assist in identifying possible source	• Increase sample to daily • Undertake sanitary survey • Identify sources of contamination • Consult CAC to assist in identifying possible source • Erect warning signs • Inform the public through the media that a public health problem exists

CAC = Catchment Assessment Checklist

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 based on two components:

- *The Microbiological Assessment Category (MAC):* this is established on the basis of five years' enterococci data for a particular site, providing a quantitative measurement of the actual water quality over time. Sites are assigned MAC categories ranging from A to D, with definitions provided in Table 2. For the Taranaki region, the Taranaki Regional Council provides the Ministry for the Environment with these data collected as part of the annual bathing beach monitoring programme.

- *The Sanitary Inspection Category (SIC)*: generates a measure of the susceptibility of a water body to faecal contamination. A site is allocated a category of either Very High, High, Moderate, Low or Very Low, and is determined using the SIC flow chart. Information used in the flow chart comes from the Catchment Assessment Checklist (CAC) which provides qualitative risk information on the catchment. Detailed information about SIC, including the SIC flow chart and the CAC can be found in the 2003 Microbiological Water Quality Guidelines (MfE, 2003).

The SIC is combined with the MAC to determine a Suitability for Recreation Grade (SFRG) for each site. The SFRG therefore describes the general condition of a site based on both qualitative risk grading of the catchment and the quantitative measurement of faecal indicators. A grade is established on the basis of the most recent five years' data and recalculation of a grade is typically performed annually.

Table 2 Microbiological Assessment Categories

MAC	MAC definitions for marine waters
A	Sample 95 percentile ≤ 40 enterococci/100ml
B	Sample 95 percentile 41 - 200 enterococci/100ml
C	Sample 95 percentile 201 - 500 enterococci/100ml
D	Sample 95 percentile > 500 enterococci/100ml

SFRGs, as defined by the Ministry for the Environment, are:

- *Very Good*: considered satisfactory for swimming at all times.
- *Good*: satisfactory for swimming most of the time. Exceptions may include following rainfall.
- *Fair*: generally satisfactory for swimming, though there are many potential sources of faecal material. Caution should be taken during periods of high rainfall, and swimming avoided if water is discoloured.
- *Poor*: generally unsuitable for swimming, as indicated by historical results. Swimming should be avoided, particularly by the very young, the very old and those with compromised immunity.
- *Very Poor*: avoid swimming.

Seventeen of the 19 coastal sites monitored by the Council had sufficient data available to calculate SFRG grades for the period spanning November 2011 to March 2016 (Table 3, Appendix II). Of these 17 sites, 14 were graded 'good' and 3 were graded 'fair'. None of the beaches graded 'poor' or 'very poor'. As 16 of the 17 beaches were assigned a SIC of 'moderate' it was not possible for any of these beaches to obtain a 'very good' SFRG grading regardless of the enterococci results used to calculate MAC. This was mainly related to either the agricultural nature of the catchment areas or the presence of nearby steams and rivers which heavily influenced the SIC assessment results.

It must be emphasized that the SFRG grade provides a conservative/precautionary guideline intended for assessing the suitability of beaches for contact recreation from a public health perspective. The grade is of limited use for assessing the state of the environment, as it includes the SIC: a static assessment based on qualitative information. Instead, the remainder of this report will focus on presenting and interpreting actual faecal indicator data collected during routine monitoring. This

quantitative information enables the assessment of general trends in coastal water quality, and can be used to measure how well management practices and policies are working, and whether environmental outcomes are being achieved.

It should be noted that the Ministry itself states that the SFRG '*reflects a precautionary approach to managing public health risks and does not represent an accurate picture of water quality in the catchment. …The grades reflect a precautionary approach to managing health risk and are not designed to represent health risks on a particular day. They tend to reflect the poorest water quality measured at a site rather than the average water quality. A site may be graded as poor but still be suitable for swimming much of the time….The indicator does not replace the site-specific information available on council websites*'[1]

Note: Table 3 takes into account data from both standard SEM samples along with extra samples required by MfE (see Section 3).

Table 3 Suitability for recreation grade for the period November 2011 to March 2016

Site	Sanitary Inspection Category	MAC			SFRG Grade	%of all inspection in compliance
		95%ile	No of samples	Category		
Wai-iti	Moderate 13	56.8	26	B	Good	100
Urenui*	Moderate 13	28.6	26	A	Good	100
Onaero	Moderate 13	260.0	100	C	Fair	95
Onaero Settlement	Low 14	98.4	26	B	Good	100
Waitara (East)	Moderate 13	227.5	65	C	Fair	96
Waitara (West)	Moderate 13	145.0	65	B	Good	98
Fitzroy	Moderate 3	42.0	100	B	Good	98
East End	Moderate 3	115.0	65	B	Good	98
Ngamotu	Moderate 3	105.0	100	B	Good	98
Oakura (SC)	Moderate 13	200.0	100	B	Good	96
Oakura (CG)	Moderate 13	49.0	65	B	Good	100
Opunake*	Moderate 3	15.5	100	A	Good	100
Ohawe	Moderate 13	415.0	65	C	Fair	93
Patea (Mana Bay)	Moderate 13	45.5	39	B	Good	97
Patea*	Moderate 13	28.6	26	A	Good	100
Waverley*	Moderate 13	27.4	26	A	Good	100
Wai-inu	Moderate 13	41.6	26	B	Good	100
Back	Low 14	Insufficient data to calculate				
Bell Block	Moderate 3	Insufficient data to calculate				

* Irreconcilable follow up
Insufficient data – a minimum of 20 samples is needed to calculate MAC
13 = River - agricultural activities/birds/feral animals
14 = River - focal points of discharge
3 = Urban stormwater

[1] *Suitability for swimming: Indicator update July 2013: INFO 690*, Ministry for the Environment

3. Monitoring methodology

3.1 SEM sample collection

The monitoring network is designed to assess coastal water quality in terms of its suitability for contact recreation. As such, the network targets the main bathing times and avoids, as far as possible, the localized influence of diffuse sources (i.e. streams and rivers) on coastal water quality. For these reasons the following criteria have been adopted during sampling:

Sample collection, field measurements, transport and analyses were undertaken according to documented Taranaki Regional Council procedures. It was intended that on average, four samples would be collected from each of the sites in each month when hydrological flow conditions permitted, within two hours of high tide. SEM sampling was performed only under dry weather flow conditions (i.e. not within three days of a fresh). Bathing water samples were taken between the hours of 0900 and 1800 hours (NZDT) to reflect the most likely period for swimming usage. Where necessary, a 2 m sampling pole was used for bacteriological sample collection immediately beneath the water surface and at a minimum of knee depth at the sites (Photo 1). Thirteen samples were collected from each site during the season.

Results for the 2015-2016 bathing season were posted on the Taranaki Regional Council website (www.trc.govt.nz) as soon as checking had been completed. Where single results fell in the Action mode, further sampling was performed when necessary i.e. where historical databases and staff expertise indicated this was warranted.

3.2 Sample analysis

Samples were analyzed for enterococci, *E. coli*, faecal coliforms and conductivity. *E. coli* and faecal coliform numbers were obtained using the mTEC agar method #9213-d, Standard Methods for the Examination of Waters and Wastewaters (APHA, 2005). Enterococci were quantified using the EPA modified method #1600 on mEI agar (EPA, 1986).

At each of the sites the following additional information was recorded: time, water temperature, weather condition, wind condition, surf condition, colour/appearance of water, and number of bathers and other users.

3.3 Programme design

The locations of the fourteen sites sampled in the 2015-2016 programme are shown in Figure 1 and Table 4.

Table 4 Location of bathing water bacteriological sampling sites 2015-2016

Beach	Location	GPS	Site code
Onaero	Opposite surf lifesaving club	2628254-6244898	SEA900085
Waitara	East Beach	1706602-5683915	SEA901033
Waitara	West Beach	1705951-5683802	SEA901037
Fitzroy	Opposite surf lifesaving club	2605036-6239351	SEA902025
Ngamotu	Centre of beach	2600022-6237765	SEA902062
Oakura	Oppostie surf lifesaving club, south of Wairau Stream	2591974-6231726	SEA903030
Oakura	Opposite motorcamp, south of Waimoku Stream	2591700-6231600	SEA903032
Opunake	Centre of beach	2583775-6193800	SEA904090
Ohawe	Adjacent to boat ramp, east of Waingongoro River	2612688-6179169	SEA906010
Patea	100m north of northern breakwater (and Patea River)	2637262-6158165	SEA907020
Mana Bay	Adjacent carpark "Mana" Bay	6237574-6158138	SEA907022
Waverley	Adjacent to baot ramp	2649820-6151265	SEA907085
Wai-inu	Adjacent to boat launching area	2659507-6147292	SEA907095

Primary beach sites are monitored each year (Figure 1). Remaining beach sites are sampled on a three year rotation, with Year 1 beaches sampled during the 2015-2016 monitoring programme (Table 5).

Table 5 Coastal bathing beach sampling programme

Annually sampled	Year 1	Year 2	Year 3
Onaero (opp. surf club)	Patea	Bell Block	Wai-iti
Waitara East	Patea Bay **	Back Beach	Urenui
Waitara West	Waverley		Onaero Settlement
Fitzroy	Wai-inu		
East End			
Ngamotu			
Oakura CG			
Oakura SC			
Opunake			
Ohawe *			

**since 1996-97*
*** since 2000-01 summer period*

Photo 1 Faecal indicator bacteria sampling

3.3.1 Additional monitoring (MfE guidelines)

The revised guidelines (MfE, 2003) generally require weekly surveillance monitoring during the 5-month recreational period, with a minimum of 20 sampling dates, regardless of weather conditions or state of the tide. This is primarily to facilitate the calculation of the Microbiological Assessment Category (See Section 2.2). Following consultation with the territorial local authorities and the Taranaki District Health Board, TRC added seven sampling dates to the SEM protocol at five of the most popular marine recreational sites (Onaero, Fitzroy, Ngamotu, Oakura and Opunake beaches) in the 2002-2003 period. These seven sampling dates were systematically selected (one per week) in weeks not sampled by the SEM programme. Sampling was undertaken regardless of prior weather conditions or tides but adhering to all other SEM programme protocols. [NB: These data will not be used for trend analysis purposes as they do not comply with the format of the originally established SEM programme].

3.4 Long-term trend analysis

For sites with sufficient data (≥10 years), non-parametric trend analysis was performed using annual median enterococci data. For each site, a LOWESS (Logically Weighted Scatterplot) line (tension 0.4) was fitted to a temporal scatter plot of the enterococci median data. Statistical significance of the trend was tested using a Mann-Kendall test. The sign (+/-) of the Kendall tau value was used to assess whether the trend was positive or negative and the significance of the trend was determined using the p value ($p < 0.05$ = significant).

When multiple correlations are undertaken, there is a chance that some will be found to be significant purely by chance. In order to deal with this potential problem, the Benjamini-Hochberg False Discovery Rate (FDR) method was applied to the results of

the Mann-Kendall test. Further justification for this statistical approach can be found in Stark and Fowles (2006).

Figure 1 SEM beach bathing bacteriological survey sites

4. Results

From 12 November 2015 to 30 March 2016 a total of 13 samples were collected at each site for the purpose of state of the environment monitoring (SEM). Whenever possible, no SEM sampling was undertaken within three days following significant river freshes. However, occasionally sampling was affected by localized rainfall and elevated river flows. An additional seven samples were taken at five of the beaches (Onaero, Fitzroy, Ngamotu, Oakura and Opunake) regardless of weather conditions for the purpose of MfE categotization (as discussed in Section 3.3.1). All results within this report are presented and discussed on a site-by-site basis for the sampling period. The timing of high tide on the dates sampled is provided in Appendix I.

Sampling was confined to weekdays, with no public holidays included. 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 utilized for bathing and other contact recreational activities, particularly at weekends, dependent on suitable weather conditions.

4.1 Onaero Beach

4.1.1 SEM programme

Onaero Beach (Photo 2), located in north Taranaki, is a relatively popular bathing beach, particularly over the Christmas holiday period. The Onaero River drains to the southern end of the beach, making a significant contribution to bacteria counts following rainfall events.

Photo 2 Onaero Beach

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

Table 6 Bacteriological results for Onaero Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
12 Nov 2015	08:25	4700	19	4	19	15.0
25 Nov 2015	08:45	4730	1	5	1	16.5
10 Dec 2015	08:30	4800	13	3	13	16.2
15 Dec 2015	11:10	4740	1	1	1	16.1
12 Jan 2016	09:25	4580	21	4	21	19.3
15 Jan 2016	11:50	4560	52	9	52	20.7
25 Jan 2016	09:15	4620	7	9	7	21.6
09 Feb 2016	09:00	4630	16	32	18	22.4
12 Feb 2016	11:20	4750	1	7	1	23.5
23 Feb 2016	09:00	4590	28	28	28	22.3
08 Mar 2016	08:00	4620	40	42	40	20.7
22 Mar 2016	08:00	4570	44	52	44	20.6
30 Mar 2016	12:00	4600	7	8	7	21.1

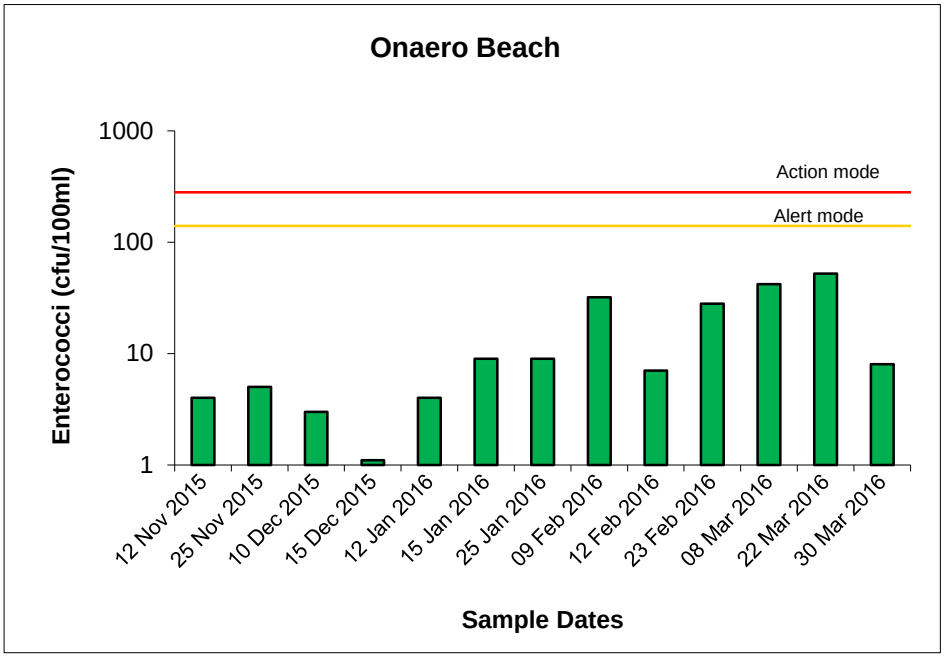

Figure 2 Enterococci counts for the 13 SEM samples taken from Onaero Beach

Table 7 Statistical summary for Onaero Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4560	4800	4620
E. coli	cfu/100 ml	13	1	52	16
Enterococci	cfu/100 ml	13	1	52	8
Faecal coliforms	cfu/100 ml	13	1	52	18
Temperature	°C	13	15.0	23.5	20.7

No high individual enterococci counts were recorded throughout the season (all counts ≤52 cfu/100 ml) and the median enterococci count was 8 cfu/100 ml (Table 15). None of the counts entered Action or Alert mode.

4.1.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Onaero Beach over 16 summers are presented in Table 8 and Figure 3.

Table 8 Summary enterococci data (cfu/100 ml) for summer surveys at Onaero Beach

Summer	96/97	99/00	01/02	02/03	03/04	04/05	05/06	06/07	
Minimum	1	4	5	< 1	<1	<1	<1	2	
Maximum	26	40	140	4200	52	1000	46	560	
Median	13	12	17	9	5	15	4	7	
Summer	**07/08**	**08/09**	**09/10**	**10/11**	**11/12**	**12/13**	**13/14**	**14/15**	**15/16**
Minimum	<1	2	3	<1	1	<1	1	<1	1
Maximum	59	64	27	96	42	32	25	24	52
Median	4	13	13	11	4	15	5	7	8

The median enterococci count obtained for the 2015-2016 summer (8 cfu/100 ml) (Table 8, Figure 3) was typical of that previously recorded at this site. The maximum enterococci count (52 cfu/100 ml), although not as low as the previous monitoring year, was relatively low for this site (Table 8).

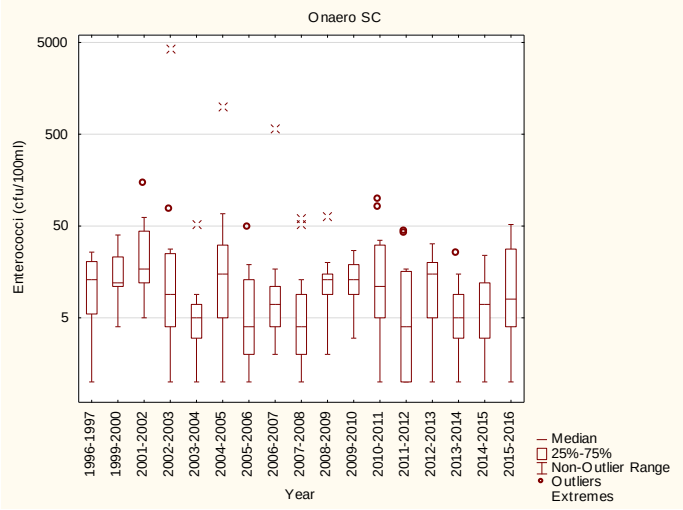

Figure 3 Box and whisker plots of enterococci for all summer SEM surveys at Onearo Beach

4.1.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median enterococci data for 14 summer seasons (Figure 4) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

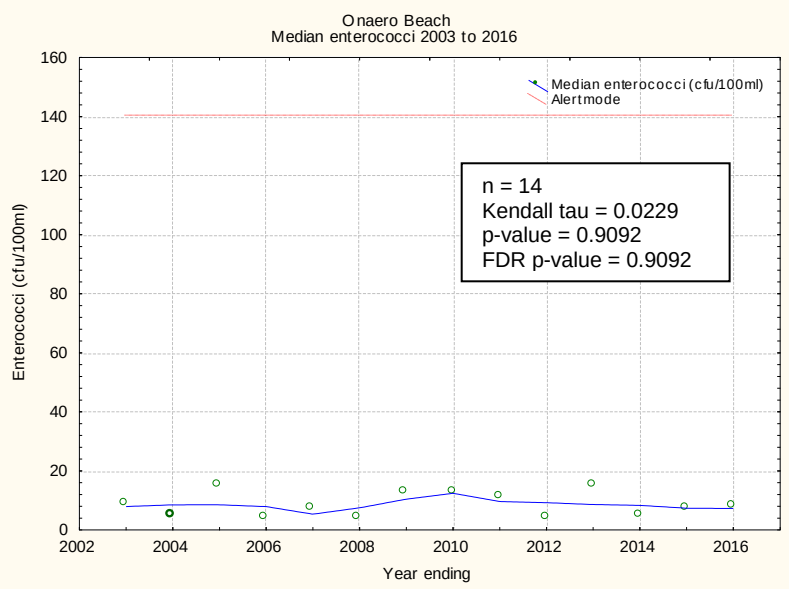

Figure 4 LOWESS trend analysis of median enterococci data at Onaero Beach

Over the 14 seasons monitored, there was a positive trend in median enterococci counts (Kendall tau = 0.023) that was not significant at the 5% level (p = 0.909).

4.1.4 MfE guidelines additional sampling

For the purpose of MfE monitoring, seven additional samples were collected at regular intervals under varying weather conditions during the survey season. All data, including additional MfE samples, are presented in Table 9 and Figure 5, with a statistical summary provided in Table 10.

Table 9 Bacteriological results for MfE samples at Onaero Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temperature (°C)
			E. coli (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	
03 Nov 2015	09:25	3260	65	8	68	15.1
15 Dec 2015	11:15	4650	7	5	7	15.5
22 Dec 2015	09:12	4310	100	28	100	17.0
06 Jan 2016	08:45	4350	25	9	25	19.2
19 Jan 2016	09:15	4080	930	1500	930	21.5
02 Feb 2016	08:55	3930	3600	5600	3700	22.2
16 Feb 2016	09:05	4690	19	13	20	23.1
15 Mar 2016	08:50	4480	39	73	39	20.4

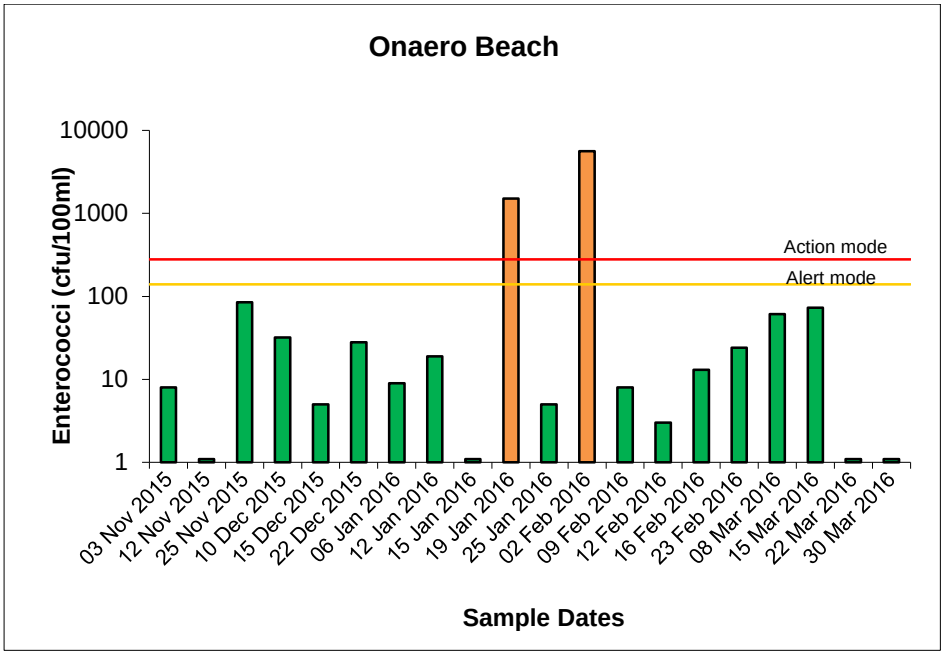

Figure 5 Enterococci counts for the 20 sample extended survey at Onaero Beach

Table 10 Summary statistics for SEM and MfE samples at Onaero Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	3260	4720	4620
E. coli	cfu/100 ml	20	0.5	3600	22
Enterococci	cfu/100 ml	20	0.5	5600	11
Faecal coliforms	cfu/100 ml	20	1	3700	22
Temperature	°C	20	14.7	23.1	20.6

Elevated enterococci counts obtained on MfE sampling dates were associated with lower conductivity (Table 9, N.B. typical conductivity of seawater is 4750 mS/m). The Onaero River which drains to the southern end of the beach is likely to have made a significant contribution to the higher bacteria counts recorded on 19 January and 2 February 2016 (Table 9). Although enterococci counts obtained on these two dates exceeded 280 cfu/100 ml, counts in the follow up samples were low i.e. 5 cfu/100 ml on 22 January and 1 cfu/100 ml on 4 February 2016. As a result the two elevated counts on 19 January and 2 February 2016 remained in Alert mode and not Action (N.B. for Action mode to be reached two consecutive sample of greater than 280 cfu/100 ml are required).

4.2 Waitara East Beach

4.2.1 SEM programme

Waitara East Beach is located to the east of the Waitara River mouth (Photo 3). Results at this site are influenced by the Waitara River which drains a large agricultural catchment and often contains high levels of bacteria.

Prior to October 2014, municipal wastewater from the Waitara township was discharged through the Waitara Marine Outfall approximately 1.8 km out to sea. Since October 2014, New Plymouth District Council has pumped municipal wastewater from the Waitara township to the New Plymouth Wastewater Treatment Plant and sewage is no longer discharged through the Waitara Marine Outfall during normal operation of the wastewater system.

Photo 3 Waitara East Beach

The data for this site are presented in Table 11 and Figure 6, with a statistical summary provided in Table 12.

Table 11 Bacteriological results for Waitara East Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temperature (°C)
			E . coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
12 Nov 2015	08:50	4210	20	1	20	14.6
25 Nov 2015	08:25	4130	81	44	82	16.2
10 Dec 2015	08:50	4530	4	1	4	15.0
15 Dec 2015	11:30	4360	11	3	11	16.3
12 Jan 2016	09:47	4400	56	21	56	18.9
15 Jan 2016	12:15	4620	1	<1	1	20.2
25 Jan 2016	09:35	4460	9	4	9	21.6
09 Feb 2016	09:55	4560	5	24	7	22.9
12 Feb 2016	12:15	4720	4	9	4	23.2
23 Feb 2016	09:55	4240	41	110	43	22.1
08 Mar 2016	08:50	4710	86	40	88	19.1
22 Mar 2016	08:50	4530	9	5	9	21.0
30 Mar 2016	12:50	4100	19	20	20	21.3

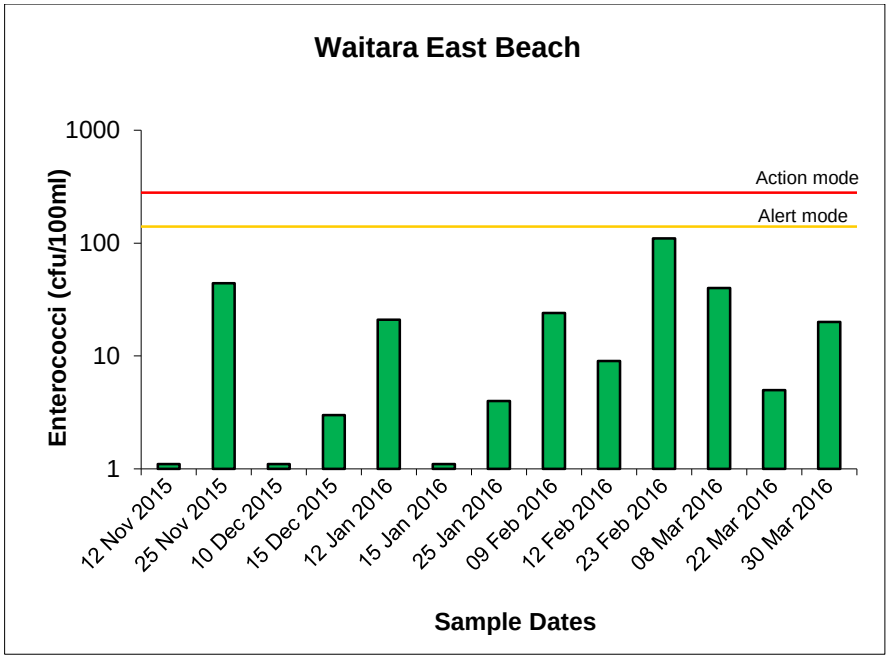

Figure 6 Enterococci counts for the 13 SEM samples taken from Waitara East Beach

Table 12 Statistical summary for Waitara East Beach

Parameter	Unit	Number	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4100	4720	4460
E. coli	cfu/100 ml	13	1	86	11
Enterococci	cfu/100 ml	13	<1	110	9
Faecal coliforms	cfu/100 ml	13	1	88	11
Temperature	°C	13	14.6	23.2	20.2

The highest enterococci count recorded during the 2015-2016 monitoring year (110 cfu/100 ml) remained within surveillance mode (<140 cfu/100 ml) and was recorded on 23 February 2016. The count was associated with lower conductivity (4240 mS/m, Table 11) indicating freshwater influence from the Waitara River on this day.

4.2.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Waitara East Beach over 21 summers are presented in Table 13 and Figure 7. The median enterococci count (9 cfu/100 ml) was well within the range of median counts previously recorded at this site. The maximum enterococci count (110 cfu/100 ml) was low relative to previous years at this site. Maxima at this site are historically high due to the influence of the Waitara River (Table 13).

Table 13 Summary enterococci data (cfu/100 ml) for summer surveys at Waitara East Beach

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	
Minimum	1	1	1	3	3	1	4	<1	<1	1	
Maximum	950	960	230	250	230	520	290	410	840	310	
Median	14	11	17	20	40	9	21	13	17	9	
Summer	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Minimum	<1	1	1	<1	<1	<1	1	<1	<1	<1	<1
Maximum	88	91	120	2400	210	1000	190	400	220	250	110
Median	9	27	12	41	15	3	6	37	7	1	9

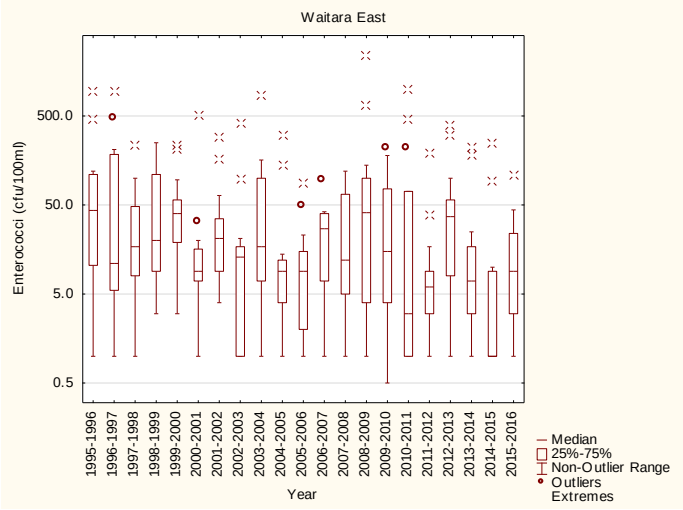

Figure 7 Box and whisker plots of enterococci for all summer surveys at Waitara East Beach

4.2.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median enterococci data for 20 summer seasons (Figure 8) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

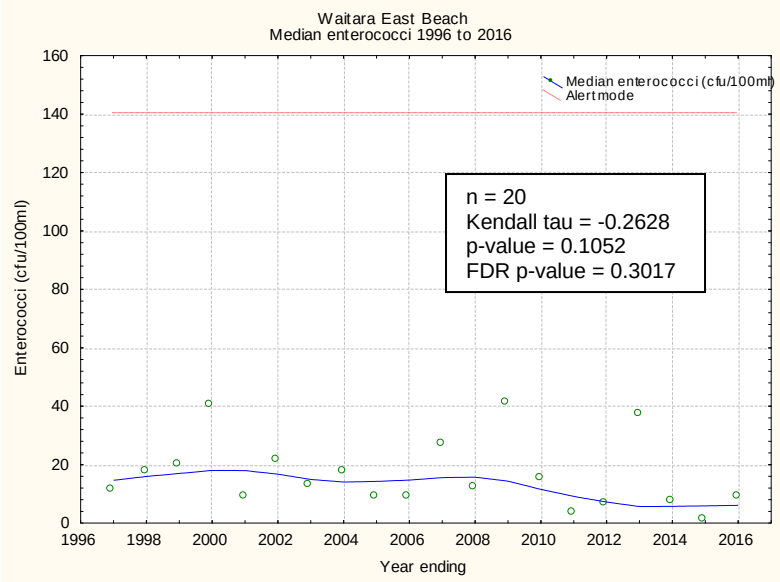

Figure 8 LOWESS trend analysis of median enterococci data at Waitara East Beach

Over the 20 seasons monitored, there was a decreasing trend in median enterococci counts (Kendall tau = -0.263) that was not significant at the 5% level (p = 0.105).

4.3 Waitara West Beach

4.3.1 SEM programme

Waitara West Beach is located to the west of the Waitara River mouth (Photo 4). As with Waitara East Beach, the results at this site can be influenced by the Waitara River.

Since October 2014, municipal wastewater from the Waitara Township has been directed to the New Plymouth Wastewater Treatment Plant and is no longer discharged through the Waitara Marine Outfall during normal operation of the wastewater system.

Photo 4 Waitara West Beach

The data for this site are presented in Table 14 and Figure 9, with a statistical summary provided in Table 15.

Table 14 Bacteriological results for Waitara West Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temperature (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
12 Nov 2015	09:25	4500	4	4	4	14.5
25 Nov 2015	08:03	4620	16	4	16	15.8
10 Dec 2015	09:10	4720	3	4	5	15.3
15 Dec 2015	11:50	4640	1	1	1	17.6
12 Jan 2016	10:10	4400	64	54	68	19.1
15 Jan 2016	12:45	4650	<1	57	<1	20.4
25 Jan 2016	10:00	4450	19	9	19	21.8
09 Feb 2016	10:20	4540	4	9	5	23.2
12 Feb 2016	12:40	4660	3	19	3	23.3
23 Feb 2016	10:25	4390	60	180	62	22.7
08 Mar 2016	09:15	4690	2800	590	2800	20.0
22 Mar 2016	09:25	4460	16	7	16	21.3
30 Mar 2016	13:20	4250	12	7	12	21.4

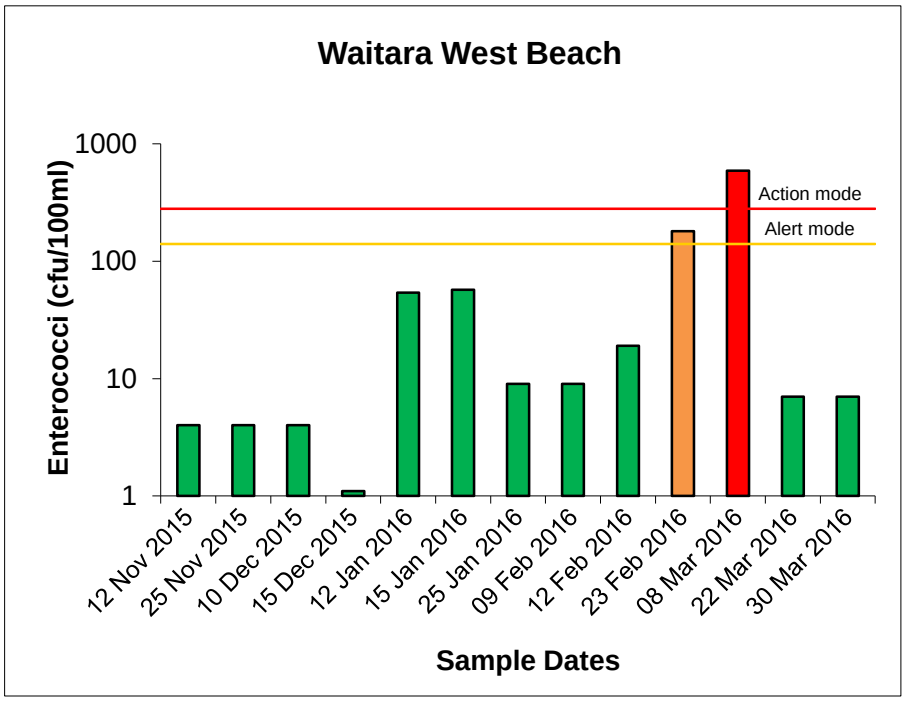

Figure 9 Enterococci counts for the 13 SEM samples taken from Waitara West Beach

Table 15 Statistical summary for Waitara West Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4250	4720	4540
E. coli	cfu/100 ml	13	<1	2800	12
Enterococci	cfu/100 ml	13	1	590	9
Faecal coliforms	cfu/100 ml	13	<1	2800	12
Temperature	°C	13	14.5	23.3	20.4

Two elevated enterococci counts were recorded during the 2015-2016 monitoring year. The first high count on 23 February 2016 (180 cfu/100 ml) reached Alert mode and was associated with lower conductivity (4390 mS/m, Table 11) indicating freshwater influence from the Waitara River. The enterococci count had dropped to 11 cfu/100 ml in the follow up sample taken on the 25 February 2016.

The sample taken on 8 March 2016, with an enterococci count of 590 cfu/100 ml, reached Action level also taking into consideration the high count in the follow up sample collected on 10 March 2016 (380 cfu/100 ml) i.e. two consecutive samples exceeded 280 cfu/100 ml. It had not rained for the few days preceding and conductivity of the sample taken on 8 March 2016 (4690 mS/m) did not indicate strong freshwater influence. King high tides occurred on both dates (3.6 m 8 March, 3.9 m 10 March). In previous years certain high counts at the two Waitara beach sites were also associted with king tides (e.g. Waitara East Beach: 250 cfu/100 ml 3.8 m high tide on 19 February 2015, 220 cfu/100 ml 3.6 m high tide on 30 January 2014). In order to investigate any potential link between high counts and king tides, additional beach (x2) and river mouth (x4) samples were collected on 9 May 2016 (3.6 m high tide). All samples collected had low enterococci counts (Waitara East 15 cfu/100 ml, Waitara West 64 cfu/100 ml, all Waitara River counts ≤100 cfu/100 ml). It was recommended not to undertake Faecal Source Tracking on samples with such low counts (ESR personal communication). The highs counts on 8 and 10 March therefore remain unexplained.

During February-March 2016 there were three unauthorized sewage discharges around the Waitara area (two out of the Waitara Marine Outfall on 13 February and 31 March and one from the reticulation system crossing the Waiongana River on 26 March). Neither the Alert level count on 23 February nor the Action level count on the 8 March can be directly explained as a result of the unauthorized discharges.

4.3.2 Comparison with previous summer surveys

Summary statistics for enterococci survey data collected at Waitara West Beach over 20 summers are presented in Table 16 and Figure 10. The median enterococci count (9 cfu/100 ml) was well within the range of median counts previously recorded at this site. The maximum enterococci count (590 cfu/100 ml), although not as low as the previous few monitoring years, was not unusual for this site (Table 8).

Table 16 Summary enterococci data (cfu/100 ml) for summer surveys at Waitara West Beach

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	
Minimum	2	1	1	1	3	1	1	1	1	1	
Maximum	4300	100	340	350	290	240	57	170	800	300	
Median	21	16	28	5	19	5	11	16	26	7	
Summer	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Minimum	1	1	1	2	3	1	<1	3	<1	<1	1
Maximum	100	240	67	530	42	910	160	90	110	100	590
Median	8	8	5	120	12	20	13	8	8	4	9

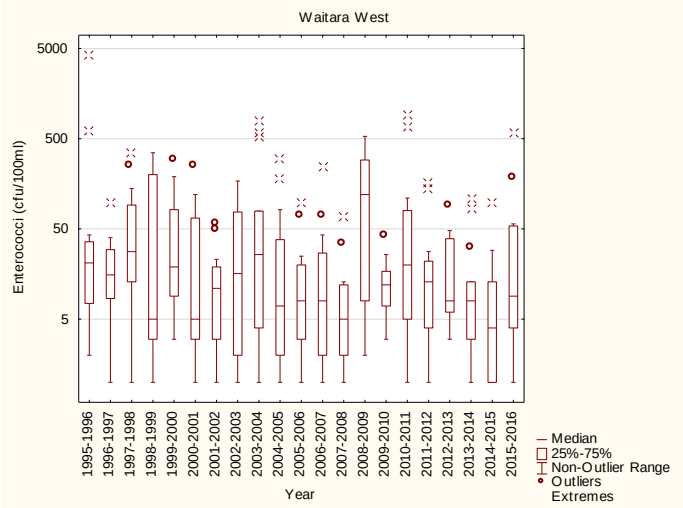

Figure 10 Box and whisker plots of enterococci for all summer SEM surveys at Waitara West Beach

4.3.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median enterococci data for 20 summer seasons (Figure 11) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

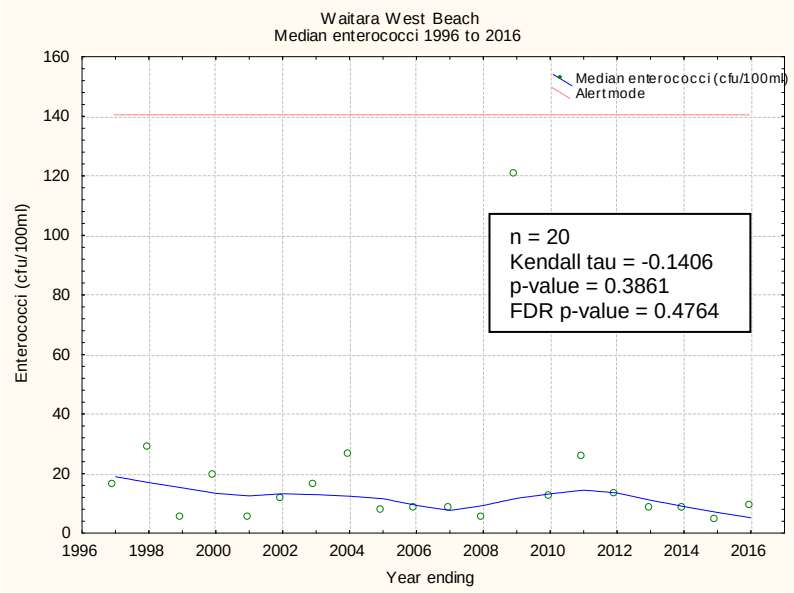

Figure 11 LOWESS trend analysis of median enterococci data at Waitara West Beach

Over the 20 seasons monitored, there was a decreasing trend in median enterococci counts (Kendall tau = -0.141) that was not significant at the 5% level (p = 0.386).

4.4 Fitzroy Beach

4.4.1 SEM programme

Fitzroy Beach is situated in New Plymouth and is one of the most popular bathing beaches in Taranaki. It is also a very popular surfing beach due to its central location and high quality waves (Photo 5).

The mouth of the Waiwhakaiho River enters the sea at the eastern end of the beach, approximately 800 m from the sample site, which on rare occasions can contribute significant amounts of freshwater during floods. Draining from a highly modified agricultural and industrial catchment, this can have a significant impact on bacteriological water quality subsequent to heavy rainfall. The river typically has a high level of contamination from birdlife.

Photo 5 Surfer at Fitzroy Beach

The data for this site are presented in Table 17 and Figure 12, with a statistical summary provided in Table 18.

Table 17 Bacteriological results for Fitzroy Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
12 Nov 2015	08:55	4740	<1	<1	<1	14.6
25 Nov 2015	08:50	4710	3	5	3	16.0
10 Dec 2015	08:40	4770	8	<1	11	14.6
15 Dec 2015	11:00	4670	4	1	4	15.6
12 Jan 2016	09:25	4530	9	5	9	18.6
15 Jan 2016	13:50	4500	<1	3	<1	20.9

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
25 Jan 2016	09:00	4670	3	4	3	21.1
09 Feb 2016	09:00	4690	4	4	4	22.4
12 Feb 2016	10:30	4660	1	<1	1	22.6
23 Feb 2016	08:55	4650	8	9	12	22.1
08 Mar 2016	08:40	4800	5	12	5	19.1
22 Mar 2016	10:40	4630	1	2	1	21.5
30 Mar 2016	12:00	4730	<1	<1	<1	20.8

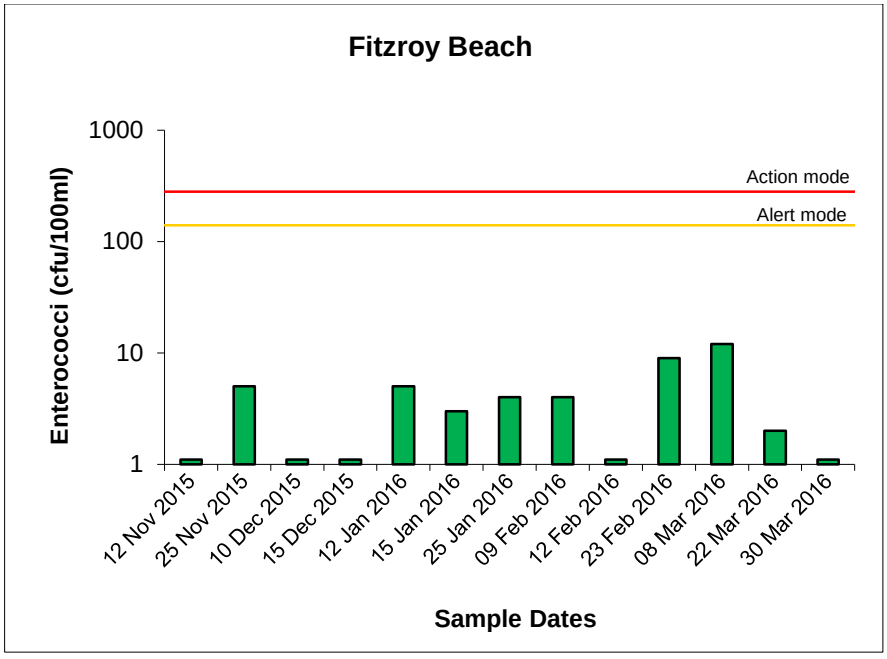

Figure 12 Enterococci counts for the 13 SEM samples taken from Fitzroy Beach

Table 18 Statistical summary for Fitzroy Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4500	4800	4670
E. coli	cfu/100 ml	13	<1	9	3
Enterococci	cfu/100 ml	13	<1	12	3
Faecal coliforms	cfu/100 ml	13	<1	12	3
Temperature	°C	13	14.6	22.6	20.8

Bacteriological water quality at Fitzroy Beach was high throughout the season, with low median and maximum values for all faecal indicator bacteria.

4.4.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Fitzroy Beach over 21 summers are presented in Table 19 and Figure 13.

Table 19 Summary enterococci data (cfu/100 ml) for summer surveys at Fitzroy Beach

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	
Minimum	3	< 1	< 1	< 1	< 1	< 1	< 1	< 1	<1	<1	
Maximum	46	280	40	79	17	98	350	580	98	52	
Median	10	15	7	7	4	7	9	5	3	4	
Summer	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Minimum	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1
Maximum	85	33	44	110	60	43	930	36	45	11	12
Median	6	3	3	10	8	4	3	3	<1	3	3

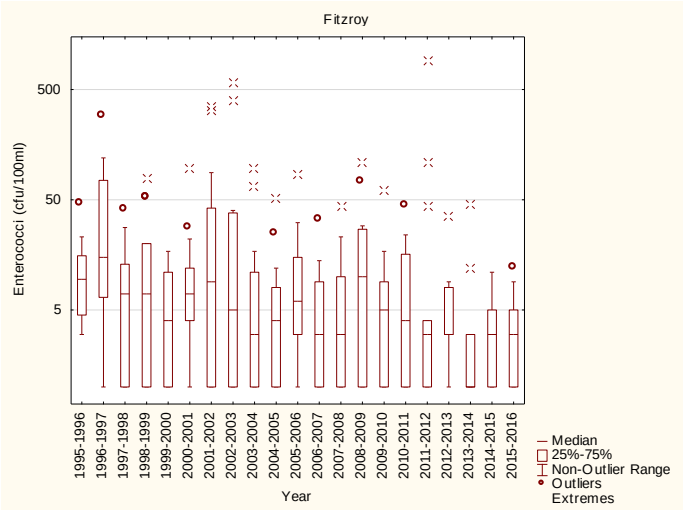

Figure 13 Box and whisker plots of enterococci for all summer SEM surveys at Fitzroy Beach

The maximum enterococci count (12 cfu/100 ml) at Fitzroy Beach was one of the lowest to date for this site. The median enterococci count (3 cfu/100 ml) was also low relative to other years and sites.

4.4.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median enterococci data for 21 summer seasons (Figure 14) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

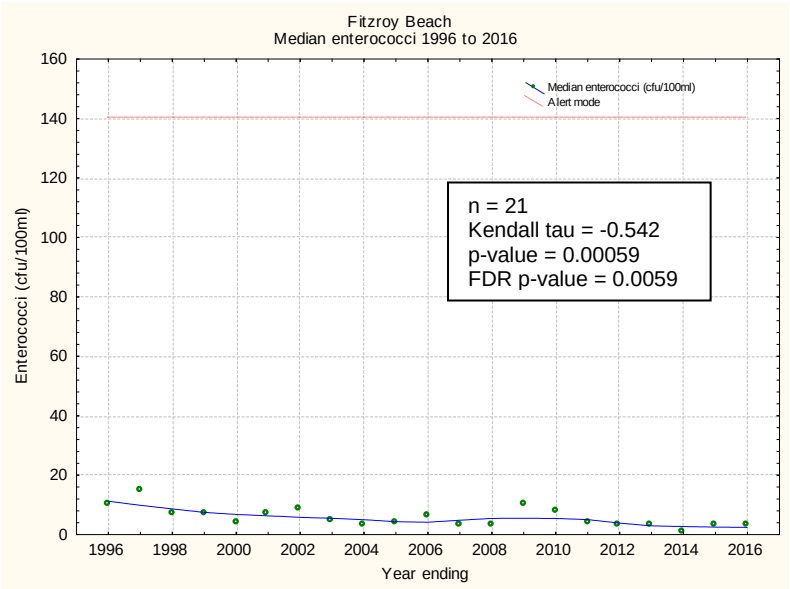

Figure 14 LOWESS trend analysis of median enterococci data at Fitzroy Beach

Over the 21 seasons monitored, there was a decrease in median enterococci counts (Kendall tau = -0.542). This negative trend was significant using the Mann-Kendall test ($p < 0.001$) and after FDR application ($p = 0.006$).

4.4.4 MfE guidelines additional sampling

For the purpose of MfE monitoring, seven additional samples were collected at regular intervals and under varying weather conditions during the survey season. All data, including additional MfE samples, are presented in Table 20 and Figure 15, with a statistical summary provided in Table 21.

Table 20 Bacteriological results for MfE samples at Fitzroy Beach

Date	Time	Conductivity @ 20°C	Bacteria			Temperature
	(NZST)	(mS/m)	*E. coli* (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	(°C)
03 Nov 2015	10:15	4580	4	1	4	15.3
22 Dec 2015	10:00	4800	1	<1	1	16.3
06 Jan 2016	10:30	4660	<1	<1	<1	20.3
19 Jan 2016	10:10	3880	3500	3300	3600	21.2
02 Feb 2016	10:20	4570	35	17	36	22.9
16 Feb 2016	10:35	4610	7	11	11	23.7
15 Mar 2016	11:25	4580	33	40	33	21.2

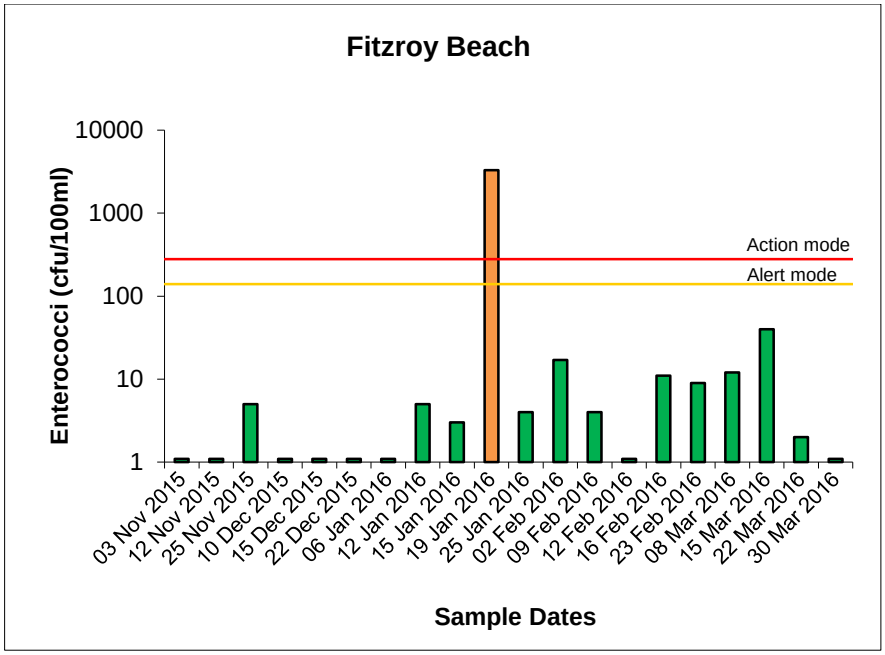

Figure 15 Enterococci counts for the 20 sample extended survey at Fitzroy Beach

Table 21 Summary statistics for SEM and MfE samples at Fitzroy Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	3880	4800	4660
E. coli	cfu/100 ml	20	<1	3500	4
Enterococci	cfu/100 ml	20	<1	3300	4
Faecal coliforms	cfu/100 ml	20	<1	3600	4
Temperature	°C	20	14.6	23.7	20.9

Additional sampling resulted in a slight increase to the overall seasonal median for enterococci (from 3 to 4 cfu/100 ml, Table 21), with counts for the majority of MfE samples remaining low (Table 20). The exception was the sample taken on 19 January 2016 which had an unusually high enterococci count for this site (3300 cfu/100 ml). In previous samples taken at Fitzroy Beach, counts had not exceeded surveillance mode i.e. >140 cfu/100 ml since 22 January 2012 (930 cfu/100 ml).

The sample taken on 19 January 2016 had a low conductivity (3880 mS/m) indicating freshwater influence. Heavy rain was recorded overnight on the 18 January2016. The low conductivity and brown/grey colouration of the sea on 19 January indicate the potential source of contamination was from nearby streams/rivers, most likely the Te Henui Stream and/or the Waiwhakaiho River. Avian sources are known to be the main contributors to feacal contamination at these sites (gulls at the mouth of the Waiwhakaiho River and ducks at the mouth of the Te Henui Stream).

4.5 East End Beach

4.5.1 SEM programme

East End Beach is situated approximately 500 m south-west of Fitzroy Beach in New Plymouth (Photo 6). This beach is popular with summer bathers and has its own Surf Life-saving Club. The Te Henui Stream enters the sea approximately 200 m to the south-west of the sample site, which can result in high freshwater inputs during significant rainfall events.

Photo 6 East End Beach

The data for this site are presented in Table 22 and Figure 18, with a statistical summary provided in Table 23.

Table 22 Bacteriological results for East End Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	
12 Nov 2015	09:25	4720	3	<1	3	14.7
25 Nov 2015	09:05	4550	24	85	24	16.1
10 Dec 2015	08:50	4660	69	32	80	14.8
15 Dec 2015	11:15	4650	7	5	7	15.5
12 Jan 2016	09:45	4540	31	19	31	18.5
15 Jan 2016	13:30	4610	1	<1	1	20.7
25 Jan 2016	09:20	4700	3	5	3	21.3
09 Feb 2016	09:20	4680	<1	8	1	22.5
12 Feb 2016	10:45	4650	4	3	5	22.7

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	
23 Feb 2016	09:10	4570	16	24	17	22.0
08 Mar 2016	08:55	4680	53	61	60	19.5
22 Mar 2016	10:25	4630	<2	1	<2	21.7
30 Mar 2016	12:30	4710	1	1	1	21.0

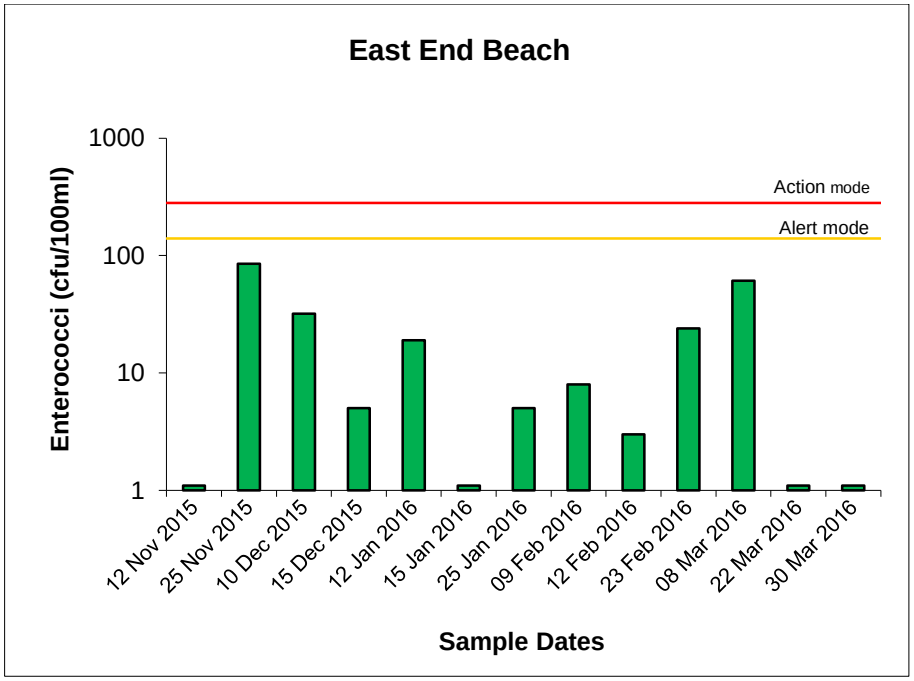

Figure 16 Enterococci counts for the 13 SEM samples taken from East End Beach

Table 23 Statistical results for East End Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4540	4720	4650
E. coli	cfu/100ml	13	<1	69	4
Enterococci	cfu/100ml	13	<1	85	5
Faecal coliforms	cfu/100ml	13	1	80	5
Temperature	°C	12	14.7	22.7	20.7

In general, water quality was good at this site with low medians for all faecal indicator bacteria (≤5 cfu/100ml).

4.5.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at East End Beach over 8 summer surveys are presented in Table 24 and Figure 19.

Table 24 Summary enterococci data (cfu/100 ml) for summer surveys at East End Beach opposite the campground

Summer	1995-96	1998-99	2001-02	2004-05	2007-08	2010-11	2013-14	2015-16
Minimum	3	1	1	<1	1	<1	<1	<1
Maximum	340	88	200	100	140	57	130	85
Median	18	7	32	4	10	11	3	5

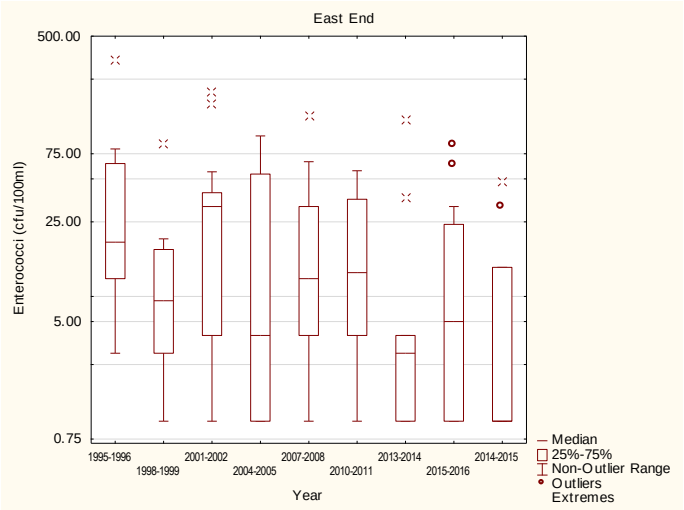

Figure 17 Box and whisker plots of enterococci for all summer SEM surveys at East End Beach

The median and maximum enterococci counts for the 2015-2016 season were at the lower end of the range typically recorded at this site (Table 24, Figure 17).

4.5.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median enterococci data for 13 summer seasons (Figure 18) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

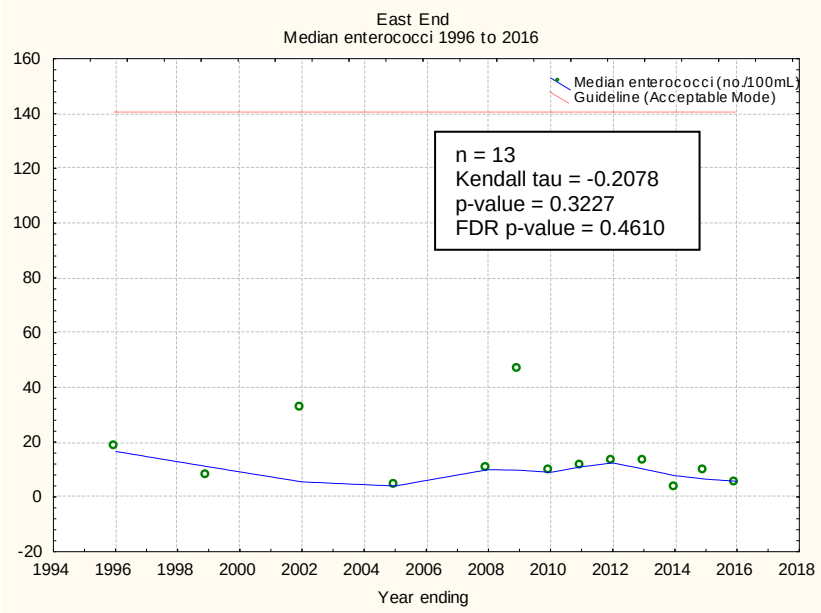

Figure 18 LOWESS trend analysis of median enterococci data at East End Beach

Over the 13 seasons monitored, there was a decreasing trend in median enterococci counts (Kendall tau = -0.201) that was not significant at the 5% level (p = 0.461).

4.6 Ngamotu Beach

4.6.1 SEM programme

Ngamotu Beach (Photo 7) is situated within Port Taranaki, in close proximity to boat traffic and Port activities. It receives urban stormwater and a piped stream. Due to its sheltered location, situated between two breakwaters, this beach is very popular with young children and school groups and is often used for sports events.

Photo 7 Ngamotu Beach

Data for this site are presented in Table 25 and Figure 19, with a statistical summary provided in Table 26.

Table 25 Bacteriological results for Ngamotu Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
12 Nov 2015	10:05	4730	4	4	4	15.2
25 Nov 2015	09:45	4740	1	1	1	16.9
10 Dec 2015	09:30	4820	1	5	3	14.8
15 Dec 2015	11:55	4810	3	7	3	14.8
12 Jan 2016	10:05	4570	1	1	1	19.1
15 Jan 2016	12:50	4700	24	34	24	20.9
25 Jan 2016	10:10	4680	<1	8	<1	22.6

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
09 Feb 2016	10:05	4680	71	110	76	22.6
12 Feb 2016	11:51	4700	<1	3	<1	23.1
23 Feb 2016	09:55	4650	3	7	3	22.4
08 Mar 2016	09:45	4830	8	25	8	18.7
22 Mar 2016	09:45	4560	52	45	63	21.3
30 Mar 2016	13:10	4750	<1	9	<1	22.2

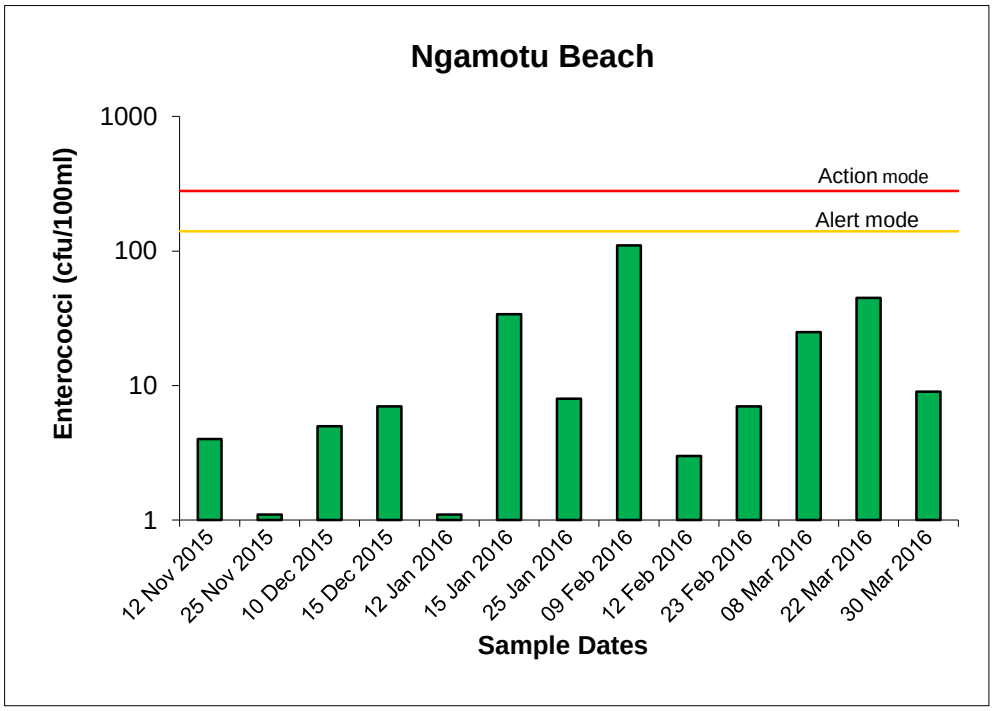

Figure 19 Enterococci counts for the 13 SEM samples taken from Ngamotu Beach

Table 26 Statistical summary for Ngamotu Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4560	4830	4700
E. coli	cfu/100 ml	13	<1	71	3
Enterococci	cfu/100 ml	13	1	110	7
Faecal coliforms	cfu/100 ml	13	<1	76	3
Temperature	°C	13	14.8	23.1	20.9

Relatively low counts were obtained for all SEM faecal indicator bacteria samples through the season (Tables 25 and 26, Figure 26).

4.6.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Ngamotu Beach over 21 summers are presented in Table 27 and Figure 20.

Table 27 Summary enterococci data (cfu/100 ml) for summer surveys at Ngamotu Beach

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	
Minimum	< 1	1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	
Maximum	160	600	310	72	85	240	630	140	60	230	
Median	16	13	5	20	11	10	44	27	5	14	
Summer	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Minimum	1	1	1	1	<1	<1	1	<1	<1	<1	<1
Maximum	90	48	350	55	23	180	1000	29	51	110	110
Median	13	12	4	9	4	8	8	4	4	7	7

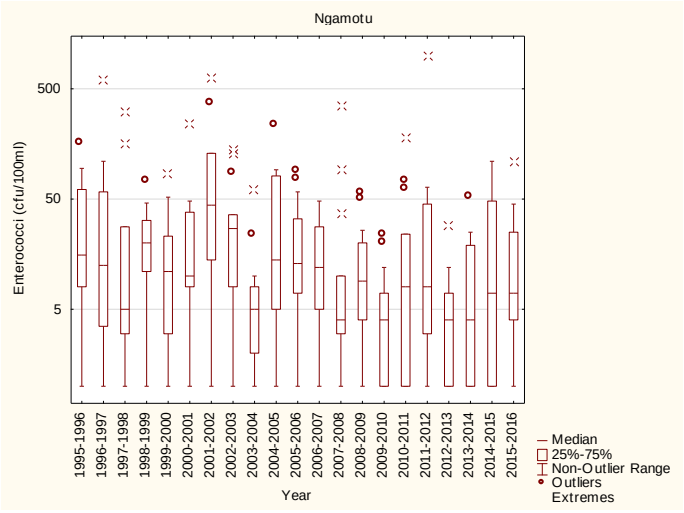

Figure 20 Box & whisker plots of enterococci for all summer SEM surveys at Ngamotu Beach

The median and maximum enterococci counts obtained for the 2015-2016 summer season were within the lower range recorded at this site and exactly the same as the previous year.

4.6.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median enterococci data for 21 summer seasons (Figure 21) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

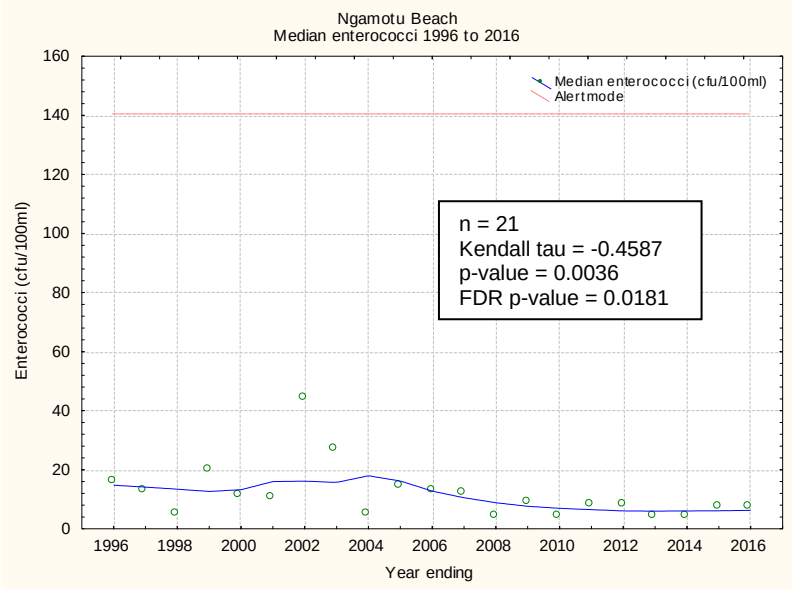

Figure 21 LOWESS trend analysis of median enterococci data at Ngamotu Beach

Over the 21 seasons monitored, there was a decrease in median enterococci count (Kendall tau = -0.459). This negative trend was significant using the Mann-Kendall test (p = 0.004) and after FDR application (p = 0.018).

4.6.4 MfE guidelines additional sampling

For the purpose of MfE monitoring, seven additional samples were collected at regular intervals and under varying weather conditions during the survey season. All data, including additional MfE samples, are presented in Table 28 and Figure 22, with a statistical summary provided in Table 29.

Table 28 Bacteriological results for MfE samples at Ngamotu Beach

Date	Time	Conductivity @ 20°C	Bacteria			Temperature
	(NZST)	(mS/m)	*E. coli* (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	(°C)
03 Nov 2015	11:05	4610	21	37	21	16.3
22 Dec 2015	11:00	4760	<1	1	<1	17.3
06 Jan 2016	11:30	4460	23	140	24	21.8
19 Jan 2016	11:15	3980	1100	520	1100	21.7
02 Feb 2016	10:45	4640	8	12	8	24.6
16 Feb 2016	11:15	4710	<1	3	<1	23.8
15 Mar 2016	11:55	4640	1	20	1	21.9

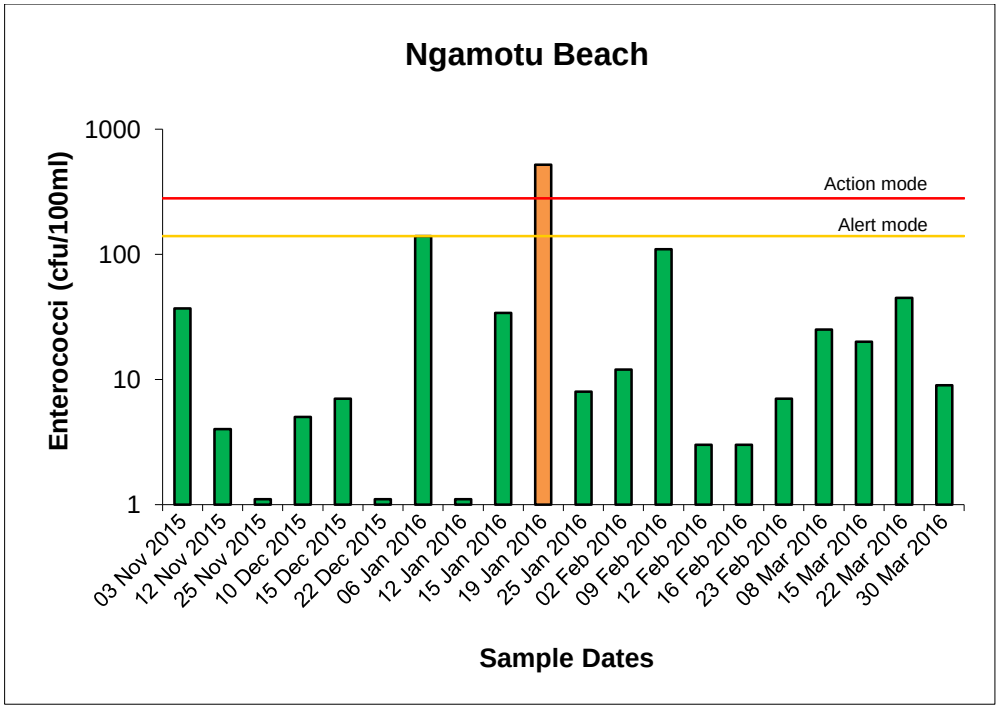

Figure 22 Enterococci counts for the 20 sample extended survey at Ngamotu Beach

Table 29 Summary statistics for SEM and additional samples at Ngamotu Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	3980	4830	4690
E. coli	cfu/100 ml	20	<1	1100	3
Enterococci	cfu/100 ml	20	1	520	9
Faecal coliforms	cfu/100 ml	20	<1	1100	3
Temperature	°C	20	14.8	24.6	21.5

Additional sampling resulted in a slight increase to the seasonal medians for all faecal indicator bacteria (Table 29). In common with other MfE sites (Onaero, Fitzroy and Oakura), an elevated enterococci count (520 cfu/100 ml) and low conductivity (3980 mS/m) was recorded on 19 January 2016 indicating freshwater influence. Heavy rain was recorded overnight on the 18 January2016.

4.7 Oakura Beach SC (opposite surf lifesaving club)

4.7.1 SEM programme

Oakura Beach (Photo 8) is popular with beach bathers during summer, and frequented by surfers all year-round. Two small lowland streams (Waimoku and Wairau) enter the beach on either side of the site, and as a consequence concentrations of faecal indicator bacteria can increase significantly during periods of high rainfall.

Photo 8 Oakura Beach

The data from this site are presented in Table 30 and Figure 23, with a statistical summary provided in Table 31.

Table 30 Bacteriological results for Oakura Beach SC

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
12 Nov 2015	10:45	4520	11	<1	11	15.6
25 Nov 2015	10:20	4710	7	3	7	16.1
10 Dec 2015	10:10	4750	7	1	7	14.5
15 Dec 2015	12:25	4640	82	54	84	15.6
12 Jan 2016	11:00	4610	<1	3	<1	19.5
15 Jan 2016	12:20	4670	<1	5	<1	19.8
25 Jan 2016	11:10	4690	<1	3	<1	22.0

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
09 Feb 2016	10:55	4690	1	1	1	22.6
12 Feb 2016	12:45	4680	<1	4	<1	22.4
23 Feb 2016	10:40	4640	1	11	1	22.0
08 Mar 2016	10:25	4730	15	12	15	20.0
22 Mar 2016	08:55	4610	1	7	1	21.3
30 Mar 2016	14:10	4670	<1	<1	<1	21.2

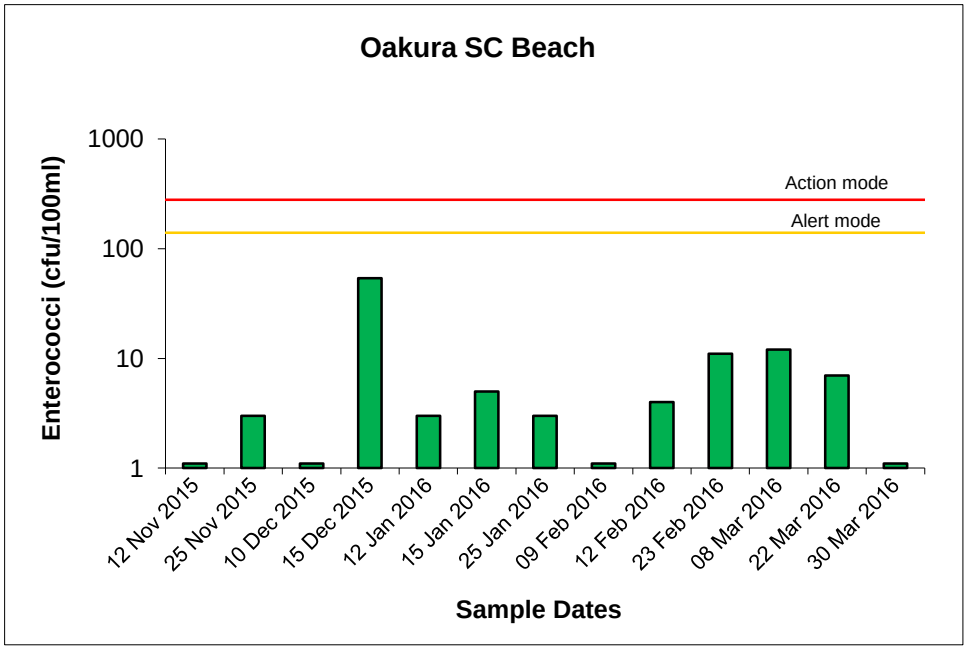

Figure 23 Enterococci counts for the 13 SEM samples taken from Oakura Beach SC

Table 31 Statistical summary for Oakura Beach SC

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4520	4750	4670
E. coli	cfu/100 ml	13	<1	82	1
Enterococci	cfu/100 ml	13	<1	54	3
Faecal coliforms	cfu/100 ml	13	<1	84	1
Temperature	°C	13	14.5	22.6	20.0

Bacteriological water quality at Oakura Beach was high throughout the season, with low median and maximum values for all faecal indicator bacteria (Table 31).

The location of the Waimoku and Wairau stream mouths can influence water quality at this site. Microbial source tracking has shown that resident wildfowl are the principal contributors to elevated faecal indicator bacteria counts within these streams, particularly in the case of the Waimoku Stream (TRC 2011-01).

The Waimoku Stream (site WMK000298) was sampled on 13 occasions during the 2013-2014 summer season and faecal indicator bacteria counts were found to be consistently high (430-3300 *E. coli* cfu/100 ml, 120-2900 enterococci cfu/100 ml).

During the 2015-2016 summer season the Waimoku Stream cut east across Oakura Beach towards the surf lifesaving club due to the build up of sand at the stream mouth. However, the position of the Waimoku Stream on the beach was lower down the shore than the previous year (Photo 9). In addition the Waimoku Stream cut across the beach to join the Wairau Stream early in the season relative to previous years, resulting in the main freshwater input being located to the east (down-current) of the sample site. The Waimoku Stream was straightened (digging a channel through sand bank) by New Plymouth District Council but not until after all beach bathing monitoring had been completed for the 2015-2016 summer season.

Photo 9 Waimoku Stream cutting high up across Oakura Beach 5 January 2015 (above) and further down the beach 15 January 2016 (below)

4.7.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Oakura Beach opposite the surf lifesaving club over 21 summers are presented in Table 32 and Figure 24.

Table 32 Summary enterococci data (cfu/100 ml) for summer surveys at Oakura SC

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	
Minimum	< 3	< 3	< 1	5	< 1	1	4	1	< 1	2	
Maximum	800	56	60	56	880	16	120	180	94	250	
Median	31	8	21	16	7	5	25	8	8	25	
Summer	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Minimum	1	<1	4	5	5	2	1	7	4	4	<1
Maximum	300	230	160	250	800	100	130	460	650	180	54
Median	12	11	32	20	45	17	36	17	29	57	3

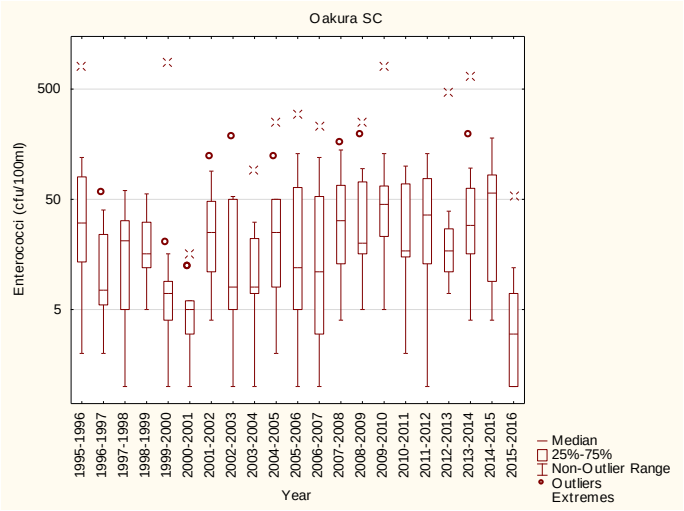

Figure 24 Box & whisker plots of enterococci for all summer SEM surveys at Oakura SC

The median enterococci count (3 cfu/100 ml) obtained for the 2015-2016 summer season was the lowest to date at this site (Table 50, Figure 27). Interannual variation in median enterococci counts at this site can be largely attributed to the changing location of the small stream mouths relative to the sampling site. The lower position of the Waimoku Stream on the beach and the location of the mouth down-current of the sample site for the majority of the season (Photo 9) could have resulted in lower faecal indicator bacteria counts during 2015-2016. It is recommended that photographs continue to be taken so that changes in position of the stream mouth can be tracked over a summer season and between summer seasons.

4.7.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median enterococci data for 21 summer seasons (Figure 25) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

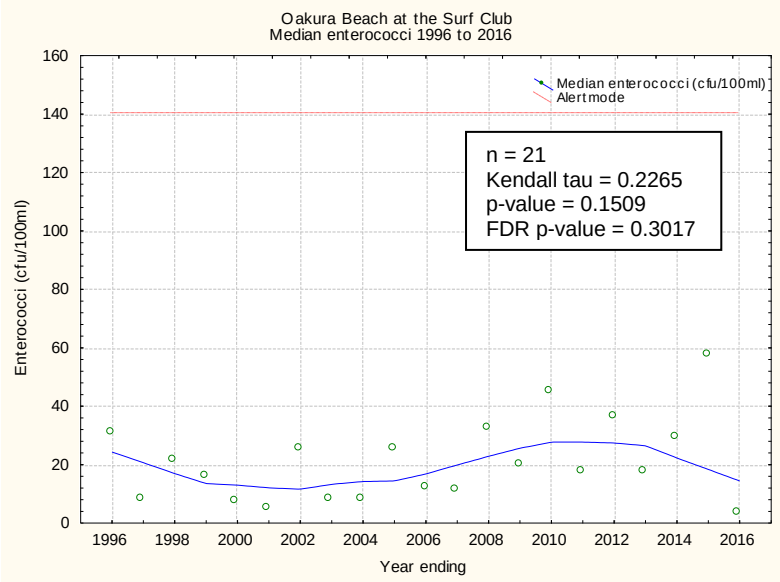

Figure 25 LOWESS trend analysis of median enterococci data at Oakura Beach SC

Over the 21 seasons monitored, there was a positive trend (i.e. an increase) in median enterococci counts (Kendall tau = 0.227) that was not significant at the 5% level (p = 0.151).

4.7.4 MfE guidelines additional sampling

For the purpose of MfE monitoring, seven additional samples were collected at irregular intervals and under varying weather conditions during the survey season. All data, including additional MfE samples, are presented in Table 33 and Figure 26, with a statistical summary provided in Table 34.

Table 33 Bacteriological results for MfE samples at Oakura Beach SC

Date	Time	Conductivity @ 20°C	Bacteria			Temperature
	(NZST)	(mS/m)	*E. coli* (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	(°C)
03 Nov 2015	11:35	4640	59	11	61	14.7
22 Dec 2015	11:15	4690	19	25	19	16.7
06 Jan 2016	12:00	4510	<1	11	<1	20.7
19 Jan 2016	11:45	4220	930	400	930	21.2
02 Feb 2016	11:15	4660	<1	<1	<1	24.0
16 Feb 2016	11:40	4510	1	8	1	23.2
15 Mar 2016	12:25	4710	<1	<1	<1	21.1

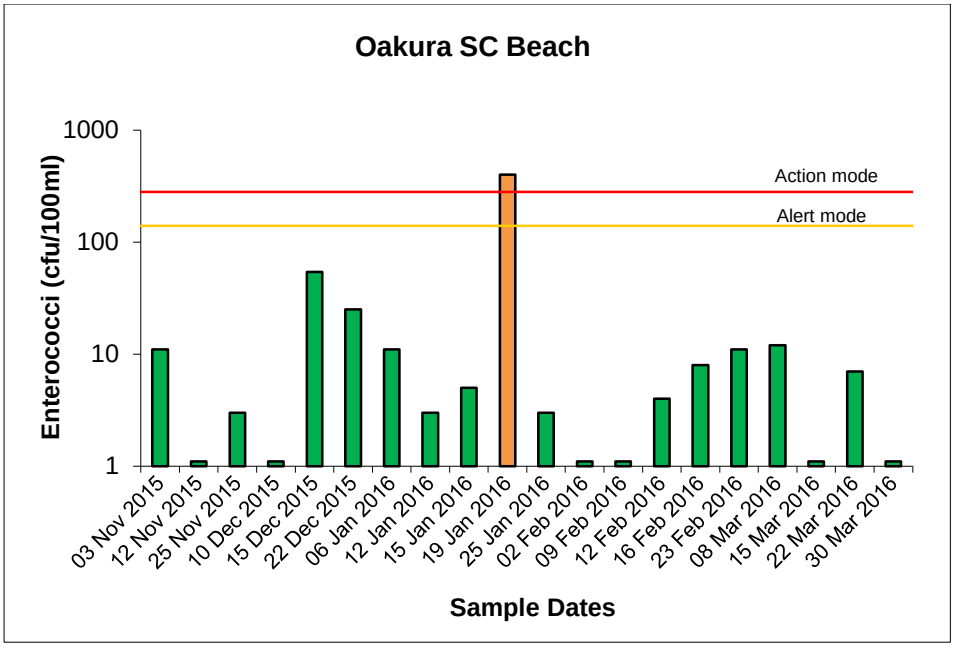

Figure 26 Enterococci counts for the 20 sample extended survey at Oakura Beach SC

Table 34 Summary statistics for SEM and MfE samples at Oakura Beach SC

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	4220	4750	4665
E. coli	cfu/100 ml	20	<1	930	1
Enterococci	cfu/100 ml	20	<1	400	5
Faecal coliforms	cfu/100 ml	20	<1	930	1
Temperature	°C	20	14.5	24	20.9

Additional sampling had little effect on the seasonal medians for all faecal indicator bacteria (Table 34). In common with other MfE sites (Onaero, Fitzroy and Ngamotu), an elevated enterococci count (400 cfu/100 ml) and low conductivity (4220 mS/m) was recorded on 19 January 2016 indicating freshwater influence. Heavy rain was recorded overnight on the 18 January2016.

4.8 Oakura Beach CG (opposite camp ground)

4.8.1 SEM programme

This site, situated at the west end of Oakura Beach in front of the campground, is a popular site with bathers and surfers (Photo 10).

Photo 10 Oakura Beach in front of the campground

The data for this site are presented in Table 35 and Figure 27, with a statistical summary provided in Table 36.

Table 35 Bacteriological results for Oakura Beach CG

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
12 Nov 2015	11:00	4670	23	1	23	15.1
25 Nov 2015	10:30	4730	3	21	3	16.5
10 Dec 2015	10:15	4730	5	1	8	14.8
15 Dec 2015	12:35	4680	3	<1	3	15.3
12 Jan 2016	10:35	4600	1	5	1	18.8
15 Jan 2016	12:00	4710	<1	<1	<1	19.8
25 Jan 2016	10:45	4710	<1	1	<1	21.4
09 Feb 2016	11:05	4700	<1	<1	<1	22.5
12 Feb 2016	13:00	4670	3	1	3	22.4
23 Feb 2016	10:50	4640	<1	16	<1	22.0
08 Mar 2016	10:35	4690	13	19	13	20.2
22 Mar 2016	08:40	4610	3	9	3	21.2
30 Mar 2016	14:15	4600	<1	<1	<1	21.2

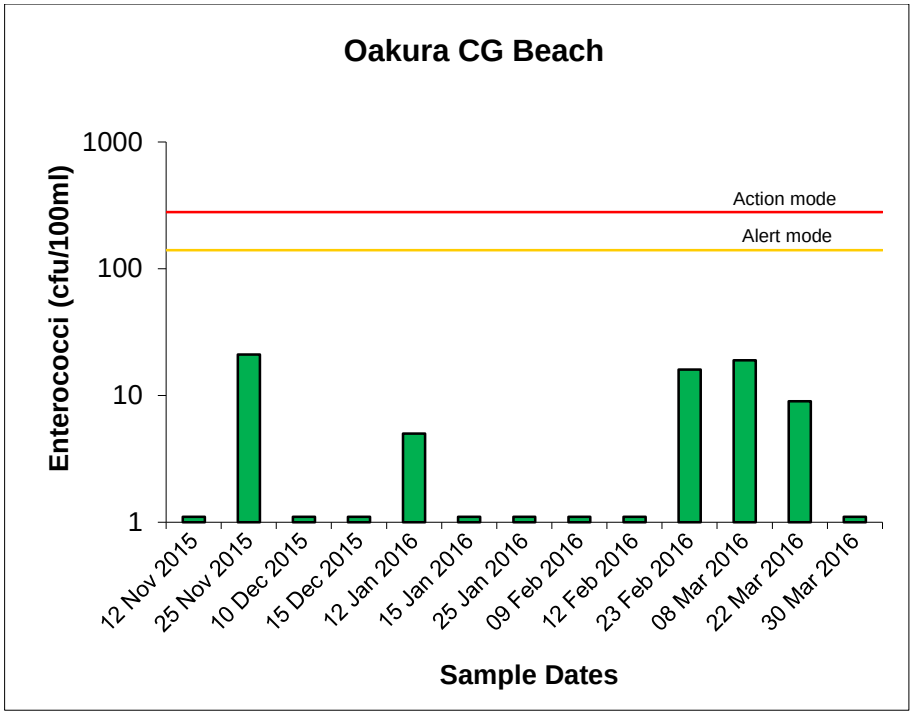

Figure 27 Enterococci counts for the 13 SEM samples taken from Oakura Beach CG

Table 36 Statistical results for Oakura Beach CG

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4600	4730	4680
E. coli	cfu/100 ml	13	<1	23	3
Enterococci	cfu/100 ml	13	<1	21	1
Faecal coliforms	cfu/100 ml	13	1	23	3
Temperature	°C	13	14.8	22.5	20.2

Water quality was good at this site with low medians and maximums for all faecal indicator bacteria (≤3 cfu/100 ml).

4.8.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Oakura Beach opposite the campground over 21 summer surveys are presented in Table 37 and Figure 28.

Table 37 Summary enterococci data (cfu/100 ml) for summer surveys at Oakura Beach opposite the campground

Summer	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	
Minimum	2	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	
Maximum	280	150	24	16	48	240	31	17	24	90	
Median	9	5	2	4	3	3	7	3	3	6	
Summer	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Minimum	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Maximum	8	260	18	30	25	33	79	260	37	160	21
Median	1	3	7	6	1	<1	4	3	3	4	1

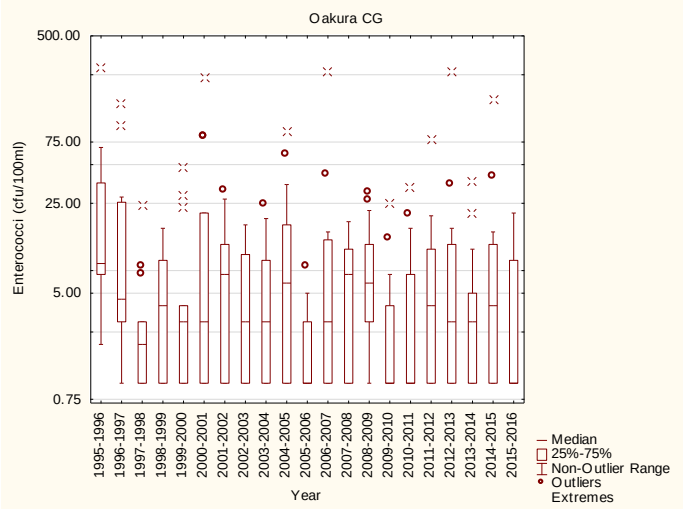

Figure 28 Box and whisker plots of enterococci for all summer SEM surveys at Oakura Beach opposite the campground

The median enterococci count for the 2015-2016 season was within the low range previously recorded at this site (1 cfu/100 ml). Over the past 21 summers water quality has remained consistently high at this site (Table 37).

4.8.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median enterococci data for 21 summer seasons (Figure 29) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

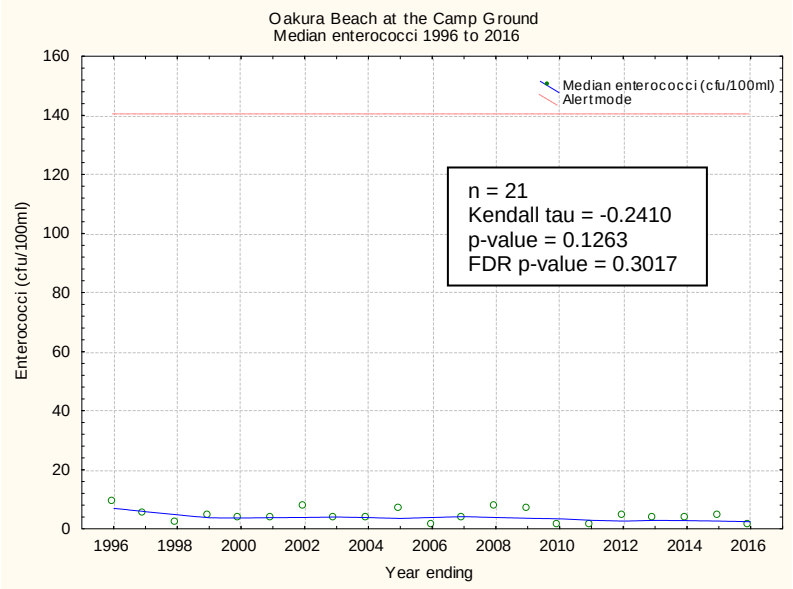

Figure 29 LOWESS trend analysis of median enterococci data at Oakura Beach Camp Ground

Over the 21 seasons monitored, there was a decreasing trend in median enterococci counts (Kendall tau = -0.241) that was not significant at the 5% level (p = 0.126).

4.9 Opunake Beach

4.9.1 SEM programme

Opunake Beach (Photo 11) is a popular swimming beach in south Taranaki. There are no large rivers in the vicinity. However, the outlet of a freshwater stream from the Opunake Power Station enters at the southern end of the beach.

Photo 11 Opunake Beach

The data for this site are presented in Table 38 and Figure 30, with a statistical summary provided in Table 39.

Table 38 Bacteriological results for Opunake Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
12 Nov 2015	12:10	4670	<1	1	<1	16.1
25 Nov 2015	11:10	4760	4	11	4	18.1
10 Dec 2015	11:35	4800	3	130	3	17.9
15 Dec 2015	13:55	4750	<1	1	<1	18.4
12 Jan 2016	13:10	4640	<1	<1	<1	19.9
15 Jan 2016	15:10	4670	1	3	1	19.1
25 Jan 2016	13:05	4640	<1	<1	<1	22.6
09 Feb 2016	12:25	4730	1	<1	1	20.9
12 Feb 2016	14:00	4720	<1	3	<1	22.8
23 Feb 2016	12:20	4430	1	1	1	22.9
08 Mar 2016	11:55	4810	1	9	1	22.8

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
22 Mar 2016	12:45	4660	8	5	8	21.8
30 Mar 2016	15:10	4710	<1	<1	1	21.1

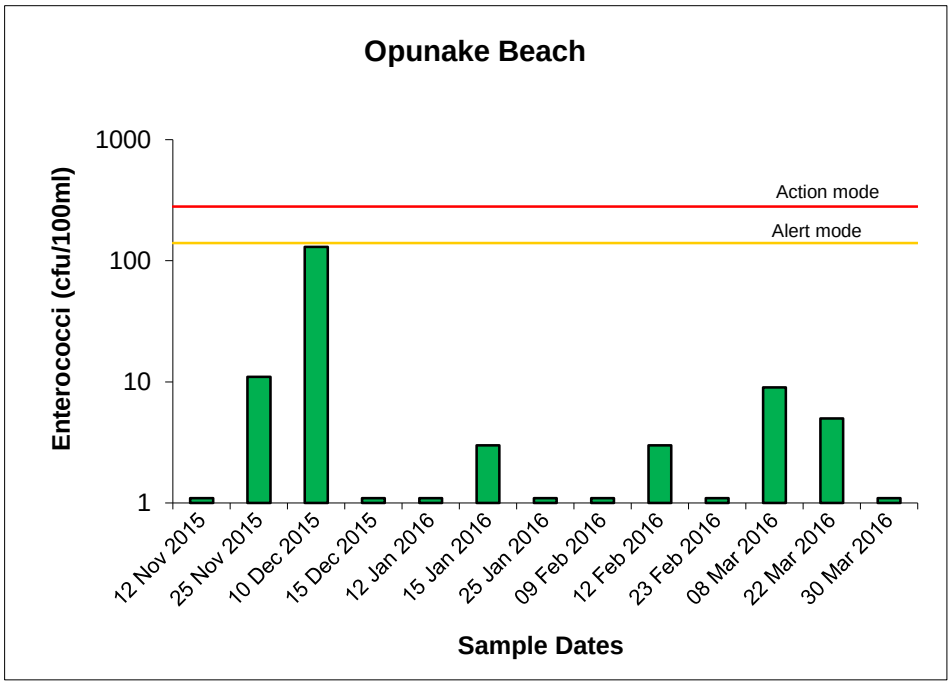

Figure 30 Enterococci counts for the 13 SEM samples at Opunake Beach

Table 39 Statistical summary for Opunake Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4430	4810	4710
E. coli	cfu/100 ml	13	<1	8	1
Enterococci	cfu/100 ml	13	<1	130	1
Faecal coliforms	cfu/100 ml	13	<1	8	1
Temperature	°C	13	16.1	22.9	20.9

Median concentrations were low for all faecal indicator bacteria (1 cfu/100 ml) indicating excellent water quality at this site.

4.9.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Opunake Beach over 21 summers are presented in Table 40 and Figure 31.

Table 40 Summary enterococci data (cfu/100 ml) for summer surveys at Opunake Beach

Summer	1995-96	1996-97	1999-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	
Minimum	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	
Maximum	74	60	73	7	41	69	140	20	9	10	
Median	9	< 1	5	< 1	1	2	4	1	1	1	
Summer	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Minimum	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Maximum	19	8	11	25	4	100	17	7	49	28	130
Median	2	1	<1	2	<1	<1	3	<1	1	4	1

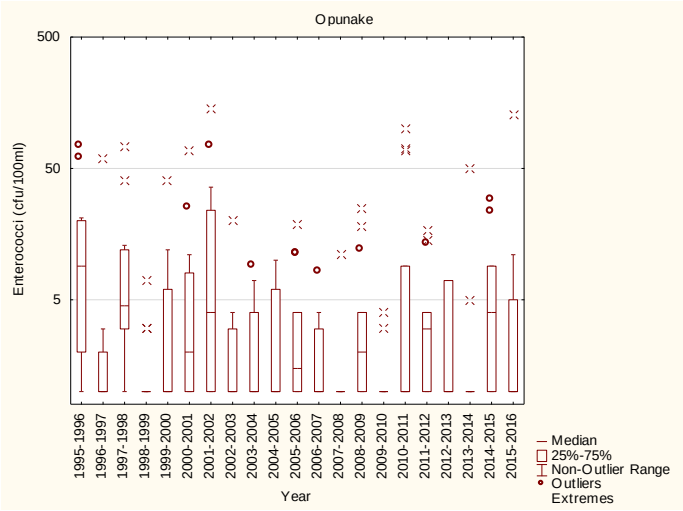

Figure 31 Box and whisker plots of enterococci for all summer SEM surveys at Opunake Beach

The low enterococci data obtained for Opunake Beach during the 2015-2016 summer continues the trend of excellent water quality at this site (Table 40, Figure 31).

4.9.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median enterococci data for 21 summer seasons (Figure 32) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

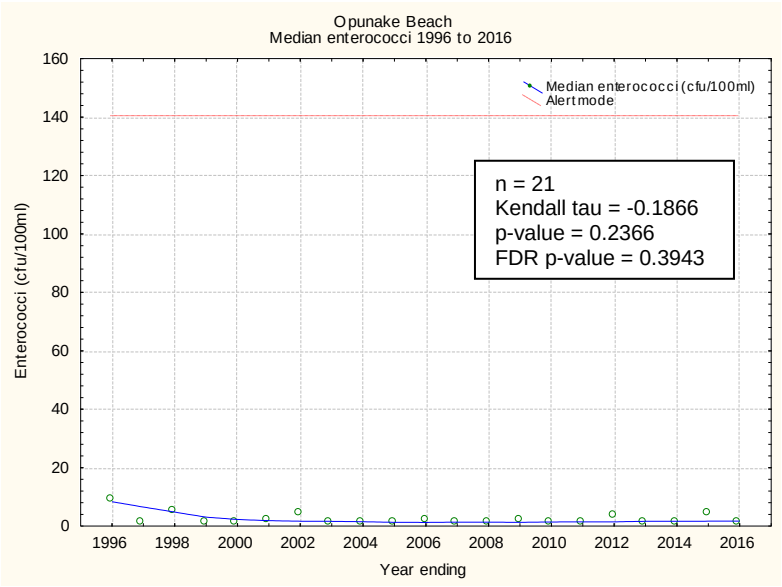

Figure 32 LOWESS trend analysis of median enterococci data at Opunake Beach

Over the 21 seasons monitored, there was a decreasing trend in median enterococci counts (Kendall tau = -0.187) that was not significant at the 5% level (p = 0.237).

4.9.4 MfE guidelines additional sampling

For the purpose of MfE monitoring seven additional samples were collected at regular intervals and under varying weather conditions during the survey season. All data, including additional MfE samples are presented in Table 41 and Figure 33, with a statistical summary in Table 42.

Table 41 Bacteriological results for MfE samples at Opunake Beach

Date	Time	Conductivity @ 20°C	Bacteria			Temperature
	(NZST)	(mS/m)	*E. coli* (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	(°C)
03 Nov 2015	12:30	4690	13	3	13	16.6
22 Dec 2015	12:00	4760	1	<1	1	17.3
06 Jan 2016	12:50	4580	<1	<1	<1	20.0
19 Jan 2016	12:35	4670	<1	<1	<1	21.0
02 Feb 2016	12:15	4700	<1	<1	<1	22.9
16 Feb 2016	12:45	4700	<1	<1	<1	23.5
15 Mar 2016	13:25	4700	1	8	1	21.4

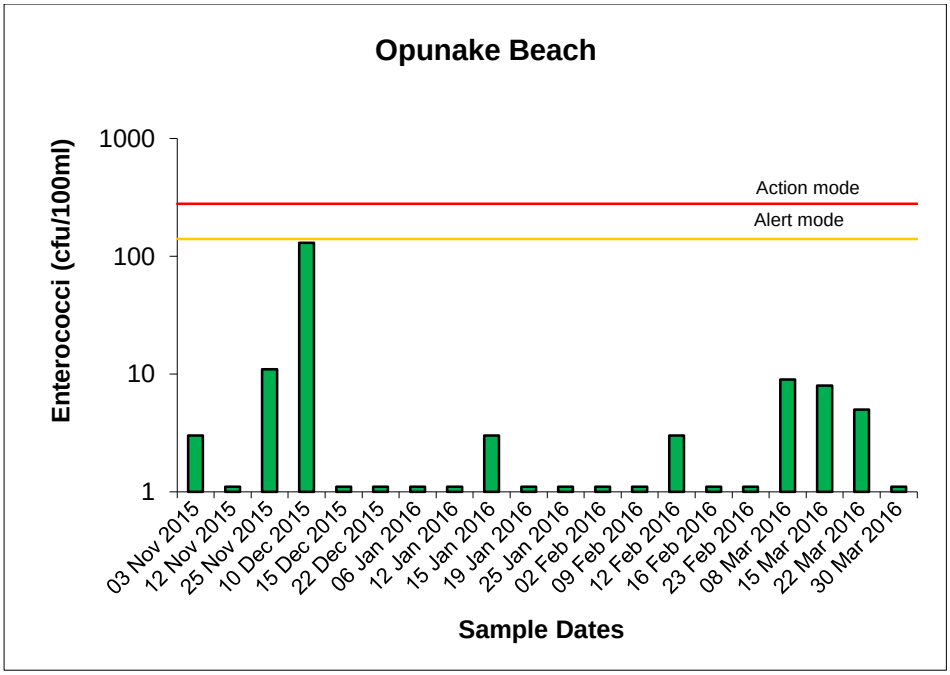

Figure 33 Enterococci counts for the 20 sample extended survey at Opunake Beach

Table 42 Summary statistics for SEM and MfE samples at Opunake Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	20	4430	4810	4700
E. coli	cfu/100 ml	20	<1	13	1
Enterococci	cfu/100 ml	20	<1	130	1
Faecal coliforms	cfu/100 ml	20	<1	13	1
Temperature	°C	20	16.1	23.5	21.0

The additional MfE samples made no difference to the medians for all faecal indicator bacteria, reflecting consistently high water quality at this site.

4.10 Ohawe Beach

4.10.1 SEM programme

Ohawe Beach (Photo 12) is located close to the large Waingongoro River in South Taranaki. The river catchment drains highly modified agricultural land.

Photo 12 Ohawe Beach

Data from this site are presented in Table 43 and Figure 34, with a statistical summary provided in Table 44.

Table 43 Bacteriological results for Ohawe Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E . coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
12 Nov 2015	10:30	4570	27	25	31	15.2
25 Nov 2015	10:05	3850	33	20	33	16.5
10 Dec 2015	10:15	3980	54	28	54	17.6
15 Dec 2015	12:30	3800	28	46	28	18.3
12 Jan 2016	11:50	3830	240	140	240	19.0
15 Jan 2016	13:45	4210	9	28	9	21.4
25 Jan 2016	11:20	4320	41	72	41	22.5
09 Feb 2016	10:55	4200	540	460	540	21.3
12 Feb 2016	12:40	4430	12	40	12	22.6
23 Feb 2016	10:45	3970	68	240	88	21.8

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E . coli (cfu/100 ml)	Enterococci (cfu/100 ml)	Faecal coliforms (cfu/100 ml)	
08 Mar 2016	10:05	4090	650	620	660	20.9
22 Mar 2016	11:25	4370	28	20	28	20.1
30 Mar 2016	14:00	4120	8	3	8	20.0

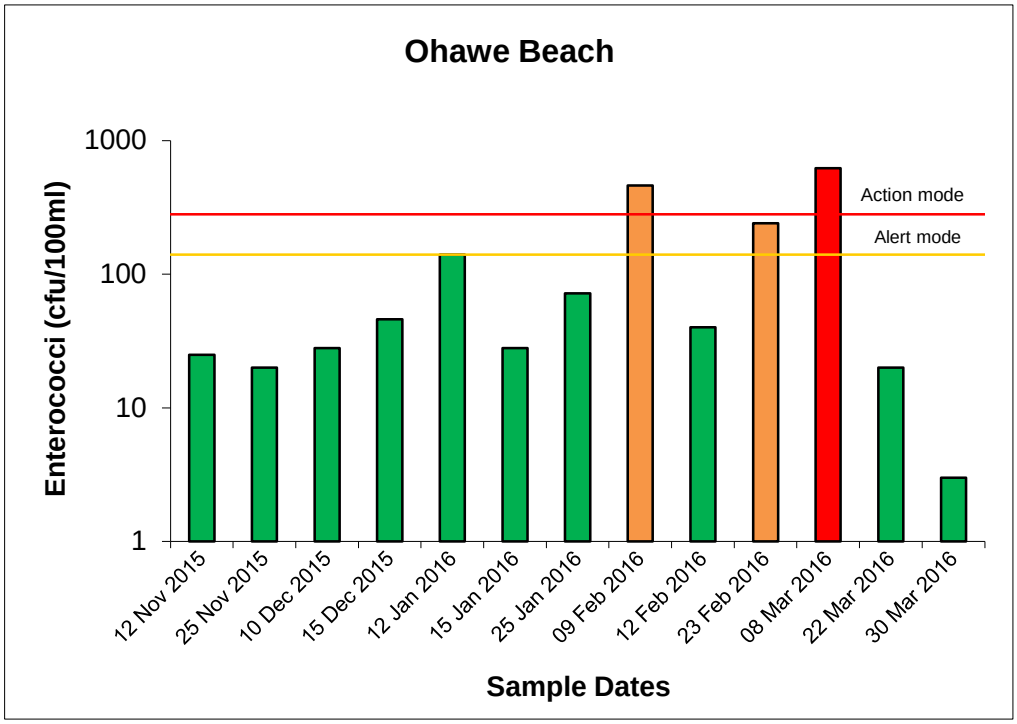

Figure 34 Enterococci counts for the 13 SEM samples at Ohawe Beach

Table 44 Statistical summary for Ohawe Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	3800	4570	4120
E. coli	cfu/100 ml	13	8	650	33
Enterococci	cfu/100 ml	13	3	620	40
Faecal coliforms	cfu/100 ml	13	8	660	33
Temperature	°C	13	15.2	22.6	20.1

The enterococci counts at Ohawe Beach were relatively high compared to other beach bathing sites in Taranaki during the 2015-2016 season. Samples on 9 February (460 cfu/100 ml) and 23 February 2016 (240 cfu/100 ml) reached Alert mode (follow up samples: 11 February 34 cfu/100 ml, 25 February 84 cfu/100 ml). The sample on 8 March 2016 reached Action mode taking into account the high count in the follow up sample (320 cfu/100 ml 10 March 2016) i.e. two consecutive samples >240 cfu/100 ml.

The site can be influenced by the Waingongoro River (see relatively low conductivities

recorded throughout the season, Table 43). Microbial source tracking from samples taken at the river mouth and just upstream of the Ohawe settlement indicate that the main source of faecal contamination in the river is from ruminants and wildfowl (TRC 2013-01).

4.10.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Ohawe Beach over 20 summers are presented in Table 45 and Figure 35.

Table 45 Summary enterococci data (cfu/100 ml) for summer surveys at Ohawe Beach

Summer	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Minimum	15	7	<1	1	3	3	5	3	<1	1
Maximum	72	650	280	68	450	1600	180	11000	330	1600
Median	21	40	17	23	48	48	16	29	23	13
Summer	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-2015**	**2015-16**
Minimum	<1	<1	2	3	<1	2	<1	<1	4	3
Maximum	80	1800	280	350	83	160	630	400	270	620
Median	7	5	20	16	7	34	37	5	24	40

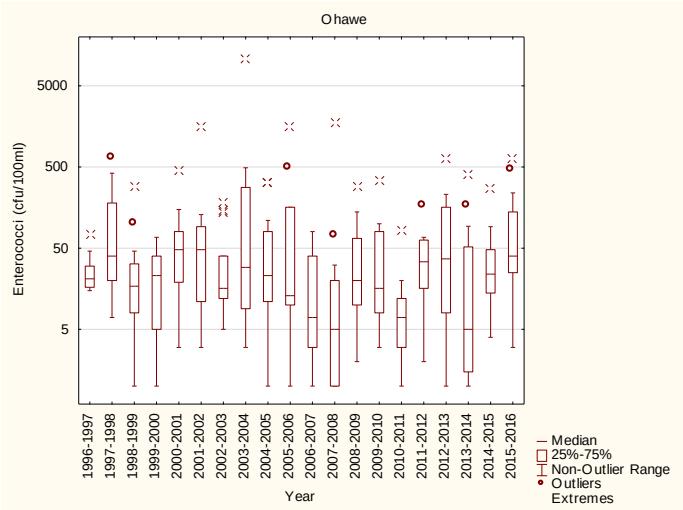

Figure 35 Box and whisker plots of enterococci for all summer surveys at Ohawe Beach

The median enterococci count (40 cfu/100 ml) at Ohawe Beach was the highest recorded for a coastal beach site in Taranaki for the 2015-2016 summer season and at the higher end of the range recorded previously at this site. Maxima and medians at this site are historically variable due to the influence of the Waingongoro River (Table 45).

In general, conductivity was lower in samples collected during the 2015-2016 season (minimum = 3800 mS/m, median = 4120 mS/m) compared to the preceding summer season (2014-2015 minimum = 4150 mS/m, median = 4400 mS/m) indicating increased freshwater influence. Taking into consideration the low flow rates recorded in the

Waingongoro River during 2015-2016 and the lower feacal indicator bacteria counts at the river mouth compared to the previous year (TRC 2016-1) it could be that a shift in the position of the river mouth resulted in a greater freshwater influence on the Ohawe Beach site. In future bathing seasons, it is recommended that photographs be taken of the position of the river mouth to allow assessment of changes in the river mouth location over a summer season and between summer seasons.

4.10.3 Long-term trend analysis

Trend analysis was performed by applying a LOWESS fit (tension 0.4) to a time scatterplot of the median enterococci data for 20 summer seasons (Figure 36) and testing the significance of any trend using the Mann-Kendall test at the 5% level, followed by Benjamini-Hochberg False Discovery Rate (FDR) analysis.

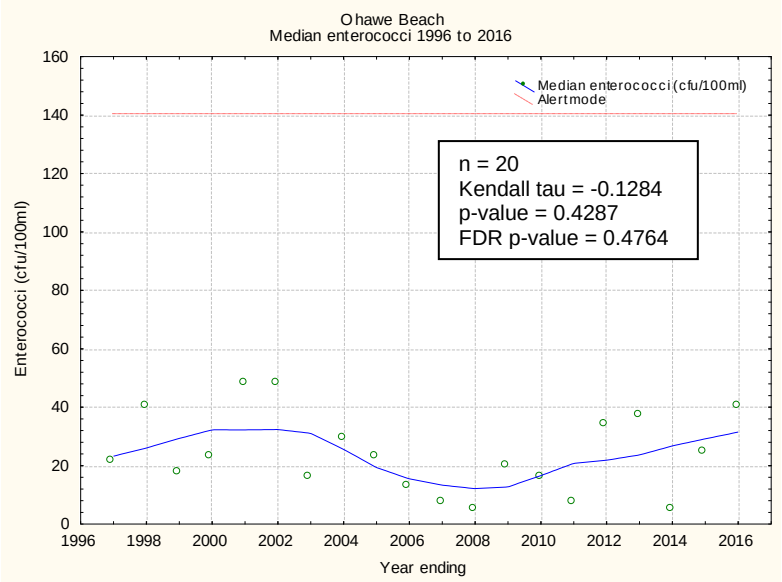

Figure 36 LOWESS trend analysis of median enterococci data at Ohawe Beach

Over the 20 seasons monitored, there was a decreasing trend in median enterococci counts (Kendall tau = -0.128) that was not significant at the 5% level (p = 0.429).

4.11 Patea Beach

4.11.1 SEM programme

Patea Beach (Photo 13) is situated at the mouth of the Patea River, which has the third largest catchment area in Taranaki. The sampling site is separated from the river by the northern of two moles, which direct the freshwater flow away from the shore. Recreational use is high over the summer holiday period, however younger swimmers tend to use the more sheltered adjacent area of Mana Bay.

Photo 13 Patea Beach

Data from this site are presented in Table 46 and Figure 37, with a statistical summary provided in Table 47.

Table 46 Bacteriological results for Patea Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	
12 Nov 2015	09:40	4650	4	2	4	14.9
25 Nov 2015	09:05	4760	8	0.5	8	16.5
10 Dec 2015	09:20	4700	15	4	15	16.7
15 Dec 2015	11:42	4670	15	17	15	18.4
12 Jan 2016	10:50	4610	3	7	3	19.0
15 Jan 2016	12:50	4700	<2	2	<2	20.8
25 Jan 2016	10:25	4660	20	28	20	22.1
09 Feb 2016	10:00	4620	1	1	1	21.8
12 Feb 2016	11:50	4650	4	4	4	22.6
23 Feb 2016	10:00	4570	5	7	5	22.2
08 Mar 2016	09:20	4740	48	15	52	21.1
22 Mar 2016	10:40	4690	6	1	6	20.4
30 Mar 2016	13:20	4700	3	3	3	19.7

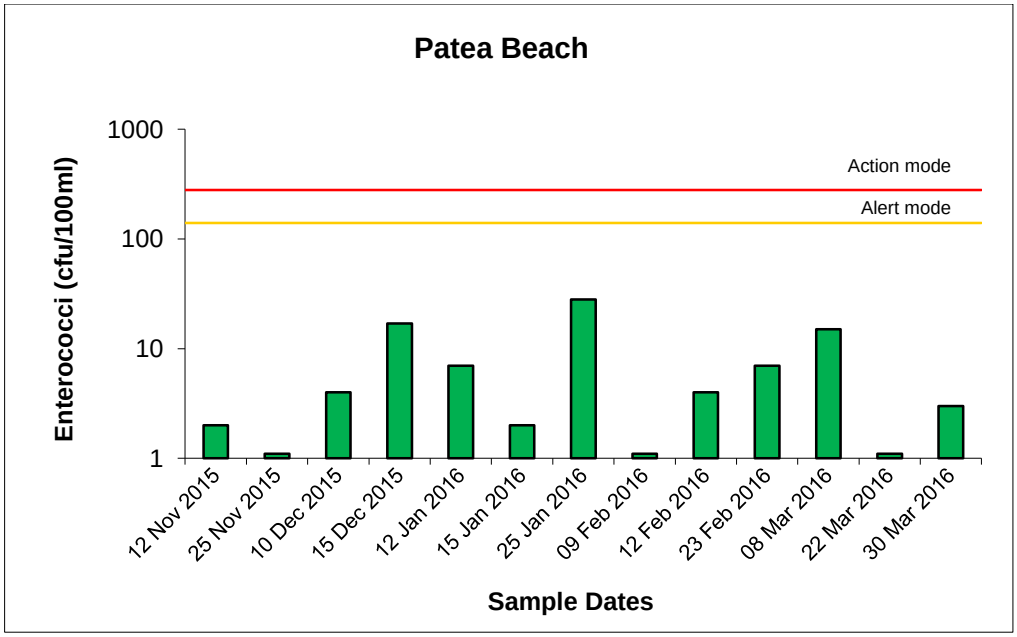

Figure 37 Enterococci counts for the 13 SEM samples at Patea Beach

Table 47 Statistical summary for Patea Beach

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4570	4760	4670
E. coli	cfu/100ml	13	1	48	5
Enterococci	cfu/100ml	13	<1	28	4
Faecal coliforms	cfu/100ml	13	1	52	5
Temperature	°C	13	14.9	22.6	20.4

Water quality at Patea Beach remained high throughout the season, with low median and maximum values for all faecal indicator bacteria (Figure 37, Table 47).

4.11.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Patea Beach over 7 summers are presented in Table 48 and Figure 38.

Table 48 Summary enterococci data (cfu/100ml) for summer surveys at Patea Beach

Summer	1997-98	2000-01	2003-04	2006-07	2009-10	2012-13	2015-16
Minimum	1	< 1	< 1	<1	<1	<1	<1
Maximum	20	37	17	40	180	31	28
Median	4	7	3	8	3	2	4

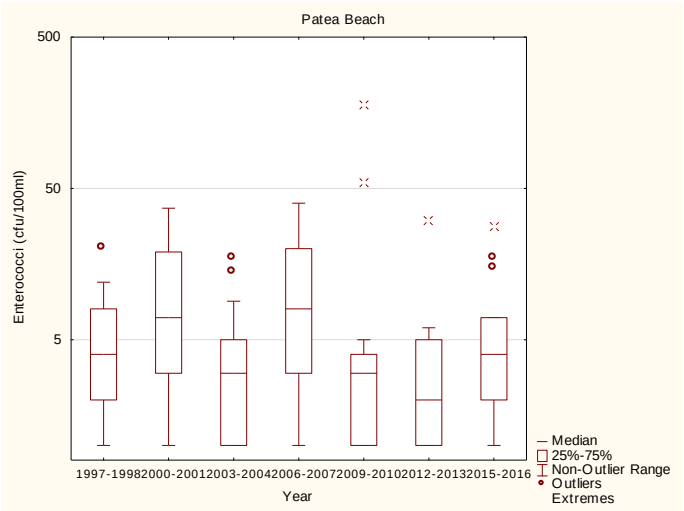

Figure 38 Box and whisker plots of enterococci for all summer SEM surveys at Patea Beach

Since the records began in 1997, median and maximum enterococci counts at Patea Beach have generally been low compared to other Taranaki beach bathing sites. The median enterococci count (4 cfu/100ml) obtained for the 2015-2016 summer season was within the range of low results previously recorded at this site.

4.12 Mana Bay

4.12.1 SEM programme

Mana Bay (Photo 14) is a sheltered area inside the northern mole at the mouth of the Patea River. Recreational use is high over the summer holiday period, particularly by young children.

Photo 14 Mana Bay

Data from this site are presented in Table 49 and Figure 39, with a statistical summary provided in Table 50.

Table 49 Bacteriological results for Mana Bay

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	
12 Nov 2015	09:30	4610	<2	1	<2	15.2
25 Nov 2015	09:30	4760	1	<1	1	16.6
10 Dec 2015	09:10	4690	840	380	840	17.4
15 Dec 2015	11:33	4670	3	11	3	18.0
12 Jan 2016	10:35	4610	13	8	13	19.1
15 Jan 2016	12:40	4700	9	<1	9	20.7
25 Jan 2016	10:15	4670	25	13	27	21.5
09 Feb 2016	09:50	4630	4	4	5	21.4
12 Feb 2016	11:45	4670	4	12	4	22.5
23 Feb 2016	09:50	4540	4	5	4	22.3
08 Mar 2016	09:15	4750	15	12	15	21.1
22 Mar 2016	10:30	4700	4	6	8	20.1
30 Mar 2016	13:15	4690	6	1	6	19.7

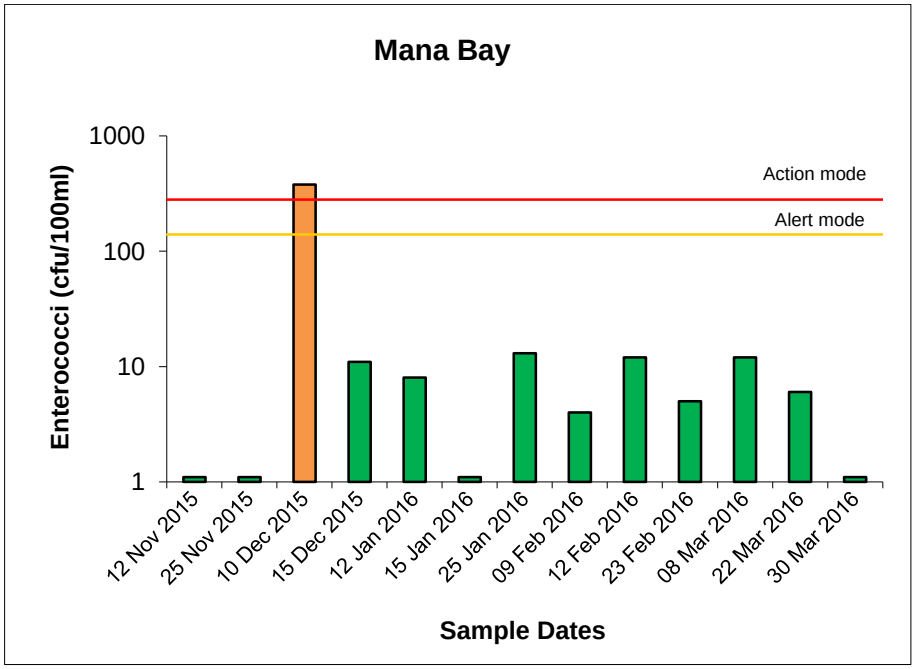

Figure 39 Enterococci counts for the 13 SEM samples at Mana Bay

Table 50 Statistical summary for Mana Bay

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4540	4760	4670
E. coli	cfu/100ml	13	1	840	4
Enterococci	cfu/100ml	13	<1	380	6
Faecal coliforms	cfu/100ml	13	1	840	6
Temperature	°C	13	15.2	22.5	20.1

With the exception of one sample collected on 10 December 2016 water quality at Mana Bay remained high throughout the season, with low median values for all faecal indicator bacteria (Figure 39, Table 50). The high enterococci count obtained on 10 December 2016 remains unexplained with high conductivity (4690 mS/m) measured for that sample.

4.12.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Mana Bay over 6 summers are presented in Table 64 and Figure 36.

Table 51 Summary enterococci data (cfu/100ml) for summer surveys at Mana Bay

Summer	2000-01	2003-04	2006-07	2009-10	2012-13	2015-16
Minimum	1	< 1	<1	<1	<1	<1
Maximum	40	54	20	48	64	380
Median	5	3	5	2	2	6

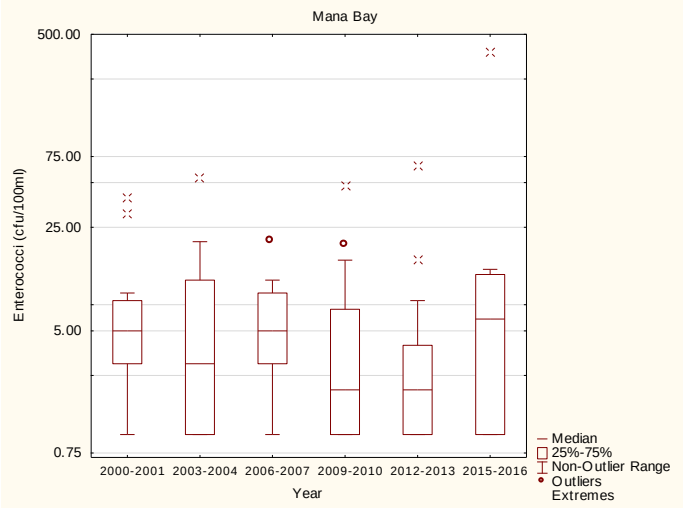

Figure 40 Box and whisker plots of enterococci for all summer surveys at Mana Bay

Since the records began in 2000, median and maximum enterococci counts at Mana Bay have been low compared to other Taranaki beach bathing sites. The median enterococci count (6 cfu/100ml) obtained for the 2015-2016 summer season was the highest on record for Mana Bay but still representative of good water quality.

4.13 Waverley Beach

4.13.1 SEM programme

Waverley Beach (Photo 15) is well used during the summer months, in part due to the location of a popular campground nearby. As the beach is relatively sheltered, it provides a safe area for recreational water sports.

Photo 15 Waverley Beach

Data from this site are presented in Table 52 and Figure 41, with a statistical summary provided in Table 53.

Table 52 Bacteriological results for Waverley Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	
12 Nov 2015	08:50	4540	54	12	54	15.4
25 Nov 2015	08:30	4730	31	45	31	16.2
10 Dec 2015	08:45	4390	17	9	20	17.2
15 Dec 2015	10:55	4390	60	16	60	17.9
12 Jan 2016	09:55	4650	1	4	1	18.3
15 Jan 2016	12:00	4650	4	5	4	20.5
25 Jan 2016	09:30	4640	<1	4	<1	21.2
09 Feb 2016	09:10	4640	3	<1	3	20.4

12 Feb 2016	11:10	4600	16	8	16	22.4
23 Feb 2016	09:15	4610	3	12	3	21.7
08 Mar 2016	08:40	4570	44	23	44	20.6
22 Mar 2016	09:45	4650	7	3	7	19.7
30 Mar 2016	12:40	4690	6	1	6	19.8

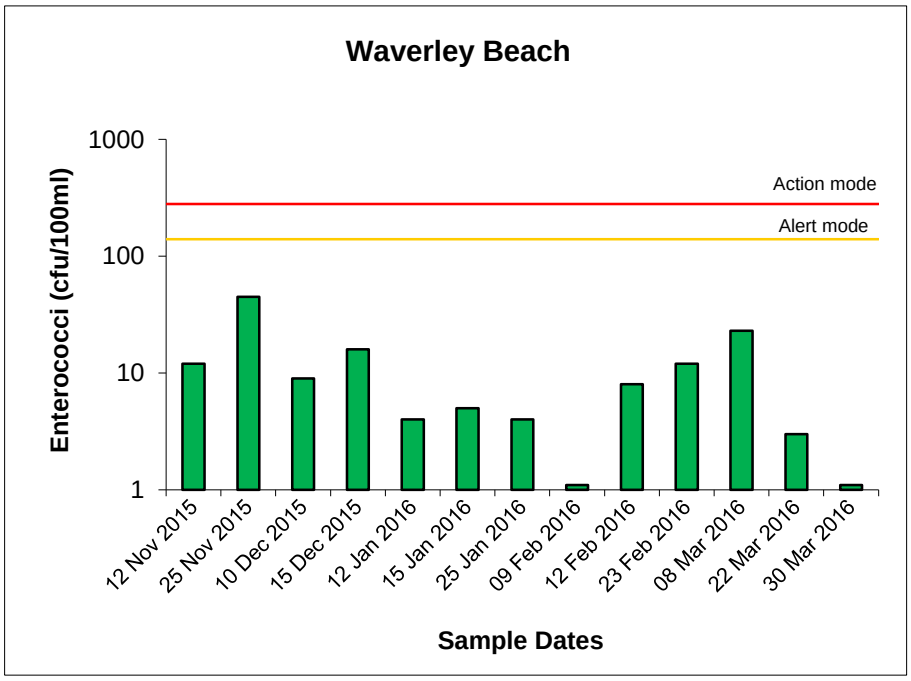

Figure 41 Enterococci counts for the 13 SEM samples at Waverley Beach

Table 53 Statistical summary for Waverley

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4390	4730	4640
E. coli	cfu/100ml	13	<1	60	7
Enterococci	cfu/100ml	13	<1	45	8
Faecal coliforms	cfu/100ml	13	<1	60	7
Temperature	°C	13	15.4	22.4	19.8

Water quality at Waverley Beach remained high throughout the season, with all samples remaining well within surveillance mode (Figure 41, Table 53).

4.13.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Waverley Bay over 6 summers are presented in Table 54 and Figure 42.

Table 54 Summary enterococci data (cfu/100ml) for summer surveys at Waverley Beach

Summer	1997-98	2000-01	2003-04	2006-07	2009-10	2012-13	2015-16
Minimum	< 1	1	< 1	<1	<1	1	<1
Maximum	31	140	9	42	8	11	45
Median	6	4	3	3	4	3	8

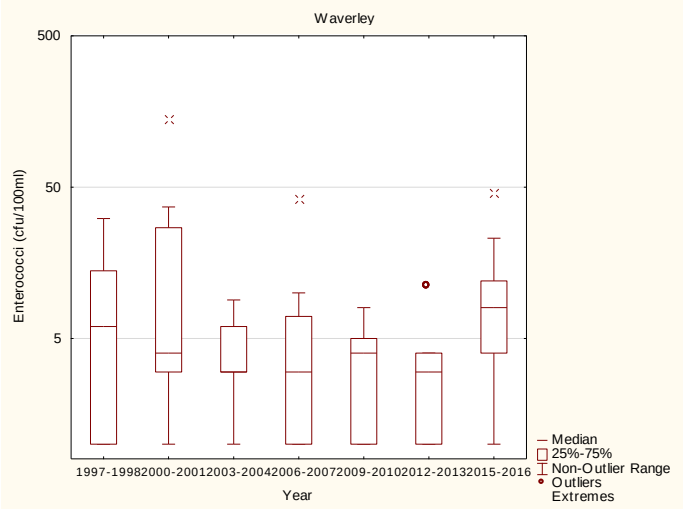

Figure 42 Box and whisker plots of enterococci for all summer SEM surveys at Waverley Beach

Since the records began in 1997, median and maximum enterococci counts at Waverley Beach have generally been low compared to other Taranaki beach bathing sites. The median enterococci count (8 cfu/100ml) obtained for the 2015-2016 summer season was the highest on record for Waverley Beach but still representative of good water quality, with a low maximum count (45 cfu/100 ml).

4.14 Wai-inu Beach

4.14.1 SEM programme

Wai-inu Beach (Photo 16) is the southern-most beach in the SEM programme. The site is adjacent to the Wai-inu Beach settlement and campground. Small fishing boats are launched over the iron-sand beach.

Photo 16 Surfer at Wai-inu Beach

Data from this site are presented in Table 55 and Figure 43, with a statistical summary provided in Table 56.

Table 55 Bacteriological results for Wai-inu Beach

Date	Time (NZST)	Conductivity @ 20°C (mS/m)	Bacteria			Temp (°C)
			E. coli (cfu/100ml)	Enterococci (cfu/100ml)	Faecal coliforms (cfu/100ml)	
12 Nov 2015	08:20	4640	7	5	7	14.6
25 Nov 2015	08:00	4700	1	<1	1	16.2
10 Dec 2015	08:10	4590	13	11	13	16.8
15 Dec 2015	10:20	4080	56	52	57	18.1
12 Jan 2016	09:15	4560	1	11	1	17.9
15 Jan 2016	11:30	4340	9	4	9	20.6
25 Jan 2016	08:55	4550	3	6	3	21.3
09 Feb 2016	08:35	4560	<1	9	<1	19.9
12 Feb 2016	10:30	4500	8	24	8	22.3
23 Feb 2016	08:40	4600	<1	1	<1	21.2
08 Mar 2016	08:05	4490	32	39	32	20.8
22 Mar 2016	09:10	4630	9	19	9	19.2
30 Mar 2016	12:10	4570	1	7	1	20.5

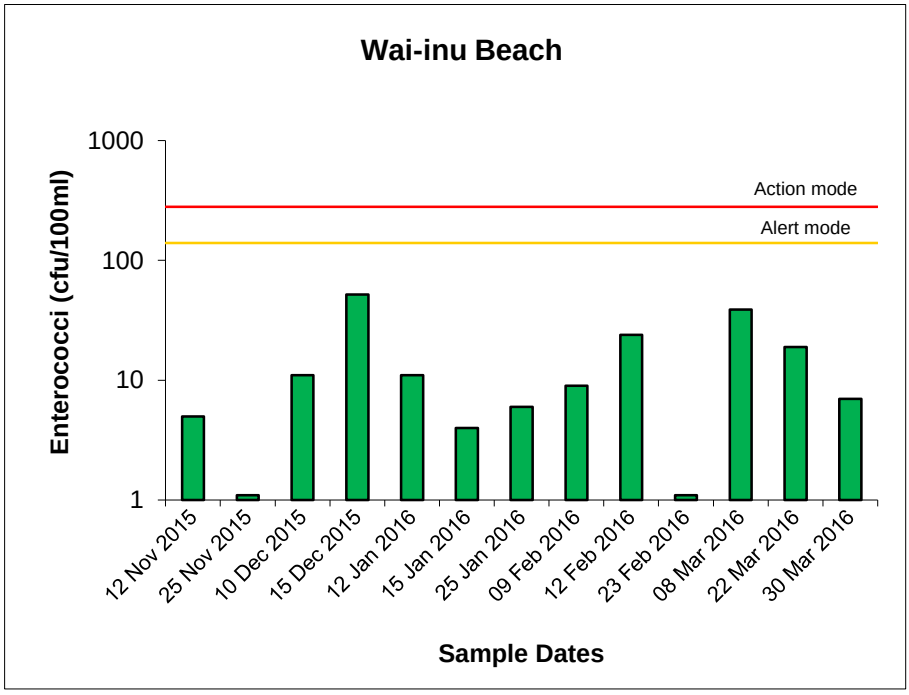

Figure 43 Enterococci counts for the 13 SEM samples at Wai-inu Beach

Table 56 Statistical summary for Wai-inu

Parameter	Unit	Number of samples	Minimum	Maximum	Median
Conductivity @ 20°C	mS/m	13	4080	4700	4560
E. coli	cfu/100ml	13	<1	56	7
Enterococci	cfu/100ml	13	<1	52	9
Faecal coliforms	cfu/100ml	13	<1	57	7
Temperature	°C	13	14.6	22.3	19.9

Water quality at Wai-inu Beach remained high throughout the season, with all samples remaining well within surveillance mode (Figure 43, Table 55).

4.14.2 Comparison with previous summer surveys

Summary statistics for enterococci data collected at Wai-inu Beach over 7 summers are presented in Table 57 and Figure 44.

Table 57 Summary enterococci data (cfu/100ml) for summer surveys at Wai-inu Beach

Summer	1997-98	2000-01	2003-04	2006-07	2009-10	2012-13	2015-16
Minimum	1	< 1	< 1	<1	<1	<1	<1
Maximum	88	15	31	210	15	16	52
Median	7	5	3	6	2	2	9

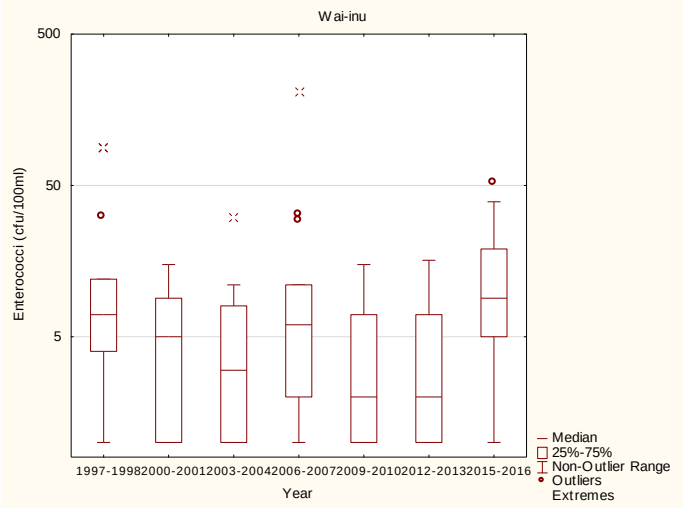

Figure 44 Box and whisker plots of enterococci for all summer SEM surveys at Wai-inu Beach

Since the records began in 1997, median enterococci counts at Wai-inu Beach have generally been low compared to other Taranaki beach bathing sites. The median enterococci count (9 cfu/100 ml) obtained for the 2015-2016 summer season was the highest on record for Wai-inu Beach but still representative of good water quality, with a low maximum count (52 cfu/100 ml).

5. General summary

5.1 Regional overview

During the 2015-2016 summer season, microbiological water quality was generally good across bathing beaches in the Taranaki region (Table 58). Median enterococci values were equal to or less than 9 cfu/100 ml for thirteen of the fourteen beaches monitored. The only elevated median enterococci count was recorded at Ohawe Beach (40 cfu/100 ml) with the site located close to the Waingongoro River mouth. Out of the 217 samples collected at 14 beach sites, 95% were below guideline Alert levels (140 enterococci cfu/100 ml). Two site reached Action mode (two consecutive samples >280 enterococci cfu/100 ml) during the 2015-2016 season (at Ohawe and Waitara West). Of the few samples which entered the Alert and Action guideline categories (5% i.e. 11 samples), the majority (9 out of 11) had been influenced by rainfall or freshwater. All sites surveyed during the 2015-2016 monitoring period obtained a Suitability for Recreation Grade of either 'good' (11/14) or 'fair' (3/14). These grades reflect qualitative risk grading of the catchment in addition to quantitative enterococci results (see Section 2.2).

Table 58 Summary results for the TRC beach bathing monitoring programme 2015-2016

Beach sites[1]	Enterococci median (cfu/100 ml)		Number of samples reaching Alert mode (>140 cfu/100 ml) & *Action mode (2x >280 cfu/100 ml)*		Trend analysis[4]			Suitability for recreation grade (SFRG)[7]
	SEM[2]	SEM+MfE[3]	SEM[2]	SEM+MfE[3]	Kendall tau[5]	Mann-Kendall p value[6]	False Discovery Rate p value	
Opunake	1	1	0	0	-0.187	0.237	0.394	Good
Oakura CG	1	-	0	-	-0.241	0.126	0.302	Good
Fitzroy	3	4	0	1	-0.542	<0.001	0.006	Good
Oakura SC	3	5	0	1	0.227	0.151	0.302	Good
Patea	4	-	0	-	-	-	-	Good
East End	5	-	0	-	-0.201	0.323	0.461	Good
Mana	6	-	1	-	-	-	-	Good
Ngamotu	7	9	0	1	-0.459	0.004	0.018	Good
Waverley	8	-	0	-	-	-	-	Good
Onaero	8	11	0	2	0.023	0.909	0.909	Fair
Wai-inu	9	-	0	-	-	-	-	Good
Waitara East	9	-	0	-	-0.263	0.105	0.302	Fair
Waitara West	9	-	1, *1*	-	-0.141	0.386	0.475	Good
Ohawe	40	-	2,*1*	-	-0.128	0.429	0.476	Fair

[1]Sites ordered in ascending order of SEM median enterococci
[2]SEM results based on 13 samples
[3]SEM+MfE results based on 20 samples (MfE data available for selected sites only)
[4]Trend analysis performed on SEM data only (Section 3.4)
[5]A negative/positive Kendall tau indicates a decreasing/increasing temporal trend in median enterococci respectively

[6]*A green/red shaded p value = significant (5%) decreasing/increasing temporal trend in median enterococci respectively*
[7]*The Suitability for Recreational Grade is calculated using the Microbial Assessment Category (based on five years enterococci data) and the Sanitary Inspection Category (a qualitative risk assessment based on the catchment) as explained in Section 2.2*
- = insufficient data

During the 2015-2016 season Opunake and Oakura Camp Ground had the region's lowest median enterococci counts of 1 cfu/100 ml (Table 58). Water quality at these two sites has remained consistently high since the Council beach monitoring programme began in 1995-1996 (Figure 46).

Ohawe recorded the highest enterococci median of the 2015-2016 season (40 cfu/100 ml). Bacteriological water quality at this site has been historically variable (Figure 46) due to the influence of the nearby Waingongoro River mouth . During the 2015-2016 season conductivity was lower than in samples collected during the preceding summer season indicating increased freshwater influence. Taking into consideration the low flow rates recorded in the Waingongoro River during 2015-2016 and the lower feacal indicator bacteria counts at the river mouth compared to the previous year (TRC 2016-1) it could be that a shift in the position of the river mouth resulted in a greater freshwater influence on the Ohawe Beach site. In future bathing seasons, it is recommended that photographs be taken of the position of the river mouth to allow assessment of changes in the river mouth location over a summer season and between summer seasons.

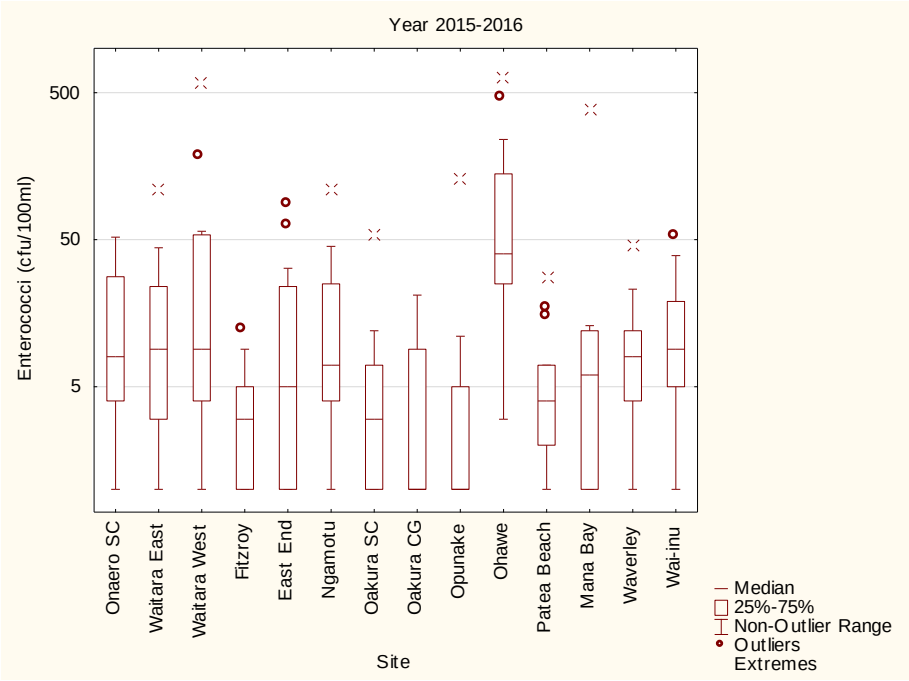

Figure 45 Box and whisker plots of enterococci at all sites during the 2015-2016 season (SEM data only)

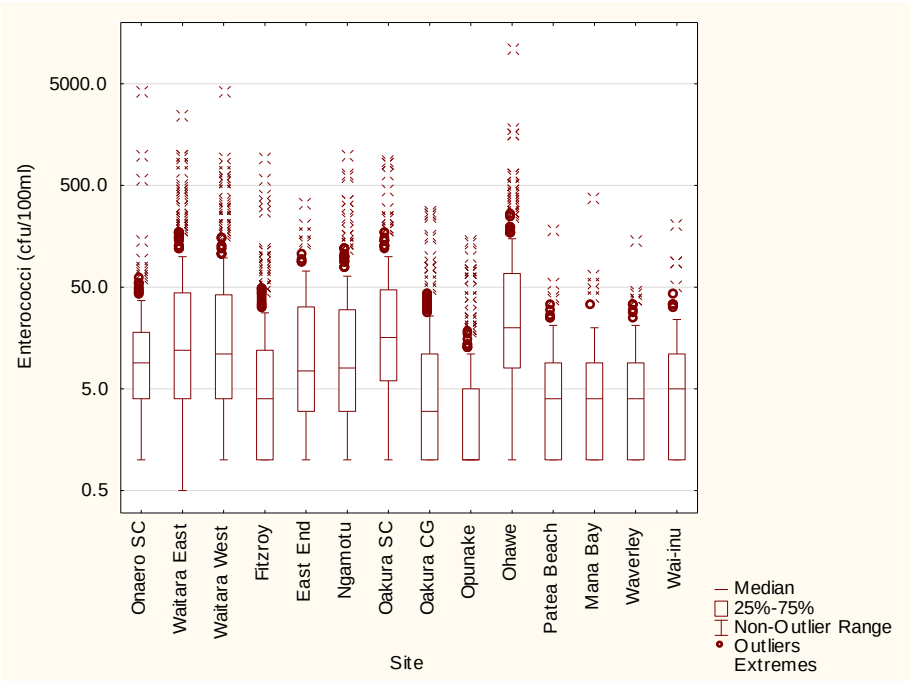

Figure 46 Box and whisker plots of long term enterococci data from 1995/implementation of monitoring to 2016 (SEM data only)

Long term trend analysis (14-21 years data) showed a significant (at the 5% level) decrease in enterococci medians at 2 of the 14 sites monitored (Fitzroy and Ngamotu). All other sites showed no significant change (Table 58, Kendall tau and Mann-Kendall p values). The site at Fitzroy Beach showed the greatest improvement in microbiological water quality since 1995 (Table 58, Kendall tau -0.542, Mann-Kendall p value <0.001). Improvements in water quality might have arisen due to work undertaken by the New Plymouth District Council as part of the Stormwater Upgrade Project at Fitzroy. As a result of this project there is now less flow of stormwater to the stormwater infiltration galleries located in the Fitzroy beach car park.

During the 2015-2016 season, Oakura Surf Club recorded the lowest SEM enterococci median count at the site in the 21 years of the programme to date (3 cfu/100 ml). This marks a significant improvement from the preceding summer season (2014-2015) when the highest enterococci median count was recorded for the site (57 cfu/100 ml). The location of the Waimoku and Wairau stream mouths can have a large influence on water quality at this site. During the 2015-2016 summer season, the Waimoku Stream cut across the beach to join the Wairau Stream early in the season relative to previous years (photo 17), resulting in the main freshwater input being located to the east (down-current) of the sample site. It is recommended that photographs continue be taken of the position of the Waimoku Stream mouth to allow assessment of changes in location over a summer season and between summer seasons.

At Mana, Waverley and Wai-inu the median enterococci count obtained for the 2015-2016 summer season were the highest to date at these sites. However the results were still representative of good water quality, with a low maximum counts.

Photo 17 Changing position of the Waimoku Stream mouth in relation to Oakura Beach: 7 January 2003 (top), 10 December 2015 (second down), 12 January 2016 (third down), 9 February 2016 (fourth down), 8 March 2016 (bottom)

5.2 Conclusion

During the 2015-2016 summer season, water quality across the Taranaki region was generally high with 95% of samples below guideline Alert levels (<141 enterococci cfu/100 ml). At seven of the fourteen sites, no sample entered the alert mode. Of the few samples which individually entered the Alert (9 samples) and Action (2 samples) guideline categories (5%), the vast majority (9 out of 11) had been influenced by rainfall or freshwater. Many of the beach sites monitored in Taranaki are located close to stream or river mouths which can act as a source of contamination during heavy rainfall. The majority of these rivers and streams drain catchments with intensive agricultural land use, including dairying. Microbial source tracking has revealed that in addition to ruminants, birds (wildfowl and gulls) can also act as a key source of contamination in Taranaki freshwater environments (TRC 2016). In order to minimize potential health risks, the Council recommends reducing coastal recreational activities for two-three days following heavy rainfall.

Photo 18 Black backed gulls at the mouth of the Waiwhakaiho River

6. Recommendations

As a result of the 2015-2016 summer marine contact recreation bacteriological survey it is recommended:

1. THAT the 2016-2017 summer survey be performed at 13 sites continuing with the existing sampling protocol (annual, plus Year 2 sites).

2. THAT the 2016-2017 summer survey also includes an additional 7 samples collected at the five principal usage sites (Onaero, Fitzroy, Ngamotu, Oakura SC, and Opunake) in accordance with MfE, 2003 guidelines.

3. THAT follow-up sampling be performed as deemed necessary by Council staff. This should include follow-up samples within 24 hours of any samples exceeding 280 cfu/100 ml in order to assess if Action level has been reached.

4. THAT photographs of the position of the Waimoku Stream and Waingongoro River mouths are taken over the 2016-2017 season to aid the interpretation of faecal indicator bacteria results at the Oakura Beach and Ohawe Beach sites respectively.

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

Glossary of common terms and abbreviations

The following abbreviations and terms are used within this report:

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

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Appendix I

High tide times

High tide times (NZST) at New Plymouth for 2015-2016 sampling dates

Date		Time of HT
Thursday	12 November 2015	0956
Wednesday	25 November 2015	0852
Thursday	10 December 2015	0856
Tuesday	15 December 2015	1209
Tuesday	12 January 2016	1113
Friday	15 January 2016	1330
Monday	25 January 2016	1038
Tuesday	9 February 2016	1012
Friday	12 February 2016	1223
Tuesday	23 February 2016	1016
Tuesday	8 March 2016	0904
Tuesday	22 March 2016	0915
Wednesday	30 March 2016	1358

Appendix II

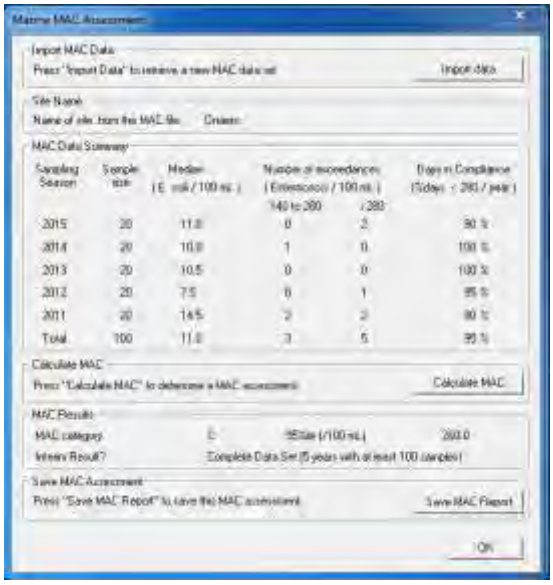
MAC assessments 2011-2016

Wai-iti

Urenui

* Irreconcilable follow-up

Onaero



Onaero Settlement

Waitara (East)

Waitara (West)

Fitzroy

East End

Ngamotu

Oakura (SC)

Oakura (CG)

Opunake

* Irreconcilable follow-up

Ohawe

Patea (Mana Bay)

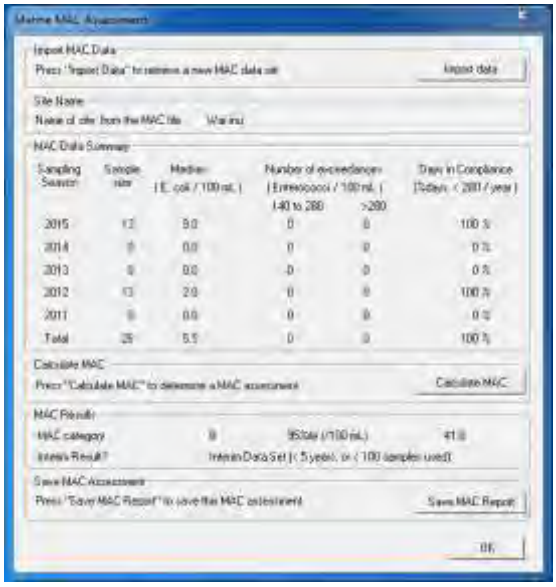
Patea Beach

* Irreconcilable follow-up

Waverley

* Irreconcilable follow-up

Wai-inu


Import MAC Data
Press "Import Data" to retrieve a new MAC data set
Import data
Site Name
Name of site from the MAC file
Wai-inu
MAC Data Summary
Sampling Season
Sample size
Median (E. coli / 100 mL)
Number of exceedances (Enterococci / 100 mL)
140 to 280
>280
Days in Compliance (Target: < 280 / year)
2015 13 9.0 0 0 100 %
2014 9 0.0 0 0 0 %
2013 9 0.0 0 0 0 %
2012 13 2.0 0 0 100 %
2011 9 0.0 0 0 0 %
Total 25 5.1 0 0 100 %
Calculate MAC
Press "Calculate MAC" to determine a MAC assessment
Calculate MAC
MAC Result
MAC category B 95%ile (/100 mL) 41.0
Interim Result? Interim Data Set (< 5 years, or < 100 samples used)
Save MAC Assessment
Press "Save MAC Report" to save the MAC assessment
Save MAC Report
OK

MAC Assessment Results
MAC Assessment B
Interim Assessment? Interim Data Set (< 5 years, or < 100 samples used)
SIC Assessment Results
SIC Assessment Moderate
Primary SIC Impact 13: River - agricultural activities/beds/feral animals
Calculate Marine SFRG
Press "Calculate SFRG" to determine a SFRG assessment
Calculate SFRG
SFRG Assessment Results
Site name Wai-inu
SFRG Assessment Good
Save this SFRG Assessment to a Single Summary File
Press "Save as a Single Entry File" to save the SFRG, MAC and SIC assessments and the MAC and SIC data in one file
Save as a Single Entry File
Save SFRG Assessment to a Multiple Summary File
Press "Save to a Database Format File" to save summary data as one line in a comma delimited file
Save to a Database Format File
Print the column labels in the file "ColumnLabelsMarine.txt"
OK