Weymouth Beach Faecal Source Investigation

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Weymouth Beach Faecal Source Investigation

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Executive summary

Weymouth Beach is in the Manukau Harbour near the Papakura Channel and has had a permanent health-warning sign in place since 2000. Historic water quality data reflects high levels of faecal contamination. This investigation was undertaken by Auckland Council in April 2014 to determine concentrations of faecal indicator bacteria (FIB) in different areas of the beach and the origins of any detected contamination.

Six sites investigated for *E.coli*, Enterococci and Microbial Source Tracking

We investigated six sample sites incorporating five beach/marine sites and the only stormwater outlet discharging to Weymouth Beach. Samples were collected on four separate occasions during dry and wet weather from 8 to 17 April 2014. Tests were run to detect two FIB, *Escherichia coli (E. coli)* (for freshwater samples) and Enterococci species (for saline samples).In addition, Microbial Source Tracking techniques were employed, using specific PCR markers to determine the biological origin of faecal contamination.

Human, bird and dog faecal sources detected at and near the stormwater outlet

Concentrations of FIB at the stormwater outlet (site 1) were consistently high, ranging from 930 to 24,000 MPN/100ml *E.coli*; and 1,800 to 24,000 Enterococci, with the highest concentrations occurring during wet weather. A human source was detected in two out of four source-tracked samples from the stormwater outlet. Bird and dog faecal sources were also detected at and near the stormwater outlet (sites 1 and 2) on several sampling occasions. Moreover, FIB concentrations at all six sites increased following heavy rainfall on 17 April and human sources were detected on this day. The results indicate that the stormwater outlet is the main source of human faecal contamination at the beach and that both birds and dogs are also contributing to faecal contamination of Weymouth Beach.

Papakura Channel had low Enterococci concentrations at all times

The Papakura Channel had consistently low bacterial contamination on the days it was sampled during this investigation and this concurs with the long-term state of the environment monitoring. Consequently, the channel is unlikely to be a significant source of faecal contamination at Weymouth Beach.

Identify and address the causes of faecal contamination and retain the public health warning sign at Weymouth Beach

This investigation indicates that human faecal sources pose the greatest health risk at Weymouth Beach and to lesser extent bird and possibly dog faecal sources. Recommendations and actions have been made as a result of this investigation. These include identifying where faecal contamination is entering the stormwater network and taking action to eliminate it. Remedial work has commenced on private stormwater and wastewater networks within the catchment to address any faults found during the system inspection. Bathing beach monitoring has now been recommenced at Weymouth over the 2015-2016 season to determine if the remedial work has been effective. We recommend retaining the health warning sign at Weymouth Beach until the faecal contamination has been addressed and FIB concentrations comply with national health guidelines.

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1.0 Introduction

1.1 Weymouth Beach in the Manukau Harbour

Weymouth Beach is situated in the south-east Manukau harbour, adjacent to the Papakura Channel. The land surrounding the beach is largely urban from which stormwater runoff discharges into the harbour. The Keith Park recreational reserve surrounds the beach and is a popular area for feeding ducks and walking dogs. In addition to urban runoff, Weymouth Beach is influenced by rural runoff, discharging via the Papakura Channel. This runoff originates from a number of tributaries with headwaters predominately situated in the rural landscape. These include but are not limited to, the Papakura Stream and Drury Creek catchments (see Figure 1-1).

1.2 State of the environment monitoring in Papakura Channel

The Research and Evaluation Unit (RIMU) of the Auckland Council (the Auckland Regional Council (ARC), prior to 2010) conducted monthly sampling, near Weymouth from October 1987 to June 2014, as part of the state of the environment (SoE) monitoring programme. The SoE sampling site is located approximately 500m west of Weymouth Beach in the Papakura Channel and is representative of the marine water which enters Weymouth Beach on the incoming tide (Figure 1-1). This data provides a long-term overview of faecal indicator bacteria concentrations, along with other environmental indicators.

During the SoE monitoring period the methods for detecting faecal indicator bacteria have changed. From October 1987 until August 2009 SoE microbial faecal indicators were measured by the ARC as faecal coliforms (Most Probably Number (MPN) per 100ml) and Enterococci coliforms (colony forming units per 100ml). Since September 2009 Auckland Council has measured microbial faecal indicators solely by Enterococci concentrations, represented as MPN per 100ml water. This parameter is in-line with national standards set by the NZ Ministry of Environment (2003).

The SoE data collected in Papakura Channel between 1987 and 2011 have consistently indicated low water quality and this site was classed as having poor water quality in 2010 and 2011 (Walker and Vaughan, 2013). Prior to 2009 monitoring data indicates that the long-standing poor water quality in Papakura Channel is predominantly due to elevated nitrate and fluctuations in suspended sediment and faecal coliform concentrations (Auckland Regional Council, 2010; Kelly, 2014; Walker and Vaughan, 2013; Wilcock and Stroud, 2000). Despite the channels low water quality classification, Enterococci concentrations recorded from 2009 to 2014 are almost consistently low, ranging between < 10 and 94 (MPN/100ml). The only exception to this was the final record, collected on 11 June 2014 after a rainfall event, which indicated elevated Enterococci levels at 410 (MPN/100ml).

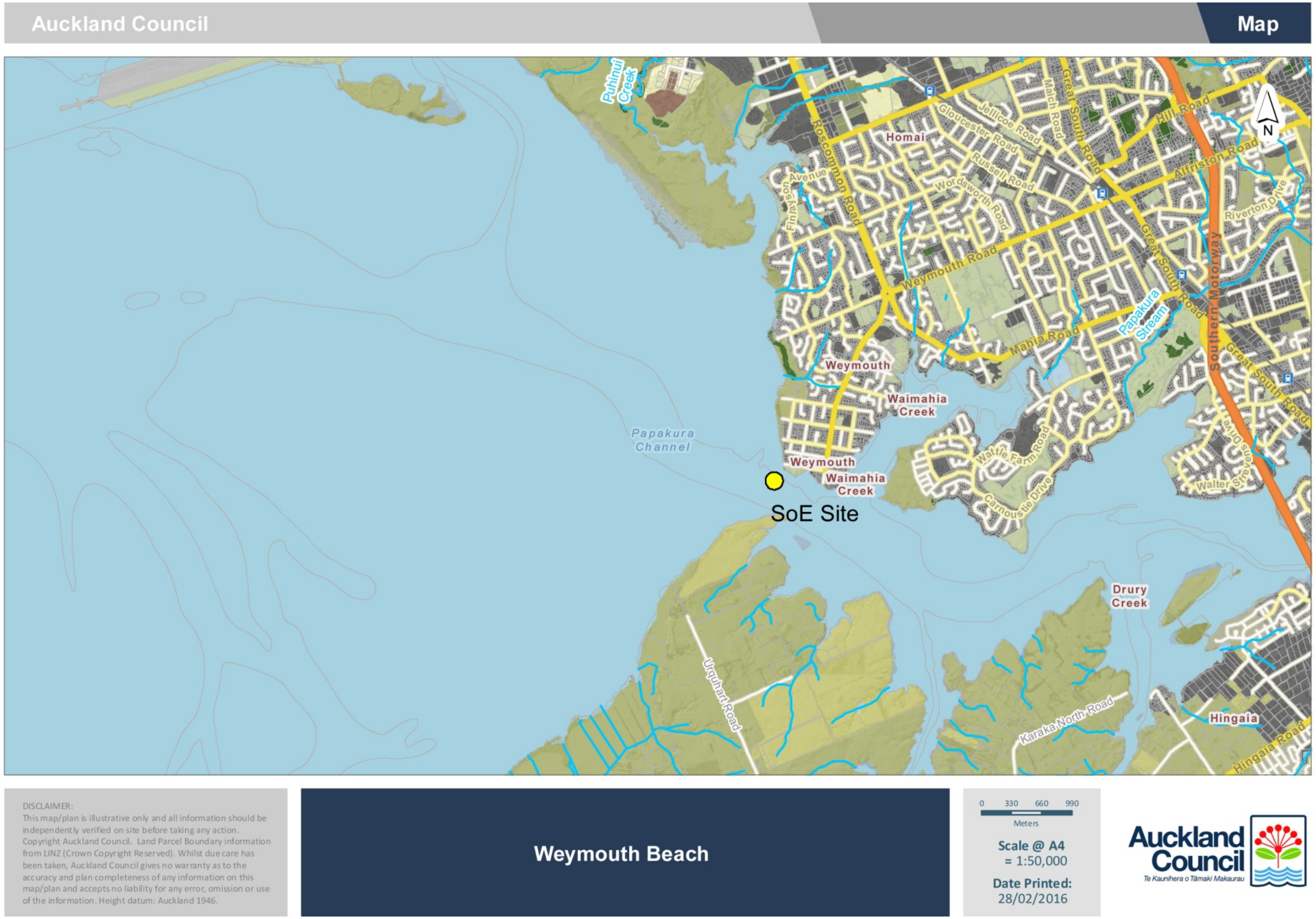


Figure 1-1 Location of Weymouth Beach and SoE monitoring site

1.3 Long standing health warnings at Weymouth Beach

In addition to SoE monitoring a bathing beach water quality monitoring program was run at Weymouth Beach to determine near-shore Enterococci concentrations. Bathing beach monitoring was undertaken by Manukau City Council (MCC) from summer 1997-1998 until summer 2009-2010 and for one further year by the Transitional Auckland Council during summer 2010-2011. Samples were collected between November and April, during the most likely swimming period. Beach monitoring over this time has indicated poor conditions due to repeated elevated concentrations of faecal indicator bacteria. Consequently, Weymouth Beach has had a permanent health-warning sign in place to discourage swimming and shellfish gathering since 2000.

Bathing beach data collected at Weymouth Beach over the final 6 year period (2005 to 2011) were used to calculate the historical 95th percentile Microbiological Assessment Category (MAC). The MAC is calculated using the Hazen method, developed by the Ministry for the Environment (MfE, 2003) to provide public health guidelines for recreational waters over time. As such, the MAC provides an indication of human health risk, in the form of likely numbers of illnesses per number of recreational events, ranging from 'A' for very good conditions to 'D', extremely poor conditions (see Appendix A). The Hazen score for Weymouth Beach between 2005 and 2011 was 2250, equating to a MAC of 'D', extremely poor.

Despite the health warning sign Weymouth Beach and boat ramp are valued by the community and are still used for a variety of water-based activities, including, swimming, fishing, boating and religious ceremonies (see Figure 1-2). Although Weymouth Beach has not been regularly monitored for bathing beach water quality since 2011 the assumption is that beach water quality continues to be poor.

Figure 1-2 Members of the local community using Weymouth Beach during a religious ceremony

1.4 Aim of this investigation

The potential health risks associated with bathing at Weymouth Beach is a topical issue among the local community; consequently the Manurewa Local Board requested that Auckland Council investigate the degree and possible sources of faecal contamination near the beach. This investigation was undertaken in April 2014, as soon as was possible, following the request. Although the study was undertaken outside the main bathing season a high level of recreational use of the beach was still observed at this time.

The aim of this investigation was to determine the drivers of faecal contamination underlying the poor water quality at Weymouth Beach. The investigation involved a walkover of adjacent wastewater and stormwater infrastructure, visual assessment of tidal inundation and channel flow and sampling for faecal indicator bacteria. Sampling was undertaken during wet and dry periods at multiple sites. In addition, Microbial Source Tracking (MST) techniques were applied to determine the biological origin of any faecal sources causing bacterial contamination of the beach.

2.0 Methodology

2.1 Site selection and location

Located in the Manukau Harbour, Weymouth Beach is influenced by both tidal flows and discharges from stormwater outlets and natural waterways, draining both rural and urban areas. Six sampling sites were established during this investigation to capture concentrations and potential sources of faecal indicator bacteria which may enter the beach from the surrounding environment. Site descriptions and locations are outlined in Table 2-1 and an aerial photo showing the position of the 6 sampling locations in relation to stormwater and wastewater networks are presented in Figure 2-1.

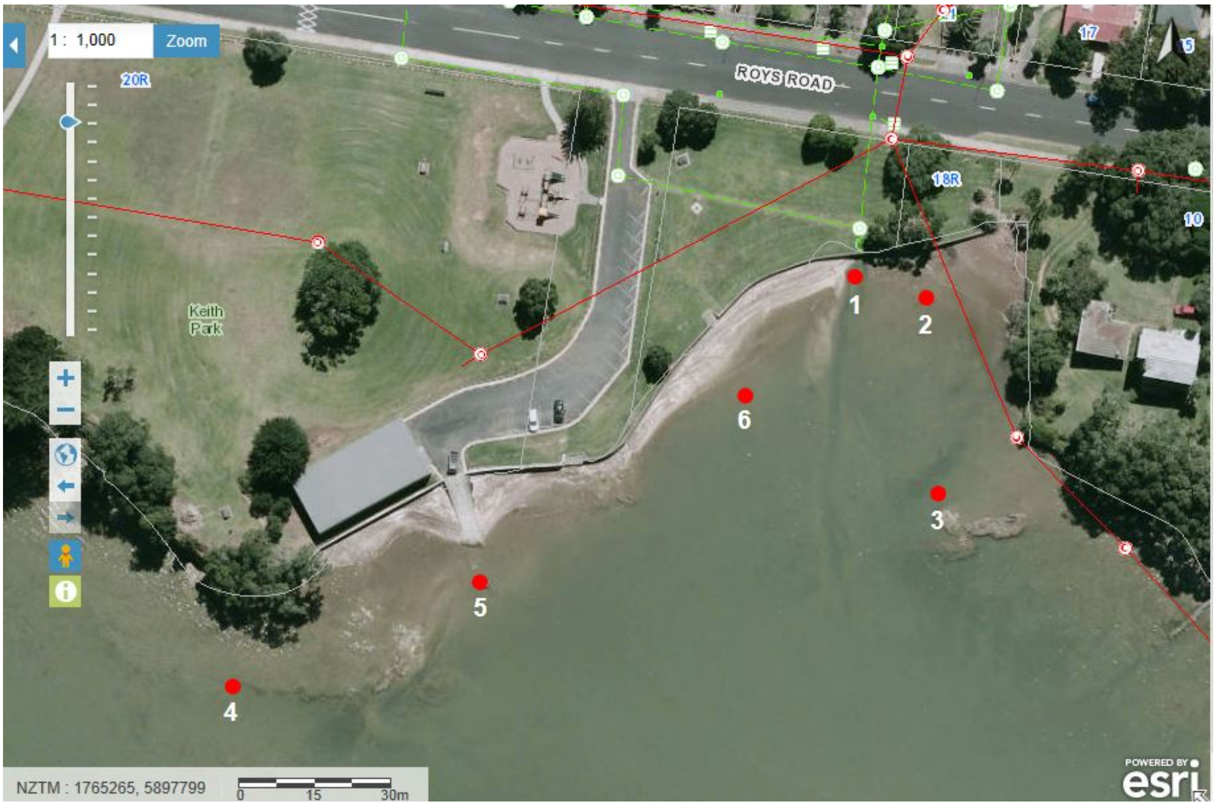


Figure 2-1 Location of 6 sampling sites visited during this investigation in 2014 (red dots). Stormwater lines and manholes are shown by green lines and green and white dots, respectively. Wastewater lines and manholes are shown with red lines and red and white does, respectively.

Table 2-1 Sampling site descriptions

Site	Location	Description
Site 1	Stormwater outlet	Delivers stormwater to Weymouth Beach via a ~ 900mm diameter outlet. This was the only stormwater outlet observed at the beach.
Site 2	Adjacent to the stormwater outlet	Adjacent to the stormwater outlet, comprising a shallow sandy-mud zone with drifts of flotsam and jetsam at the high tide mark. This area is used extensively by the resident duck population.
Site 3	Eastern side of beach	Chosen to detect any bird faecal sources arising from significant intertidal use of the foreshore area by seabirds at the eastern end of the bay. A nearby Watercare Services Ltd trunk sewer runs under the beach with a sealed manhole ~ 50m east of this site.
Site 4	Western side of beach	Selected to measure the water quality entering Weymouth Beach on the incoming tide. This site was in the channel, approximately 1m from the ledge of the wave-cut platform and was subject to tidal flow from the Manukau Harbour.
Site 5	Adjacent to the boat ramp	One of two popular recreational sites in the bay, being easily accessible from the boat ramp.
Site 6	Below steps adjacent to the beach	Corresponding to the bathing beach monitoring site. This is the most likely bathing point due to proximity to the stairs leading down to the sandy beach. For these reasons water quality results at this site will be of greatest interest for future decision making.

2.2 Rainfall records and tidal information

Rainfall records and tidal ranges for Weymouth Beach were recorded over the sampling period to help determine the influence of stormwater runoff and the incoming tide on microbiological results. Rainfall can influence concentrations of faecal indicator bacteria when stormwater overwhelms wastewater systems, due to incorrect drainage network connections. Tidal flows may wash faecal bacteria towards the beach either from recently inundated tidal flats or from hindering the drainage of nearby stormwater outlets and streams. Daily rainfall values were taken from the Auckland Council rain gauge at the Botanic Gardens (1769932E, 5902088S, NZTM) from 8 to 17 April 2014. The gauge measures rainfall with an automatic tipping bucket (0.5mm) whereby the inspection totals are corrected to storage gauge totals. Tidal information was gathered over the same time period, based on tide charts for the Papakura Channel. Tidal information on the four sampling days is shown in Table 2-2 below.

Table 2-2 Tidal information sourced from Papakura Channel

Sample date	High tide (24 hrs)	Low tide	Tidal range (m)
8 April	16:58	10:45	2.8m
13 April	09:20	03:00	3.4m
16 April	11:19	05:02	3.7m
17 April	11:59	05:43	3.7m

2.3 Sample collection and analyses

Weymouth Beach is influenced by both marine and freshwater inputs; consequently salinity levels fluctuated at some of the sampling sites during this investigation. For this reason tests were run to detect two faecal indicator bacteria (FIB); *Escherichia coli (E. coli)*, indicative of faecal contamination in freshwater and Enterococci species, indicative of faecal contamination in marine waters (MfE, 2003).

Water samples were collected at each sample site on 4 separate days; 8 April, 13 April, 16 April and 17 April 2014. Sampling was carried out in dry conditions as recommended by Van Duivenboden (2008) on three of the four sampling occasions. The fourth sampling occasion was completed during a rainfall event to determine if concentrations and sources of bacterial contamination alter during wet weather.

The majority of samples were collected during high tide to represent likely bathing times. Two additional samples were collected during low tide at the stormwater outlet (site 1) to determine if there were detectable levels of faecal contamination at the outlet during dry weather and low tide conditions. Detection of elevated FIB concentrations under such conditions would indicate possible cross-connections between stormwater and wastewater pipes, i.e. a private wastewater pipe erroneously connected into a stormwater pipe. This sampling regime provided a total of 26 water samples, comprising 24 high tide and 2 low tide samples collected over 4 days.

We analysed all samples for *E. coli* and Enterococci concentrations. Samples that had FIB concentrations above national guidelines were also analysed for faecal bacteria sources. The *E. coli* and Enterococci samples were collected in sterile 100ml bottles, while 2l bottles were used for the Microbial Source Tracking (MST) samples. The stormwater outlet was sampled immediately prior to being covered by the rising tide, followed quickly by all the marine sampling sites. Marine water samples were collected approximately 15cm below the surface in knee-deep water (~ 0.5m depth) according to MfE national health guidelines (2003). The samples were stored at less than 4°C and couriered to Aqualab NZ for analysis within 24 hours of sample collection. Water salinity was measured by Aqualab NZ to assure that the appropriate FIB was applied.

Water samples collected at the stormwater outlet (site 1) were predominately freshwater, with the exception of 16 April when tidal waters infiltrated the outlet and salinity increased to 26.8 (ppt). Therefore, Enterococci was applied as the FIB at site 1 on 16 April. Conversely, the sampling site adjacent to the stormwater outlet (site 2) was predominately saline, with the exception of 17 April when heavy rainfall and the resulting high outflow from the stormwater outlet caused salinity to drop dramatically to 2.4 (ppt). Therefore, *E. coli* was applied as the

FIB at site 2 on 17 April, while Enterococci was the applied FIB on all other sample days. The selection of the appropriate FIB was based on national guidelines outlined by Ministry for the Environment (MfE, 2003).

The *E. coli* and Enterococci samples were analysed using the Colilert-quantitray method, consistent with Bull et al. (2008) and van Duivenboden (2008) and are reported as Most Probable Number (MPN) per 100ml. All samples exceeding the MfE national guidelines (> 550 MPN/100ml *E.coli* or > 280 MPN/100ml Enterococci, depending on water salinity) were filtered for bacteria source analysis, known as Microbial Source Tracking (MST).

The MST samples in this investigation were passed through a 0.45µm filter by Aqualab NZ and the filters were frozen. Once all water sampling was complete, the frozen filters were couriered to the Environmental Science and Research (ESR) laboratory in Christchurch for MST analysis.

Polymerase Chain Reaction (PCR) was used for MST analysis in this investigation as it detects bacterial contamination from a wide range of sources using DNA markers. Markers include, human, canine (dog), avian (duck, swan, seagull, geese and chicken), ruminant (cows, sheep, goat, deer), equine (horse), possum and a range of other animal sources.

Bacteria sources identified during PCR analyses were compared to an existing DNA library. A total of 5 PCR markers were analysed during this investigation based on the likely sources of bacterial contamination at Weymouth Beach. These included; dog (DogBac), avian (GFD), two human markers (BacH and BiADO) and a general marker (GenBac). Microbial Source Tracking results are reported on a scale from ‘extremely strong positive’ to ‘very weak positive’ for the general faecal bacteria marker and present or not detected for all other markers. Guidance on interpretation of the MST results is provided by ERS in their laboratory report (see Appendix C).

3.0 Results

3.1 Heavy rainfall occurred on 17 April

Heavy rainfall occurred on the 17 April with 49mm recorded at the Botanic Gardens rain gauge that day (Figure 3-1). Conditions were predominantly dry during all other sampling days with only minor rainfall (3mm over 24hrs) occurring on 16 April. This fell after water samples had been collected that day. Cumulative rainfall, recorded up to 72 hrs prior to the day of sampling, ranged from 0.5 to 8.5mm over the sampling period (Table 3-1).

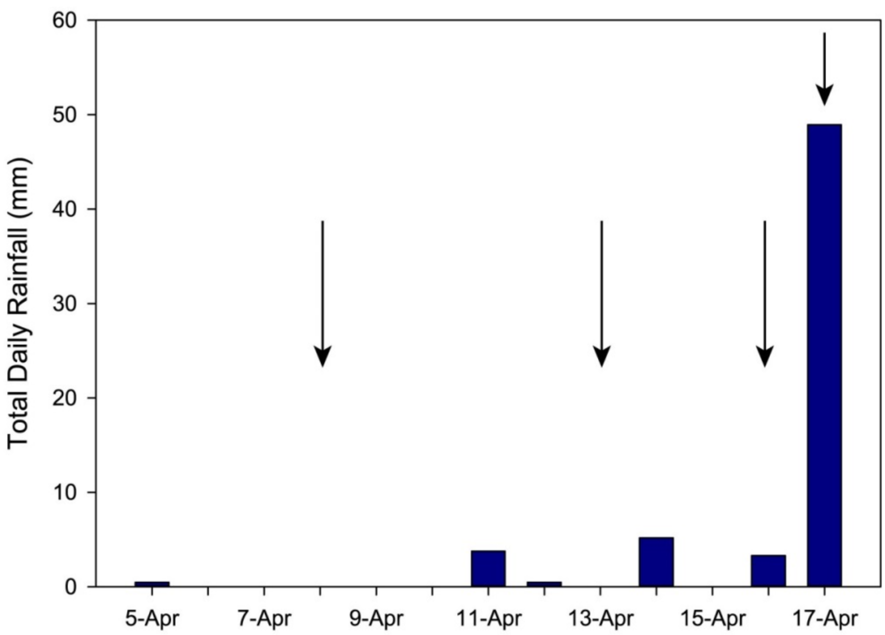


Figure 3-1 Total daily rainfall at the Auckland Botanic gardens, arrows indicate sample dates

Table 3-1 Total rainfall at Auckland Council Botanic Gardens, on the day of and prior to water quality sampling

	Rainfall (mm)		
Sample date	Sample day	Previous 24 hrs	Previous 72 hrs
8 April	0	0	0.5
13 April	0	0.5	4.2
16 April	3.3	0	5.2
17 April	49	3.3	8.5

3.2 Microbiological results

3.2.1 Stormwater outlet (sites 1 and 2) had the highest bacterial contamination

Concentrations of faecal indicator bacteria exceeded national health guidelines (>550 *E.coli* MPN/100ml freshwater; or >280 Enterococci MPN/100ml saltwater) on all sampling occasions at site 1, the stormwater outlet (Figure 3-2). Moreover, *E.coli* concentrations remained above national guidelines during low tide samples, collected at site 1 on 8 and 16

April, during dry conditions (Table 3-3). Elevated *E.coli* concentrations during dry weather and low tide indicate possible cross-connections between stormwater and wastewater pipes. Similarly, samples collected at site 2, adjacent to the stormwater outlet, exceeded guidelines on 13 and 17 April (Figure 3-2). Sites 1 and 2 had the highest microbiological readings recorded during this investigation and coincided with the rainfall event on 17 April. Site-specific *E. coli* and Enterococci results are presented in Figures 3-2 (a and b) and the raw microbiological data is presented in Appendix B.

3.2.2 Human, dog and bird faecal sources found at and adjacent to the stormwater outlet (sites 1 and 2)

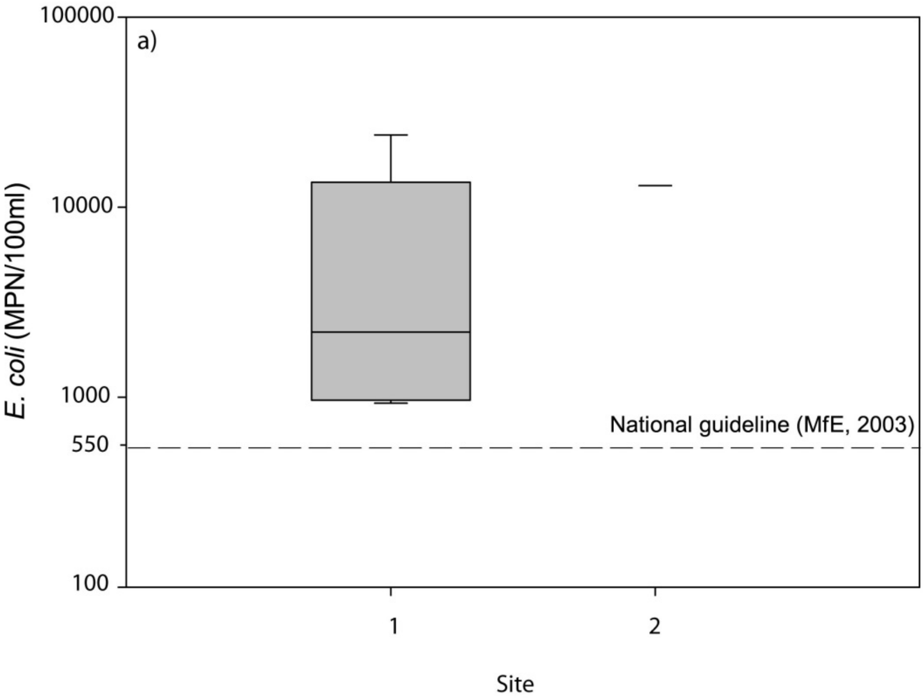
Human faecal sources were detected at the stormwater outlet (site 1) on 3 out of 4 sampling days, regardless of tidal position (Table 3-3). Bird faecal sources were also detected on 16 April (during high tide) and dog faecal sources were detected on 17 April. Bird faecal sources were detected adjacent to the stormwater outlet (site 2) on the 13 April, during dry weather. Human and dog faecal sources were detected at site 2 on the 17 April, during heavy rainfall. The Microbial Source Tracking (MST) results are shown in Table 3-3 and the full ESR lab report is presented in Appendix C.

3.2.3 Papakura Channel (site 4) consistently fell within national health guidelines

Papakura Channel (site 4) did not exceed national health guidelines and consistently fell within 'safe' limits during the sampling days, with Enterococci concentrations at ≤ 10 MPN/100ml. Enterococci concentrations only marginally increased to 10 MPN/100ml during the rainfall event on 17 April but were still well within national guidelines. Therefore, no samples collected from the channel were analysed for microbial source.

3.2.4 Beach sites (3, 5 and 6) exceeded national guidelines during rainfall

The three beach sites 3, 5 and 6 exceeded the 'safe' level of the national guidelines (> 280 Enterococci MPN/100ml) during the heavy rainfall event on 17 April (Table 3-3). This suggests that stormwater inputs and windy/stormy conditions are underlying the microbiological contamination of Weymouth Beach. Conversely, all three beach sites fell within national guidelines during dry weather, on the previous three sampling days. The general faecal marker was detected at all three sites on 17 April with MST readings ranging from positive to very weak positive (Table 3-3). However, no clear faecal source was detected through any of the other selected markers (dog, bird or human).



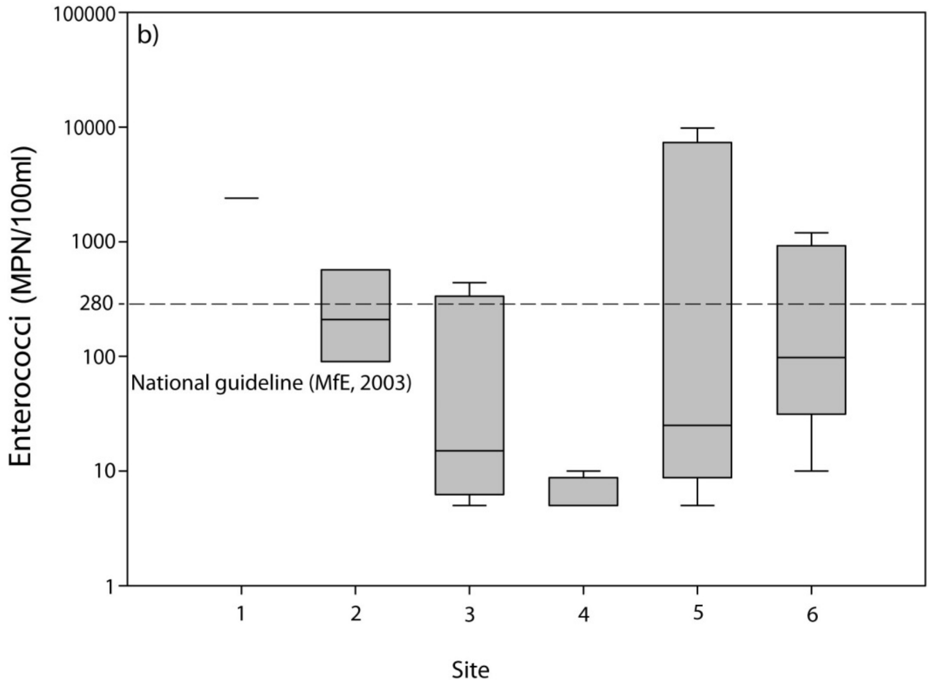


Figure 3-2 Boxplot showing the distribution of **a)** *E. coli* data for each of the freshwater samples and **b)** Enterococci data for each of the saline samples from Apr 2014. Boxes represent the interquartile range, the midline represents the median value and the upper and lower error bars represent the highest and lowest values, respectively. A single freshwater sample was collected at Site 2 **(a)** and a single saline sample was collected at Site 1 **(b)**.

Table 3-2 Microbial Source Tracking results for stormwater at high and low tide

Date	Site	Tide	Salinity (ppt)	Enterococci (MPN/100ml)	*E. coli* (MPN/100ml)	General marker result (GenBac)	Faecal sources
8 Apr	1	High	0	1,800	*2,200*	Very strong positive	Human (BiADO and BacH)
8 Apr	1	Low	0	2,900	*1,000*	Very strong positive	Weak human (BacH)
13 Apr	1	High	0	3,700	*3,100*	Strong positive	Not Detected
13 Apr	2	High	32.4	*570*	3,800	Strong positive	Bird
16 Apr	1	High	26.8	*2,400*	2,600	Very strong positive	Human (BiADO and BacH), bird
16 Apr	1	Low	0.2	2,200	*930*	Strong positive	Not Detected
17 Apr	**1**	**High**	**0**	**24,000**	***24,000***	**Very strong positive**	**Human (BiADO and BacH), dog**
17 Apr	**2**	**High**	**2.4**	**24,000**	***13,000***	**Very strong positive**	**Human (BiADO), dog**
17 Apr	**3**	**High**	**32.5**	***440***	**310**	**Very weak positive**	**Not Detected**
17 Apr	**5**	**High**	**28.1**	***9,800***	**3,000**	**Positive**	**Not Detected**
17 Apr	**6**	**High**	**32.1**	***1,200***	**780**	**Weak positive**	**Not Detected**

NB: **bold** text indicates days with heavy rainfall (> 40mm), all other samples were collected during dry weather. The appropriate indicator to apply, based on water salinity, are indicated by *underlined italics*.

4.0 Discussion

This section discusses the causes of bacterial contamination at Weymouth Beach and provides a comparison with previous investigations at the beach and in Papakura Channel. This section also discusses future monitoring and evaluation and the limitations of this study.

4.1.1 The stormwater outlet was the source of human faecal pollution at Weymouth Beach

Concentrations of faecal indicator bacteria (FIB) at the stormwater outlet (site 1) were high on all sampling days, particularly during wet weather. In addition, Microbial Source Tracking detected both human markers (BiADO and BacH) in water samples collected at and adjacent to the stormwater outlet. Human markers were not detected at the other sites, except for site 2 during wet weather. This indicates that discharge from this stormwater pipe is the main source of human faecal material at Weymouth Beach.

In general, concentrations of FIB increased across all sites during wet-weather. Moreover, the greatest incidences of contamination were observed at sites 1 and 2 (at and adjacent to the stormwater outlet), regardless of weather conditions. Consequently, water samples collected at the stormwater outlet never met national health guidelines for recreational waters (MfE, 2003) and only 50% of samples collected at site 2 met national guidelines during this investigation. These findings are indicative of the high level of faecal contamination in stormwater entering Weymouth Beach and the potential for this source to result in contamination of the wider coastal area.

4.1.2 Possible causes of human faecal material underlying contamination of stormwater at Weymouth Beach

Microbial Source Tracking results indicated that human faecal sources are originating from the single stormwater outlet on Weymouth Beach. This has the potential to impact the water quality of the entire beach, particularly during wet weather which corresponded with higher concentrations of FIB detected across all sample sites. Human faecal contamination of stormwater could be caused by either a cross-connection between residential stormwater and wastewater infrastructure, or infiltration of wastewater into stormwater pipes.

To identify the presence of faults in the infrastructure a follow-up inspection of the stormwater and wastewater network was undertaken by the council. The inspection involved an integrated approached to pinpoint which individual properties or sections of the stormwater and wastewater networks were underlying the contamination. The approach included; visual inspections of 30 manholes within the catchment, robotic closed-circuit television (CCTV) inspections of trunk and branch pipelines (totalling 900m of internal pipe), condition assessments and 325 private property wastewater inspections in conjunction with Watercare. This last action included smoke testing of the public and private wastewater networks to detect breakages or connections to stormwater.

The smoke testing and property visits identified faults or issues with private wastewater systems on 27 properties. These included stormwater to wastewater cross-connections, low gully traps potentially allowing surface water to enter wastewater lines and broken wastewater pipes underground. However, no direct wastewater to stormwater cross-connections were found, nor did visual or CCTV inspections find any faults in stormwater lines.

In addition to the direct faecal contamination originating from the stormwater outlet, diffuse faecal contamination may be entering the beach from surrounding urban areas, such as Manurewa and Wattle Downs, and from rural streams. Contaminants from these diffuse sources may not have been detected during this short-term investigation.

4.1.3 Dogs and birds were also sources of faecal contamination

Dog faecal sources were detected (along with human sources) during wet weather at sites 1 and 2, at and adjacent to the stormwater outlet. The stormwater outlet is considered to be the likely origin of this contamination due to low water salinity recorded at the time this sample was collected. The only saline sample that exceeded national health guidelines at site 2 was of bird origin. This result was not unexpected as more than 50 ducks were observed in the area immediately adjacent to the sample site. Moreover, many water birds were observed on the beach and reserve next to the beach over the investigation period, including up to 60 ducks, over 200 oyster catchers, seagulls and shags (pers. obs. R. van Duivenboden). However, the population of wading birds was lower during the investigation period than it would be during the summer season, due to seasonal migration. Therefore, faecal material originating from water fowl and dogs has the potential to reduce water quality at Weymouth Beach but the true extent of this may not have been captured in this investigation.

4.1.4 Beach sites had low concentrations of faecal material during dry weather

During this investigation sites 3, 5 and 6 only exceeded the national guidelines for seawater (MfE, 2003) in wet, stormy weather. The high rainfall observed on 17 April coincided with detection of human faecal contamination at the beach sites. This was an exceptionally heavy rainfall event, when bacteria can not only be washed into the sea but may also be released from sediments remobilized by stormy conditions (Muirhead et al., 2004; Nagels et al., 2002). For these reasons the national health guidelines advise against swimming in coastal waters within 48hrs of heavy rainfall. It should be noted that this investigation was carried out during the shoulder season, at the end of the Safeswim monitoring period.

A quarter of the samples taken from the marine environment during this investigation exceeded national guidelines. No specific animal marker could be detected at any of the beach sites during wet weather, despite elevated bacterial contamination and a positive result of the general faecal marker. This could be due to naturalised bacteria being released from re-suspended sediments during stormy, unstable conditions (Pachepsky and Shelton, 2011). Naturalised populations of bacteria originating from sediment, sand or other organic matter cannot be reliably detected via source tracking; fresh faecal material provides the most reliable results. The longer faecal material is exposed to the environment the greater the chance of degradation, dilution, predation (by zooplankton or other bacteria) or irradiation from sunlight (pers. comm. B. Gilpin). Alternatively, the specific marker for the faecal source may not have been selected (e.g. livestock/ruminants). High concentrations of ruminant faecal material have been detected in Papakura Stream (Meijer, 2015); however, great concentrations of ruminant faecal material would be necessary in order for it to be detected at Weymouth Beach.

The fact that microbiological results from all beach sites exceeded national guideline levels on at least one sampling occasion during this short-term investigation indicates a serious public health concern, particularly following rainfall. Moreover, given that the bathing beach monitoring program (run from 1997 to 2011) indicates there has been a health risk at Weymouth since 1999, the presence of the public health warning sign is justified until the source can be remedied or at least minimised.

4.1.5 Papakura Channel had low Enterococci concentrations at all times

The Papakura Channel (site 4) had consistently low bacterial contamination, both on the days it was sampled during the 2014 investigation and since 2005 long-term SoE monitoring of the channel. The one exception to this was the final SoE record, following rainfall on 11 June 2014, at which time Enterococci levels exceeded national guidelines for the first time since 2005. The channel sampling site may be indicative of the quality of water that fills Weymouth Beach on the incoming tide. However, water quality at Weymouth Beach will be influenced by complex water movement processes such as eddies, tidal currents and freshwater inputs. In addition, the flush rates of stormwater discharging from the outlet are not well understood at Weymouth Beach. For example, during the incoming tide stormwater may flow above incoming marine water due to differences in water density. Alternatively stormwater may not readily drain away and instead be pushed back towards the beach by incoming tidal waters. While on the outgoing tide stormwater may drain away more readily and gradually mix with marine waters, it is worth noting that no water samples were collected during the outgoing tide during this investigation.

Overall, data collected during SoE monitoring and throughout the 2014 investigation indicates very good microbiological conditions in the Papakura Channel, west of Weymouth Beach. Therefore, it is unlikely that water from the Papakura Channel is negatively affecting near shore FIB concentrations, or that channel waters are responsible for the microbiological exceedances observed in the past council water quality data at Weymouth Beach.

4.1.6 Health risks and future monitoring

The findings of this investigation indicate that the stormwater outlet is a significant contributor of human and to a lesser extent dog faecal contamination at Weymouth Beach. The human health risks associated with faecal contamination are generally greatest when contamination is of human or ruminant origin and less if it originates from birds or dogs (Moriarty pers comms., Moriarty et al., 2011). The potential health risks highlight the importance of addressing the contamination of stormwater entering the beach.

Since this water quality investigation, follow-up inspections have taken place to identify faults in the stormwater and wastewater infrastructure, as outlined in section 4.1.2 above. At the time of writing, the majority of these faults have been repaired and council officers are working with land owners to ensure that their wastewater systems are functioning correctly. In addition to the follow-up inspection of infrastructure, regular beach monitoring was recommenced over the 2015-2016 summer period. Once the final network faults have been fixed, another faecal contamination investigation will be undertaken to determine if the contamination has been reduced and assess any on-going public health risks associated with recreational activity at Weymouth Beach.

5.0 Conclusions

1. Microbial conditions at Weymouth Beach in April 2014 regularly exceeded national health guidelines.

2. The one stormwater outlet (site 1) that discharges to Weymouth Beach is a significant source of human faecal contamination to the beach during dry and wet weather.

3. Human, dog and bird faecal sources contributed to contamination at and adjacent to the stormwater outlet.

4. Faecal contamination of the beach/marine sample sites occurred predominantly during wet weather.

5. Unidentified faecal sources intermittently contaminate all marine sample sites with the exception of site 4, near Papakura Channel.

6. The Papakura Channel is unlikely to be underlying the faecal contamination at Weymouth Beach.

6.0 Recommendations

- Take action to eliminate human faecal contamination of the stormwater network.
- Undertake further monitoring at Weymouth Beach once human faecal contamination of stormwater is thought to have been addressed.
- Investigate ways to reduce faecal contamination from birds and dogs at Weymouth Beach.
- Retain warning sign at Weymouth Beach until faecal contamination levels have been substantially reduced to comply with national health guidelines.

7.0 References

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Appendix A Microbiological national guidelines for recreational waters MfE, 2003

Water quality testing was conducted by the former Manukau City Council at Weymouth Beach from summer 1997-1998 until summer 2009-2010 and for one further year by the Transitional Auckland Council during summer 2010-2011. Samples collected from 2003 onwards were taken in accordance with the Ministry for the Environment (MfE) and Ministry of Health (MoH) national health guidelines (MfE, 2003). The national guideline trigger levels relating to three modes (Green/Safe, Amber/Alert and Red/Action) are shown in Table 1 below for seawater. Amber and Red exceedances require re-tests until results return to the Green mode. Two consecutive Red exceedances require public health warning signs to be erected until results return to the green/surveillance mode.

Table 1 Seawater trigger levels from the national guidelines

Enterococci (MPN /100ml)	Mode
Single sample ≤140	Green/Safe – Continue routine monitoring
Single sample >140	Amber/Alert – Daily sampling required until results return to Green/Safe
Two samples >280	Red/Action - Daily sampling required until results return to Green/Safe. Erect warning signs after two consecutive samples >280

Under the national guidelines the last five years of results (100 data points) can be used to generate a Microbiological Assessment Category (MAC) for marine waters. The MAC is based on the 95th percentile using the Hazen method. Table 2 below sets out the MAC based on the Hazen ranges.

Table 2 Microbiological Assessment Category and ranges for seawater

MAC	Ranges – 95th Hazen percentile
A	≤ 40 enterococci/100 ml
B	41–200 enterococci/100 ml
C	201–500 enterococci/100 ml
D	> 500 enterococci/100 ml

The national guideline trigger levels relating to three modes (Green/Safe, Amber/Alert and Red/Action) are shown in Table 3 below for freshwater. The actions required following an exceedance are the same for fresh and seawater.

Table 3 Freshwater trigger levels from the national guidelines

E. coli (MPN/100ml)	Mode
Single sample ≤ 260	Green/Safe – Continue with routine sampling
Single sample > 260 - 550	Amber/Alert - Sampling increased to daily
Single sample > 550	Red/Action - Sampling continues daily until levels return to Green/Safe mode. Council places warning signage.

Appendix B Summary of microbiological data

Table 1 Median, standard deviation, minimum and maximum *E. coli,* Enterococci and salinity values for each site

Site Number	*E.coli*		Enterococci		Salinity (ppt)	
	Median ± S.D.	Min - Max	Median ± S.D.	Min - Max	Median ± S.D.	Min - Max
1	2,400 ± 9,037	930 – 24,000	2,650 ± 8,761	1,800 – 24,000	0 ± 11	0 - 26.8
2	4,100 ± 5,336	490 – 13,000	390 ± 11,857	90 – 24,000	32.4 ± 15	2.4 - 33.2
3	200 ± 219	75 - 540	15 ± 214	<10 - 440	33.4 ± 0	32.5 - 33.5
4	70 ± 59	20 - 140	5 ± 3	<10 - 10	33.4 ± 0	32.9 - 33.4
5	80 ± 1,465	50 – 3,000	25 ± 4,891	<10 – 9,800	33.4 ± 3	28.1 - 33.4
6	445 ± 504	85 – 1,100	98 ± 567	10 – 1,200	33.4 ± 1	32.1 - 33.9

Table 2 Raw data for each site, colours indicate trigger levels form national guidelines, green = safe, amber = alert and red = action

Site	Date	Tide	*E.coli* (MPN/100ml)	Enterococci (MPN/100ml)	Salinity (ppt)
1	8-Apr	High	2,200	1,800	0
1	8-Apr	Low	1,000	2,900	0
1	13-Apr	High	3,100	3,700	0
1	16-Apr	High	2,600	2,400	26.8
1	16-Apr	Low	930	2,200	0.2
1	17-Apr	High	24,000	24,000	0
2	8-Apr	High	4,400	210	33.2
2	13-Apr	High	3,800	570	32.4
2	16-Apr	High	490	90	32.4
2	17-Apr	High	13,000	24,000	2.4
3	8-Apr	High	540	20	33.5
3	13-Apr	High	90	< 10	33.4
3	16-Apr	High	75	10	33.4
3	17-Apr	High	310	440	32.5
4	8-Apr	High	20	< 10	33.4
4	13-Apr	High	110	< 10	33.4
4	16-Apr	High	30	< 10	33.4
4	17-Apr	High	140	10	32.9
5	8-Apr	High	110	< 10	33.4
5	13-Apr	High	50	30	33.4
5	16-Apr	High	50	20	33.4
5	17-Apr	High	3,000	9,800	28.1
6	8-Apr	High	1,100	100	33.9
6	13-Apr	High	110	95	33.4
6	16-Apr	High	85	10	33.4
6	17-Apr	High	780	1,200	32.1

Appendix C ESR Microbial Source Tracking report

6 June 2014

To: Andrew Noble
Auckland Council
8 Hereford Street, Newton
Auckland

Email: Andrew.Noble@aucklandcouncil.govt.nz

Purchase order: 3000148112

From: Dr Brent Gilpin
ESR Christchurch Science Centre
PO Box 29181
CHRISTCHURCH

REPORT ON FAECAL SOURCE TRACKING ANALYSIS – WEYMOUTH SITE

The following water samples were received on 7th May 2014 and were analysed for faecal source PCR markers.

ESR Number	Client Reference	Sample Details	*E.coli* MPN/100mL	Enterococci MPN/100mL
CMB140443	18902/2	Site 1 AM	1000	2900
CMB140444	18902/3	Site 1 PM	2200	1800
CMB140445	18920/1	Site 1	3100	3700
CMB140446	18920/2	Site 2	3800	570
CMB140447	18932/1	Site 1 AM	930	2200
CMB140448	18932/2	Site 1 PM	2600	2400
CMB140449	18937/1	Site 1	24000	24000
CMB140450	18937/2	Site 2	13000	24000
CMB140451	18937/3	Site 3	310	440
CMB140452	18937/5	Site 5	3000	9800
CMB140453	18937/6	Site 6	780	1200

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Results of PCR analysis:

ESR No	Sampled	*E.coli*	*Entero*	General GenBac	Human BacH	Human BiADO	Dog DogBac	Bird GFD	Conclusion
Site 1									
CMB140443	Site 1 AM, 8/04/2014	1000	2900	very strong positive	ND / present	ND	ND	ND	Faecal contamination – weak indication human source
CMB140444	Site 1 PM, 8/04/2014	2200	1800	very strong positive	present	present	ND	ND	Faecal contamination – human source
CMB140445	Site 1, 13/04/2014	3100	3700	strong positive	ND	ND	ND	ND	Unidentified faecal source
CMB140447	Site 1 AM, 16/04/2014	930	2200	strong positive	ND	ND	ND	ND	Unidentified faecal source
CMB140448	Site 1 PM, 16/04/2014	2600	2400	very strong positive	present	present	ND	present	Faecal contamination – human, and avian sources
CMB140449	Site 1, 17/04/2014	24000	24000	very strong positive	present	present	present	ND	Faecal contamination – human and dog sources
Site 2									
CMB140446	Site 2, 13/04/2014	3800	570	strong positive	ND	ND	ND	present	Faecal contamination – avian source
CMB140450	Site 2, 17/04/2014	13000	24000	very strong positive	ND	present	present	ND	Faecal contamination – human and dog sources
Other sites									
CMB140451	Site 3, 17/04/2014	310	440	very weak positive	ND	ND	ND	ND	Unidentified faecal source
CMB140452	Site 5, 17/04/2014	3000	9800	positive	ND	ND	ND	ND	Unidentified faecal source
CMB140453	Site 6, 17/04/2014	780	1200	weak positive	ND	ND	ND	ND	Unidentified faecal source

Abbreviations:
NA = sample was not analysed for this determinant.
ND = sample was analysed, but the determinant was not detected.

PCR Marker Interpretation Guidance Notes:

General marker

- The general PCR marker was detected in all samples.
- In samples where it was detected at very strong or strong levels we would expect source specific markers to be detected if the contamination was a recent event.
- Where the general marker was detected more weakly - this suggests a more diluted or aged source and thus source specific markers would be less likely to be detected.

Human markers

- Where human markers were detected they were not at “high levels”.
- These markers occur at variable levels in human sewage. Thus detecting them at lower levels may still represent a dominant source of pollution.
- Where human indicative markers was either detected in both assays or not detected in both assays this gives a higher level of confidence to conclude that a human source is present / not present.

Dog Marker

We have seen some cross reaction in this assay from human effluent samples but not from individual human faecal samples. This may indication that dog faecal material was present in the effluent samples we tested. In our view, septic tank and urban effluent cannot be presumed to be solely from human sources. When assessing the significance of the dog marker results for these samples consider the likelihood of dogs being present near the sampling area as well as the potential for any human contamination to be from a mixed source.

Bird Marker

The avian specific marker GFD detects duck, swan, seagull, geese and chicken faecal sources

Notes:

PCR Markers: Each marker is strongly associated with, but not exclusive to the source tested for. They each have some degree of non-specificity. The detection limit of these methods is 1.00E+03, or 1.00×10^{3}.

Brief details of the methods of analysis are available on request.
These results relate to samples as received.
This report may not be reproduced except in full.

Xuejin Lin

Paula Scholes	Beth Robson	Susan Lin
Laboratory Manager	Senior Technician	Scientist

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