Laingholm Beach Water Quality Investigation

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Laingholm Beach Water Quality Investigation

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Executive summary

A review of bathing beach monitoring data revealed a pattern of poor water quality due to microbiological contamination along the northern Manukau Harbour coastline. Laingholm Beach was chosen as a case study for detailed investigation into potential sources of contamination within the marine environment. Three freshwater sites, a stormwater discharge point and four marine sites were sampled approximately weekly for five weeks in March and April 2014. Microbial Source Tracking (MST) analysis was undertaken on selected samples in addition to standard faecal indicator bacteria testing (*E. coli* and enterococci). All samples were compared to Ministry for the Environment recreational contact guidelines (MfE, 2003).

A total of 32 samples were collected and tested for faecal indicator bacteria. Nine samples were either green/safe (n=7) or amber/alert (n=2) and all of these were marine samples. The remaining 23 samples exceeded the red/action trigger level for recreational contact, six of which were from marine sites and all others from freshwater inputs. Of the 23, 16 samples were further analysed for MST, specifically for human, dog or avian host-specific markers using Polymerase Chain Reaction (PCR) analysis.

All samples tested positive for the general faecal bacteria marker (GenBac), with host-specific markers identified in ten of these samples. Human faecal source markers were identified in nine of the 16 samples, canine markers were found in seven samples and avian markers in four samples. Host specific markers were isolated to freshwater inputs, with no host specific markers identified in the marine samples.

The following conclusions can be drawn from this investigation:

- All freshwater inputs to Laingholm Beach had elevated levels of faecal indicator bacteria indicating chronic contamination irrespective of weather conditions.
- Human faecal contamination was the most commonly detected source of contamination, followed by canine faecal contamination.
- The Manukau Harbour has generally good microbiological water quality and therefore it is considered that the main driver of poor microbiological water quality at Laingholm Beach is land based contamination.

To better manage the faecal contamination of Laingholm Beach and to address the current public health risk, a range of recommendations are presented, including (but not limited to):

- Undertake a streamwalk type survey of the stream draining to Laingholm Beach to document all piped inputs to the stream and identify potential sources of human wastewater contamination.
- Undertake an investigation of the Site 1 stormwater pipe network to determine the source of human wastewater inputs.
- Investigate whether historic septic tanks may be an issue within the catchment.
- Install health warning signage at the ponded, downstream end of the stream and consider the feasibility of establishing a monitoring/maintenance regime to manage the ponding (e.g. mechanical removal of sandbanks).

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1.0 Introduction

A review of bathing beach monitoring data, from Auckland Council's Safeswim programme, revealed a pattern of poor water quality due to microbiological contamination at several beaches along the northern Manukau Harbour coastline. To better understand the problem a pilot investigation was initiated in 2013 at six beaches - French Bay, Wood Bay, Titirangi Beach, Green Bay, Jenkins Bay (South Titirangi Beach) and Laingholm Beach (Auckland Council unpublished data). Nine sites across the six beaches were sampled, with samples being taken from either streams where they entered the marine environment or at stormwater outfalls. This included two sites at Laingholm Beach.

The pilot involved faecal indicator bacteria analysis of inputs to the marine environment over twelve sampling occasions which was supplemented by faecal sterol analysis (Sullivan *et al*., 2010) of some samples. For many of the samples the faecal sterol results did not provide sufficiently robust information to determine the source of contamination. It was therefore determined that a more rigorous investigation was required to provide more comprehensive information regarding potential sources of microbiological contamination.

Laingholm Beach case study

The pilot investigation, the number of known wastewater overflows and historic bathing beach data indicated the Laingholm Beach had the worst microbiological water quality of the Northern Manukau beaches. Therefore, a more comprehensive investigation was undertaken to investigate microbiological water quality at multiple sites on the beach with concurrent testing of the stormwater outfalls and streams discharging to Laingholm Beach during March and April 2014. The investigation aimed to determine the key sources of microbiological contamination of the water quality at Laingholm Beach.

Safeswim programme

Laingholm Beach is located on the northern shoreline of the Manukau Harbour in the Waitakere Local Board area and is a popular recreational spot used by local communities over the summer months. The microbiological water quality of Laingholm Beach has been monitored during summer under the council bathing beach 'Safeswim' programme in accordance with the Ministry for the Environment (MfE) national guidelines for recreational areas (MfE, 2003) since summer 2002–2003.

The Safeswim monitoring programme (see Appendix A for more details) is designed to provide regular assessments of water quality at a range of locations in the region that are used for recreation (including marine and freshwater beaches). Under the programme, the council monitors 71 (2015-16 season) beaches in the Auckland region on a weekly basis and the results are communicated to the public via the Safeswim webpage. Consistent with the MfE guideline the council takes action to warn the public of health risks if the results of testing indicate elevated levels of faecal indicator bacteria (*Escherichia coli* (*E. coli)* in freshwater or enterococci in marine waters) including erecting warning signs on the affected beach.

Microbiological data from the Safeswim monitoring programme indicates frequent exceedances of the recreational guidelines at Laingholm Beach (Figure 1-1), with more frequent exceedances since the 2007/08 season.

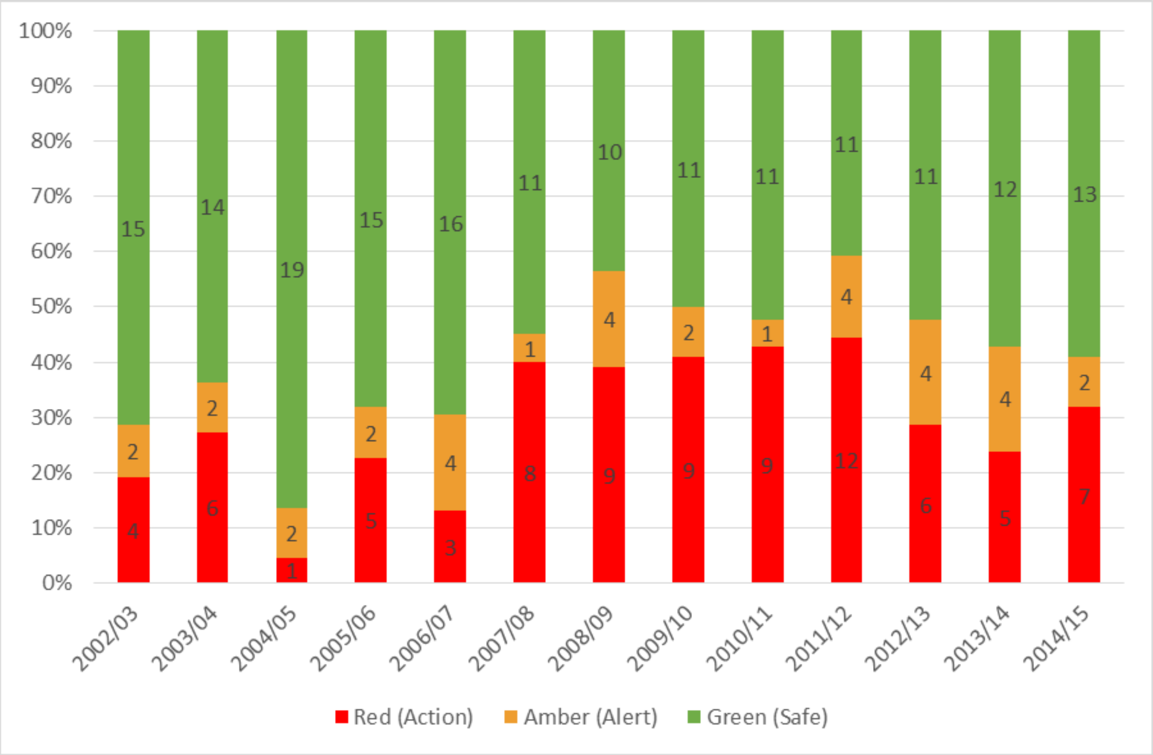

Figure 1-1 Laingholm Beach Safeswim monitoring results (Auckland Council website, historic Safeswim data) (Note: the number of samples in each mode is shown on the bar graph).

The Safeswim monitoring results show that according to MfE national guidelines the beach frequently poses a health risk (Hazen risk score of 'Extremely Poor' – Hazen of 8,700 from 2008 - 2013). Based on data from the last three years, Laingholm Beach has an overall recreation risk classification of 'caution'; that is, people are exposed to a high risk of infection (greater than 10%) from contact with the water (LAWA, 12/04/2016).

The Microbiological Assessment Category (MAC) for Laingholm Beach was calculated in accordance with the national guidelines. This provides a long term measurement of actual water quality over time (MfE/MoH 2003). This was calculated to be a 'D' which is the poorest category (refer to Appendix A for the guidelines and data around how this is calculated).

In summary, the long-term data for Laingholm beach indicates an elevated public health risk for recreational contact. These results, coupled with complaints from the public led to this more comprehensive investigation being undertaken.

We know there is contamination but not where it is coming from

The monitoring undertaken as part of the Safeswim project confirms that there is microbiological contamination at Laingholm Beach on a frequent basis. Sample analysis is limited to enterococci (as per the MfE guidelines) and as a result is restrictive in terms of what information this can provide for management interventions. The presence of faecal indicator bacteria does not necessarily confirm the presence of faecal contamination as they can exist in the environment without input from faecal sources (Byappanahalli et al, 2012). Further, enterococci, like *E. coli*, are ubiquitous in the intestines of warm-blooded animals, therefore the presence of faecally-derived indicator bacteria may be from a range of possible animal hosts that makes effective management of any contamination difficult without further information (Walker et al, 2015).

Within the Laingholm catchment there are several potential sources of microbiological contamination. Watercare reports that there is one existing engineered wastewater overflow point (#29) within the immediate Laingholm Bay catchment at the Laingholm pump station (Watercare, 2013). The overflow from the pump station has been sealed with a metal bar and padlock, however if it were to fail, the overflow would enter the unnamed tributary and then discharge to the beach approximately 50 m downstream.

There are several other known wastewater overflow points within the wider Laingholm catchment (as described by Watercare, 2013), however these discharge into the marine environment outside of the immediate Laingholm Bay. There have also been four reported dry weather overflows within the wider catchment, however not into the Laingholm Bay (unpublished Watercare data). Auckland Council GIS shows the wastewater network is in close proximity to the stream which may be a potential additional source of contamination through aged or leaky infrastructure.

Dogs frequent the parks and reserves along the unnamed tributary discharging into the beach and at the beach itself. Birds are frequently observed at the beach, in the water and within the recreational reserve alongside the beach.

Therefore, there are a number of potential sources of microbiological contamination to the aquatic environment at Laingholm Beach, however the enterococci results do not provide information to be able to identify whether human, dog or avian sources are present.

Recent advances in molecular techniques have led to the development of microbial source tracking (MST) tools based on ribosomal DNA markers associated with the Bacteroidales order of bacteria (Bernhard & Field 2000, Roslev & Bukh, 2011). General and host-specific markers potentially allow the identification of whether high faecal indicator bacteria concentrations are a result of faecally-derived contamination and furthermore, what the source animal is. The benefits of knowing the source of faecal contamination allows a financially-efficient, targeted management response (Gilpin et al. 2002). Therefore, the aim of this investigation was to provide more comprehensive information about the faecal sources contaminating Laingholm Beach than the pilot study previously undertaken, to inform appropriate management interventions in order to improve water quality.

2.0 Methodology

Water samples were collected and tested for *E. coli*, enterococci and a range of faecal source markers (using PCR analysis) at seven sites in the freshwater and marine environment at Laingholm Beach. The seven sites were selected to provide information on the spatial distribution and potential sources of any identified contamination. Depending on the salinity of the water at the sample site, either one or both of the faecal indicator bacteria were tested for, consistent with MfE guidelines. The sampling rationale and site descriptions are detailed below.

2.1 Sampling site description and rationale

Prior to identifying sample locations, a pre-sampling survey was undertaken by Auckland Council staff to confirm the number of stormwater and stream discharges to Laingholm Beach and to observe key infrastructure such as sewage trunk lines, public toilets and sewage pump stations. This information was used to determine the final sampling locations for this investigation.

A total of seven sampling sites were sampled as part of this investigation. Three of these sites were marine sites, one was a stormwater outfall discharging directly into the marine environment and the remaining three were stream sampling sites. One of the marine sample sites was a regular Safeswim monitoring site, with additional marine sites included to provide greater resolution as to the spatial variation of contamination along the beach. Two sites were consistent with those sampled in the 2013 pilot study (site 1 and site 3).

Additional sites upstream and within stormwater pipes were identified as potential sampling sites, however had minimal flow over the very dry summer and were therefore not sampled as part of this investigation. Water quality sampling locations are shown in Figure 2-1 and Table 2-1 below describes the sampling locations and rationale for choosing each site.

2.2 Sampling frequency

A single sample was taken at each site, approximately weekly for a period of 5 weeks between 6 March 2014 and 14 April 2014. The intention was to capture a combination of wet and dry weather conditions. Samples were taken either at high tide or mid-high tide which is when swimming (contact recreation) is most likely due to the shallow intertidal range.

Figure 2-1 Sampling sites for Laingholm Beach Investigation.

Table 2-1 Site names, description and rationale.

Site Name (Hydstra number)	Site Descriptions And Rationale	Easting	Northing
Site 1 (440940)	600mm diameter stormwater discharge outlet (290251) that discharges stormwater directly to the beach. Chosen as it isolates potential contamination sources from the Victory Road part of the catchment.	1746224.54	5907479.68
Site 1a (440941) Laingholm Beach @ South (Marine)	Identified as a potential swimming location, marine site located to the southern end of the beach, closest to stormwater (site 1) discharge location.	1746175.59	5907510.90
Site 2 (440942) Laingholm Beach @ Centre (Marine)	Safeswim sampling location, marine site located in the centre of the beach.	1746164.21	5907542.65
Site 2a (440943) Laingholm Beach @ North (Marine)	Identified as a potential swimming location, marine site located to the northern end of the beach, closest to stream discharge location.	1746168.45	5907582.60
Site 3 (440944) Laingholm Trib 440964 @ F/shr S/Water Outfall 299584	Most downstream point of the unnamed tributary (440964) through the centre of the Laingholm catchment. Sample site downstream of stormwater discharge point from small, immediate roading network. Tidally influenced, but isolated from the marine environment when a sandbank forms at the mouth.	1746132.46	5907610.65
Site 4 (440495) Laingholm Trib 440964 @ 12a Western Road	Site in unnamed tributary (440964) location in Council reserve located at 12a Western Rd. Chosen to give spatial resolution to the sampling undertaken in the northern part of the catchment.	1745886.67	5907512.29
Site 5 (440946) Laingholm Trib 440964 @ 63a Western Road	Site in unnamed tributary (440964) location in Council reserve located at 63a Western Rd. Chosen to give spatial resolution to the sampling undertaken in the northern part of the catchment.	1745644.29	5907495.16

2.3 Sample collection and analysis

Water quality samples were collected by Auckland Council staff in sterile 100mL bottles for faecal indicator bacteria analysis. A 2L bulk sample was taken at the same sampling location immediately after the microbiological sample for microbiological source tracking.

Marine water samples were collected subsurface in knee deep water (0.5m) according to MfE guidelines (MfE, 2003). Samples taken from the outfall were collected only when the outfall was flowing and were collected from the water discharging from the pipe. Samples taken from the stream were collected subsurface according to MfE guidelines.

All samples were chilled following collection and delivered to AquaLab Laboratory (NZ) Limited (‘AquaLab’) for analysis. The samples were analysed using the Colilert test (APHA, 2012) method which provides a Most Probable Number (MPN) of *E. coli* (APHA 9223B) and enterococci (APHA 9230D) per 100mL (detection limit 10 MPN/100mL for each of *E. coli* and enterococci) in accordance with the 2003 MfE guidelines.

Enterococci are the recommended indicator in marine environment and *E. coli* for freshwater (i.e. streams and stormwater). Sites 1, 3, 4 and 5 are freshwater sampling sites (stormwater outfall and stream) and the indicator bacteria tested for was *E. coli*. Sites 1a, 2 and 2a are marine sites and the indicator bacteria tested for was enterococci. Site 3 was tidally influenced on three occasions and so both faecal bacterial indicators were tested for. Refer to Figure 2-1 for the locations of all sample sites at Laingholm and to Table 2-1 for more detailed descriptions of the sites.

Site observations were recorded on each sampling day, including the presence of animals (particularly dogs and birds), recreational usage and weather and tidal conditions.

2.4 Microbial Source Tracking (MST)

The samples collected for MST analysis were processed by AquaLab within 24 hours of sample collection. All samples collected were filtered through a 0.45µm membrane filter until blocked and then a GITC buffer (Guanidinium thiocyanate) was added. The filters were then frozen and stored until the end of the investigation. This process maintains the sample integrity for at least six months (Gilpin et al., 2013).

At the close of the investigation the frozen samples were compared to their matching microbiological result and particular samples selected for MST analysis. The selection process was a pragmatic approach, where the requirement for information on sources was balanced with the fiscal constraints of the investigation. In general, those filtered samples with corresponding microbiological concentrations >550 *E. coli* MPN/100mL for freshwater or >280 enterococci MPN/100mL for seawater were sent to the Institute of Environmental Science and Research (ESR) laboratory for MST analysis using the Polymerase Chain Reaction (PCR) method. This is consistent with previous studies, where the use of molecular techniques is more likely to yield useful results when faecal indicator bacteria are high (Cornelisen et al., 2012).

However, none of the samples from the Day 3 sampling were selected for MST analysis. There was an extreme rainfall event preceding Day 3 (Cyclone Lusi) and it was considered that these unusual circumstances did not represent typical conditions in the catchment. Therefore, given the budgetary constraints of the investigation, the MST analysis was focussed on those samples collected after normal rain events (i.e. under conditions that would commonly occur in the catchment/area).

The MST method amplifies the DNA from host specific bacteria in the filtered water samples and tests for the presence of markers for the animal species of interest. The markers chosen for analysis in this investigation were the general faecal marker (GenBac), and specific markers for dog (DogBac), avian (GFD) and human (BiADO and BacH) sources. The avian marker GFD detects duck, swan, seagull, geese and chicken faecal sources. There were no livestock observed in the catchment, so bovine and ruminant markers were not included in the analysis.

The human BacH marker is more sensitive than the BiADO marker, but it has higher non-specificity than the BiADO marker with other animal species such as possum, dog, cat, rabbit, goat and chicken faecal sources. Therefore the BacH marker cannot definitively show the faecal source is human (ESR 2014). However the BiADO marker persists longer in the environment and is evidence of human (wastewater) contamination because it has low-level non-specificity with other animal markers such as possum, dog and waterfowl markers (pers. com. P Scholes 2014). Where both BacH and BiADO markers are present, there is a higher level of confidence to conclude that a human source is present (ESR, 2014).

2.4.1 Interpreting MST results

The general faecal bacteria indicator (GenBac) results are reported on a semi-quantitative scale from ‘extremely strong positive’ to ‘very weak positive’, or ‘not detected.’ Extremely strong positive results indicate recent faecal contamination and conversely very weak positive results indicate an aged or partially treated source, which may have degraded the faecal indicative markers.

All other specific markers are reported as ‘present’, ‘present/not detected’ or ‘not detected’ for each animal marker based on Table 2-2 below. If a high GenBac level is present but no specific marker is identified, the samples are interpreted as not consistent with fresh or untreated faeces from the sources tested (ESR 2014).

Table 2-2 Interpretation of the ESR MST results.

Results	Marker type
Extremely strong positive	General faecal marker only
Very strong positive	General faecal marker only
Strong positive	General faecal marker only
Positive	General faecal marker only
Weak positive	General faecal marker only
Very weak positive	General faecal marker only
Present	Specific faecal source detected
Present/ND	Weak specific faecal source at the limit of reporting
Not Detected (ND)	Specific faecal source not detected

2.5 Rainfall records from Waituna @ Huia rain gauge

Rainfall data for the dates of the investigation were obtained from Auckland Council Research and Evaluation Unit (RIMU). This data was obtained from the closest rain gauge to Laingholm, which is the Huia filter treatment station (Waituna, Site ID 649625).

Rainfall data was reported in terms of cumulative volume of rain that fell in the 12, 24, 48 and 72 hours prior to sampling.

3.0 Results

3.1 Rainfall

All sampling days, except Day 2, had rain in the preceding 72 hours and therefore the results are likely to have been influenced to some extent by rainfall. Day 5 had the wettest antecedent conditions, with 9.5mm of rain falling in the 12 hours prior to sampling. A significant volume of rain fell three days prior to sampling being undertaken on Day 3. This rain event was associated with Cyclone Lusi, however it is considered that as only 1mm of rain fell in the 24 hours preceding sampling, this sampling day was not representative of a wet weather event.

While no rain fell in the 12 hours preceding sampling, between 4.5mm and 6mm fell in the 48 hours prior to sampling on Days 1 and 4. This is sufficient volume to not be considered ‘dry weather’ and as a result, Day 2 was the only truly dry weather event with no rain in the preceding three days.

Table 3-1 Rainfall records for Waituna @ Huia rain gauge.

Day	Date	Estimated time of sampling	12hr	24hr	48hr	72hr
Day 1	6/03/2014	15:03	0	0.5	4.5	7.5
Day 2	14/03/2014	10:14	0	0	0	0
Day 3	17/03/2014	Midday*	0	1	6	30
Day 4	4/04/2014	14:33	0	3.5	6	6
Day 5	14/04/2014	Midday*	9.5	9.5	9.5	18

Note: sampling on Days 3 and 5 was undertaken at mid-tide, but the time of sampling is unknown. For the purposes of determining rainfall, it has been assumed that the mid-tide sampling was undertaken at midday. Sampling on Days 1, 2 and 4 were undertaken at high-tide and this time has been provided (based on Onehunga tide chart sourced from LINZ).

3.2 Site observations

The following is a brief summary of the observations made on each of the sampling days.

Day 1 sampling was undertaken either side of high tide (15:03) on 6 March 2014. No rain fell on the day of sampling, however a total of 7.5mm had fallen over the preceding 72 hours. The downstream extent of the stream (Site 3) had formed a lagoon-like environment due to a sandbank having formed at the stream mouth. Approximately 25 ducks were observed within the reserve. No flow was observed at Site 1 and as such a sample could not be taken.

Day 2 sampling was undertaken either side of high tide (10:14) on 14 March 2014. There was no rain on the day of sampling and none in the preceding nine days. The sandbank was still present at Site 3, however was being cleared by Auckland Council due to the imminent Cyclone Lusi expected over the weekend (to prevent potential upstream flooding). Approximately 20 ducks were observed in the reserve. No flow was observed at Site 1 and as such a sample could not be taken.

Day 3 sampling took place after Cyclone Lusi at mid to high tide on 17 March 2014. There was a total of 30mm in the 72 hours preceding sampling. There were more birds present on the beach than previous sampling days, consisting of approximately 85 oyster catchers, 30 ducks and five seagulls. The stormwater pipe at Site 1 was flowing and a sample was taken.

Day 4 sampling took place either side of high tide (14:33) on 4 April 2014. Approximately 6mm of rain was recorded in the previous 72 hours, with 3.5mm in the 24 hours prior to sampling however this did not result in flow at Site 1 meaning a sample could not be taken there. There were children and dogs in the water and approximately 35 ducks in the domain.

Day 5 sampling took place at mid to high tide on 14 April 2014. In the 12 hours prior to sampling, 9.5mm of rain fell and a total of 18mm fell in the preceding 72 hours. A strong onshore breeze meant that the water was stirred up and murky. There were approximately 90 ducks at the Sandys Parade domain.

3.3 Microbiological sampling results

A total of 32 samples were collected as part of this investigation. Of these, only 7 (22%) were green/safe according to the MfE guidelines. Two were amber/alert (6%) indicating the need for daily re-sampling (if in the SafeSwim programme). All nine of the green and amber samples were obtained from marine sites, whereas all of the samples from the freshwater inputs triggered the red/action level in the recreational guidelines. Summary results for the Laingholm sampling project are provided in Table 3-2 below.

Table 3-2 Summary microbiological results for Laingholm Beach.

Site Name	Site type	FIB parameter (MPN/100mL)	Day 1	Day 2	Day 3	Day 4	Day 5
			6/03/2014	14/03/2014	17/03/2014	4/04/2014	14/04/2014
Site 1	SW pipe	*E. coli*	NS	NS	730	NS	2500
Site 1a	Beach	Enterococci	<10	2900	290	10	4100
Site 2	Beach	Enterococci	10	30	180	170	7700
Site 2a	Beach	Enterococci	10	110	380	<10	1200
Site 3	Stream	*E. coli*	3600	10500	2200	1700	16000
		Enterococci	N/A	N/A	450	460	>24200
Site 4	Stream	*E. coli*	8600	1700	1000	2700	12000
Site 5	Stream	*E. coli*	8700	1300	1300	990	7700

NB: NS = No Sample, N/A = Not Assessed. Highlighting represents MfE 2003 guidelines trigger levels of green/safe, amber/alert and red/action. Units are MPN/100mL. FIB = Faecal Indicator Bacteria

Stormwater pipe has microbiological contamination when it's flowing

Site 1, a 600mm diameter stormwater pipe, was sampled on only two of the five occasions, due to a lack of flow. On the two occasions a sample was taken, *E. coli* was above recreational contact guidelines being 730 *E. coli* MPN/100mL and 2,500 *E. coli* MPN/100mL on Days 3 and 5 respectively. Despite 3.5 mm of rain falling the day before sampling on Day 4, there was no flow at Site 1 to sample.

The stream has microbiological contamination during wet and dry weather

All of the samples collected from the freshwater flows onto the beach showed evidence of microbiological contamination, with all samples exceeding relevant guidelines. Sites 4 and 5 were only tested for *E. coli* while Site 3 was tested for both *E. coli* and enterococci due to its proximity to the tidal interface.

The *E. coli* results at the stream sites ranged from 990 MPN/100mL to 16,000 MPN/100mL. The site with the highest levels of faecal indicator bacteria on any given day varied, indicating that while there is microbiological contamination present throughout the stream, there is not a clear spatial pattern in concentrations along the stream.

Enterococci was tested for at Site 3 on Days 3, 4 and 5 after the sandbank (described in Table 2-1) had been mechanically removed (on 14 March 2014), which allowed saline water to flow into the stream mouth. On all three days the red/action trigger level was exceeded, with a maximum enterococci level of >24,200 MPN/100mL recorded on Day 5. On Day 2, following nine days of dry weather and the presence of a sandbank restricting the egress of flows from the stream mouth, the most downstream site (Site 3) had a considerably higher concentration of *E. coli* (10,500 MPN/100mL) than the upstream sites (Sites 4 and 5, 1,700 and 1,300 MPN/100mL respectively).

Marine sites are cleaner than the freshwater inputs

Of the three marine sites, Site 1a had the highest number of red/action exceedances, with three of the five sampling occasions on Days 2, 3 and 5 (median of exceedances 2,900 MPN/100mL).

Site 2 exceeded the red/action trigger on one occasion (Day 5), but also exceeded the amber/alert trigger on Days 3 and 4.

Site 2a was the cleaner of the marine sites, with only two red/action exceedances on Days 3 and 5 (red/action trigger) of 380 MPN/100mL and 1200 MPN/100mL respectively.

There is no obvious pattern to the spatial distribution of enterococci results along the beach, however it is noted that Site 1a is closest to the stormwater discharge location and Site 2a closest to the stream.

There is no clear relationship between rainfall and faecal indicator bacteria concentration

It is considered that no relationship between rainfall and microbiological contamination can be identified based on the results of this investigation due to the small sample size (n=5(days)). In addition, a qualitative assessment of the effect of rainfall on Faecal Indicator Bacteria (FIB) concentration indicates that any relationship with rainfall is more complex than can be described using the data from this study. For example, on Day 2, there was no rain, but Site 1a exceeded the red trigger level for enterococci. In contrast, on Days 1 and 4, rainfall in the preceding 24 hours did not result in elevated enterococci concentrations at the same site.

Time of sampling may impact results

Marine samples taken at high tide generally had lower concentrations of enterococci than those taken at mid tide, however there is insufficient replication in sampling to determine if this is due to tidal stage or confounding factors, such as rain. The marine water samples collected at high tide on Days 1 and 4 had the lowest concentrations of enterococci (median 10 MPN/100mL, n=3). Whereas, samples collected on Days 3 and 5 exhibited the highest number of exceedances across all sites (n=6 and n=7 respectively for red/action trigger exceedances), which coincided with sampling being undertaken at mid tide, rather than high tide. Based on only two sampling events there is insufficient information to undertake meaningful statistical analysis to determine if the tidal stage is a factor, but it should be considered in any future investigations.

3.4 Microbial source tracking results

The key points from the MST analyses are described below and in Table 3-3; the full MST results from ESR are provided in Appendix B.

GenBac was detected in all samples and specific source markers found in ten of the 16 samples analysed. Human specific faecal source markers were the most commonly detected in nine out of 16 samples. Canine was the next most common faecal source marker (seven out of 16 samples) and bird markers were found in four samples, but all from the same location (Site 3) (Table 3-3). The MST analysis was unable to determine the origin of the faecal contamination in three stream samples and all of the marine samples, despite positive results for GenBac and elevated Faecal Indicator Bacteria (FIB) levels in these samples.

Human faecal markers found at all freshwater inputs

Very strong positive results for GenBac were recorded at Site 3 (all four samples), Site 4 (three of four samples) and Site 5 (two of four samples).

Human contamination was identified at all of these three sites. Both human markers (BacH and BiADO) were present on Day 5 at all stream sites, indicating strong evidence that human wastewater contamination was present in the stream throughout the catchment on this sampling day.

Both human markers were also detected on Day 4 at Site 4, however for all other samples, only one human marker was present (once at Site 4 and 5) or no faecal source was identified (once at Site 4 and twice at Site 5).

The stormwater drain (Site 1) recorded a very strong positive for GenBac. The dog marker and both human markers (BacH and BiADO) were present, indicating strong evidence of the presence of human wastewater contamination within the stormwater drain.

Avian contamination only found in lower stream site

Avian faecal sources were recorded at Site 3 for all four samples analysed for MST. No other sites recorded avian markers during this investigation. Site 3 is located closest to the beach and periodically forms a lagoon which may provide favourable habitat for birds. The avian faecal marker was not detected in the marine samples.

Dogs contribute to the microbiological contamination

The dog faecal marker was detected in seven of the samples tested, at all stream sites and in the stormwater sample. The sites are located in areas where dogs were observed during sample collection. The dog faecal marker was not detected in the marine samples.

No host specific markers detected in the marine samples

The MST analysis did not detect any host-specific markers in the marine samples and was therefore unable to determine the origin of the faecal contamination that was indicated by the elevated Faecal Indicator Bacteria (FIB) results and the presence of the GenBac marker.

Table 3-3 Faecal source results for Laingholm Beach

Site	Date	*E. coli* (MPN/100mL)	Enterococci (MPN/100mL)	General GenBac	Conclusion
Stormwater pipe					
Site 1	14/04/2014	2500	NA	VSP	Human (BiADO & BacH) & dog
Marine sites					
Site 1a	14/04/2014	NA	4100	P	Unidentified
Site 2	14/04/2014	NA	7700	P	Unidentified
Site 2a	14/04/2014	NA	1200	VWP	Unidentified
Site 3 (stream)					
Site 3	6/03/2014	3600	NA	VSP	Human (BiADO), dog & avian
Site 3	14/03/2014	10500	NA	VSP	Dog & avian
Site 3	4/04/2014	1700	460	VSP	Human (BiADO), dog & avian
Site 3	14/04/2014	16000	>24200	VSP	Human (BiADO & BacH), dog & avian
Site 4 (stream)					
Site 4	6/03/2014	8600	NA	SP	Unidentified
Site 4	14/03/2014	1700	NA	VSP	Human (BacH)
Site 4	4/04/2014	2700	NA	VSP	Human (BiADO & BacH)
Site 4	14/04/2014	12000	NA	VSP	Human (BiADO & BacH) & dog
Site 5 (stream)					
Site 5	6/03/2014	8700	NA	SP	Unidentified
Site 5	14/03/2014	1300	NA	SP	Unidentified
Site 5	4/04/2014	990	NA	VSP	Human (BiADO)
Site 5	14/04/2014	7700	NA	VSP	Human (BiADO & BacH) & dog

NB: no source tracking analysis was undertaken on Day 3. Refer to section 2.4.1 for detail about interpretation of results.

4.0 Discussion

Monitoring results from the Auckland Council's SafeSwim programme have demonstrated elevated concentrations of Faecal Indicator Bacteria (FIB) at Laingholm Beach that are in excess of guidelines and are considered a risk to human health. This investigation has expanded upon the regularly undertaken SafeSwim monitoring programme through the inclusion of MST and additional sampling sites to provide more information about the potential sources of contamination within the catchment.

There is one engineered wastewater overflow within the catchment, which is the Laingholm pump station. The overflow pipe at this location has been sealed and it is unlikely that this is the source of any faecal contamination to the catchment (Watercare, 2013). If it were to overflow, it would discharge to the unnamed tributary approximately 50m upstream of the beach. The reticulated wastewater network is located in close proximity to the unnamed tributary. There have been no recorded overflows by Watercare within the immediate catchment however this is based on phone reports from the public and as such the reliability of this information is unknown.

This short term investigation assessed Laingholm Beach water quality with commonly used faecal indicator bacteria which are used to indicate the level of public health risk and additional faecal source tracking to determine the biological source of the bacteria. The water quality of the beach and freshwater inputs (streams and stormwater pipe) were investigated during both wet and dry weather conditions over five days spanning five weeks.

4.1 The stream is contaminated with human wastewater

There was strong evidence that human wastewater was present within the stream which drains to Laingholm Beach. The MST analysis detected human markers in samples from each of the stream sampling sites on multiple occasions.

Analysis was undertaken for two human markers, BacH and BiADO, which together provide strong evidence of human wastewater contamination. BacH is the more sensitive of the two human markers; however, it is also less host-specific so cannot be used as a definitive indicator of human contamination if it is the only human marker detected.

One or both of these markers were found at all stream sites across the sampling period. There was no clear pattern to the spatial distribution of these markers throughout the stream.

Based on the results obtained it appears that there may be multiple sources of human wastewater entering the stream environment.

4.2 Dog and bird faecal sources are present in the stream and stormwater discharge

The dog faecal marker was recorded in the stormwater and stream samples, indicating that faecal matter from dogs is being washed either directly into the stream or into stormwater catchpits. All stream monitoring sites were located within public reserve areas where dogs are likely to be frequent.

Site 3 was the only site where an avian faecal source was recorded and it was present in all four of the samples analysed for MST. Site 3 is located at the tidal interface/mouth of the stream and can sometimes form a lagoon, due to the build-up of sand restricting flows to discharge to the marine environment. It is likely that birds frequent the stream mouth when it is ponded, however additional sources of avian contamination may enter the stream via overland flow or through stormwater drains. The sandbank was present on both samplings Days 1 and 2, which may have restricted the discharge of contamination into the marine receiving environment and provides a semi-stable environment for bacteria to proliferate in.

Following the removal of the sand bank, the concentration of faecal indicator bacteria reduced from 10,500 MPN/100mL (Day 2) to 2,200 MPN/100mL (Day 3). Following rain on Day 5, the concentration increased to 16,000 MPN/100mL. It is recognised that there are several environmental parameters that contribute to the decay or persistence of faecal indicator bacteria in the environment, however little is known about these interactions and subsequent effects on bacterial populations (Harwood et al, 2014).

It is hypothesised that the ponding of the stream creates an environment which may result in increased concentrations of faecal indicator bacteria at this location, by both providing a favourable habitat for waterfowl but also as a reservoir for upstream contamination. The current study does not provide sufficient data to provide more certainty around this; however, it does suggest that active management, such as mechanical removal of the sandbank may be required to reduce the potential risk of microbiological contamination from avian sources in the ponded area. However, this would need to be assessed by appropriate technical experts with consideration of resource consenting requirements.

4.3 Microbiological contamination in the marine environment diluted

MST analysis for the marine samples was only undertaken on Day 5, and no faecal sources could be identified at any of the marine Sites 1a, 2 and 2a. Despite enterococci levels being elevated following wet weather, the GenBac assessment resulted in only a positive or very weak positive presence. The lack of a specific faecal marker indicates aged, degraded and/or diluted faecal sources.

On the day of sampling (Day 5), human, dog and avian markers were detected in the samples from the freshwater inputs to the marine environment. DNA markers in marine water typically persist longer than in freshwater, despite greater exposure to light (Green et al. 2011), so it is considered likely that dilution has contributed to the inability to isolate the specific markers in the marine environment.

Re-suspension of sediments in the marine environment has been known to contribute to high faecal indicator bacteria (personal comms, K. Gerrard), however there was no evidence to conclude that this occurs at Laingholm Beach.

Notwithstanding potential dilution effects, the Safeswim monitoring indicated that the levels of faecal indicator bacteria in the marine environment are a risk to public health. The results of this investigation provide evidence that management interventions need to focus on the land-based discharges to address the marine based health risk.

5.0 Conclusions

This investigation has revealed that there are multiple sources of microbiological contamination to Laingholm Beach.

1. All sites revealed high levels of faecal indicator bacteria, with all stream sites exceeding the recreational contact guideline on all sampling occasions. All 16 samples analysed for MST revealed the presence of GenBac, with ten of these showing either dog, avian and/or human specific faecal markers.
2. There is chronic contamination of freshwater inputs to Laingholm Beach with strong evidence of human and canine sources throughout the catchment. Contamination with avian sources is isolated to the downstream freshwater site.
3. Given that the general microbiological water quality of the Manukau Harbour is good (Walker and Vaughan 2013), it is considered that land based contamination, namely freshwater inputs, is likely to be the primary driver of the poor microbiological quality of the water at Laingholm Beach.
4. MST analysis was undertaken on a limited number of marine samples of which those tested failed to identify the presence of host specific markers.

6.0 Recommendations

Auckland Council is responsible for managing discharges to water under the Resource Management Act 1991 (s30) and health risks under the Health Act 1956 (s23). Where a human faecal source (wastewater) is polluting stormwater Council is obligated to remedy this so that adverse effects on the environment and public health are minimised or eliminated. To better manage the faecal contamination of Laingholm Beach and to address the current public health risk, a range of recommendations are presented below:

- Undertake a streamwalk type survey of the unnamed tributary to its headwaters (approximate length 0.9km to 1.5km based on overland flow path layer) to document every input into the stream and identify potential sources of human wastewater contamination. This survey should specifically look to isolate potential sewage fungus or pipes flowing during dry weather. This would be a starting point to determine if there are cross connections or leaking pipes and may lead to additional, more targeted sampling of these inputs.
- Undertake an investigation of the Site 1 stormwater pipe network to determine the source of the human wastewater inputs. The section of stormwater pipe is approximately 1km in length with few contributing sub catchments. Systematic sampling in manholes along the catchment may be appropriate, however given the limited number of potentially contributing sub catchments, a CCTV type approach or fibreoptic cable with temperature sensors may be cost effective options.
- Determine whether there are any septic tanks in the area, particularly those that may be located within proximity of the stream. This information may be available from Watercare, LIM reports for properties, or may require a house-to-house survey.
- Inspect the known wastewater overflow location to determine whether there is any evidence of overflow and to confirm the integrity of the seal.
- Consider the placement of permanent warning signs to inform the public about the water quality problems in the marine environment and specifically to avoid swimming in the ponded area at Site 3.
- Investigate the development of a monitoring and maintenance regime to reduce the ponding at Site 3, such as regular mechanical removal of sandbanks. This will potentially reduce the likelihood of avian contamination and provides a less stable habitat for faecal indicator bacteria proliferation.

However, the regulatory and wider environmental effects of such a management regime need to be fully explored.

- Investigate options for improving dog and bird control at the beach and local reserves, including encouraging dog owners to pick-up after their dogs and to not feed the birds.

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Appendix A Recreational Water Quality Guidelines

Bathing beach monitoring has been undertaken at Laingholm Beach since 2002 according to the Ministry for the Environment (MfE) and Ministry of Health (MoH) national guidelines (MfE/MoH 2003).

Table 7-1 below shows the national guidelines trigger levels for each mode. Amber and red exceedances require re-tests until results return to the green/surveillance mode. Red/action exceedances require public health warning signs to be erected until results return to the green/surveillance mode.

Table 7-1 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

Table 7-2 below shows the national guidelines trigger levels for each mode for freshwater, which in this case is the stormwater discharge. Amber and red exceedances require re-tests until results return to the green/safe mode. One red/action exceedance requires public health warning signs to be erected until results return to the green/surveillance mode.

Table 7-2 Freshwater trigger levels from the national guidelines

Freshwater (*E. coli* /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.

Under the national guidelines the last five years of results (100 data points) can be used to generate a Microbiological Assessment Category. This was calculated to aid in the understanding of the historic water quality results for Laingholm beach.

Table 7-3 Microbiological Assessment Category ranges for seawater

A	Sample 95 percentile ≤ 40 enterococci/100 mL

B	Sample 95 percentile 41–200 enterococci/100 mL
C	Sample 95 percentile 201–500 enterococci/100 mL
D	Sample 95 percentile > 500 enterococci/100 mL

Source: (MfE/MoH 2003)

Appendix B Faecal Source Tracking Report

Institute of Environmental Science & Research Limited
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protecting people and their environment through science

6 June 2014

To: Andrew Noble
Auckland Council
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Auckland

Email: Andrew.Noble@aucklandcouncil@govt.nz
Purchase order: 3000147856

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

REPORT ON FAECAL SOURCE TRACKING ANALYSIS – LAINGHO LM SITE

The following water samples were received on 30th April 2014 and were analysed for faecal source PCR markers.

ESR Number	Client Reference	Sample Details	*E.coli* MPN/100ml	*Entero* MPN/100ml
CMB140417	18769/4	Site 3	3600	
CMB140418	18769/5	Site 4	8600	
CMB140419	18769/6	Site 5	8700	
CMB140420	18803/4	Site 3	10500	
CMB140421	18803/5	Site 4	1700	
CMB140422	18803/6	Site 5	1300	
CMB140423	18891/4	Site 3	1700	460
CMB140424	18891/5	Site 4	2700	
CMB140425	18891/6	Site 5	990	
CMB140426	18925/1	Site 1	2500	
CMB140427	18925/2	Site 1a		4100
CMB140428	18925/3	Site 2		7700
CMB140429	18925/4	Site 2a		1200
CMB140430	18925/5	Site 3	16000	>24200
CMB140431	18925/6	Site 4	12000	
CMB140432	18925/7	Site 5	7700	

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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
CMB140426	Site 1 14/04/2014	2500		very strong positive	present	present	present	ND	Faecal contamination – human & dog sources
CMB140427	Site 1a 14/04/2014		4100	positive	ND	ND	ND	ND	Unidentified faecal source
CMB140428	Site 2 14/04/2014		7700	positive	ND	ND	ND	ND	Unidentified faecal source
CMB140429	Site 2a 14/04/2014		1200	very weak positive	ND	ND	ND	ND	Unidentified faecal source
Site 3									
CMB140417	Site 3 6/03/2014	3600		very strong positive	ND	present	present	present	Faecal contamination – human, dog & avian sources
CMB140420	Site 3 14/03/2014	10500		very strong positive	ND	ND	present	present	Faecal contamination – dog & avian sources
CMB140423	Site 3 4/04/2014	1700	460	very strong positive	ND	present	present	present	Faecal contamination – human, dog & avian sources
CMB140430	Site 3 14/04/2014	16000	>24200	very strong positive	present	present	present	present	Faecal contamination – human, dog & avian sources
Site 4									
CMB140418	Site 4 6/03/2014	8600		strong positive	ND	ND	ND	ND	Unidentified faecal source
CMB140421	Site 4 14/03/2014	1700		very strong positive	present	ND	ND	ND	Faecal contamination – human source
CMB140424	Site 4 4/04/2014	2700		very strong positive	present	present	ND	ND	Faecal contamination – human source
CMB140431	Site 4 14/04/2014	12000		very strong positive	present	present	present	ND	Faecal contamination – human & dog sources

ESR No	Sampled	*E.coli*	*Entero*	General GenBac	Human BacH	Human BiADO	Dog DogBac	Bird GFD	Overall Conclusion
Site 5									
CMB140419	Site 5 6/03/2014	8700		strong positive	ND	ND	ND	ND	Unidentified faecal source
CMB140422	Site 5 14/03/2014	1300		strong positive	ND	ND	ND	ND	Unidentified faecal source
CMB140425	Site 5 4/04/2014	990		very strong positive	ND	present	ND	ND	Faecal contamination – human source
CMB140432	Site 5 14/04/2014	7700		very strong positive	present	present	present	ND	Faecal contamination – human & dog sources

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 1.00x10^3.

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.

[redacted]

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