Waikawa Stream and Manakau Stream Faecal Source Tracking Report

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FOREWORD

Water quality monitoring undertaken during the bathing season of 2013-14 showed that the Waikawa Estuary regularly had high levels of *Escherichia coli* (*E. coli*) that were unable to be accounted for with our current knowledge of land use activities in this catchment. To further investigate the source of this microbiological contamination, a detailed water quality sampling programme was conducted throughout the Waikawa catchment during the period December 2014 to April 2015.

At sites where high levels of *E. coli* were detected, faecal source tracking was used to identify the source of this contamination. Faecal source tracking looks specifically at humans, sheep, cows and birds as potential sources of the contamination and is able to distinguish between these groups and identify the major contributor of contamination.

During low flow conditions – that is, when there had not been prior rainfall, and when *E. coli* is generally expected to be low – high *E. coli* counts were recorded in the upper reaches of the Manakau Stream (a major tributary of Waikawa Stream) and in the lower reaches of Waikawa Stream. Faecal source tracking at three sites (Manakau Stream at South Manakau Road, Waiauti at upstream Manakau Stream confluence and Waikawa Estuary at Footbridge) was carried out, with the following key findings:

- No human markers were detected at any of the sites, meaning that leaking/overflowing septic tanks are not a major contributor to the *E. coli* in this catchment; and
- The faecal contamination at the upstream sites is sourced from ruminants, specifically cattle, and land use analysis suggests this is not from dairy cows. At the Waikawa Estuary contamination appears to be derived from a mixture of cattle and bird sources.

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1 Introduction

Results of Horizons Regional Council's contact recreational water quality monitoring during the season of 2013-14 (Patterson & Brown, 2015) showed that the Waikawa Estuary regularly had high levels of *Escherichia coli* (*E. coli*) that were unable be accounted for with our current knowledge of land use activities in the catchment. Because *E. coli* is present in the gut of mammals and birds, high levels of *E. coli* can indicate the presence of faecal contamination and therefore the possible presence of other potentially infectious micro organisms, such as bacteria and viruses. For this reason *E. coli* is used as indicator bacteria in the freshwater environment.

The Waikawa Estuary is popular for contact recreation. Weekly monitoring at the Footbridge site during 2013-14 showed that *E. coli* regularly exceeded the Ministry for the Environment (MfE) and Ministry of Health (MoH) microbiological water quality guidelines (MfE/MoH, 2003), which were designed to ensure that people using water for contact recreation are not exposed to significant health risks. Therefore, the water quality of Waikawa Estuary may not be acceptable for contact recreation purposes. It was decided that a more detailed water quality investigation of the Waikawa catchment would be useful to identify major sources of *E. coli* contamination. Faecal source tracking techniques could then be used to determine specific sources of this contamination, be it human, sheep, cow or avian.

2 Methods

The detailed investigation involved water quality sampling in the Waikawa Estuary at 12 upstream locations, on five occasions during the period December 2014 to February 2015.

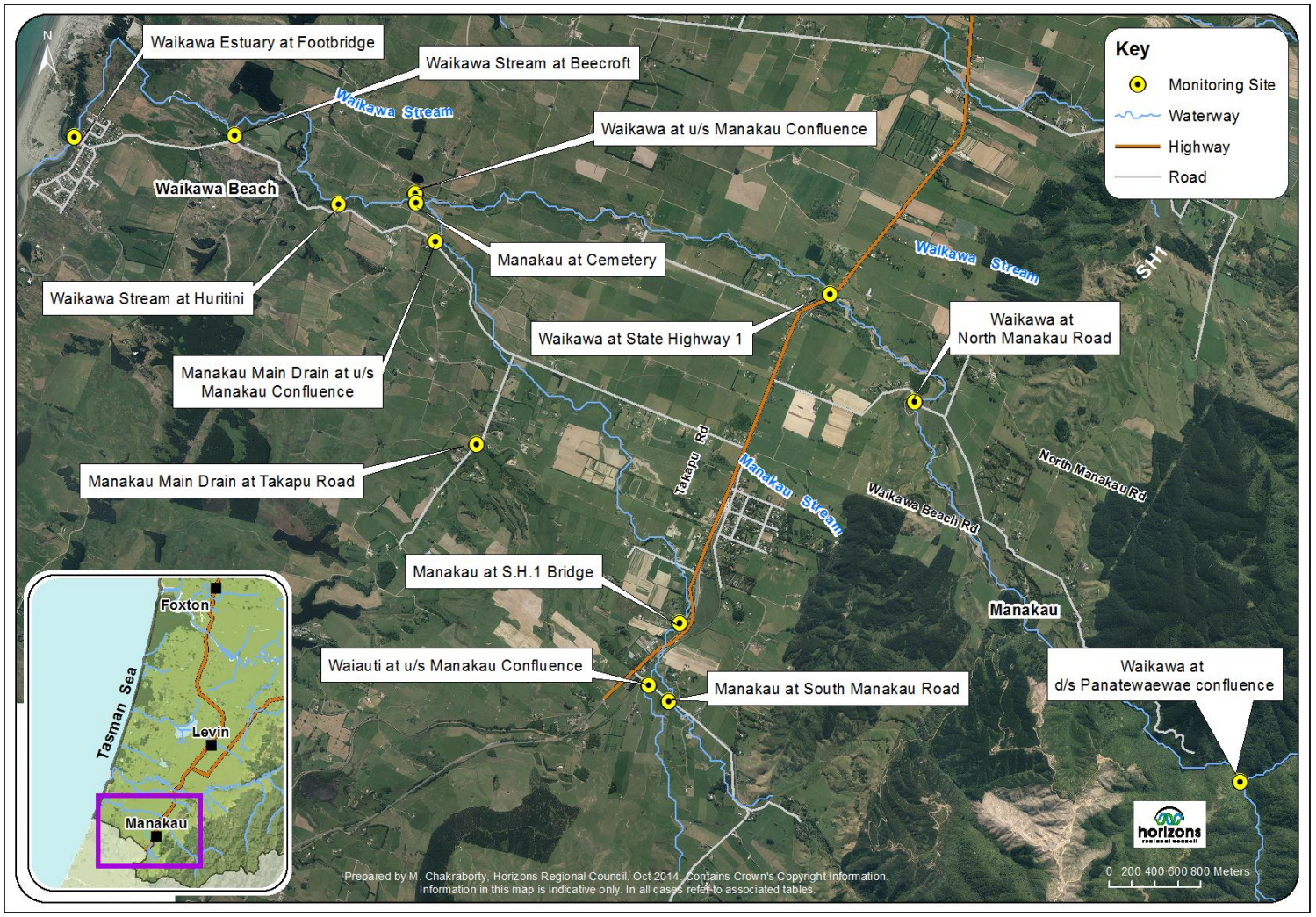
2.1 Site Selection

The monitoring programme was designed to cover the entire extent of the Waikawa Catchment, including its major tributary, the Manakau Stream. The sites were located at key points along the streams to ensure that all land uses in the catchment – and their potential effects on water quality – were represented. Map 1 shows the sampling site locations, major tributaries and townships, while Map 2 shows land use within the catchment.

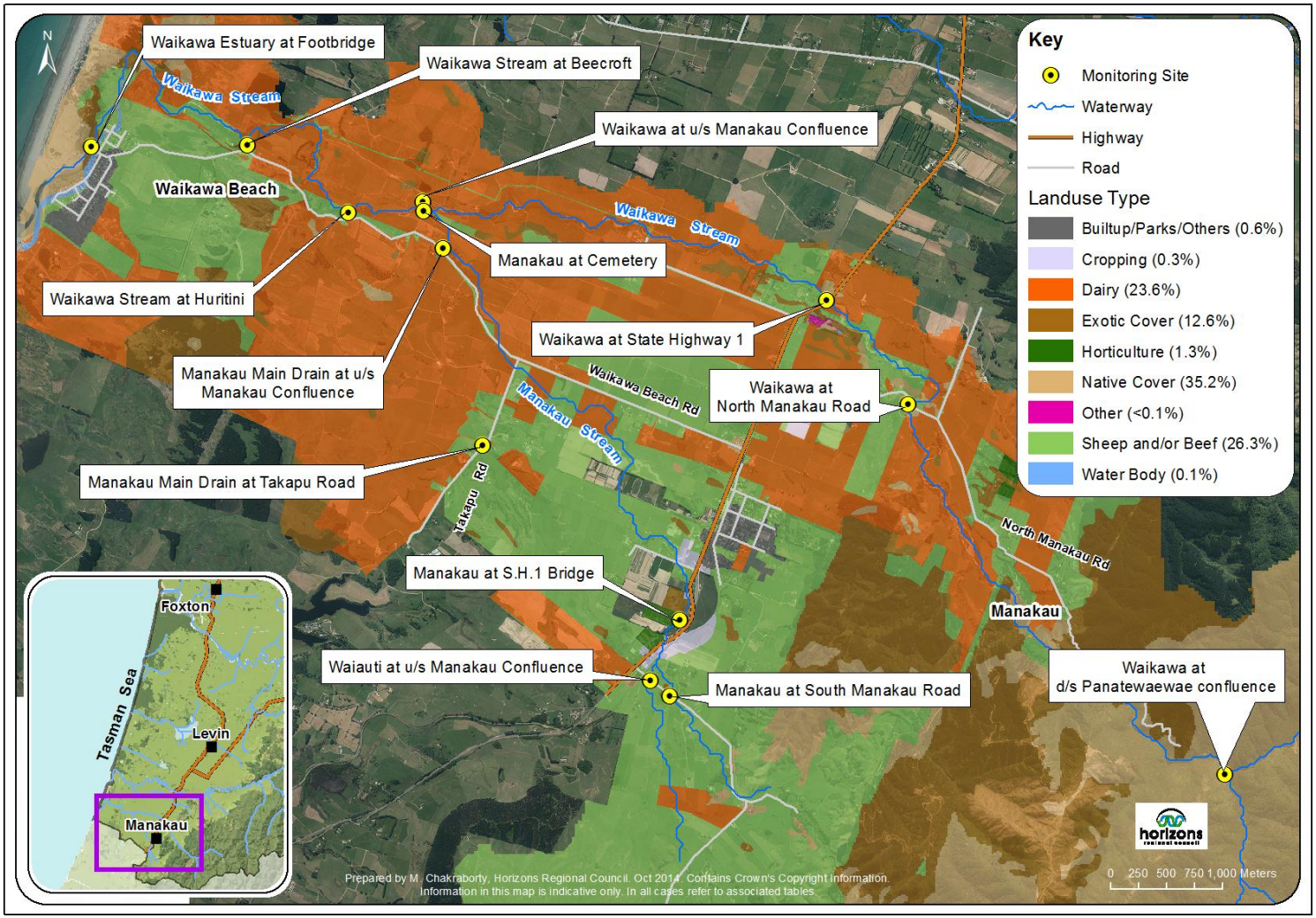
Note site names are abbreviated on the graphs as shown in Table 1.

Table 1: Full site names and coded site names that will appear on graphs.

Full site name	Displayed names on graphs
Waikawa at d/s Panatewaewae confluence	W. d/s Panatewaewae
Waikawa at North Manakau Road	W. at Nrth Manakau
Waikawa at State Highway 1	W. at SH1
Waikawa at u/s Manakau Confluence	W. u/s Manakau
Manakau at South Manakau Road	M. at Sth Manakau
Waiauti at u/s Manakau Confluence	Waiauti u/s Manakau
Manakau at S.H.1 Bridge	M. at SH1
Manakau Main Drain at Takapu Road	M. Mn Drn at Takapu
Manakau Main Drain at u/s Manakau Confluence	M. Mn Drn u/s Manakau
Manakau at Cemetery	M. at Cemetery
Waikawa Stream at Huritini	W. at Huritini
Waikawa Stream at Beecroft	W. at Beecroft
Waikawa Estuary Footbridge	W. Estuary



Map 1: Sampling sites within the Waikawa Catchment



Map 2: Land use and sampling sites within the Waikawa Catchment

2.2 Monitoring Methods

Water samples were taken as per standard monitoring procedures carried out by Horizons Regional Council. Bottles used for microbial samples were pre-sterilised and were opened under the surface of the water in order to ensure a consistent and accurate result. Where possible, samples were taken 10 to 15 centimetres below the surface of the water and in an area of the site selected as being representative. These samples were then placed in a chilly bin with ice packs to minimise cell division during transportation and were delivered to an accredited microbial laboratory within 24 hours of initial sampling. Nutrient samples were taken at the same time and the bottles for these were also supplied from the sample laboratory to ensure that they were uncontaminated.

Faecal source tracking was undertaken on three separate runs and the sites selected were based on information from the water quality monitoring. These samples were first tested for *E. coli* to ensure there was sufficient *E. coli* present to undertake the more expensive faecal source tracking; therefore faecal source tracking was not always carried out at all the sites. In all cases tests were done for generic markers (to ensure that the faecal source tracking process would work), human markers (to test if there were human sources), ruminant markers (to test for all ruminants), ruminant sheep (specifically for sheep), ruminant cow (specifically for cattle) and GFD2 (avian marker for birds).

2.3 Analysis of Samples

All analysis of samples was carried out at Environmental Laboratory Services in accordance with nationally accepted (IANZ accredited) procedures. The faecal source tracking sample analysis was carried out at ESR (Institute of Environmental Science and Research).

2.4 Stream Flow measurement

During the water quality monitoring runs, stream flows were measured. Two sites (Waikawa at North Manakau Road and Manakau at S.H.1 Bridge) are permanent flow sites that monitor stream flows on a continuous basis. At all other sites, manual flow gaugings were carried out using a current meter. Due to extreme low flows it was not always possible to complete enough readings to calculate an accurate flow, in which case an estimate was made based on a partial gauging. For the purpose of this report the estimates are considered accurate enough to include; however, it is necessary to note that the sites with extreme low flow may not be absolutely accurate.

3 Results

Nine different water quality parameters, including nutrients, were measured on five occasions during the monitoring period. While nutrients are important in a technical sense, the main interest in this report is finding the source of faecal contamination. For this reason, the nutrient results are not analysed within this report[1]. *E. coli* is the key indicator in the MfE/MoH national water quality guidelines for contact recreation

[1] The nutrient data is available upon request from Horizons Regional Council

in fresh waters and is used as an indicator organism for faecal contamination. The *E. coli* results are attached as Appendix A.

3.1 E. coli

Levels of *E. coli* varied significantly depending on the amount of recent rainfall in the catchment. In this report we use flows as a surrogate to indicate when rainfall is likely to have impacted sampling events. Table 2, which displays the 50th and 20th flow percentile for the Manakau at S.H.1 Bridge site, and Table 3, which shows flows at the Manakau at S.H.1 Bridge site on the dates of sampling, allow us to compare flows during the different sampling events[2].

As stated above, rainfall events can significantly increase *E. coli* counts in-stream. What is important for the purpose of this report is to note which sites have high *E. coli* counts even when flows are not elevated. The upper four sites on the Waikawa Stream generally sit well below the One Plan flow-based *E. coli* thresholds; however, the Manakau at South Manakau, Waiauti u/s Manakau Confluence and Manakau at State Highway 1 all have elevated *E. coli* counts on multiple occasions, even when high flow events are not obvious (Table 3). This could suggest a significant source of contamination near these sites.

Figure 1 shows that the *E. coli* results on 10 December 2014 are greatly elevated throughout the catchment. This sampling event coincided with a heavy rainfall event and subsequent washing of nutrients and bacteria off land and into nearby waterways.

In order to clearly display the *E. coli* data from other sampling events, a second graph has been added (Figure 2) with those samples taken on 10 December 2014 removed. On the graphs are two One Plan flow-based threshold lines of 260 MPN/100ml and 550 MPN/100ml. For all flows under the 50th flow percentile the 260 MPN/100ml value is used. For any flow between the 50th and 20th flow percentile the 550 MPN/100ml value is used. In other words, during low flow conditions *E. coli* should be relatively low (< 260 MPN/100ml) but if flows are elevated due to recent rainfall then *E. coli* may be temporarily elevated and a slightly higher result (< 550 MPN/100ml) is deemed acceptable. Following analysis of the flow conditions during sampling (shown in Table 3) it was deemed that the 260 MPN/100ml value applies for all of the 2015 sampling dates, while the 550 MPN/100ml value applies to the 16 December 2014 sampling occasion. As the flows on 10 December 2014 were so high, this is considered to be flood flows and therefore no *E. coli* value applies.

Table 2: Manakau at S.H.1 Bridge and Waikawa at North Manakau Road flow exceedance percentiles (based on provisional data from 3 May 2006 – 3 June 2014 and 18 May 2006 – 3 June 2014 respectively. Result of PDist calculation as at 13 September 2015)

Exceedance percentiles		
Percentile	Manakau at S.H.1 Bridge Flow (l/s)	Waikawa at North Manakau Flow (l/s)
50 (median)	159	842
20	370	1750

[2] Please note that these tables have been made using provisional data only. This means that an initial check has been carried out on the data but it has not been fully verified as accurate. Likewise, the flow exceedance percentiles were calculated using eight years of data where a minimum of 10 years would normally be recommended. This data has been included because for the purpose of this report it is important to be able to see the relative size of the flows and compare these to the *E. coli* results.

Table 3: Manakau at S.H.1 Bridge and Waikawa at North Manakau Road flow on date of sampling (results from the Horizons Regional Council provisional archive as at 13 Auust 2015)

Date	Manakau at S.H.1 Bridge Flow (l/s)	Waikawa at North Manakau Flow (l/s)
10/12/2014	1,501	5,623
16/12/2014	247	1,403
22/01/2015	59	403
4/02/2015	91	544
23/02/2015	62	298

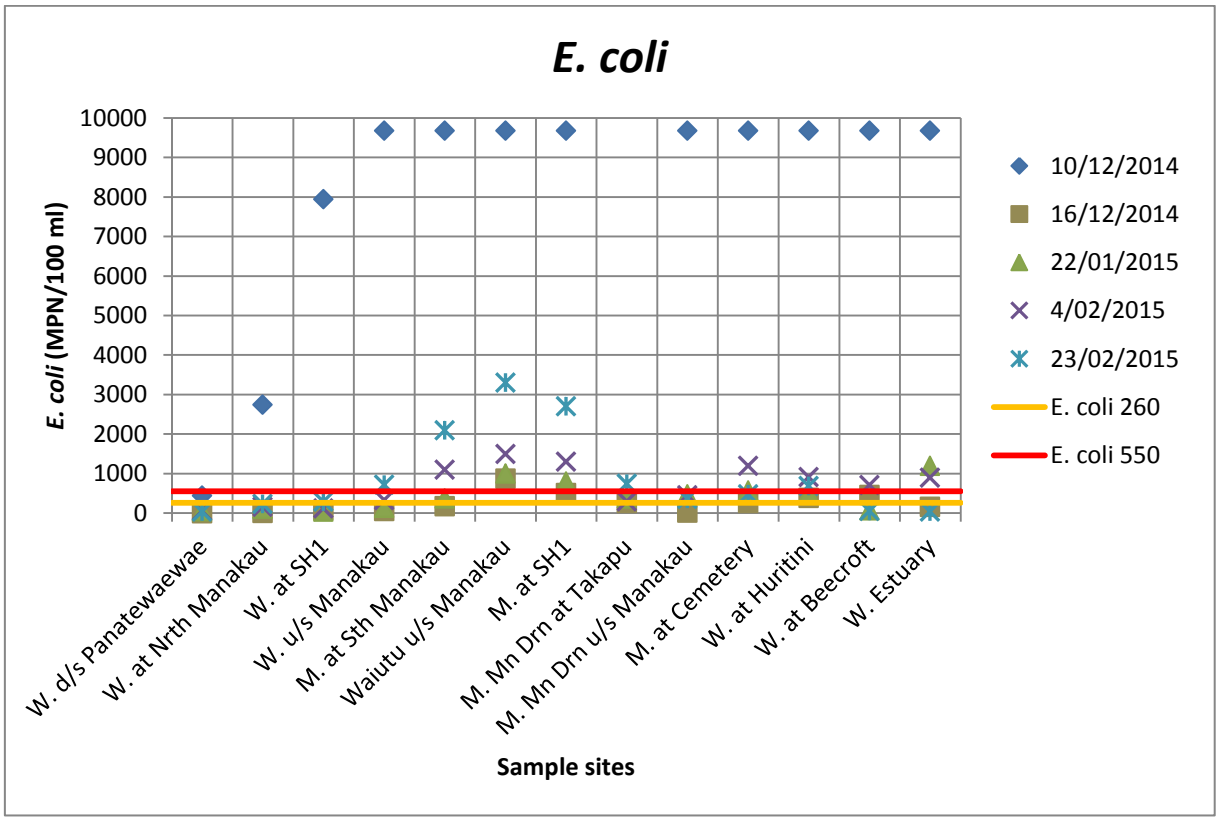


Figure 1: *E. coli* concentrations at 13 sites on all five sampling dates.

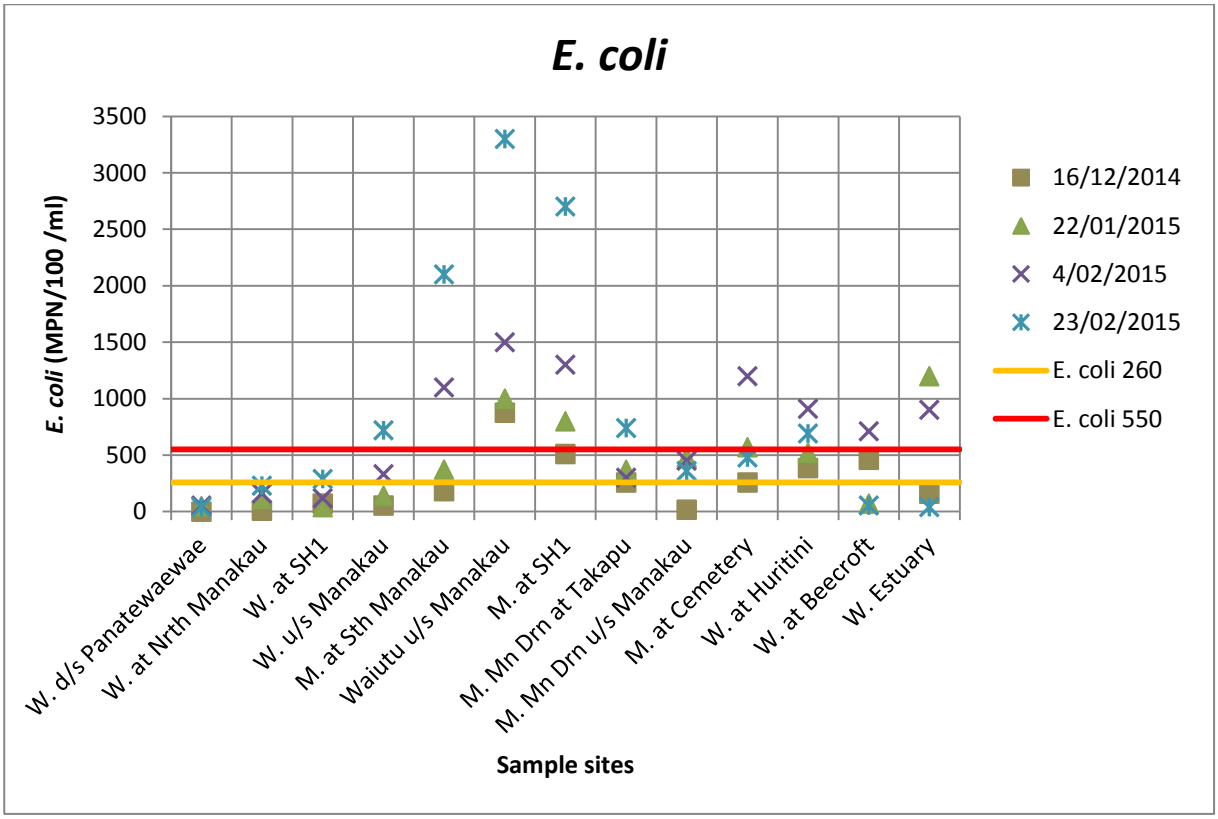


Figure 2: *E. coli* concentrations at 13 sites on four of the five sample dates (not including 10 December 2014).

3.2 Faecal Source Tracking Results

Following the general water quality sampling, initial analysis showed three sites at which faecal source tracking would be useful: Manakau Stream at South Manakau Road, Waiauti at u/s Manakau confluence and Waikawa Estuary at Footbridge. While it was necessary to take a sample at each site, there was no way of knowing if the sample would have sufficient *E. coli* for faecal source tracking to be undertaken, until the sample reached the lab. For this reason it took three separate runs before faecal source tracking results were available for all sites. The results from this monitoring are displayed in Table 4. Points to note:

- General marker. This is to show that there is sufficient viable *E. coli* cells present that the rest of the markers will have something to bind to; thus it protects against a false negative (i.e., if there was a negative result for all markers, including the general marker, then there were insufficient viable *E. coli* cells present; if all sites had the general marker but no other markers detected it would mean that there was sufficient *E. coli* present but that none of it had come from the specific markers selected).
- Human marker. This is to detect human faecal source material, which is likely to come from leaking or overflowing septic tanks.
- General ruminant marker. This is more generalised than the sheep or cow specific marker. It has some degree of quantitative measurement attached to it i.e., 'Up to 50%', '50 to 100%, and 'up to 100%'. The laboratory has stated that:
  - "Samples reported as up to 100% ruminant are consistent with all of the general faecal marker having come from a ruminant source".
  - "Lower levels (10-50%) may be a consequence of the presence of other sources of pollution, or in fact ruminant sources may still account for all the

pollution, but this may include aged faecal material where relative levels of the ruminant marker decline more rapidly than the general indicator".

- Finally, they state that "…for comparison, if ruminant pollution was only a minor contributor, values of 0.1% or 1% would be observed".

- The ruminant sheep and ruminant cow marker are markers that are specific to either sheep or cattle, respectively. The laboratory has said that the sheep assay is more sensitive than the cow assay, so that if sheep markers are present they are far more likely to be picked up. If the results are "yes" for cattle and "no" for sheep then, while sheep can not be entirely ruled out, the major contributor is cattle.
- The avian (bird) marker is of particular interest in the estuary where shag populations, as well as other water birds like ducks, are known to exist.

Table 4: Faecal source tracking results summary

Site	Date sampled	General marker	Human marker	General ruminant marker	Ruminant sheep marker	Ruminant cow marker	Avian marker	Overall conclusion
Manakau at South Manakau Road	24/03/2015	Very strong positive	No	yes up to 100%	No	Yes	Yes	Almost entirely ruminant (cow) + some avian
Waiauti at u/s Manakau confluence	24/03/2015	Very strong positive	No	yes up to 100%	No	Yes	Yes	Almost entirely ruminant (cow) + some avian
Waiauti at u/s Manakau confluence	7/04/2015	Very strong positive	No	yes 50-100%	No	Yes	Yes	Mostly ruminant (cow) + some avian
Manakau at South Manakau Road	7/04/2015	Very strong positive	No	yes up to 100%	No	Yes	Yes	Almost entirely ruminant (cow) + some avian
Waikawa Estuary at Footbridge	23/04/2015	Very strong positive	No	yes up to 50%	No	Yes	Yes	Some ruminant (cow) + Some avian

4 Discussion

4.1 *E. coli*

E. coli is a bacteria that is used as an indicator in the national microbiological water quality guidelines (MfE/MoH, 2003). It is incorporated into the One Plan as a measure of the suitability of fresh waters for contact recreation. It is called an indicator bacteria because it is not responsible for all waterborne infections or sicknesses. Rather, because it is found in the stomach of mammals and birds, it is an indicator of whether or not the waterway has been contaminated with faecal

matter. In this way it gives a likely indication of the presence of other microbes that could cause people to become unwell if they interact with the water.

The purpose of the survey was primarily to try and locate the areas of the Waikawa Catchment that have high levels of *E. coli* present in waterways. This would allow targeted faecal source tracking to occur. The sampling found that, following heavy flow events, high *E. coli* occurred throughout the catchment. However, what we are particularly interested in is the areas that continue to have high *E. coli* during lower flows, when contact recreation is more likely to occur. Sampling on occasions when there had not been prior rainfall in the catchment found that three sites had consistently elevated *E. coli*: Manakau Stream at South Manakau Road, the Waiauti Stream upstream of the Manakau confluence and the Manakau Stream at S.H.1. At two of these sites, faecal source tracking was then carried out to identify exactly what the source of contamination was (i.e., human, cows, sheep or avian). Note that the site Manakau at S.H.1 was not sampled for faecal source tracking as the site is in essence a combination of the Manakau Stream at South Manakau Road and the Waiutu Stream upstream of the Manakau confluence sites (refer to Map 1). The Waikawa Estuary at Footbridge site was also selected for faecal source tracking as this is the final point in the catchment and would give an overview of the source of contamination for the entire catchment.

4.2 Faecal Source Tracking

Faecal source tracking monitoring was carried out on three separate occasions, with two faecal source tracking results obtained at two sites (Manakau Stream at South Manakau Road and Waiauti Stream upstream of the Manakau confluence) and one faecal source tracking result obtained for Waikawa Estuary at Footbridge. There are a few general statements that can be made immediately from looking at the results. Firstly, no human marker was detected at any of the sites. Due to the sensitivity of the test this does not entirely rule out the possibility of human-source faecal material entering these waterways but it does clearly show that this is, at most, only a minor source of contamination in this catchment. Therefore, overflowing or leaking septic tanks do not appear to be a major source of the *E. coli* entering the catchment. This is of particular importance at the Waikawa Estuary site; the site is immediately downstream of much of the Waikawa Beach Township, which is on septic tanks.

The second general statement that can be made is that the majority of the marker (often up to 100% of the *E. coli*) at the two sites in the upper catchment (Manakau Stream at South Manakau Road and Waiauti Stream upstream of the Manakau confluence) is picked up by the general ruminant marker. The laboratory states that "samples reported as up to 100% ruminant are consistent with all the general faecal marker having come from a ruminant source. Lower levels (10-50%) may be a consequence of the presence of other sources of pollution, or in fact ruminant sources may still account for all the pollution, but this may include aged faecal material where relative levels of the ruminant marker decline more rapidly than the general indicator". Therefore, we can confidently state that the large majority of the *E. coli* is sourced from ruminants at the upper two sites. In contrast, at the Waikawa Estuary site ruminant markers are only one component of all markers detected (up to 50%). The other marker detected is avian. While there is the possibility that some of the ruminant bacteria may have degraded, it also appears that there is a large proportion of avian contamination occurring at the estuary site.

Finally, all sites are showing up cow-specific ruminant marker but none of the sites show a sheep-specific ruminant marker. The laboratory has stated that "the sheep assay is more sensitive than the cow assay, so in our opinion if significant levels of fresh sheep faecal material was present we would expect to have seen it". The results therefore show that while there may be a small amount of sheep-sourced *E. coli* present, the vast majority is sourced from cattle. Note that this does not rule out other ruminants, such as deer; however, the land use in this area of the catchment (Figure 2) is almost entirely sheep and beef farming. Dairy farmers have a requirement to fence streams in order to exclude stock from waterways; this is not the case with sheep and beef farming and this could explain the high *E. coli* contamination occurring in this area. Please note that land use in these catchments continues to change and the land use data used in this report was collated in 2007 (Clark and Roygard, 2008).

In conclusion, the majority of the *E. coli* found at the upstream sites (on the Manakau Stream tributary of Waikawa Stream) is sourced from ruminants, specifically from cattle, and based on land use maps it does not appear to be dairy-derived. At the Waikawa Estuary faecal contamination appears to be derived from a mixture of cattle and bird sources.

5 References

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Ministry for the Environment and Ministry of Health. 2003. *Microbiological Water Quality Guidelines – For Marine and Freshwater Recreation Areas.* Ministry for the Environment and the Ministry of Health, Wellington, New Zealand.

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6 Appendix

6.1 Water Quality Results

Site Name	Date	E. coli
Manakau at Cemetery	10/12/2014	9678.4
Manakau at Cemetery	16/12/2014	257.6
Manakau at Cemetery	22/01/2015	570
Manakau at Cemetery	4/02/2015	1200
Manakau at Cemetery	23/02/2015	480
Manakau at S.H.1 Bridge	10/12/2014	9678.4
Manakau at S.H.1 Bridge	16/12/2014	509.6
Manakau at S.H.1 Bridge	22/01/2015	800
Manakau at S.H.1 Bridge	4/02/2015	1300
Manakau at S.H.1 Bridge	23/02/2015	2700
Manakau at South Manakau Road	10/12/2014	9678.4
Manakau at South Manakau Road	16/12/2014	180
Manakau at South Manakau Road	22/01/2015	370
Manakau at South Manakau Road	4/02/2015	1100
Manakau at South Manakau Road	23/02/2015	2100
Manakau Main Drain at Takapu Road	10/12/2014	0
Manakau Main Drain at Takapu Road	16/12/2014	258
Manakau Main Drain at Takapu Road	22/01/2015	370
Manakau Main Drain at Takapu Road	4/02/2015	300
Manakau Main Drain at Takapu Road	23/02/2015	740
Manakau Main Drain at u/s Manakau Confluence	10/12/2014	9678.4
Manakau Main Drain at u/s Manakau Confluence	16/12/2014	16.4
Manakau Main Drain at u/s Manakau Confluence	22/01/2015	480
Manakau Main Drain at u/s Manakau Confluence	4/02/2015	450

Site Name	Date	E. coli
Manakau Main Drain at u/s Manakau Confluence	23/02/2015	360
Waiauti at u/s Manakau Confluence	10/12/2014	9678.4
Waiauti at u/s Manakau Confluence	16/12/2014	874.8
Waiauti at u/s Manakau Confluence	22/01/2015	1000
Waiauti at u/s Manakau Confluence	4/02/2015	1500
Waiauti at u/s Manakau Confluence	23/02/2015	3300
Waikawa at North Manakau Road	10/12/2014	2746.8
Waikawa at North Manakau Road	16/12/2014	8
Waikawa at North Manakau Road	22/01/2015	110
Waikawa at North Manakau Road	4/02/2015	160
Waikawa at North Manakau Road	23/02/2015	230
Waikawa at State Highway 1	10/12/2014	7945.2
Waikawa at State Highway 1	16/12/2014	69.2
Waikawa at State Highway 1	22/01/2015	39
Waikawa at State Highway 1	4/02/2015	120
Waikawa at State Highway 1	23/02/2015	290
Waikawa at u/s Manakau Confluence	10/12/2014	9678.4
Waikawa at u/s Manakau Confluence	16/12/2014	52.4
Waikawa at u/s Manakau Confluence	22/01/2015	140
Waikawa at u/s Manakau Confluence	4/02/2015	330
Waikawa at u/s Manakau Confluence	23/02/2015	720
Waikawa Estuary Footbridge	10/12/2014	9678.4
Waikawa Estuary Footbridge	16/12/2014	159.6
Waikawa Estuary Footbridge	22/01/2015	1200
Waikawa Estuary Footbridge	4/02/2015	900
Waikawa Estuary Footbridge	23/02/2015	39
Waikawa Stream at Beecroft	10/12/2014	9678.4
Waikawa Stream at Beecroft	16/12/2014	458

Site Name	Date	E. coli
Waikawa Stream at Beecroft	22/01/2015	70
Waikawa Stream at Beecroft	4/02/2015	710
Waikawa Stream at Beecroft	23/02/2015	54
Waikawa Stream at Huritini	10/12/2014	9678.4
Waikawa Stream at Huritini	16/12/2014	384
Waikawa Stream at Huritini	22/01/2015	520
Waikawa Stream at Huritini	4/02/2015	910
Waikawa Stream at Huritini	23/02/2015	690
Waikawa at d/s Panatewaewae confluence	10/12/2014	444.7
Waikawa at d/s Panatewaewae confluence	16/12/2014	0
Waikawa at d/s Panatewaewae confluence	22/01/2015	49
Waikawa at d/s Panatewaewae confluence	4/02/2015	53
Waikawa at d/s Panatewaewae confluence	23/02/2015	39

6.2 Flow Monitoring Results

	Flow M3/second				
	10-Dec-14	16-Dec-14	22-Jan-15	4-Feb-15	23-Feb-15
Waikawa Estuary Footbridge					0.298
Waikawa Stream at Beecroft					
Waikawa Stream at Huritini		2.528	0.345		0.209
Manakau at Cemetery		0.8388	0.302		0.186
Waikawa at u/s Manakau Confluence		1.731	0.089		0.003
Manakau Main Drain at u/s Manakau Confluence		0.179	0.12		0.01786
Manakau Main Drain at Takapu Road			0.046		0.024
Waikawa at State Highway 1		1.959			0.241
Manakau at S.H.1 Bridge	27.088	0.295	0.067	0.112	0.061
Waiauti at u/s Manakau Confluence		0.124	0.03		0.025
Waikawa at North Manakau Road	37.449	1.651	0.435	0.678	0.314
Manakau at South Manakau Road		0.209	0.03		0.02
Waikawa at d/s Panatewaewae Confluence		1.556	0.3965		0.3657

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