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Purpose

This report summarises the findings of an intensive bacteriological water quality survey of the contributing tributaries of the Puhokio Stream catchment. The main purpose of this report is to identify areas within the catchment that have impaired water quality for bathing and to identify what possible sources of contamination contribute to this. Possible methods of improving water quality within the catchment are also identified.

Background

The lower reaches of the Puhokio Stream has shown water quality that is often unsuitable for bathing since monitoring first began there (Sevicke – Jones 2001, Roberts 2002).

Further research has shown that almost a third of the E.coli exceedance samples during the 2001/2001 bathing season were not rainfall related (Stansfield 2002).

The poor water quality of the Puhokio Stream prompted Hawke's Bay Regional Council to investigate further the possible sources of contamination to the Puhokio Stream and to identify areas within the catchment at which contributions to contamination are greatest.

Introduction

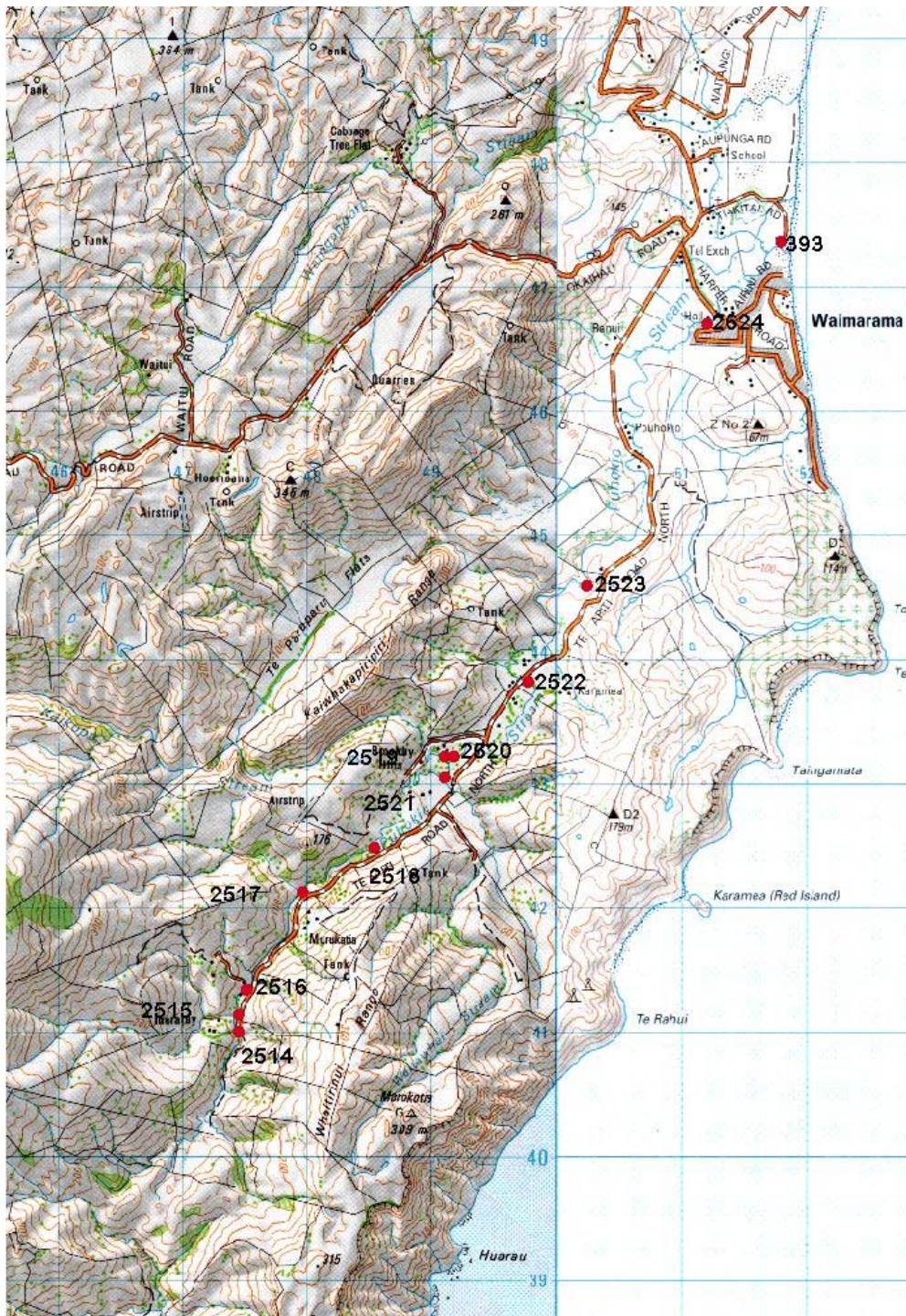
The Puhokio Stream is a fourth order stream which has its headwaters located in the edge of the Maraetotara Plateau and it follows a course predominantly surrounded by pastoral farming and discharges to sea at Waimarama Beach. The lower reaches of the stream forms a lagoon which has historically been a popular bathing site for many people. The lagoon is a dynamic water body which often has variable salinity due to tides, closures at the mouth (caused by sea swells) and flooding.

Like many small agricultural streams in New Zealand, the Puhokio Stream has suffered a history of neglect in terms of surrounding land use and wastewater disposal practices (see appendix 1 for details). Grazing has been to the waters edge for most of the stream length that has resulted in a moderate degree of stream bank erosion and a lack of any riparian vegetation regeneration apart from pasture grasses.

Methods

12 sites within the Puhokio Stream catchment were monitored for turbidity, e.coli and enterococci bacteria. 300ml water samples were taken from the sampling sites and were transferred to a chilli bin with slicker pads and delivered to Kersons laboratory within 24 hrs. The intensive sampling programme focused on rainfall events when runoff was likely to be highest. In addition to the standard bacteria monitoring, water quality at the two lower sites (Gillies crescent and Puhokio lagoon) were monitored for faecal sterols and whitening agents following a high rainfall period (27/11/01) and a more stable flow period (31/01/02). The faecal sterol test is a new technique used to fingerprint whether the bacterial contamination is of human or animal origin. Whitening agents that are common in washing powders were also monitored and their

presence in water often indicates the presence of grey water in a stream. The sites are illustrated in the table and map that follows.



Puhokio Stream sampling sites

● Sites 

Table 1: Water Quality Monitoring Sites

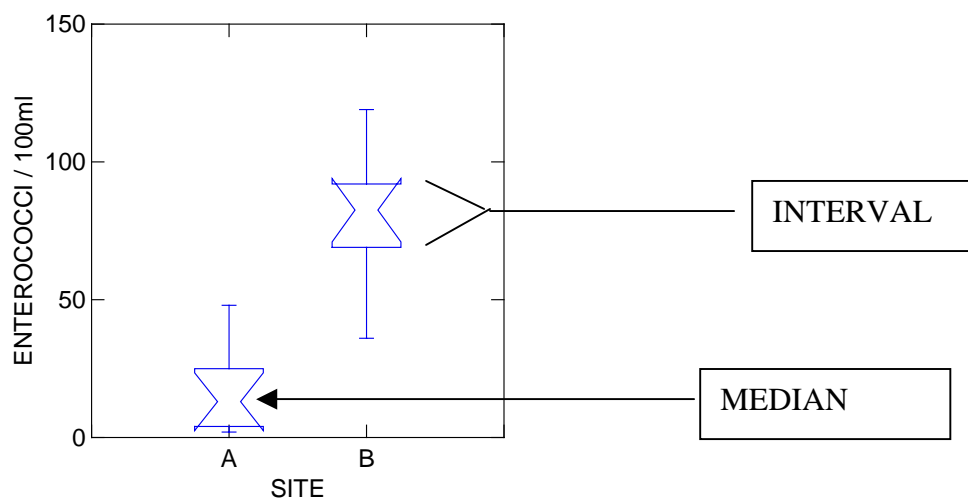
Site ID	Site	GPS Coordinate	Map	Reason for inclusion
2514	End of Apiti Rd	2847437 6141003	W21	Top of catchment
2515	By gate d/s of confluence	2847437 6141137	W21	Incoming tributary
2516	By red shearing shed	2847500 6141339	W21	Land use effects
2517	Opposite Green Shed	2847948 6142122	W21	Land use effects
2518	By silver pipe	2848531 6142477	W21	Land use effects
2521	U/s of Puhokio / Waitahi confluence	2849089 6143050	V22	Land use effects
2520	D/s of confluence	2849170 6143213	W21	Effects of incoming tributary
2519	Kaikopu Stream	2849092 6143219	W21	Incoming tributary
2522	Allen's Bridge	2849759 6143811	W21	Land use effects
2523	By Pine Trees	2850239 6144590	W21	Land use effects
2624	At Gillies Crescent	2851200 6146700	W22	Human settlement
393	Puhokio @ Waimarama	2851795 6147360	W22	Human settlement

E.coli bacteria generally survive in water for shorter periods compared to enterococci (Donnison 1998). Sites with high Enterococci: E coli ratios are therefore likely to represent sites that contribute a more continuous source of contamination to the streams water. The ratio of Enterococci : E.coli concentrations were therefore also examined to determine whether any sites had higher ratios.

Water Quality

The water quality results in this section are presented as box and whisker plots. A diagrammatical explanation of a box and whisker plot follows.

Figure 2: Box and Whisker Plot



A significant difference is detectable (with 95% confidence) if the confidence intervals around two medians do not overlap (McGill, Tukey, & Larsen 1978). Figure 2 shows that site B has significantly higher Enterococci concentrations

compared to site A. This is depicted by the intervals around the two medians not overlapping.

If two intervals in a box and whisker plot do overlap but a trend is observed then the sites are referred to as being generally lower or higher to each other.

If the data has a wide range of values for a site, outliers will be represented by an asterisk while extreme outliers will be represented by a small circle.

Results

Figure 3: Box and whisker plots for E. coli.

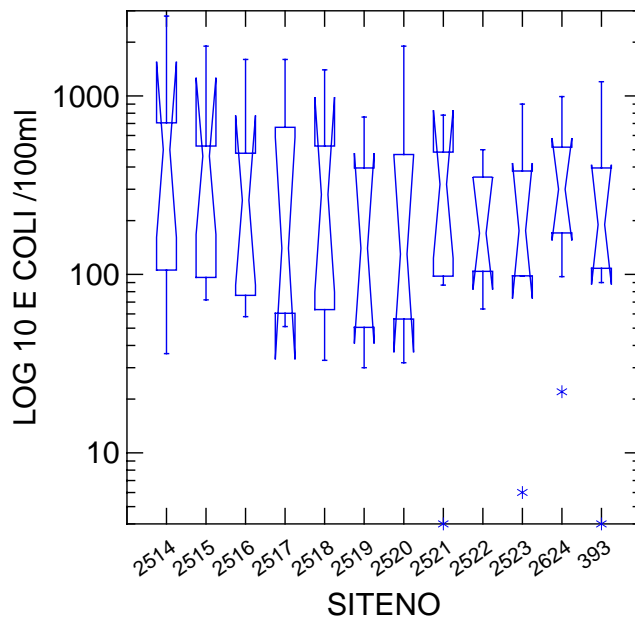


Figure 3 shows that E.coli concentrations within the Puhokio Catchment are very similar. No sites have significantly different E.coli concentrations.

Figure 4: Box and whisker plots of Enterococci

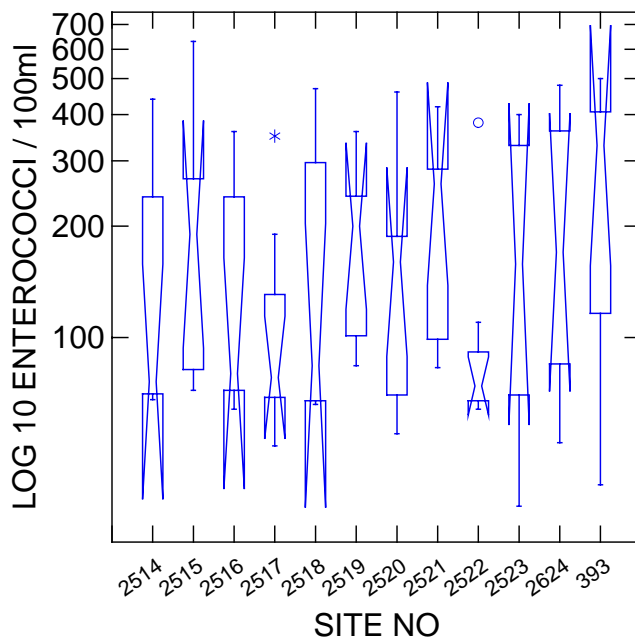


Figure 4 shows that with the exception of sites 2522 and 2517, all sites within the Puhokio Catchment have similar concentrations of Enterococci bacteria. The reason for the lower Enterococci concentrations at sites 2522 and 2517 is unclear.

Figure 5: Box and whisker plots of ratio Enterococci: E.coli

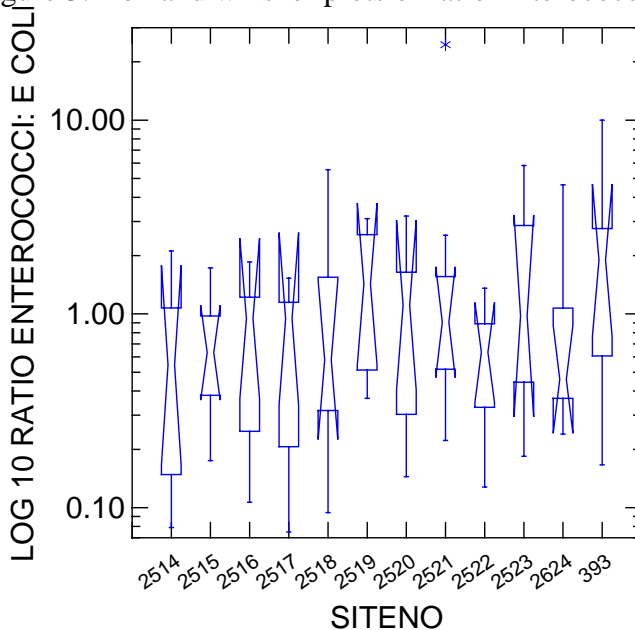
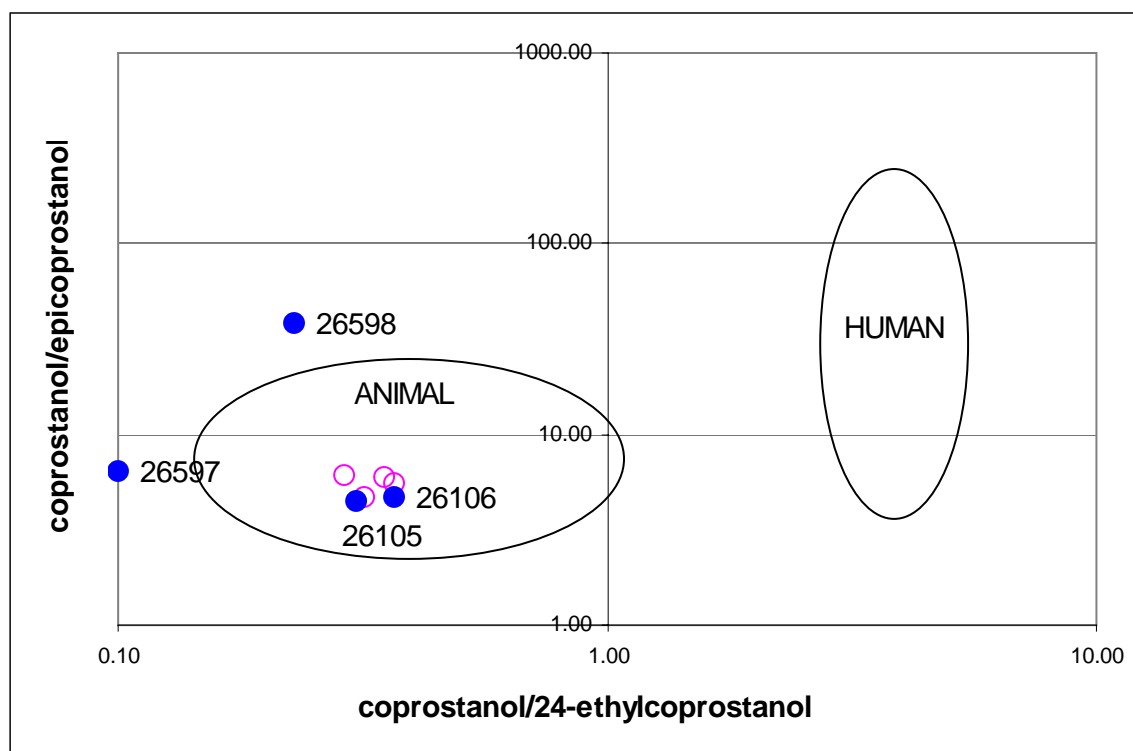


Figure 5 shows that no sites within the Puhokio catchment show significantly different Enterococci: E.coli ratios. This indicates that no one site can be targeted as a problem site providing a more continuous source of contamination to the stream.

Faecal Sterol Analyses



The faecal sterol analyses for the high rainfall (26105, 26106) and stable flow period (26597, 26598) indicate that the contamination occurring within the Puhokio Stream Catchment is of animal origin. The open circles indicate some analyses done on the Motuwaireka Lagoon in Riversdale which is also an agricultural stream that forms a lagoon prior to discharging to sea.

Whitening agents

Table 2: Analysis of whitening agents

Description	Puhokio Stream @ Gillies Crescent	Puhokio Stream @ Lagoon	Puhokio Stream @ Gillies Crescent	Puhokio Stream @ Lagoon
Date sampled	27/11/01	27/11/01	31/01/02	31/01/02
FWA (ug/L)	<0.01	0.12	<0.01	<0.01

The water quality testing showed that whitening agents were often less than detectable concentrations. However during the high rainfall event at lagoon end of the Puhokio small concentration of whitening agents was detected. It is likely that these whitening agents came from septic tank seepages during this period of high rainfall. It is likely that disposal fields of septic tanks were saturated and some septic tank effluent was reaching the Puhokio Stream during this time.

Conclusion

This report indicates that there is no one area of the Puhokio Stream Catchment that is more contaminated than the other. Diffuse agricultural runoff is entering the Puhokio Stream as a result of the surrounding land use practices. The faecal sterol analysis indicates that the contamination of the stream is predominantly of animal origin. The whitening agents analysis indicates that septic tank waste is entering the stream during high rainfall periods but that this contamination is not the overriding source of contamination to the stream. It is likely that the sediments of the Puhokio Stream provide many bacteria which are contributing to the poor water quality during the bathing season.

Remediation of the bacteriological water quality of the Puhokio Stream can only occur if catchment scale protection of the stream is undertaken. That is to say that all tributaries and the main stem of the Puhokio Stream would need to be fenced and planted in riparian margins to reduce the input of diffuse agricultural runoff it currently receives. Protection of wetland margins would also benefit stream water quality.

Ongoing riparian enhancement of the Puhokio Stream will have a positive effect on its ecological health or life supporting capacity as riparian margins offer a good buffering system to surrounding land use practices occurring within the catchment.

Literature Cited

Donnison, A. (1998) The potential for ultraviolet disinfection of meat processing wastewater. Water and Wastes in New Zealand. March 1988

Roberts, K. (2002) Recreational Water Quality in Hawke's Bay. Review of the 2001 – 2002 Recreational water Quality Survey. Environmental Management Group Technical Report ISSN 1174 – 3077

Sevicke – Jones, G. (2001) Recreational Water Quality in the Hawke's Bay Region, Part 1 Review of the 200/2001 Recreational Water Quality Survey. Hawke's Bay Regional Council Technical report 01/01, Napier New Zealand.

Stansfield, B. T. (2002) Effects of Rainfall on Bacteriological Water Quality. Internal Report, Hawke's Bay Regional Council, Napier New Zealand.

Appendix 1: Report From Healthcare Hawke's Bay

Hi Brett, this is to confirm that a report into the actions taken by the Public Health Unit on the 29th January this year will be forwarded shortly

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Please call if there are any issues around this
cheers

Bruce

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REPORT

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6 May 2002

Hawkes Bay Regional Council
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Attention: Brett Stansfield

REPORT ON THE EXAMINATION OF WATER SAMPLES SUBMITTED FOR ANALYSIS

Name	26105	26106	26597	26598
Description	Puhokio Stream @ Gillies Crescent	Puhokio Stream @ Lagoon	Puhokio Stream @ Gillies Crescent	Puhokio Stream @ Lagoon
Date sampled	27/11/2001	27/11/2001	31/01/2002	31/01/2002
Time of sampling	09:36	10:00	9.45	10:05
Faecal coliforms/100mL			900	2200
<i>E. coli</i>			850	2000
Enterococci/100mL			90	430
Bifidobacterium/100mL			<1	<1
FWA (ug/L)	<0.01	0.12	<0.01	<0.01
Faecal sterols				
Coprostanol	0.023	0.035	0.006	0.038
24-ethylcoprostanol	0.076	0.095	0.071	0.167
Epicoprostanol	0.005	0.007	0.001	0.001
Cholesterol	1.860	2.540	1.170	1.670
Cholestanol	0.070	0.077	0.037	0.089
24-ethylepicoprostanol	0.020	0.030	0.010	0.050
Coprostanol:24-ethylcoprostanol	0.31	0.37	0.09	0.23
Coprostanol:24-ethylepicoprostanol	1.17	1.16	0.65	0.77
Coprostanol:cholestanol	0.33	0.45	0.18	0.43
Coprostanol:epicoprostanol	4.51	4.72	6.46	38.35
cop/cop+24 ethyl*100 (human only >73% non-human only <38%)	23.50	26.84	8.35	18.65

Notes:

FWA = fluorescent whitening agent (used in washing powders to brighten clothing).

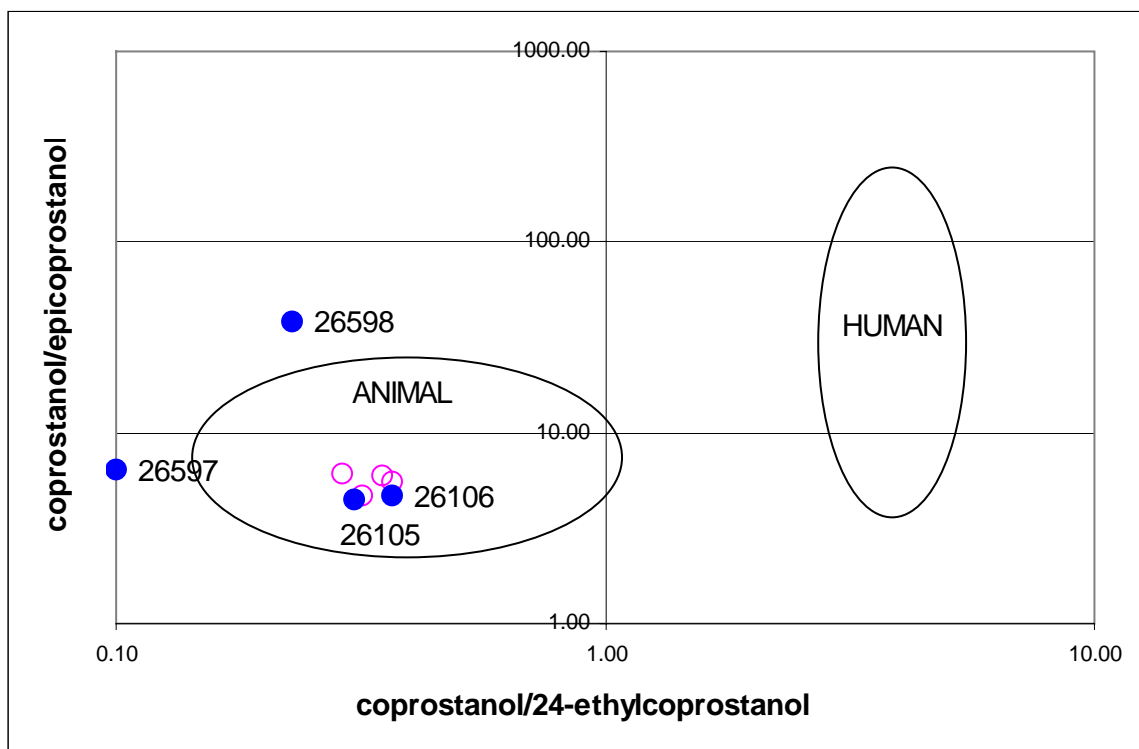
Faecal sterols: The sterol cholesterol can be hydrogenated to one or more of four possible stanols. In humans, cholesterol is preferentially reduced to coprostanol, whereas in the environment cholesterol is predominately reduced to cholestanol. Similarly, plant-derived 24-ethylcholesterol is reduced in the gut of herbivores to 24-ethylcoprostanol and 24-ethylepicoprostanol, whereas in the environment it is primarily reduced to 24-ethylcholestanol.

Interpretation

The faecal sterol results do not support significant human contamination of these water samples. The levels of the stanols detected are all low, and ratio analysis all supports non-human faecal contamination.

The ratio of Coprostanol:cholestanol can indicate whether coprostanol present is of faecal origin. Ratio greater than 0.5 suggests faecal contamination, whereas ratio less than 0.3 may suggest environmental reduction by for example anaerobic bacteria in sediments. Both stream samples at Gillies Crescent had a ratio less than 0.3, while the slightly higher ratios at the other sites may not be significant, or may suggest faecal contamination from other sources.

When the ratios of coprostanol/epicoprostanol to coprostanol/24-ethylcoprostanol are plotted alongside previously analysed human and animal effluent, the four samples analysed all cluster closer to the animal effluent, than the human. Also shown on the graph below are samples previously analysed for Brett Stansfield (open circles).



The presence of FWA in 26106 is interesting. The faecal sterol results do not support a human faecal contamination, while presence of FWAs is usually associated with

human faecal pollution. One explanation could be that the FWAs detected are from grey water input that has not mixed with human sewage.

In conclusion this chemical analysis suggests that the *E. coli* detected are not of human origin. They may be from birds or other animals. Confirmation of this will require analysis with other microbial based assays, which are currently in development.

Brent Gilpin
Research Scientist